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Integrated Data Base Report—1995: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics

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PREFACE

The information in this report summarizes the U.S. Department of Energy (DOE) data base for inventories, projections, and characteristics of domestic spent nuclear fuel and radioactive waste. This report is updated annually to keep abreast of continual waste inventory and projection changes in both the government and commercial sectors. Baseline information is provided for DOE program planning purposes and to support DOE program decisions. Although the primary purpose of this document is to provide background information for program planning within the DOE community, it has also been found useful by state and local governments, the academic community, and some private citizens. To sustain the objectives of this program in providing accurate and complete data in this field of operation, comments and suggestions to improve the quality and coverage are encouraged. Such comments and any general inquiries should be directed to DOE's Office of Environmental Management at either of the following:

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An important part of the Integrated Data Base Program is the Steering Committee, whose members provide both generic guidance and technical input. The membership of this committee, shown on the following page, represents all of the major DOE sites and programs for spent nuclear fuel and radioactive waste management. Each support committee member is assisted by a technical liaison as needed. The participation and assistance of these individuals are acknowledged with appreciation.

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^dWith support from DOE LLW Management Program (ATL International) and National Low-Level Waste Management Program.

Major DOE data sources supporting the Integrated Data Base Program report

Name of data source	Waste type information provided	Supporting DOE program office	Principal contractor and mailing address (Phone number)
DOE Office of Civilian Radioactive Waste Management	Commercial spent nuclear fuel inventories	DOE/RW Office of Storage and Transportation (RW-40)	DOE/RW Waste Acceptance Division (DOE/RW-44) Forrestal Building 1000 Independence Avenue, S.W. Washington, D.C. 20585-0001 (202/586-9867)
Integrated Spent Nuclear Fuel Database System	DOE spent nuclear fuel	Office of Spent Fuel Management (EM-67)	Lockheed Martin Idaho Technologies National Spent Fuel Program P.O. Box 1625 Idaho Falls, ID 83415 (208/526-8909)
Environmental Restoration Core Database	DOE/EM-40 contaminated media/waste	Office of Environmental Restoration (EM-40)	DOE/EM Office of Program Integration (DOE/EM-43) Cloverleaf Building U.S. Department of Energy 20400 Century Boulevard Germantown, MD 20874 (301/903-8121)
International Nuclear Model, Personal Computer Version (PCINM)	Commercial spent nuclear fuel projections	Energy Information Administration (DOE/EIA)	DOE/EIA Analysis and Systems Division Nuclear Fuel Cycle Branch Route Symbol EI-531 950 L'Enfant Plaza Washington, D.C. 20024 (202/426-1129)
Manifest Information Management System (MIMS)	Commercial low-level waste	Office of Waste Management (EM-30)	Lockheed Martin Idaho Technologies National Low-Level Waste Management Program P.O. Box 1625 Idaho Falls, ID 83415 (208/526-9717)

Major DOE data sources supporting the Integrated Data Base Program report (continued)

Name of data source	Waste type information provided	Supporting DOE program office	Principal contractor and mailing address (Phone number)
Uranium Reserve Assessment Program	Commercial uranium mill tailings	Energy Information Administration (DOE/EIA)	DOE/EIA Analysis and Systems Division Nuclear Fuel Cycle Branch Route Symbol EI-531 950 L'Enfant Plaza Washington, D.C. 20024 (202/426-1128)
Transuranic Waste Baseline Inventory Database and Report (TWBID and TWBIR)	DOE transuranic waste	DOE Carlsbad Area Office National Transuranic Program Office (NTPO)	Drez Environmental Associates 8816 Cherry Hills Road, N.E. Albuquerque, NM 87111 (505/828-9857)
DOE Site Treatment Plan Database/ 1995 MWIR Database	RCRA-regulated DOE mixed wastes	Office of Waste Management (EM-30)	DOE/EM Office of Waste Management Office of Planning and Analysis Route Symbol EM-35 Trevion II Building U.S. Department of Energy 19901 Germantown Road Germantown, MD 20874-1290 (301/903-7126)

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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

In this report, all abbreviations, acronyms, and initialisms are defined in text before they are used. In some cases, they are redefined in text for the reader's convenience.

ACRR	Annular Core Research Reactor (at SNL/NM)
AEA	Atomic Energy Act of 1954
AEC	Atomic Energy Commission
Ames	Ames Laboratory, Ames, Iowa
ANC	American Nuclear Corporation
ANL-E	Argonne National Laboratory-East, Argonne, Illinois
ANL-W	Argonne National Laboratory-West, INEL, Idaho
ARCO	Atlantic Richfield (Medical Products) Company, Reading, Pennsylvania
ARRR	Aerotest Radiography and Research Reactor, San Ramon, California
ASI	Advanced Sciences, Inc.
ATL	Advanced Technologies and Laboratories International, Inc.
ATL 1	Atlantic Site 1 (38°30'N, 72°06'W)
ATL 2	Atlantic Site 2 (37°50'N, 70°35'W)
ATR	Advanced Test Reactor (at INEL ICPP)
BAPL	Bettis Atomic Power Laboratory, West Mifflin, Pennsylvania
BARN	Barnwell, South Carolina (commercial waste site)
BCL	Battelle Columbus Laboratories, Columbus, Ohio
BCLDP	Battelle Columbus Laboratories Decommissioning Project, Columbus, Ohio
BDM	BDM Federal, Inc., Germantown, Maryland
BEMR	Baseline Environmental Management Report
BETY	Beatty, Nevada (commercial waste site)
BMI	Battelle Memorial Institute, Columbus, Ohio
BMRR	Brookhaven Medical Research Reactor (at BNL)
BNi	Bechtel National, Inc., Oak Ridge, Tennessee
BNL	Brookhaven National Laboratory, Upton, New York
BR	Belgium reactor
BSR	Bulk Shielding Reactor (at ORNL)
B&W/LTC	Babcock and Wilcox/Lynchburg Technology Center, Lynchburg, Virginia
BWR	Boiling-water reactor
CADMUS	The Cadmus Group, Inc.
CANDU	Canadian Deuterium Reactor
CCMV	Converse County Mining Venture, Converse County, Wyoming
CE	Combustion Engineering Site (FUSRAP site), Windsor, Connecticut
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CEU	Consolidated Edison Uranium (at ORNL)
CFC	Chlorinated fluorocarbon
CH	Contact-handled (transuranic waste)

CISS	Colonie Interim Storage Site, Colonie, New York
CRWMS-M&O	Civilian Radioactive Waste Management System—Management and Operating (contractor)
CY	Calendar year
DAW	Dry active waste
DOD	Department of Defense, U.S.
DOE	Department of Energy, U.S.
DOE/AL	DOE Albuquerque Operations Office, Albuquerque, New Mexico
DOE/CAO	DOE Carlsbad Area Office, Carlsbad, New Mexico
DOE/CH	DOE Chicago Operations Office, Argonne, Illinois
DOE/DP	DOE Office of Defense Programs (Headquarters), Germantown, Maryland
DOE/EIA	DOE Energy Information Administration, Washington, D.C.
DOE/EM	DOE Office of Environmental Management (Headquarters), Germantown, Maryland
DOE/FN	DOE Fernald Area Office, Cincinnati, Ohio
DOE/HQ	DOE Headquarters, Washington, D.C. and Germantown, Maryland
DOE/ID	DOE Idaho Operations Office, Idaho Falls, Idaho
DOE/NV	DOE Nevada Operations Office, Las Vegas, Nevada
DOE/OAK	DOE Oakland Operations Office, Oakland, California
DOE/OH	DOE Ohio Field Office, Miamisburg, Ohio
DOE/OR	DOE Oak Ridge Operations Office, Oak Ridge, Tennessee
DOE/OSTI	DOE Office of Scientific and Technical Information, Oak Ridge, Tennessee
DOE/RF	DOE Rocky Flats Office, Golden, Colorado
DOE/RL	DOE Richland Operations Office, Richland, Washington
DOE/RW	DOE Office of Civilian Radioactive Waste Management (Headquarters), Washington, D.C.
DOE/SR	DOE Savannah River Operations Office, Aiken, South Carolina
DOE/WIPP	DOE WIPP Project Office, Carlsbad, New Mexico
DOE/WVAO	DOE West Valley Area Office, West Valley, New York
DOT	Department of Transportation, U.S.
DRCT	Dry rod consolidation technology
DWCS	Defueling water cleanup system
DWMP	Defense Waste Management Plan
DWPF	Defense Waste Processing Facility
D&D	Decontamination and decommissioning
EA	Environmental assessment
EBR	Experimental Breeder Reactor (at ANL-E)
EC	Electron capture
ECF	Extended Core Facility (at INEL NRF)
EG&G/ID	EG&G Idaho, Inc., Idaho Falls, Idaho (former management and operating contractor for Idaho National Engineering Laboratory)
EIA	Energy Information Administration (DOE)
EIS	Environmental impact statement
EMAD	Engine maintenance assembly and disassembly (at NTS)
ENVR	Envirocare facility, Clive, Utah
EOY	End of (calendar) year
EPA	Environmental Protection Agency, U.S.
ERR	Elk River Reactor, Elk River, Minnesota
ETEC	Energy Technology Engineering Center, Canoga Park, California [also referred to as the Santa Susana Field Laboratory (SSFL)]
FEMP	Fernald Environmental Management Project, Fernald, Ohio
FFCA	Federal Facility Compliance Act of 1992
FFTF	Fast Flux Test Facility, Hanford, Washington

FIS	Farallon Islands (Pacific Ocean off Central California)
FNAL	Fermi National Accelerator Laboratory, Batavia, Illinois
FRR	Foreign Research Reactor
FSVR	Fort St. Vrain Reactor, Platteville, Colorado
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal year
GA	General Atomics, San Diego, California
GAP CON	Gap conductance
GDP	Gaseous diffusion plant
GE	General Electric
GETR	General Electric Test Reactor, Pleasanton, California
GJPO	(DOE) Grand Junction Projects Office, Grand Junction, Colorado
GJRAP	Grand Junction Remedial Action Project
GPU	General Public Utilities Corporation, Parsippany, New Jersey
GTCC	Greater-than-Class-C (low-level waste)
Hanford	Hanford Site, Richland, Washington
HAZWRAP	Hazardous Waste Remedial Actions Program
HCF	Hot Cell Facility (at SNL/NM)
HEDL	Hanford Engineering Development Laboratory (at Hanford)
HEN	Cape Henry (Atlantic Ocean off Virginia)
HFBR	High-Flux Beam Reactor (at BNL)
HFEF	Hot Fuel Examination Facility (at ANL-W)
HIC	High-integrity container
HLW	High-level waste
HTGR	High-temperature, gas-cooled reactor
HWVP	Hanford Waste Vitrification Plant (at Hanford)
ICPP	Idaho Chemical Processing Plant, Idaho National Engineering Laboratory
IDB	Integrated Data Base (Program)
IE	Irradiation effects
IFSF	Irradiated Fuel Storage Facility (at INEL)
I/I	Industrial and institutional (waste)
INEL	Idaho National Engineering Laboratory, Idaho Falls, Idaho
ISA	Interim Storage Area (at Hanford)
ISFSI	Independent Spent Fuel Storage Installation
ISL	In situ leaching
IT	Isomeric transition
ITRI	Inhalation Toxicology Research Institute, Kirtland Air Force Base, Albuquerque, New Mexico
JAI	(E.R.) Johnson Associates, Inc., Oakton, Virginia
JIO	Joint Integration Office, Albuquerque, New Mexico
K-25	Oak Ridge K-25 Site, Oak Ridge, Tennessee (formerly called the Oak Ridge Gaseous Diffusion Plant)
KAPL	Knolls Atomic Power Laboratory, Schenectady, New York
KCP	Kansas City Plant, Kansas City, Missouri
KESS	Kesselring Site (at KAPL)
LANL	Los Alamos National Laboratory, Los Alamos, New Mexico
LBL	Lawrence Berkeley Laboratory, Berkeley, California
LDR	Land disposal restriction

LEHR	Laboratory for Energy-Related Health Research, Davis, California
LEU	Low-enriched uranium
LFRSB	Loose fuel-rod shipping basket
LGR	Light-water cooled, graphite-moderated reactor
LLNL	Lawrence Livermore National Laboratory, Livermore, California
LLR	LOFT lead rod
LLRWPA	Low-Level Radioactive Waste Policy Act of 1980
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LLW	Low-level waste
LLWMP	Low-Level Waste Management Program
LMER	Lockheed Martin Energy Research (Corporation), Oak Ridge, Tennessee
LMES	Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee
LMFBR	Liquid Metal Fast Breeder Reactor
LMIT	Lockheed Martin Idaho Technologies, Idaho Falls, Idaho
LOC	Loss of coolant
LOFT	Loss-of-fluid test
LSA	Low specific activity
LWBR	Light-water breeder reactor
LWR	Light-water reactor
MACTEC	MAC Technical Services Company
MAPI	Mitsubishi Atomic Power Industries
MASS	Massachusetts Bay
MED	Manhattan Engineer District (Manhattan Project)
MFKY	Maxey Flats, Kentucky (commercial waste site)
MFRP	Midwest Fuel Recovery Plant, Morris, Illinois (commercial spent fuel storage site)
MIMS	Manifest Information Management System
MLLW	Mixed low-level waste
Mound	Mound Plant, Miamisburg, Ohio
MRM	Miscellaneous radioactive material
MSR	Molten Salt Reactor (at ORNL)
MSRE	Molten Salt Reactor Experiment
MTIHM	Metric tons initial heavy metal
MTR	Materials Test Reactor (at INEL)
MTRUW	Mixed transuranic waste
MTU	Metric tons uranium
MURR	Missouri (University of) Research Reactor, Columbia, Missouri
MWIR	Mixed Waste Inventory Report
NA	Not applicable
NARM	Naturally occurring and accelerator-produced radioactive material
NBSR	National Bureau of Standards Reactor, Gaithersburg, Maryland
NEPA	National Environmental Policy Act of 1969
NFS	Nuclear Fuel Services, Erwin, Tennessee
NORM	Naturally occurring radioactive material
NPL	National priorities list
NR	Naval reactors
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility (at INEL)
NTIS	National Technical Information Service, Springfield, Virginia
NTPO	National Transuranic Waste Program Office
NTS	Nevada Test Site, Mercury, Nevada
NUMEC	Nuclear Uranium Materials and Equipment Corporation

NUS	NUS Corporation, Gaithersburg, Maryland
NWPA	Nuclear Waste Policy Act of 1982
NYSERDA	New York State Energy Research and Development Authority, Albany, New York
OPTRAN	Operational transit
OR	Oak Ridge complex: Oak Ridge National Laboratory, K-25 Site, and Oak Ridge Y-12 Plant, Oak Ridge, Tennessee
ORAU	Oak Ridge Associated Universities, Oak Ridge, Tennessee
ORIGEN2	Oak Ridge Isotope Generation and Depletion Code (Version 2)
ORISE	Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee
ORNL	Oak Ridge National Laboratory, Oak Ridge, Tennessee
ORR	Oak Ridge Research Reactor (at ORNL)
OTS	Office of Technical Services, Roy F. Weston, Inc./H&R Technical Associates, Inc., Germantown, Maryland
PAD	Paducah Gaseous Diffusion Plant, Paducah, Kentucky
PANT	Pantex Plant, Amarillo, Texas
PCB	Polychlorinated biphenyl
PER	(Special) Power Excursion Reactor (test) (at INEL)
PFP	Plutonium Finishing Plant (at Hanford)
Pinellas	Pinellas Plant, Largo, Florida
PNNL	Pacific Northwest National Laboratory, Richland, Washington
PNRO	DOE Pittsburgh Naval Reactors Office, West Mifflin, Pennsylvania
PORTS	Portsmouth Gaseous Diffusion Plant, Portsmouth, Ohio
PPPL	Princeton Plasma Physics Laboratory, Princeton, New Jersey
PWR	Pressurized-water reactor
PUREX	Plutonium/uranium extraction
RA	Remedial action
RAP	Remedial action project
RASB	Radioactive asbestos
RBOF	Receiving Basin for Off-Site Fuels (at SRS)
RCF	RCRA (see below) facility assessment
RCRA	Resource Conservation and Recovery Act of 1976
REECO	Reynolds Electrical and Engineering Co., Inc., Mercury, Nevada
RFETS	Rocky Flats Environmental Technology Site, Golden, Colorado
RH	Remote-handled (transuranic waste)
RI	Rockwell International Corporation, Pittsburgh, Pennsylvania
RIA	Reactivity initiated accident
RICH	Richland, Washington (commercial waste site)
RMI	Reactive Metals, Incorporated Titanium Company Extrusion Plant, Ashtabula, Ohio
RPCB	Radioactive polychlorinated biphenyl
RSWF	Radioactive Scrap and Waste Facility (at ANL-W)
SAIC	Science Applications International Corporation
SCB	Santa Cruz Basin (Pacific Ocean off Santa Cruz, California)
SDG	San Diego (Pacific Ocean off San Diego, California)
SDS	Submerged demineralizer system
SEG	Scientific Ecology Group, Inc., Oak Ridge, Tennessee
SFD	Severe fuel damage
SFMP	Surplus Facilities Management Program
SHEF	Sheffield, Illinois (commercial waste site)
SLAC	Stanford Linear Accelerator Center, Palo Alto, California

SM	Stationary media
SNF	Spent nuclear fuel
SNL/CA	Sandia National Laboratories/California, Livermore, California
SNL/NM	Sandia National Laboratories/New Mexico, Albuquerque, New Mexico
SNM	Special nuclear material
SNRO	DOE Schenectady Naval Reactors Office, Schenectady, New York
SNRS	Stationary Neutron Radiography System, Sacramento, California
SPF	Spontaneous fission
SRS	Savannah River Site, Aiken, South Carolina
SRTC	Savannah River Technical Center (at SRS)
SS	Stainless steel
SSFL	Santa Susana Field Laboratory, Canoga Park, California [also referred to as the Energy Technology Engineering Center (ETEC)]
SWIMS	Solid Waste Information Management System
SWU	Separative work unit
TAN	Test Area North (at INEL)
TBD	To be determined
TBE	Teledyne Brown Engineering, Westwood, New Jersey
TC	Thermocouple
TCLP	Toxicity characteristic leaching procedure
TESS	TRW Environmental Safety Systems, Inc.
THOREX	Thorium extraction
TMI	Three Mile Island reactor site, Middletown, Pennsylvania
TRA	Test Reactor Area (at INEL)
TREAT	Transient Reactor Test Facility (at ANL-W)
TRIGA	Training Reactor, Isotopes, General Atomic
TRU	Transuranic
TRUW	Transuranic waste
TSCA	Toxic Substances Control Act of 1976
TSR	Tower Shielding Reactor (at ORNL)
T/S/D	Treatment, storage, and disposal
TVA	Tennessee Valley Authority, Knoxville, Tennessee
TWBID	Transuranic Waste Baseline Inventory Database
TWBIR	Transuranic Waste Baseline Inventory Report
UMT	Uranium mill tailings
UMTRAP	Uranium Mill Tailings Remedial Action Project
USAMC	U.S. Army Material Command, Rock Island, Illinois
USGS	U.S. Geological Survey
VA	Veterans Administration, U.S.
VEPCO	Virginia Electric Power Company, Richmond, Virginia
WAC	Waste acceptance criteria
WEC	Westinghouse Electric Corporation, Pittsburgh, Pennsylvania
WHC	Westinghouse Hanford Company, Richland, Washington
WHPP	(Transuranic) Waste Handling and Packaging Plant, Oak Ridge National Laboratory
WIND	Windsor Site (at KAPL)
WIPP	Waste Isolation Pilot Plant, Carlsbad, New Mexico
WMin	Waste minimization
WPIO	Waste Isolation Pilot Plant Project Integration Office, Albuquerque, New Mexico
WSSRAP	Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri

WTAC	Waste Isolation Pilot Plant Technical Assistance Contractor
WTWBIR	Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report
WVDP	West Valley Demonstration Project, West Valley, New York
WVNS	West Valley Nuclear Services Company, Inc., West Valley, New York
WVNY	West Valley, New York (commercial waste site from 1963–1981)
W/WIPP	Westinghouse/WIPP Project, Carlsbad, New Mexico
Y-12	Oak Ridge Y-12 Plant, Oak Ridge, Tennessee
11e(2)	By-product material as defined in Sect. 11e(2) of the Atomic Energy Act of 1954
M11e(2)	Mixed 11e(2) by-product material

INTEGRATED DATA BASE REPORT—1995: U.S. SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE INVENTORIES, PROJECTIONS, AND CHARACTERISTICS

ABSTRACT

The Integrated Data Base Program has compiled historic data on inventories and characteristics of both commercial and U.S. Department of Energy (DOE) spent nuclear fuel and commercial and U.S. government-owned radioactive wastes. Except for transuranic wastes, inventories of these materials are reported as of December 31, 1995. Transuranic waste inventories are reported as of December 31, 1994. All spent nuclear fuel and radioactive waste data reported are based on the most reliable information available from government sources, the open literature, technical reports, and direct contacts. The information forecasted is consistent with the latest DOE/Energy Information Administration (EIA) projections of U.S. commercial nuclear power growth and the expected DOE-related and private industrial and institutional activities.

The radioactive materials considered, on a chapter-by-chapter basis, are spent nuclear fuel, high-level waste, transuranic waste, low-level waste, uranium mill tailings, DOE Environmental Restoration Program contaminated environmental media, naturally occurring and accelerator-produced radioactive material, and mixed (hazardous and radioactive) low-level waste. For most of these categories, current and projected inventories are given through the calendar-year 2030, and the radioactivity and thermal power are calculated based on reported or estimated isotopic compositions.

0. OVERVIEW

0.1 INTRODUCTION

This report is an update of the previous document¹ on spent nuclear fuel (SNF) and radioactive waste inventories and projections that was prepared for use in the planning and analysis of various SNF and waste management functions. Quantities of SNF and radioactive wastes produced from both commercial and U.S. Department of Energy (DOE)-sponsored activities are reported. Except for transuranic wastes (TRUW), whose inventories are reported as of December 31, 1994, historical SNF and radioactive waste inventories are reported as of December 31, 1995. Projections of future SNF and radioactive wastes are generally reported for the calendar-year (CY) period 1996–2030. Such projections may change in future revisions of this report as waste minimization (WMin), environmental restoration, and decontamination and decommissioning (D&D) programs and activities at various government and commercial sites are defined and become operative. The tables of this document report historical inventories and projection data on a CY basis. These tables use a horizontal line to mark the point in time when past history ends and future projections begin. Because historical SNF and radioactive waste inventories are generally reported as of December 31, 1995, the line is drawn between the data entries for 1995 and 1996. Data reported for 1996 in this document are regarded as projected information.

This document contains information that has been assembled as a part of the Integrated Data Base (IDB) Program at Oak Ridge National Laboratory (ORNL), which has the lead responsibility for maintaining and reporting summary files of pertinent data on current and projected inventories and characteristics of permanently discharged domestic SNF and radioactive wastes. While this report documents inventories and projections of radioactive wastes from commercial and DOE site activities, estimates for certain other waste categories are not fully reported because of the current unavailability of data. These categories include naturally occurring and accelerator-produced radioactive material (NARM),

discussed in Sect. 0.2, and wastes from U.S. Department of Defense (DOD) activities, particularly those resulting from the cleanup of military sites contaminated with significant amounts of radioactive waste. A study² by the U.S. General Accounting Office indicates that as many as 420 DOD locations could be contaminated with radioactive wastes. Future updates of this report will work toward reporting information and data on NARM and DOD site radioactive wastes as they become available.

This report also does not report inventories of nonradioactive materials. These include hazardous wastes, sanitary wastes, and materials not categorized as waste (MNCAW), such as uncontaminated scrap metal. Preliminary estimates of inventories of MNCAW are reported in ref. 3.

Except for some NARM, most radioactive waste originates from five major sources: (1) the commercial nuclear fuel cycle; (2) DOE-related activities; (3) institutions such as hospitals, universities, and research foundations; (4) industrial uses of radioisotopes; and (5) mining and milling of uranium ore. The waste is broadly categorized as SNF, high-level waste (HLW), TRUW, low-level waste (LLW), and uranium mill tailings (UMT). Large quantities of radioactive waste also result from DOE site environmental restoration activities and the D&D programs of DOE and commercial nuclear facilities. This report also documents inventories and projections of mixed low-level waste (MLLW), which is both hazardous and radioactive.

The primary purpose of this document is to report U.S. SNF and radioactive waste inventories, projections, and characteristics. The data presented were obtained through the cooperation and assistance of the offices and programs that were established by DOE to oversee the management of the various radioactive wastes and SNFs. In addition, the recent literature was reviewed to aid in selecting the data that are presented herein and to help establish a basis for many of the calculated radioactivity levels and heat-generation rates that are included. In this report, SNF and radioactive wastes are characterized from the standpoint of their volumes (or masses) and their nuclear, physical, and

chemical properties. The data reported are selected from more extensive information; that information is available upon request.

This annual inventory report contains summarized data of types found to be useful for programmatic planning purposes within the DOE community. The data are intended to provide a common basis for both DOE management-level planning and for more detailed analyses of the waste management system that are conducted by DOE contractors and field offices. However, this report is not intended to present the detailed types of information required as input to such analyses. The best sources of such information are the appropriate DOE operations offices, waste sites, or relevant documents previously issued, some of which may be referenced in this report.

This report does not address the programmatic implications of the data presented, such as the possible future need for interim SNF storage facilities. Discussion of the data is minimized to explain mainly what the data represent. Major DOE data sources providing information and data for this report are identified in a table following the preface. Likewise, discussions of packaging details, shielding and transportation requirements, health and environmental effects, and costs are purposely avoided. Questions regarding the information and data presented may be addressed to the IDB Program.

The DOE waste information and data contained in this report are furnished by the DOE contractor sites listed in Table 0.1. This table indicates also the types of radioactive waste managed at each site. The DOE site data (waste inventories, projections, and characteristics) are used by DOE-Headquarters (DOE-HQ), operations offices, and operating contractors for the management and strategic planning of various waste programs. The objective of this report is to provide waste information that is consistent, reflects current inventories and projections, and includes the types of basic data best suited to meet DOE waste program planning needs.

Information for this report is provided by a variety of sources. The DOE site waste data reported were received from DOE contractors through DOE operations offices. DOE-HQ assigns to selected organizations major responsibilities for providing information on particular topics involving SNF and radioactive waste management. Further detailed information is generally available from data bases maintained at the specific DOE and commercial sites. Additional information on the reference sites and facilities referred to in this report is provided in Appendix C.

0.2 CHARACTERIZATION OF WASTE FORMS

The major characteristics of radioactive materials and wastes are described in the following:

● Spent Nuclear Fuel (SNF)

SNF consists of irradiated fuel discharged from a nuclear reactor. Unless otherwise identified, all SNFs discussed in this report are assumed to be permanently discharged and eligible for repository disposal. Three categories of permanently discharged SNF are considered: (1) fuel from commercial light-water reactors (LWRs); (2) fuel from non-LWR commercial reactors [e.g., the Fort St. Vrain high-temperature, gas-cooled reactor (HTGR)]; and (3) special fuels associated with government-sponsored research and demonstration programs, universities, and private industries. This report does not track the inventories of government production reactor SNFs that have been reprocessed in the manufacture of nuclear weapons for national defense. However, the inventories of HLW resulting from the reprocessing of these fuels are reported in Chapter 2. Also, Chapter 1 reports quantities of DOE SNF.

Currently, most LWR SNF assemblies are stored in pools at the reactor sites. The bulk of the remainder is in storage at the West Valley Demonstration Project (WVDP) site at West Valley, New York; the Idaho National Engineering Laboratory (INEL) at Idaho Falls, Idaho; and the Midwest Fuel Recovery Plant (MFRP) at Morris, Illinois. The WVDP facility is currently being decommissioned. All utility-owned SNF assemblies previously stored there have been returned to the utilities, and the fuel remaining is DOE-owned material.

SNFs discharged from a variety of reactors are currently stored at the Hanford Site (Hanford) and INEL. Hanford contains inventories of fuel from the N Reactor, the Fast Flux Test Facility (FFTF), and pressurized-water reactor (PWR)—Core II fuel from Shippingport. Fuel from the damaged Three Mile Island (TMI)—Unit 2 reactor, as well as some of the SNF from the Fort St. Vrain HTGR, are stored at INEL. Some special SNFs are stored at the Savannah River Site (SRS) and at INEL. These special fuels are government owned and are not scheduled for reprocessing in support of DOE activities.

- **High-Level Waste (HLW)**

For this report, HLW means the highly radioactive material resulting from the reprocessing of SNF. This material includes mainly the liquid wastes remaining from the recovery of uranium and plutonium in a fuel reprocessing plant. This HLW may also be in the form of sludge, calcine, or other products into which such liquid wastes are converted to facilitate their handling and storage. Such waste contains fission products that result in the release of considerable decay energy.⁴ For this reason, heavy shielding is required to absorb penetrating radiation, and provisions (e.g., cooling systems) are needed to dissipate decay heat from HLW.

- **Transuranic Waste (TRUW)**

TRUW refers to radioactive waste that contains more than 100 nCi/g of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years.^{5,6} Such waste results primarily from fuel reprocessing and from the fabrication of plutonium weapons and plutonium-bearing reactor fuel. Generally, little or no shielding is required ["contact-handled" (CH) TRUW], but energetic gamma and neutron emissions from certain transuranic (TRU) nuclides and fission-product contaminants may require shielding or remote handling ["remote-handled" (RH) TRUW].

- **Low-Level Waste (LLW)**

Several statutes (refs. 4, 6, and 7) define LLW not by what it is, but by what it is not. In general, LLW is radioactive waste not classified as SNF, HLW, TRUW, nor by-product materials such as UMT or thorium mill tailings. However, there are slight differences between the specific regulatory definitions of DOE-generated LLW and commercial LLW.

The definition of DOE LLW is based on DOE Order 5820.2A,⁶ which specifies DOE's policy for radioactive waste management. According to this order, LLW includes all radioactive waste not classified as either HLW, TRUW, SNF, or the bulk of the by-product tailings containing uranium or thorium and their decay products from processed ore. The DOE policy, as stated in Order 5820.2A, allows small volumes of fissionable material to be irradiated for research and development (R&D) only—but not for the production of power or plutonium—and small concentrations of TRU (<100 nCi/g) radionuclides to be managed as LLW. The same DOE policy allows

small volumes of DOE waste containing by-product material [specified in Sect. 11e(2) of the Atomic Energy Act of 1954 (AEA)]⁸ or NARM to be managed as LLW. Any LLW that also contains hazardous chemicals covered by either the Resource Conservation Recovery Act (RCRA)⁹ or the Toxic Substances Control Act (TSCA)¹⁰ requires management as a "mixed waste."

The definition of commercial LLW is based on two statutes, the Nuclear Waste Policy Act (NWPA)⁴ and the Low-Level Radioactive Waste Policy Amendments Act (LLRWPA).⁷ According to both the NWPA and the LLRWPA, commercial LLW is radioactive material that (a) is not HLW, SNF, TRUW, or by-product material as defined in Sect. 11e(2) of the AEA; and (b) consistent with existing law, is classified by the U.S. Nuclear Regulatory Commission (NRC) as LLW.

The radiation level from LLW waste may sometimes be high enough to require shielding for handling and transport. For commercial LLWs, the NRC has defined, in ref. 11, four disposal categories of LLW that require differing degrees of confinement and/or monitoring: classes A, B, C, and Greater-Than-Class-C (GTCC). The NRC excludes NARM from the LLW category. DOE LLWs are classified by groupings of disposal categories that are site specific, yet similar to the NRC categories. This report documents inventories of solid LLW either destined for disposal or awaiting treatment prior to disposal. It includes no liquid or gas waste in storage.

- **Uranium Mill Tailings (UMT)**

UMT are the earthen residues that remain after the extraction of uranium from ores. Tailings are generated in very large volumes and contain low concentrations of naturally occurring radioactive materials. These materials comprise a potential health hazard; the isotopes of major concern are ²²⁶Ra and its daughter, ²²²Rn.

- **Naturally Occurring and Accelerator-Produced Radioactive Material (NARM)**

NARM wastes include both accelerator wastes (LLW) and naturally occurring radioactive material (NORM) that contain radionuclides (e.g., ²²⁶Ra, ²²²Rn, ²³²Th, ²³⁸U) existing throughout the earth's crust. Accelerator wastes include accelerator targets, wastes from accelerator maintenance or D&D, and wastes from radiopharmaceutical manufacture. NORM

wastes are classified according to their specific activity as either discrete or diffuse. Discrete NORM wastes have a relatively small volume but large radioactivity and include industrial gauges, old radium watch and industrial dials, radium needles in medical equipment, and resins (filters) that remove radioactive radium and some radiopharmaceutical waste from contaminated public drinking water. Diffuse NORM wastes are characterized by a relatively large volume with small radioactivity. These materials result from industrial processes and include:

- coal ash and slag from utility electrical generation;
- solid wastes from geothermal energy production;
- slag, leachate, and tailings from the mining and processing of metals other than uranium or thorium (e.g., copper);
- sludge from drinking water treatment;
- scale, sludge, produced water, and equipment from oil and natural-gas production containing NORM; and
- wastes (phosphogypsum and slag) from mining phosphate ores for fertilizer (ammonium phosphate) production.^{12,13}

Current inventories of total domestic NARM wastes are not known. Future updates of this document will include additional information on NARM waste inventories, projections, and characteristics as they become available.

• **Mixed Low-Level Waste (MLLW)**

MLLW contains concentrations of both low-level radioactive materials and hazardous chemicals. The hazardous component of mixed waste has characteristics identified by any or all of the following statutes: the RCRA, as amended;⁹ the TSCA;¹⁰ and state regulations. Typically, MLLW from activities supporting DOE programs includes a variety of contaminated materials, such as air filters, cleaning solutions, engine oils and grease, paint residues, soils, construction and building materials, water-treatment chemicals, and decommissioned plant equipment. This report documents inventories and generation rates of various types of mixed wastes stored at DOE sites based on updated information and data from the DOE Site Treatment Plan Data Base¹⁴ and TSCA waste information and data reported to the IDB Program by DOE sites.

• **Generated, Treated, Stored, and Disposed Wastes**

It should be emphasized that all of the types of radioactive materials and wastes discussed in this

report can exist either as material generated, treated, stored, or disposed. The distinctions among these various waste conditions or "states" are as follows:

- *Generated waste.* A material recently discharged from a facility production process or operation that can be regarded as a waste because it has no economic value. In this report, quantities of generated waste are measured in units of volume [cubic meters (m³)] or mass (kg) produced during a calendar year.
- *Treated waste.* A waste that, following generation, has been altered chemically or physically to reduce its toxicity or prepare it for storage or disposal on- or off-site. Waste treatment can include volume-reduction activities, such as incineration or compaction, which may be done prior to either storage or disposal or both (discussed next).
- *Stored waste.* A waste that, following generation (and usually some treatment), is being (temporarily) retained and monitored in a retrievable manner pending disposal. In this report, inventories and projections of stored radioactive materials or wastes are reported in volume (m³) or mass (kg) units or both.
- *Disposed waste.* A waste that has been put in final emplacement to ensure its isolation from the biosphere, with no intention of retrieval. Deliberate action is required to regain access to the waste. Disposed waste includes materials placed in a geologic repository, buried underground in shallow pits, dumped at sea, or discarded by hydrofracture injection. The latter two techniques were past practices and are no longer performed.

Throughout this report, the reader is urged to note the distinctions among these waste conditions. Such conditions have a great impact on the regulatory status of the waste materials considered in this report.

0.3 METHODS AND ASSUMPTIONS USED IN REPORT PREPARATION

This report consolidates a large amount of information from many sources. Some of these data are historical in nature, some are current, and some are projected; some have been calculated or estimated, and some have been measured. Over the years, waste regulations have been revised, waste category definitions have changed,

measurement instruments and calibration methods have been improved, and record-keeping has been upgraded at all waste-generating and -receiving sites. In preparing this report, a major effort has been made to integrate waste data from many sources and to strive for a consistent and technically rational approach for the entire scope of coverage. Our primary sources of data are referenced, and, for calculated values (e.g., decayed radioactivity and thermal power), the bases for the calculations are identified. To achieve adequate integration of data, numerous factors had to be considered; these are cited in footnotes that generally accompany the tables and figures of this report. In some cases, a more thorough explanation is provided in the text.

Each chapter details the assumptions on which its waste inventories and projections are based. The broader assumptions are mentioned here and are listed in Table 0.2. These include the projected time frame and specific assumptions used for estimating commercial and government (DOE) waste projections. For the commercial fuel cycle, the SNF and waste projections depend upon the nuclear power growth scenario. The commercial fuel cycle waste projections reported in this document assume a reference projection of nuclear power growth and no SNF reprocessing. The reference nuclear power electrical growth projection (and associated discharged SNF schedule) used throughout this report is the 1996 DOE/Energy Information Administration (EIA) Low Case (No New Orders).¹⁵ Throughout this report, this case will be referred to as the Low Case. The Low Case SNF and power-capacity projection cases are based on a set of assumptions involving nuclear electricity generation growth, reactor fuel burnup levels, reactor construction schedules, and reactor operating lifetimes and capacity factors. These assumptions are documented by DOE/EIA in ref. 15. In particular, the Low Case assumes that no new advanced LWRs will become operational before the year 2015 and that all current nuclear units are retired on the dates when their initial license-terms expire.

Detailed information about reactors already built, being built, or planned in the United States for domestic use or export as of December 31, 1995, is provided in report DOE/OSTI-8200-R59 (ref. 16), which contains a comprehensive listing of all domestic reactors categorized by primary function or purpose: civilian, production, military, export, and critical assembly.

The data for total waste inventories (which comprise historical data) are obviously less accurate than the values recorded for recent waste additions. The number of digits used in reporting these values is generally greater than justified in terms of numerical significance, but this proves useful and necessary for bookkeeping purposes. In some cases, the values cited are significantly different from those previously reported. This is generally a result of improved

estimates, new measurements, or redefinition of terms. Explanations are given in such cases. Many of the comments received during the final review stage of this report deal with changes that have occurred after December 31, 1995—some as recently as November 1996. These changes are generally cited in footnotes.

For the sake of brevity, many of the figures and tables of this report use the exponential (E) notation. As examples of this notation, the constant 1.234E+2 means 1.234×10^2 , or 123.4; and 1.234E-4 means 1.234×10^{-4} , which is 0.0001234.

0.4 WASTE CHARACTERISTICS AND UNITS REPORTED

Principal characteristics reported for most radioactive wastes discussed in this report include volume, radioactivity, and thermal power. All characteristics are reported in metric units and, depending on the waste form, can be significant considerations in meeting the requirements for waste treatment, storage, and disposal. Waste volume is reported in cubic meters (m^3) and generally reflects the amount of space occupied by the waste and its container. Radioactivity represents the rate of spontaneous disintegration of the radionuclides comprising the waste. In this report, radioactivity is measured by a unit called a curie (Ci), which is 3.7×10^{10} nuclear disintegrations per second. Over time, radionuclides decay to nonradioactive, stable isotopes. As an example, the short-lived radionuclides found in SNF rapidly decay during the first few years after the fuel is removed from a reactor.

It should be noted that while waste volumes accumulate with time by conventional addition, total radioactivity does not. Because of radioactive decay, cumulative activity cannot be based on reported annual additions; rather it must be estimated from knowledge of the waste composition, which includes the radionuclides comprising the waste, their concentrations, and decay attributes (e.g., half-lives and decay schemes). In this report, decayed radioactivity is generally estimated for some wastes by an abridged version of the ORIGEN2 code (ref. 17). Annual levels of radioactivity (Ci) reported in this document include contributions from both parent and daughter decay products.

Thermal power is a measure of the rate of heat-energy emission resulting from the decay of radionuclides in a waste. Like radioactivity, thermal power is not cumulative by conventional addition because of radioactive decay. Information on thermal power is needed in the design of shipping casks, storage facilities, and repositories where temperature rise, especially with regard to SNF and HLW, is an important concern. Thermal energy generation rates

are highest for SNF, HLW, and RH TRUW. They may also be important for certain types of LLW. The unit of thermal power used in this report is the watt (W), which represents 1 joule (J) of thermal energy emitted per second. Estimates of thermal power are based on radionuclide composition as well as total activity. While levels of thermal power may not be significant for certain waste forms (particularly some types of LLW), they are nevertheless reported for the major radioactive waste categories referenced in this report to provide a standard for comparison.

For SNF and TRUW, mass is reported to provide better assurances of accountability. SNF is reported in units of metric tons of *initial* heavy metal (MTIHM) to avoid difficulties and confusion arising from the need to estimate ranges of varied heavy-metal content (MTHM) that result from different levels of enrichment and reactor fuel burnup. Mass is reported in kilograms (kg) for the TRU radionuclides comprising TRUWs.

In this report, quantities of generated wastes are expressed in terms of either the amount of mass (kg) or volume (m^3) produced in a given calendar year. Thus, generation rates for wastes are expressed in either kilograms per year (kg/year) or cubic meters per year (m^3 /year), depending on the availability of site information. Annual generation rates are reported in this document for SNF, TRUW, LLW, and MLLW. No HLW from SNF reprocessing was generated during 1995. In previous issues of this document, annual generation rates have not been reported for HLW in part because there are problems in accurately estimating HLW generation levels. One major difficulty is accounting for net waste-quantity changes due to the combined effects of various modes of site waste management operations such as evaporation and calcination.

Quantities of wastes can also be reported in terms of the number and types of waste containers. LWR SNF inventories and projections can be expressed in terms of the number of permanently discharged boiling-water reactor (BWR) and PWR fuel assemblies. HLW will be immobilized in either borosilicate glass or a glass/ceramic matrix solidified in stainless steel canisters. Quantities of LLW and stored TRUW can be based on the number and types of drums, boxes, or containers used or scheduled for use.

Waste characteristics are also identified by waste composition. Throughout this report, waste composition is expressed in terms of the following:

- radioactivity (Ci) or specific-activity (Ci/m^3) breakdown by radionuclide (with accompanying daughter products) and
- physical form (solid, liquid, gas, or sludge) or chemical content (by chemical component),

expressed in terms of either volume (m^3) or mass (kg) or as a percentage of total weight (wt %), volume (vol %), or activity (act %).

0.5 CHAPTER OVERVIEWS

A brief summary of each chapter in this report is presented in the following paragraphs.

0.5.1 Spent Nuclear Fuel (SNF)

Chapter 1 of this report presents national data on the quantities of permanently discharged SNF from commercial nuclear power reactors. Historical data on commercial SNF inventories are reported along with 1996 DOE/EIA projections for the Low Case.¹⁵ The Low Case is the baseline commercial scenario used throughout this report to make waste projections. For the projection period considered in this report (CYs 1996–2030), the Low Case assumes that no new reactors will be ordered.

DOE SNF inventories are also reported in Chapter 1. These include various types of research reactor SNFs which are stored at the SRS and the INEL.

In this report, the mass of discharged SNF is generally measured in MTIHM. The term “initial heavy metal” refers to the original mass of the actinide elements of the fuel, most of which is uranium. (Elements of the actinide group are those with atomic numbers greater than 89.)

0.5.2 High-Level Waste (HLW)

The inventories of HLW in storage at the end of CY 1995 and projected through CY 2030 are given in Chapter 2. The waste forms include liquid, sludge, salt cake, slurry, calcine, precipitate, zeolite, glass, and capsules of separated strontium and cesium. Vitrified defense HLW is projected after the startup of the Defense Waste Processing Facility (DWPF) at SRS in 1996, and projections of vitrified HLW from commercial reprocessing activities are given for the WVDP. Projections recently made of the number of canisters containing the final immobilized form for the DOE HLW at Hanford and the INEL are also reported. In addition, Chapter 2 gives the locations, volumes, and radioactivities of HLW.

In 1992, DOE decided to phase out the reprocessing of its production reactor SNFs. Until then, the reprocessing activities recovered enriched uranium and plutonium which were used to support nuclear weapons production. As a consequence of ceasing to reprocess reactor SNFs, little additional HLW is expected to be generated at DOE sites in the future.

0.5.3 Transuranic Waste (TRUW)

The locations, inventories, and projections of TRUW buried and stored at DOE sites are presented in Chapter 3. Inventories of TRUW are reported as of December 31, 1994, and are virtually all derived from government operations. The inventories documented in this report are based on data provided by the sites and include waste volumes and the masses and radioactivities of contained radionuclides. Projected future TRUW volumes through CY 2022 were also requested from the sites, but the sites were not able to make such estimates in all cases. Projections are reported through CY 2022 for those sites that provided estimates.

In 1984, DOE (with input from other federal agencies) revised the minimum radioactivity concentration level for defining TRUW from greater than 10 nCi/g to greater than 100 nCi/g.¹⁸ Consequently, some waste currently in the inventory may contain wastes stored under both criteria. This redefinition, as well as the development of instrumentation to detect these low levels of radioactivity, may reduce the volume of TRUW. As the waste is assayed, that portion of it which is greater than 10 nCi/g and less than 100 nCi/g will be reclassified to other waste categories.

0.5.4 Low-Level Waste (LLW)

Data for LLW from commercial and government activities are given in Chapter 4 and Appendix A. Commercial fuel-cycle LLW is generated from the conversion of yellowcake to uranium hexafluoride (UF₆), enrichment, fuel fabrication, and reactor operation. LLW also results from commercial operations by private organizations that are licensed to use radioactive materials. These include institutions and industries engaged in research and various medical and industrial activities. DOE LLW is similar in nature to the commercial industrial and institutional (I/I) waste and the commercial fuel cycle LLW.

A wide variety of radionuclides are found in LLW. Uranium isotopes and their daughters dominate in the conversion, enrichment, and fuel-fabrication steps of the nuclear fuel cycle. Reactor operations produce LLW containing mostly activation products and fission products. A significant fraction of institutional LLW that is shipped to disposal sites is contaminated with small quantities of ³H and ¹⁴C.

By the end of 1995, approximately 66% of the total cumulative volume of disposed LLW resulted from various DOE activities. The remaining 34% resulted from domestic commercial activities. About 29% of the volume of LLW disposed during 1995 resulted from commercial activities.

0.5.5 Uranium Mill Tailings (UMT)

Current inventories and projections of tailings from commercial uranium mill operations are summarized in Chapter 5. Twenty-six licensed uranium mills have accumulated tailings from their operations. Half of these mills have accumulated both commercial and government tailings. By the end of 1995, only one NRC-licensed mill was operational. To date, almost all domestic uranium has been produced by conventional mining and milling methods from which these tailings derive. A small portion has been obtained via in situ leaching, recovery from mine water, recovery from copper/vanadium dump leach liquor, and recovery from wet-process phosphoric acid effluents. Tailings from the now inactive mills that produced uranium only for government operations are being stabilized under DOE's Environmental Restoration Program (see Chapter 6).

0.5.6 Environmental Restoration Program

The overall mission of the DOE Office of Environmental Restoration (EM-40) is to protect human health and the environment from the risks posed by inactive, surplus structures and contaminated environmental media. An overview of the EM-40 program is given below. Further details are provided in Chapter 6. The scope of Chapter 6 is limited to radioactive and mixed (radioactive and chemically hazardous) wastes that could be generated by environmental restoration activities. Nonradioactive hazardous and sanitary wastes are outside the scope of this report.

The EM-40 program includes a bias for action to expedite actual cleanup wherever and whenever possible. Activities are prioritized based on factors such as the need to eliminate risks at sites not controlled by the federal government, the goal of reducing risks at all sites, and compliance with various laws, regulations, and agreements. Most activities are designed to either remove or contain contamination in the environment or to decommission contaminated structures. Related activities include treatment of contaminated materials and wastes, transportation of these materials and wastes to storage and disposal facilities, and disposal of wastes in permitted facilities.

The total volume of solid radioactively contaminated material being addressed by the EM-40 program is approximately 88 million m³. About one-half of this volume is expected to be managed in-situ using remedies such as capping, monitoring, and retention of land-use controls. The total volume of radioactive waste resulting from ex-situ remedies is approximately 44 million m³; the largest source of waste is associated with the Uranium Mill Tailings Remedial Action Program (30 million m³) which

is scheduled to be completed in 1997. Ninety percent of the waste from this program (27 million m³) is already in disposal cells. Most of the remaining waste volume is LLW (12 million m³). Strategies for managing the radioactive wastes associated with the EM-40 program are presented in Chapter 6.

0.5.7 Naturally Occurring and Accelerator-Produced Radioactive Material (NARM)

Chapter 7 describes the characteristics of NARM (and NORM). Some inventories and projections of these materials, based on information currently available, are also reported.

0.5.8 Mixed Low-Level Waste (MLLW)

Current inventories and generation rates of MLLW from both DOE and commercial sources are summarized in Chapter 8. These wastes are contaminated with both low-level radioactivity and chemically hazardous substances. The radioactive components are defined by the AEA,⁸ while the hazardous components are defined by the RCRA,⁹ the TSCA,¹⁰ and pertinent state regulations. As of the end of 1995, inventories of MLLW at DOE sites totaled about 131,400 m³.

0.5.9 Appendixes

Several appendixes are included in this report. Appendix A is a compilation of source terms and characteristics used for waste projections. Source terms include both quantitative and descriptive characteristics used to describe radioactive wastes. As developed and used in the IDB Program, the source term for a particular waste is comprised of two components unique to that

waste: (1) the number of curies of radioactivity, expressed either per unit of facility production or per unit of waste volume or mass, and (2) a listing of the relative contributions of component radioisotopes per curie of radioactivity of the waste. A tabulation of the properties of important radionuclides is given in Appendix B. Appendix C lists the sites and facilities referred to in this report. Appendix D describes how to get computer access to this document via the Internet, and Appendix E describes a reader comment form, which is provided in the front of this report.

0.6 SUMMARY DATA

A few graphical presentations and summary tables are included in this chapter to provide a broad overview. Figures 0.1 and 0.2, respectively, show the volumes and decayed radioactivities of commercial and DOE wastes and SNF accumulated through 1995.

Summaries of SNF and radioactive waste inventories and projections are provided in Tables 0.3 and 0.4. In general, material to be sent to R&D facilities or to the proposed national geologic repository for SNF and HLW is still listed in each individual site's inventory.

DOE waste volume summaries for specific sites are given in Tables 0.5–0.7. Waste generation for 1995 is presented in Table 0.5, and cumulative 1995 inventories for stored and buried wastes are provided in Tables 0.6 and 0.7, respectively.

In recent years, various types of DOE and commercial wastes have been disposed of at a facility operated by Envirocare of Utah, Inc., near Clive, Utah. A summary of 1995 disposed waste volume inventories at the Envirocare Facility is given in Table 0.8 (data from ref. 19).

0.7 REFERENCES

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17. A. G. Croff, *ORIGEN2—A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code*, ORNL-5621, Oak Ridge National Laboratory, Oak Ridge, Tennessee (July 1980).
18. U.S. Department of Energy, DOE Order 5820.2, *Radioactive Waste Management*, Washington, D.C., Feb. 6, 1984 [updated by DOE Order 5820.2A (ref. 6)].
19. Al Rafati, Envirocare of Utah, Inc., Salt Lake City, Utah, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, dated Aug. 8, 1996.

*Permanently discharged reactor fuel. Includes spacing between fuel assembly rods.

**DOE wastes include both retrievably stored and buried materials. Excludes wastes disposed of at the Envirocare Facility.

***Includes contributions from disposed wastes only. Excludes LLW disposed of at Envirocare.

****Includes retrievably stored RCRA and TSCA materials only. Excludes MLLW disposed of at Envirocare.

Fig. 0.1. Total volumes of DOE and commercial radioactive wastes and SNF through 1995.

* Estimate of commercial LWR fuel permanently discharged.

** DOE wastes include both retrievably stored and buried materials. Excludes LLW disposed of at the Envirocare Facility.

*** Includes contributions from disposed wastes only. Excludes LLW disposed of at Envirocare.

Fig. 0.2. Total decayed radioactivities of DOE and commercial radioactive wastes and SNF through 1995.

Table 0.1. Types of radioactive wastes managed at DOE sites referenced in this report^a

Site(s)	Symbol/label	SNF	HLW	TRUW	LLW	MLLW	UMT
Ames Laboratory	Ames			X	X	X	
Argonne National Laboratory--East	ANL-E	X ^a		X	X	X	
Argonne National Laboratory--West	ANL-W	X		X	X	X	
Atlantic Richfield (Medical Products) Company	ARCO			X			
Battelle Columbus Laboratories	BCL			X	X		
Brookhaven National Laboratory	BNL	X			X	X	
Energy Technology Engineering Center	ETEC			X	X	X	
Fermi National Accelerator Laboratory	FNAL				X		
Fernald Environmental Management Project	FEMP				X	X	
Hanford Site ^b	Hanford	X	X	X	X	X	
Idaho National Engineering Laboratory ^c	INEL	X	X	X	X	X	
Inhalation Toxicology Research Institute	ITRI				X	X	
K-25 Site (Oak Ridge)	K-25				X	X	
Kansas City Plant	KCP				X	X	
Lawrence Berkeley Laboratory	LBL			X		X	
Lawrence Livermore National Laboratory	LLNL			X	X	X	
Los Alamos National Laboratory	LANL	X		X	X	X	
Missouri (Univ. of) Research Reactor	MURR			X			
Mound Plant	Mound			X	X	X	
Naval Reactors Facilities and Shipyards ^d	NR Sites			X	X	X	
Nevada Test Site	NTS			X	X	X	
Oak Ridge Institute of Science and Education	ORISE				X		
Oak Ridge National Laboratory	ORNL	X		X	X	X	
Paducah Gaseous Diffusion Plant	PAD			X	X	X	
Pantex Plant	PANT			X	X	X	
Pinellas Plant	Pinellas				X	X	
Portsmouth Gaseous Diffusion Plant	PORTS				X	X	
Princeton Plasma Physics Laboratory	PPPL				X	X	
Reactive Metals, Inc., Extrusion Plant	RMI				X	X	
Remedial Action Program Sites ^e	RAP Sites			X	X	X	X
Rocky Flats Environmental Technology Site	RFETS			X	X	X	
Sandia National Laboratory/California	SNL/CA				X	X	
Sandia National Laboratory/New Mexico	SNL/NM	X		X	X	X	
Savannah River Site	SRS	X	X	X	X	X	
Stanford Linear Accelerator Center	SLAC				X		
Teledyne Brown Engineering	TBE			X			
U.S. Army Material Command	USAMC			X			
West Valley Demonstration Project	WVDP	X	X	X	X	X	
Y-12 Plant (Oak Ridge)	Y-12				X	X	

^aAn "X" entry in this table indicates that the listed site manages waste of the category indicated. General site information is given in Appendix C.

^bIncludes Pacific Northwest National Laboratory (PNNL).

^cIncludes the Idaho Chemical Processing Plant (ICPP); excludes ANL-W.

^dThese sites are listed in Table C.2 of Appendix C.

^eThese sites are listed in Chapter 6.

Table 0.2. Major assumptions used in this report

Inventory/projection basis

- Inventories are reported as of December 31, 1995
- Projections are generally reported for the CYs 1996–2030

HLW solidification activities

- For WVDP, HLW solidification (glass production) starts in 1996 and is completed in 1998
- For SRS, HLW solidification (glass production) at the Defense Waste Processing Facility (DWPF) starts in 1996 and continues through 2021
- For INEL, HLW solidification (immobilization) starts in 2019 and continues through 2035
- For Hanford, HLW solidification (borosilicate glass production) starts in 2002 and concludes in 2028

Commercial activities

- DOE/EIA projections of installed net LWR electrical capacity for the Low Case^a of ref. 15:

Low Case

CY	1996	2000	2005	2010	2015	2020	2025	2030
GW(e)	101	101	101	94	64	49	22	2

- DOE/EIA assumptions for LWR fuel enrichment and design burnup:

LWR fuel	CY fuel is loaded	Fuel enrichment (% ²³⁵ U)	Design burnup (MWd/MTIHM)
BWR	1993	3.17	36,000
	1998	3.34	40,000
	2006	3.50	43,000
	2018	3.67	46,000
PWR	1993	3.84	42,000
	1998	4.07	46,000
	2004	4.39	50,000
	2008	4.73	55,000
	2018	5.04	60,000

- SNF from commercial reactors is not reprocessed. Thus, a fuel cycle without reprocessing is assumed for all commercial projections

^aThis case assumes that each reactor will be retired when the expiration date specified in its operating license is reached. Previously, this case was referred to as the No New Orders Case.

Table 0.3. Cumulative SNF and radioactive waste inventories as of December 31, 1995

Waste category	TRU isotopes (kg)	Mass (MTIHM)	Volume (m ³)	Radioactivity ^a (10 ⁶ Ci)	Thermal power (10 ³ W)
SNF					
Commercial					
BWRs		11,415	4,602 ^b	c	c
PWRs		20,538	8,279 ^b	c	c
DOE		2,647	1,282	c	c
HLW					
Savannah River (DOE)			126,500	502.2	1,406.0
Idaho (DOE)			11,170	49.3	142.8
Hanford (DOE) ^d			233,500	339.9	976.7
West Valley (commercial)			2,200	24.1	69.7
TRUW (DOE) ^e					
Buried	c		141,000	0.75	c
Stored (site operations) ^f	c		75,600	2.63	c
Stored (environmental restoration activities)	c		43	c	c
LLW					
DOE sites					
Generated			29,199	0.4	c
Stored (site operations)			65,775	2.5	c
Stored (environmental restoration activities)			180,000	c	c
Disposed			3,011,459	12.5	22.2
Commercial sites					
Disposed			1,538,416	5.4	20.8
Envirocare disposal facility			155,694	c	c
Uranium mill tailings (commercial licensed mill sites) ^g			118,700,000	c	c
11e(2) by-product material (from DOE environmental restoration) ^h		c	27,000,000	c	c
MLLW (stored)					
DOE ⁱ		c	131,379	c	c
Commercial		c	c	c	c
Envirocare disposal facility		c	20,143	c	c

^aExcept for transuranic wastes, radioactivity data are calculated decayed values as of December 31, 1995.

^bIncludes volume of spacing between the fuel rods of each assembly.

^cInformation not available.

^dHanford tank wastes consist of HLW, TRUW, and LLW. However, in the interim storage mode, the tank wastes are managed as if they contain HLW and, therefore, are included in the HLW inventory.

^eData as of December 31, 1994.

^fAs-generated wastes, mixed and nonmixed.

^gIncludes contributions from 26 NRC-licensed mills.

^hIncludes contributions from mixed as well as radioactive wastes.

ⁱIncludes contributions from environmental restoration activities.

Table 0.4. Current and projected cumulative quantities of radioactive waste and SNF

[Quantities are expressed as volume (10^3 m^3) unless otherwise indicated]

Source and type of material	End of calendar year				
	1995	2000	2010	2020	2030
DOE sites					
SNF, mass, MTIHM ^a	2,647	b	b	b	b
HLW					
Interim storage	373.4	337	284	129	4
Glass or glass/ceramic ^c	0	0.7	2.6	10.7	18.8
TRUW					
Buried	141 ^d	141	141	141	141
Stored (as generated)	77.0 ^d	b	b	b	b
LLW					
Buried ^e	3,011	3,427	4,124	4,813	5,503
Stored	246	b	b	b	b
MLLW	131.4	b	b	b	b
Commercial sites					
LWR SNF, mass, MTIHM ^{a,f}					
(no reprocessing)					
Low Case	32,022	43,100	63,600	80,000	87,900
HLW (WVDP)					
Interim storage	2,180	0.0	0.0	0.0	0.0
Glass	0.0	0.24	0.24	0.24	0.24
LLW (no reprocessing)	1,538	1,636	b	b	b
Mill tailings (no reprocessing)	118,700	b	b	b	b
MLLW	b	b	b	b	b
Envirocare disposal facility ^g					
LLW	155.7	b	b	b	b
MLLW	20.1	b	b	b	b
NARM	277.6	b	b	b	b
11e(2) by-product	127.4	b	b	b	b

^aHistorically, spent nuclear fuel has been measured in units of mass (MTIHM) rather than units of volume.^bInformation not available.^cIncludes projections for glass at SRS and glass/ceramic at INEL.^dProjected inventory level for end of CY 1995. Includes mixed and nonmixed wastes.^eProjections include contributions from SRS saltstone.^fThe 1995 discharged spent nuclear fuel mass is a BWR and PWR mass sum rounded to the nearest metric ton. Such rounding may result in slight differences between the spent nuclear fuel inventories and projections reported in this document and those reported by DOE/EIA.^gIncludes wastes from DOE-, commercial-, DOD-, and EPA-sponsored activities.

Table 0.5. Volume (m³) of DOE site wastes generated during CY 1995

Site(s)	HLW	TRUW		LLW ^b	MLLW		Total (site)
		CH ^a	RH ^a		RCRA ^c	TSCA	
Ames				10	d	e	10
ANL-E				253	22		275
ANL-W					74	e	74
BNL				480	<1	<1	482
ETEC				528	<1	19	548
FEMP					31	d	31
FNAL				34	d		34
Hanford		450	72	3,902	840	7	5,271
INEL				2,624	180	<1	2,805
ITRI				33	d		33
K-25				2,922	269	322	3,513
KCP				<<1	d		<<1
LANL		262	1	1,585	21	69	1,938
LBL				24	1	<1	26
LLNL		27		124	353		504
Mound				687	1	7	695
NR sites		<<1	1	1,818	31	22	1,872
NTS				3	530		533
ORISE				10	d		10
ORNL		9	12	1,668	113	20	1,822
PAD						1,061	1,061
PANT				139	184	358	681
Pinellas				201	d		201
PORTS					709	260	969
PPPL				22	d		22
RFETS		108		549	801	d	1,458
SLAC				15	d		15
SNL/CA				171	d		171
SNL/NM		d		77	68		145
SRS		427	4	10,043	1,135		11,605
WVDP		5		686	8	36	735
Y-12				591	346	52	989
Others ^f		<<1			7		7
Total	0 ^g	1,288	90	29,199	5,725	2,234	38,536

^aProjected annual addition to as-generated waste stored inventory during 1995. Includes contributions from both mixed and nonmixed wastes.

^bExcludes wastes from DOE environmental restoration programs.

^cAnnual average based on reported five-year projection.

^dInformation unavailable or unknown.

^eTrace amount.

^fIncludes contributions from 14 sites.

^gFrom SNF reprocessing. (No SNF was reprocessed during CY 1995.)

Table 0.6. Volume (m³) inventory of stored DOE site SNF and radioactive wastes as of December 31, 1995

Site(s)	SNF	HLW	TRUW ^a		LLW	MLLW		Total (site)
			CH	RH		RCRA	TSCA	
Ames					18		1	19
ANL-E	0.1		25		564	34	57	680
ANL-W	9		3	22		412	13	459
BNL	9				297	24	3	333
ETEC			2	6	425	1		434
FEMP					140,000	2,390		142,390
FNAL					91	b		91
Hanford	378	233,500	11,450	273		8,170	103	253,874
INEL	493	11,170	39,300	200	18,634	25,734	2	95,533
ITRI					50			50
K-25					13,638	23,076	8,159	44,873
KCP					<<1			<<1
LANL	<1		11,262	94		609	6,192	18,158
LBL			<1		35	6	<1	43
LLNL			257		644	454	<1	1,356
Mound			274		3,392	97	45	3,808
NR sites	88			<1	3	77	18	187
NTS			616		301	306	<<1	1,223
ORISE					<<1	b		b
ORNL	17		1,339	1,842	1,842	2,841	16	7,897
PAD			2		5,200	1,032	3,930	10,164
PANT			<1		208	132	3	344
Pinellas					124			124
PORTS					9,000	8,011	3,600	20,611
PPPL								
RFETS			1,978		5,463	13,558	191	21,190
SLAC					174	c		174
SNL/CA					26			26
SNL/NM	6		7		360	70		443
SRS	130	126,500	6,977		1,616	6,940	110	142,273
WVDP	11	2,200	43	529	14,936	148	82	17,949
Y-12					2,934	13,730	941	17,605
Others	140			581	25,800	59		26,580
Total	1,282	373,370	73,537	3,548	245,775	107,911	23,468	828,891

^aProjected for the end of CY 1995. Includes both mixed and nonmixed as-generated wastes.

^bInformation unavailable or unknown.

Table 0.7. Volume (m³) inventory of buried DOE site wastes^{a,b,c,d}

Site(s)	TRUW ^e	LLW ^f	Total (site)
Ames		200	200
ANL-E			
ANL-W			
BNL		839	839
ETEC			
FEMP		343,220	343,220
FNAL			
GJPO			
Hanford	63,600	630,234	693,834
INEL	57,000	149,899	206,899
ITRI			
K-25		81,048	81,048
KCP			
LANL	14,000	224,198	238,198
LBL			
LLNL		9,102	9,102
Mound			
NR sites			
NTS		501,332	501,332
ORISE			
ORNL	176	209,991	210,167
PAD		7,613	7,613
PANT		134	134
Pinellas			
PORTS		12,110	12,110
PPPL			
RFETS			
SLAC			
SNL/CA			
SNL/NM	1	3,218	3,219
SRS	4,870	686,978	691,848
WVDP	1,350	^g	1,350
Y-12		151,343	151,343
Total	140,997	3,011,459	3,152,456

^aExcludes 89,472 containers (94,273 Ci, undecayed) of LLW in 50- and 80-gal drums disposed of by sea dumping.

^bExcludes 17,300 m³ (1,300,000 Ci, undecayed) of LLW grout injected into shale underlying the ORNL site.

^cExcludes wastes from environmental restoration activities.

^dExcludes contributions from DOE wastes disposed of at the Envirocare Facility as of the end of 1995. See Table 0.8.

^eAs of December 31, 1994.

^fAs of December 31, 1995. The data listed for LLW represent disposed inventories and include materials that are not buried.

^gOnly commercial LLW is buried at WVDP.

Table 0.8. Volume (m³) summary of radioactive wastes disposed of at the Envirocare Facility near Clive, Utah^a

Waste type	DOE wastes		Commercial wastes		Other wastes ^b		Total radioactive wastes	
	1995	Cumulative	1995	Cumulative	1995	Cumulative	1995	Cumulative
LLW ^c	11,698	14,118	12,860	133,290	483	8,286	25,041	155,694
MLLW	4,398	5,667	2,821	6,713	3,676	7,763	10,895	20,143
NARM	0	0	591	12,524	37,053	265,110	37,644	277,634
11e(2) ^d	21,098	24,922	62,343	102,510	0	0	83,441	127,432
Total	37,194	44,707	78,615	255,037	41,212	281,159	157,021	580,903

^aBased on ref. 19.

^bWastes from activities supported by DOD and EPA.

^cLLW received from nonroutine operations, such as cleanups.

^dBy-product material as defined in Sect. 11e(2) of the Atomic Energy Act of 1954 (Pub. L. 83-703).

1. SPENT NUCLEAR FUEL

1.1 INTRODUCTION

This chapter reports the quantities and characteristics of spent nuclear fuel (SNF) that has been permanently discharged from commercial LWRs and one-of-a-kind reactors. In addition, this chapter contains a mass summary report of DOE SNF (see Sect. 1.4). Though currently in storage at numerous commercial and DOE sites, this fuel will ultimately require geologic disposal.

Some commercial SNF in inventory will be reinserted into reactors for further irradiation. However, this amount is relatively small, and the schedules for reinsertions are not always predictable. Therefore, for the purposes of this report, all SNF is considered permanently discharged from the reactors.

Historical inventories of commercial LWR SNF have been updated through December 31, 1995.¹ The data reported in this chapter include the inventories of SNF stored at the West Valley Demonstration Project (WVDP), the Midwest Fuel Recovery Plant (MFRP), and the Idaho National Engineering Laboratory (INEL) sites in addition to those stored at the various reactor sites. Figure 1.1 shows the locations of existing and planned power reactor sites and commercial LWR SNF storage facilities. A list of commercial reactors is given also in report DOE/OSTI-8200-R58 (ref. 2).

Projections of nuclear capacity and SNF discharges are given for the calendar years (CY) 1996–2030 for the DOE/EIA Low Case (No New Orders) forecast schedule reported in ref. 3. Starting with an estimate for 1996 of 100.6 GW(e), the Low Case (No New Orders) forecast, hereafter referred to simply as the Low Case, projects installed commercial nuclear electric capacity to start declining in the year 2000, ultimately decreasing to 2.3 GW(e) by 2030.

The Low Case reference scenario considered for projecting accumulated SNF assumes a fuel cycle with no reprocessing. SNF discharge projections, in terms of cumulative mass discharged, are graphically illustrated for the DOE/EIA Low Case in Fig. 1.2.

DOE/EIA projections for the Low Case assume that current average equilibrium burnup levels of discharged

SNF will be 33,000 and 41,000 MWd/MTIHM for BWR and PWR fuel, respectively.³

1.2 COMMERCIAL SPENT NUCLEAR FUEL

1.2.1 Inventories and projections

The total inventory of commercial LWR SNF in storage at the WVDP site, the MFRP, INEL, and the reactor sites as of December 31, 1995, amounted to 32,022 MTIHM. Of this total amount, 26 MTIHM are in storage at the WVDP site,⁴ 674 MTIHM are in storage at the MFRP,¹ and 42 MTIHM are in storage at INEL.¹ The remainder is stored at the reactor sites. These inventories do not include the SNF reprocessed at the WVDP site when the facility was operated as a fuel reprocessing plant. The WVDP SNF inventories include 125 LWR fuel assemblies (representing 26 MTIHM), which are owned by DOE.

A BWR/PWR breakdown of the electric power generating capacity for the Low Case forecast, along with historical reactor capacity data, is given in Table 1.1. The buildups of permanently discharged LWR SNF mass are given on a historical basis in Table 1.2 and for the projected DOE/EIA Low Case in Table 1.3.

1.2.2 Characterization

Reference characteristics of BWR and PWR fuel assemblies, obtained from refs. 5 and 6, are summarized in Table 1.4. More detailed information on SNF characteristics may be found in ref. 7.

1.3 DISPOSAL

Through the first half of 1995, the Office of Civilian Radioactive Waste Management (OCRWM) met regulatory milestones by completing the first Technical Basis Report on surface processes and by submitting the

Annotated Outline for the License Application. Extensive surface-based and underground investigation is being conducted. This investigation is essential to evaluate the suitability of the Yucca Mountain site before a license application can be submitted to the Nuclear Regulatory Commission (NRC). This work is well underway and will lead to a determination of the suitability of the Yucca Mountain site in 1998.

Tunnel excavation is proceeding well despite ground conditions that have been more difficult than anticipated. The assembly of the 25-ft-diam Tunnel Boring Machine (TBM) was completed, and the TBM was moved into the Starter Tunnel in early August 1994. The TBM has excavated over 3.5 miles of the 5-mile exploratory studies facility tunnel. A revised program plan was issued in June 1996. Primary emphasis remains on evaluating the suitability of the Yucca Mountain site.

The DOE Office of Civilian Radioactive Waste Management (OCRWM) is developing an approach for the performance of its waste acceptance, storage, and transportation responsibilities as set forth in the Nuclear Waste Policy Act (NWPA), as amended, and in the Standard Contract for disposal of SNF and HLW (see Glossary of Terms). A presolicitation conference was held on July 9, 1996, to discuss technical and contractual issues related to the potential acquisition of transportation services. At the presolicitation conference, OCRWM made available a draft Statement of Work and a draft Concept of Operations for the waste acceptance and transportation services acquisition. The Department anticipates that a draft request for proposals (RFP) should be issued for public review and comment in December 1996, followed by another presolicitation conference in February or March 1997.

OCRWM is pursuing an acquisition process that is market-driven, relying on private industry (contractors) to provide all necessary services and equipment to fulfill OCRWM's mission at competitive fixed prices and fixed rates. The contractors would accept SNF from its owners

and generators (purchasers) and supply casks and equipment for transporting SNF to (and possibly storage at) a designated federal facility. Contractors would work with purchasers to determine the best way to service a site and would recommend to the NRC preferred transportation routes to a federal facility.

OCRWM may award up to four contracts, covering four regions of the United States. The intent is to develop a market infrastructure to foster competition and innovative approaches to waste acceptance and transportation. The phased approach to contract implementation would allow flexibility and would include sequential development of business/servicing plans that would describe each contractor's general approach, how it might acquire casks and equipment, and its approach to transportation operations.

1.4 DOE SPENT NUCLEAR FUEL

Summary inventory characteristics of DOE SNF as of June 1996 are given in Table 1.5 (based on ref. 4). Projected site inventories for CY 2035 are also included.

For purposes of clarification, the quantities of SNF reported in Table 1.5 include contributions from other nuclear fuels besides those permanently discharged from production reactors. SNFs reported in this table also include DOE-owned nuclear fuel that has been withdrawn from or resides for storage in a nuclear reactor following irradiation, the constituent elements of which have not been separated by processing. In addition to intact fuel, reactor-irradiated fuel materials requiring special handling (e.g., defective fuel and special fuel forms) are also considered SNF and are eligible for inclusion in Table 1.5. This table also lists some commercially generated nuclear fuels and nuclear fuels from foreign reactors and university research reactors which are stored at DOE sites. More detailed information on these special nuclear fuels will be included in future updates of this report.

1.5 REFERENCES

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4. Elwood P. Stroupe, National Spent Nuclear Fuel Program, Idaho National Engineering Laboratory, Idaho Falls, Idaho, correspondence to Jerry A. Klein, IDB Program, Oak Ridge National Laboratory, Oak Ridge, Tennessee, "Spent Nuclear Fuel Data for the Integrated Data Base," EPS-117-96, dated Nov. 19, 1996.
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COMMERCIAL NUCLEAR POWER REACTORS IN THE UNITED STATES

31 DECEMBER 1995

Fig. 1.1. Locations of commercial nuclear power reactors as of December 31, 1995. Courtesy of U.S. Department of Energy, Office of Scientific and Technical Information, Oak Ridge, Tennessee.

ORNL DWG 96-3532

Fig. 1.2. Historical and projected mass (MTIHM) of cumulative commercial spent nuclear fuel discharged for the DOE/EIA Low Case.

Table 1.1. Historical and projected installed LWR electric power generating capacity for the DOE/EIA Low Case

End of calendar year	Historical capacity ^a [GW(e)]			End of calendar year	Low Case projected capacity ^b [GW(e)]		
	BWR	PWR	Total		BWR	PWR	Total
1960	0.1	0.2	0.3	1996	33.5	67.1	100.6
1961	0.1	0.2	0.3	1997	33.5	67.1	100.6
1962	0.1	0.2	0.4	1998	33.5	67.1	100.6
1963	0.1	0.2	0.4	1999	33.5	67.1	100.6
1964	0.1	0.2	0.4	2000	33.5	67.0	100.5
1965	0.1	0.2	0.4	2001	33.5	67.0	100.5
1966	0.1	0.2	0.4	2002	33.5	67.0	100.5
1967	0.1	1.3	1.4	2003	33.5	67.0	100.5
1968	0.2	1.2	1.4	2004	33.5	67.0	100.5
1969	0.8	1.7	2.6	2005	33.5	67.0	100.5
1970	2.9	2.9	5.8	2006	33.2	66.5	99.7
1971	4.3	3.7	8.0	2007	32.8	65.6	98.4
1972	7.0	6.5	13.5	2008	32.5	65.0	97.5
1973	8.1	14.1	22.1	2009	31.9	63.9	95.8
1974	13.3	19.4	32.7	2010	31.2	62.3	93.5
1975	15.0	23.3	38.3	2011	30.9	61.8	92.7
1976	16.8	27.9	44.7	2012	29.5	59.1	88.6
1977	16.8	30.4	47.2	2013	25.4	50.7	76.1
1978	17.6	32.2	49.8	2014	21.9	43.7	65.6
1979	17.6	32.2	49.8	2015	21.2	42.5	63.7
1980	17.6	34.3	51.9	2016	19.2	38.3	57.5
1981	17.6	38.6	56.2	2017	18.2	36.5	54.7
1982	18.7	40.5	59.2	2018	17.4	34.8	52.2
1983	19.7	43.6	63.3	2019	17.4	34.8	52.2
1984	24.2	45.8	70.0	2020	16.4	32.7	49.1
1985	26.8	51.7	78.5	2021	15.3	30.7	46.0
1986	28.9	55.2	84.1	2022	13.9	27.9	41.8
1987	31.8	60.8	92.6	2023	12.6	25.1	37.7
1988	31.8	63.1	94.9	2024	9.6	19.2	28.8
1989	33.8	64.1	97.9	2025	7.4	14.7	22.1
1990	32.9	66.7	99.6	2026	4.2	8.4	12.6
1991	32.0	67.7	99.6	2027	2.3	4.7	7.0
1992	31.8	67.1	98.9	2028	1.1	4.6	5.7
1993	31.8	67.2	99.0	2029	0.0	3.5	3.5
1994	31.9	67.2	99.1	2030	0.0	2.3	2.3
1995	32.2	67.2	99.4				

^aBased on ref. 1.

^bData from ref. 3. Assumes that no new reactors will be ordered. Projections assume that one-third of the total capacity will be provided by BWRs and the remainder by PWRs.

Table 1.2. Historical mass (MTIHM) of permanently discharged commercial SNF by reactor type^a

End of calendar year	BWR ^b		PWR ^c		Total LWR ^d	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1968-1970		16		39		55
1971	65	81	44	83	109	164
1972	146	226	100	183	246	410
1973	94	320	67	250	161	570
1974	242	562	208	458	449	1,020
1975	226	787	322	780	548	1,567
1976	298	1,085	401	1,181	699	2,266
1977	383	1,469	467	1,648	850	3,116
1978	384	1,852	699	2,346	1,082	4,199
1979	400	2,252	721	3,068	1,121	5,320
1980	620	2,872	618	3,686	1,238	6,558
1981	459	3,331	676	4,362	1,135	7,692
1982	357	3,688	640	5,002	998	8,690
1983	491	4,179	771	5,773	1,263	9,952
1984	498	4,677	841	6,614	1,339	11,291
1985	532	5,209	861	7,475	1,393	12,684
1986	458	5,667	996	8,472	1,454	14,139
1987	597	6,264	1,109	9,581	1,706	15,844
1988	536	6,799	1,117	10,697	1,652	17,497
1989	698	7,497	1,215	11,913	1,913	19,410
1990	633	8,130	1,504	13,417	2,137	21,547
1991	588	8,718	1,271	14,688	1,859	23,406
1992	695	9,413	1,596	16,284	2,291	25,697
1993	700	10,113	1,532	17,816	2,232	27,929
1994	675	10,788	1,207	19,024	1,882	29,811
1995	627	11,415	1,514	20,538	2,141	31,952 ^e

^aBased on refs. 1 and 3.

^bBWR = boiling-water reactor.

^cPWR = pressurized-water reactor.

^dLWR = light-water reactor.

^eExcludes 70 MTIHM of discharged fuel assemblies that are expected to be reinserted.

Table 1.3. Current and projected mass (MTIHM) of permanently discharged commercial LWR SNF for the DOE/EIA Low Case^a

End of calendar year	Annual	Cumulative
1995 ^b	2,141	32,022 ^c
1996	2,300	34,300
1997	2,400	36,700
1998	2,200	38,900
1999	1,900	40,900
2000	2,200	43,100
2001	2,000	45,100
2002	2,300	47,300
2003	2,300	49,600
2004	1,800	51,400
2005	2,000	53,500
2006	2,200	55,700
2007	1,800	57,500
2008	2,000	59,500
2009	2,200	61,700
2010	1,900	63,600
2011	2,000	65,500
2012	2,100	67,700
2013	2,500	70,100
2014	2,400	72,500
2015	1,400	73,900
2016	1,600	75,500
2017	1,300	76,800
2018	1,000	77,800
2019	1,000	78,800
2020	1,100	80,000
2021	1,000	81,000
2022	1,300	82,200
2023	1,000	83,200
2024	1,400	84,700
2025	800	85,500
2026	1,200	86,700
2027	600	87,200
2028	200	87,500
2029	300	87,800
2030	100	87,900

^aAssumes no future fuel reprocessing. Note that cumulative levels reported may not equal sum of annual additions because of independent rounding.

^bActual data.

^cIncludes 70 MTIHM of discharged fuel assemblies that are expected to be reinserted.

Table 1.4. IDB reference characteristics of LWR nuclear fuel assemblies

Characteristics	BWR ^a	PWR ^b
Overall assembly length, m	4.470	4.059
Cross section, cm	13.9 × 13.9	21.4 × 21.4
Fuel rod length, m	4.064	3.851
Active fuel height, m	3.759	3.658
Fuel rod outer diameter, cm	1.252	0.950
Fuel rod array	8 × 8	17 × 17
Fuel rods per assembly	63	264
Assembly total weight, kg	319.9	657.9
Uranium/assembly, kg	183.3	461.4
UO ₂ /assembly, kg	208.0	523.4
Zircaloy/assembly, kg	103.3 ^c	108.4 ^d
Hardware/assembly, kg	8.6 ^e	26.1 ^f
Total metal/assembly, kg	111.9	134.5
Nominal volume/assembly, m ³	0.0864 ^g	0.186 ^g

^aRef. 5.^bRef. 6.^cIncludes Zircaloy fuel-rod spacers and fuel channel.^dIncludes Zircaloy control-rod guide thimbles.^eIncludes stainless steel tie-plates, Inconel springs, and plenum springs.^fIncludes stainless steel nozzles and Inconel-718 grids.^gBased on overall outside dimension. Includes spacing between the stacked fuel rods of an assembly.

Table 1.5. Summary inventory of DOE SNF for years 1996 and 2035^a

Site/category	Facility ^b	1996 total mass (kg)	1996 volume (m ³)	Discharged heavy metal (MTHM)	
				1996	2035
ANL-E	Alpha-gamma hot cell	257.10	0.10	0.08	0.08
	Chicago Pile-5	12.80	0.01	0.00	0.00
	Subtotal	269.90	0.12	0.08	0.08
ANL-W	EBR-II	10,242.05	0.84	8.72	8.72
	HFEF	5,172.90	0.95	0.61	0.61
	RSWF	24,878.44	2.34	18.83	18.83
	TREAT	206.81	4.95	0.02	0.02
	Subtotal	40,500.20	9.08	28.18	28.18
BNL	BMRR	165.46	0.13	0.00	0.01
	HFBR	4,263.69	8.46	0.25	1.34
	Subtotal	4,429.15	8.59	0.26	1.34
FRR	FRR	-	-	-	16.37
FSVR	ISFSI	187,392.00	130.27	14.73	14.73
Hanford	Area 200 (burial)	801.95	143.79	0.32	0.32
	Area 400 (ISA)	317.60	0.08	0.02	0.02
	Area 618 (burial)	0.00	0.00	0.00	0.00
	Bldg. 324	4,077.50	1.19	2.28	2.28
	Bldg. 325	50.00	0.00	0.01	0.01
	Bldg. 327	39.00	0.01	0.02	0.02
	FFTF	56,083.89	18.28	11.02	11.02
	PFP	1,023.40	0.02	0.01	0.01
	T-plant	38,500.00	9.45	15.82	15.82
	105-K East Basin	1,723,772.00	99.94	1,146.43	1,146.43
	105-K West Basin	1,804,017.00	104.91	956.05	956.05
	Subtotal	3,628,682.34	377.67	2,131.98	2,131.98
INEL	ICPP-603	20,548.68	9.38	2.03	2.03
	ICPP-666	461,754.34	148.54	14.56	14.56
	ICPP-749	257,781.88	96.55	78.60	78.60
	ICPP-IFS	131,390.79	86.11	10.02	10.02
	MTR canal	1,990.70	0.75	0.26	0.26
	PER-620	5,580.50	0.84	0.56	0.56
	TAN-607	333,480.56	131.85	85.29	85.29
	TAN-790	56,375.01	11.78	38.37	38.37
	TRA-660	577.62	0.46	0.23	0.23
	TRA-670	6,578.04	6.74	0.69	2.53
	Subtotal	1,276,058.12	493.00	230.59	232.44
INEL/NRF	ECF	381,784.69	88.34	6.01	6.01
LANL	CMR Building	421.40	0.60	0.01	0.01

Table 1.5 (continued)

Site/category	Facility ^b	1996 total mass (kg)	1996 volume (m ³)	Discharged heavy metal (MTHM)	
				1996	2035
ORNL	Bldg. 7827	1,978.90	4.01	0.15	0.15
	Bldg. 7829	782.40	0.48	0.03	0.03
	Bldg. 7920	204.30	0.10	0.00	0.00
	Bldg. 7900 pools	9,233.40	7.86	0.47	1.15
	BSR	327.04	0.40	0.06	0.06
	MSR	8,940.00	3.88	0.04	0.04
	TSR	182.00	0.10	0.01	0.01
	Subtotal	21,648.04	16.82	0.75	1.43
SNL/NM	ACRR	100.00	0.09	0.00	2.36
	Dense pack	900.00	1.12	0.10	0.10
	HCF	15.00	0.00	0.00	0.00
	Manzano storage	12,800.00	5.20	0.00	0.00
	Subtotal	13,815.00	6.41	0.10	2.46
SRS	F-Canyon	23,268.24	5.20	22.61	22.61
	H-Canyon	430.00	0.42	0.07	0.07
	K-Basin	20,400.00	29.14	3.24	3.24
	K/L/P-Basin	2,478.40	3.36	0.06	0.06
	L-Basin	135,986.47	43.22	117.96	117.96
	P-Basin	10,700.00	14.51	1.39	1.39
	RBOF	96,527.97	33.65	60.82	60.82
	SRTC	5.28	0.00	0.00	0.00
	Subtotal	289,796.35	129.50	206.14	206.14
U.S. Navy	U.S. Navy Shipyards	-	-	-	50.15
WVDP	Fuel Receiving and Storage Facility	42,780.00	11.34	26.31	26.31
Other	Non-DOE-owned domestic reactors				
	Armed Forces Radiobiological Facility	323.00	0.08	0.02	0.02
	ARRR	263.90	0.07	0.01	0.01
	DOW TRIGA Reactor	265.20	0.06	0.01	0.01
	GA TRIGA Reactor Facility	884.60	0.22	0.06	0.06
	GE Pleasanton	80.00	0.05	0.01	0.01
	Hot cell facility (GA)	28.90	0.08	0.01	0.01
	Lynchburg Technology Center	77.05	0.03	0.04	0.04
	NBSR	830.98	2.16	0.02	0.11
	Omaha VA Medical Center	162.40	0.04	0.01	0.01
	SNRS	306.00	0.07	0.02	0.02
	USGS Facility of Denver, Colorado	547.40	0.13	0.03	0.04
	Subtotal	3,769.43	3.00	0.24	0.34
	University				
	Cornell University	418.20	0.10	0.02	0.03
	Georgia Institute of Technology	0.00	0.00	0.00	0.15

Table 1.5 (continued)

Site/category	Facility ^b	1996 total mass (kg)	1996 volume (m ³)	Discharged heavy metal (MTHM)	
				1996	2035
Other (contd.)	University (contd.)				
	Iowa State University Reactor	38.55	0.19	0.02	0.02
	Kansas State University	377.40	0.09	0.02	0.03
	Massachusetts Institute of Technology	292.00	0.14	0.03	0.12
	North Carolina State University	880.00	0.24	0.53	0.53
	Ohio State University	200.00	2.14	0.02	0.02
	Oregon State University	326.40	0.08	0.02	0.04
	Pennsylvania State University	615.40	0.15	0.04	0.04
	Purdue University	3.72	0.01	0.00	0.03
	Reed Reactor Facility	227.80	0.06	0.01	0.01
	Rhode Island Nuclear Science Center	99.00	0.10	0.02	0.17
	State University of New York— Buffalo	1,000.00	0.13	0.66	0.66
	Texas A&M	632.40	0.15	0.03	0.08
	University of California—Irvine	384.20	0.09	0.02	0.02
	University of Massachusetts—Lowell	230.00	0.15	0.00	0.05
	University of Texas—Austin	523.60	0.13	0.03	0.03
	University of Arizona	333.20	0.08	0.02	0.02
	University of Florida	313.00	0.66	0.01	0.03
	University of Illinois	662.00	0.16	0.04	0.05
	University of Maryland	316.20	0.08	0.02	0.03
	University of Michigan	598.00	0.71	0.10	0.47
	University of Missouri	793.60	0.93	0.08	0.59
	University of Utah	403.10	0.11	0.03	0.03
	University of Virginia	191.40	0.19	0.04	0.09
	University of Wisconsin	775.20	0.19	0.04	0.09
	Washington State University	731.00	0.18	0.04	0.09
	Worcester Institute of Technology	150.80	0.16	0.02	0.02
	Subtotal	11,516.17	7.41	1.91	3.57
	Grand total	5,902,862.79	1,282.13	2,647.32	2,721.56

^aBased on ref. 8. Inventories for 1996 are reported as of June 1996.

^bAbbreviations used in this table: ACRR—Annular Core Research Reactor, ARRR—Aerotest Radiography and Research Reactor, BMRR—Brookhaven Medical Research Reactor, BSR—Bulk Shielding Reactor, CMR—Chemistry and Metallurgical Research, EBR—Experimental Breeder Reactor, ECF—Extended Core Facility, FFTF—Fast Flux Test Facility, FRR—Foreign Research Reactor, FSVR—Fort St. Vrain Reactor, GA—General Atomics, GE—General Electric, HCF—Hot Cell Facility, HFBR—(Brookhaven) High Flux Beam (Research) Reactor, HFEF—Hot Fuel Examination Facility, ICPP—Idaho Chemical Processing Plant, IFSF—Irradiated Fuel Storage Facility, ISA—Interim Storage Area, ISFSI—Independent Spent Fuel Storage Installation, MSR—Molten Salt Reactor, MTR—Materials Test Reactor, NBSR—National Bureau of Standards Reactor, PER—(Special) Power Excursion Reactor (Test), PFP—plutonium finishing plant, RBOF—Receiving Basin for Off-Site Fuels, RSWF—Radioactive Scrap and Waste Facility, SNRS—Stationary Neutron Radiography System, SRTC—Savannah River Technical Center, TAN—Test Area North, TRA—Test Reactor Area, TREAT—Transient Reactor Test Facility, TRIGA—Training Reactor, Isotopes, General Atomic, TSR—Tower Shielding Reactor, USGS—U.S. Geological Survey, and VA—Veterans Administration.

2. HIGH-LEVEL WASTE

2.1 INTRODUCTION

High-level waste (HLW) is generated by the chemical reprocessing of spent research and production reactor fuel, irradiated targets, and naval propulsion fuel. HLW generally contains more than 99% of the nonvolatile fission products produced during reactor operation. HLW from a facility that recovers both uranium and plutonium contains a residual amount of about 0.5% of those elements, while HLW from a facility that recovers only uranium contains a residual 0.5% of the uranium and essentially all of the plutonium. Most fission products have short half-lives and therefore quickly decay. HLW older than 1 year contains primarily the fission radionuclides ^{137}Cs and ^{90}Sr and very small amounts of transuranic (TRU) nuclides.

When generated, HLW is a highly radioactive, acidic liquid which generates heat and must be handled remotely behind heavy shielding in corrosion-resistant vessels, usually made of stainless steel. At the Hanford Site (Hanford), because stainless steel was in short supply, HLW was neutralized with caustic soda (sodium hydroxide), and sodium nitrite was then added for corrosion control so that the HLW could be stored safely in carbon-steel tanks. This practice continued at Hanford, the Savannah River Site (SRS), and the West Valley Demonstration Project (WVDP), even when stainless steel became more readily available. Neutralization with caustic soda forms sodium nitrate (which remains in solution) and hydrated oxides of certain radionuclides and non-radioactive chemicals (which precipitate and collect as a sludge on the floor of the tank). In addition, the ^{137}Cs remains largely in solution. At the Idaho National Engineering Laboratory (INEL), however, the waste has always been stored as an acidic liquid in stainless steel tanks and then converted later into a granular solid (calcine) by thermal processing, which drives off water and decomposes nitrate salts to oxides.

The supernatant liquid resulting from neutralization may become concentrated by evaporation—either by self-boiling or in evaporators. If enough water is removed from the waste, sodium nitrate and sodium nitrite will crystallize from the solution. The crystals then will settle to the

bottom of the tank liquid and on top of the sludge. If there are many crystals, a salt cake will form.

To reduce heat generation in tanks, large quantities of the radionuclides ^{137}Cs and ^{90}Sr were removed from some Hanford HLW and encapsulated in concentrated form as halide salts. Some of these capsules were subsequently leased to non-DOE organizations for beneficial use. All of the leased capsules have now been returned to Hanford.

In summary, HLW exists in a variety of physical or chemical forms (alkaline or acidic, supernatant liquid, sludge, salt cake, calcine solid, etc.), all of which must be stored behind heavy shielding and usually in underground tanks or bins.

Most of the current U.S. inventory of HLW has resulted from DOE activities. HLW is stored at SRS (Aiken, South Carolina), INEL (Idaho Falls, Idaho), and Hanford (Richland, Washington). A small amount of HLW was generated by commercial operations at the Nuclear Fuel Services (NFS) plant, near West Valley, New York, between 1966 and 1972, at a site owned by the New York State Energy Research and Development Authority (NYSERDA). After 1972, fuel reprocessing operations at this plant were discontinued. In 1980, Congress passed the West Valley Demonstration Project Act (Pub. L. 96-368), which authorizes DOE to conduct, jointly with NYSERDA (90% DOE, 10% NYSERDA), a demonstration of solidification of HLW for disposal and the decontamination and decommissioning (D&D) of facilities used in the demonstration. The HLW data presented in this chapter are based on separate submittals provided by Hanford, INEL, SRS, and WVDP in ref. 1.

In 1992, DOE decided to phase out the domestic reprocessing of irradiated nuclear fuel for the recovery of enriched uranium or plutonium in support of defense activities; thus, no new HLW is expected to be generated by this source for the immediate future. However, some future D&D activities may generate waste with radioactivity levels high enough such that the waste will require management in ways similar to HLW. An example of such a future activity is the flushing of residual wastes found in reprocessing facilities.

2.2 AGREEMENTS AND INTERFACES

HLW is considered to be a mixed waste (i.e., waste containing both radioactivity and hazardous substances) unless demonstrated to the contrary. The hazardous substances of HLW are defined by the Resource Conservation and Recovery Act (RCRA).² Liquid HLW is *characteristic* mixed waste (i.e., as stored, it shows the characteristic of corrosivity because of its acidity or alkalinity). Some HLW may also be *listed* mixed waste (i.e., it contains substances on any one of several lists regulated under RCRA). Mixed wastes must be managed according to RCRA² and Atomic Energy Act (AEA)³ requirements.

The Federal Facility Compliance Act (FFCA)⁴ of 1992 amends the Solid Waste Disposal Act to require (among other things) that DOE prepare a Site Treatment Plan (STP) for each site which generates, stores, or treats mixed waste. In effect, these STPs constitute a legally enforceable agreement between DOE and the host state that DOE must comply with certain requirements for mixed waste management. STPs must be approved by the host state for the site.

Two such prior agreements exist: both involve tri-party arrangements. One (for Hanford) is among DOE, the U.S. Environmental Protection Agency (EPA), and the state of Washington. This tri-party agreement⁵ serves as an STP, is legally enforceable, and requires DOE to undertake specific actions at Hanford on a prescriptive timetable.

The other tri-party agreement (for SRS) involves DOE, EPA, and the state of South Carolina. However, this agreement applies only to those waste storage tanks that do not meet current DOE and regulatory criteria for secondary containment and leak detection. Consequently, an STP is being prepared for SRS.

Concerning INEL, an amended Notice of Noncompliance Consent Order was issued to DOE in March 1994 by the Idaho Department of Health and Welfare. The Order includes provisions for proposing waste treatment technologies and deadlines for removing liquid waste from specific tanks. Because no prior agreements with WVDP specifically address mixed waste treatment, a proposed STP has been submitted to the state regulator for WVDP to address such treatment.

2.3 WASTE CHARACTERIZATION

Generic characterization of HLW at some sites has been hampered over the years by the use of several different flowsheets for the processes that generated the waste or prepared the wastes for storage (e.g., nuclide separation, precipitation, and evaporation). In some

instances, wastes have been blended. Information for all sites is based on historic records of reprocessing feeds and, for Hanford, SRS, and WVDP, extensive sampling of stored HLW.

Prior to Revision 11 of this report, HLW data were presented by physical form in some detail (e.g., liquid, sludge, slurry, salt cake, and precipitate). Starting with Revision 11 and continuing in this year's revision, the data are more simply categorized as solid, liquid, or process-generated (canistered) material. Each of these three waste categories requires different storage and processing methods. As HLW pretreatment and vitrification processes proceed, inventories of liquid and solid waste will generally decrease, and canistered material will increase.

Chemical and radionuclide compositions and inventories are given for the current and projected HLW at Hanford (Tables 2.11 and 2.16), INEL (Tables 2.12 and 2.17), SRS (Tables 2.13 and 2.18); and WVDP (Tables 2.14 and 2.19).

2.4 INVENTORIES AND PROJECTIONS

Tables 2.1–2.3, respectively, present historical and projected volumes, radioactivity, and thermal power inventories of HLW currently in storage. The radioactivity and resultant thermal power of HLW decay, over time, in a manner characteristic of the constituent radionuclides, but, as previously mentioned, the volume depends significantly on the specific treatment history of the waste. When one takes into account all radionuclides in HLW, total radioactivity and thermal power each decrease about 2 to 4% per year within storage units to which no new waste has been added.

Locations of the four HLW sites and the relative volumes of HLW are represented in Fig. 2.1. The total volume and radioactivity for the HLW (solid and liquid) stored at the four sites is shown graphically in Fig. 2.2. Historical and projected cumulative volumes of HLW stored or produced at each site are graphically illustrated in Fig. 2.3. The number of waste canisters projected to be produced by each site are depicted in Fig. 2.4.

Current DOE plans are to immobilize and package HLW for disposal in a licensed, underground geologic repository. Figures 2.5–2.8 show, for each of the four sites, the general treatment processes by which the HLW will be immobilized to a form acceptable for disposal in a repository. Tables 2.4–2.6, respectively, give the projected volume, radioactivity, and thermal power for HLW immobilized as borosilicate glass. Table 2.7 gives estimates, year by year and by site, of the number of HLW canisters to be produced based on reference flowsheets.

Canister estimates for SRS [Defense Waste Processing Facility (DWPF)] and WVDP are fairly well established (both projects began radioactive operations in FY 1996), while canister estimates for INEL and Hanford are less certain because pretreatment and waste minimization processes have not yet been finalized. Tables 2.8–2.10 give the volume, radioactivity, and thermal power, respectively, of stored HLW by site and by physical form. Currently available summary information about the radionuclide distribution for stored HLW and projected associated wastes for each site has been given in Tables 2.11–2.14. Significant changes in any of these tables from the previous IDB report (Rev. 11)⁶ are presented in Table 2.15. It should be noted that the radioactivity reported in Tables 2.2, 2.5, and 2.9 include contributions from both parent and daughter products.

Projected inventories (volume, radioactivity, and thermal power) for HLW presented in Tables 2.1–2.6 have been generated by each site based on certain assumptions and therefore should be considered only as current best estimates. It is possible that new treatment methods or waste forms may be developed and may supersede current baseline projections for Hanford or INEL. All sites are moving toward shutdown; consequently, very little additional HLW will be generated. Major HLW activities will be (a) continued safe storage, (b) preparation for solidification, (c) solidification, and (d) interim storage pending shipment to a national repository. Thus, the inventory of liquid HLW in storage generally will decrease, and the inventory of solidified HLW in interim storage, pending shipment to a national repository, will increase. The *Waste Acceptance System Requirements Document*⁷ for the national repository states that receipt of DOE HLW will begin no sooner than 6 years after initial receipt of utility spent nuclear fuel (SNF). Thus, the canisters of solidified HLW will remain in interim storage, most likely at the production site. The current projected number of HLW canisters (Table 2.7) for Hanford, INEL, and SRS is significantly different from the value reported in the previous IDB report. For INEL, the new projections reflect a state of Idaho, Department of the Navy, and DOE Settlement Agreements completed in 1995.

Summary flowsheets of the reference solidification processes are given for Hanford (Fig. 2.5), INEL (Fig. 2.6), SRS (Fig. 2.7), and WVDP (Fig. 2.8). Overall, these flowsheets are very similar; process differences reflect differences among sites in waste characteristics.

2.4.1 Hanford

Hanford HLW is stored in underground carbon-steel tanks. The HLW inventory (as of December 31, 1995) consists of 143,700 m³ considered to be "solid" HLW (salt

cake and sludge in single- and double-shell tanks) and 89,800 m³ of "liquid" HLW (supernatant in single- and double-shell tanks and drainable interstitial liquid in single-shell tanks), for a total of 233,500 m³. At Hanford, waste in single- and double-shell tanks consists of HLW, TRUW, and several LLWs. However, in the interim storage mode, the tanks are managed as if they contain only HLW. Thus, their contents are included in the HLW inventory.

A total of 2,217 capsules have been manufactured at Hanford, some of which have been leased off-site for beneficial purposes. Of the 1,577 cesium and 640 strontium capsules, a total of 249 cesium capsules and 35 strontium capsules have been dismantled. The inventory of capsules that have been dismantled is not expected to be returned to Hanford for interim storage and future processing. This leaves 1,328 cesium capsules and 605 strontium capsules to be processed (overpacked) and disposed of as HLW.

The HLW projections for Hanford are based on the assumptions that (1) fuel reprocessing is not resumed, (2) pumpable liquids are transferred from single-shell tanks to double-shell tanks, (3) double-shell tanks will continue to receive D&D-generated waste, and (4) volume reduction of stored wastes through evaporation will continue.

2.4.2 INEL

INEL HLW is currently being stored as both acidic liquid and calcined solids (calcine). Underground, high-integrity, stainless-steel tanks contain about 7,400 m³ of acidic liquid waste. [Of this waste, only 1,100 m³ is actual HLW; the rest is sodium-bearing waste (SBW), which is managed the same way as is HLW because of site practice.] Underground stainless-steel bins currently store about 3,800 m³ of calcine, an interim waste form. More than 90% of the total radioactivity is in the calcine.

For INEL, HLW projections are based on the recommended option from a new systems engineering approach to integrate all DOE Office of Environmental Management waste streams at the INEL. The HLW projections include streams associated with the intermediate calcining of liquid waste, followed by separation of HLW and LLW fractions in the remaining liquid waste and redissolved calcine. No new HLW from reprocessing activities was produced after FY 1992; SNF reprocessing facilities are being placed into cold standby pending D&D. The current reference waste form at INEL is a glass. According to the October 17, 1995, Settlement Agreement, INEL is to calcine all of the liquid waste currently stored in the tanks by December 31, 2012. All of the HLW must be treated to be converted to the final

waste form and be "road ready" by December 31, 2035. It is assumed that INEL will begin radioactive operations and thus produce canisters in 2020 and continue this operation through 2035 (see Fig. 2.6). The projections reported in Tables 2.1–2.7 reflect this assumption.

2.4.3 SRS

SRS HLW is stored as alkaline liquid, sludge, salt cake, and precipitate. The current inventory of about 126,500 m³ is stored in underground, single- and double-shelled carbon-steel tanks. Although reprocessing operations are being phased out, the HLW tank farms are continuing to receive HLW from the canyons as part of cleanout operations. The preparation of some HLW for vitrification during the original in-tank precipitation demonstration generated cesium precipitate, and on-going HLW sludge-washing in extended sludge processing (ESP) has generated partially washed sludge. Pretreatment of HLW is performed in the In-Tank Precipitation Facility. Characterization data for SRS HLW are based on sampling and process knowledge. Allowable facility design variability of feed composition is limited; therefore, the data reported in Tables 2.1–2.6 assume a uniform feed rate and composition. The current budget projections have both (a) limited the waste-blending capability to feed a uniform composition and (b) reduced the feed rate. The radiochemical streams are assumed to be processed at a uniform rate with adjustments made for radioactive decay.

2.4.4 WVDP

Reprocessing at the West Valley NFS plant was terminated in 1972, after which no additional HLW has been generated. HLW at WVDP is stored in underground tanks. The current HLW inventory of 2,200 m³ consists of liquid alkaline waste and solid waste (composed of both alkaline sludge and inorganic zeolite ion-exchange material contaminated with radio-cesium). The waste is stored in an underground carbon-steel tank. The cesium-loaded zeolite was transferred and blended with the sludge and alkaline waste in 1995. The small amount of acidic waste remaining from reprocessing of a thorium fuel was also blended into the alkaline waste in 1995.

2.5 SOLIDIFICATION FOR PERMANENT DISPOSAL

All HLW will be processed and solidified to a form acceptable for permanent disposal in a geologic repository.^{8–12} Borosilicate glass has been selected as the

reference waste form for all sites.¹³ Projections are based on current funding guidance provided to the sites by DOE.

2.5.1 Hanford

The current technical baseline for Hanford is to retrieve and process all (>99 vol %) of the tank wastes using a two-phase approach which will depend on private contractors to design, construct, operate, and finance most of the required processing capability. The demonstration phase (Phase I) facilities for supernatant (liquid) pretreatment and LLW and HLW immobilization are scheduled to begin operation in June 2002 and will process waste through 2011. HLW sludges will be pretreated in-tank using water washing and caustic leaching as appropriate. Up to 13 vol % of the supernatant and 6 vol % of the sludges will be processed during Phase I. Full-scale production facilities, including out-of-tank sludge pretreatment, are scheduled to begin operating in 2012. These facilities will be sized to complete immobilization of LLW by 2024 and HLW by 2028 in order to meet current Tri-Party Agreement milestones.

The pretreatment processes separate the majority of the radioactivity contained in the tank waste for HLW vitrification and the bulk of the tank waste volume for LLW immobilization. The current technical baseline uses settle/decant to separate solids from the liquids, ion exchange to reduce the radioactivity in the supernatants, and caustic leaching to reduce the volume of HLW sludges requiring vitrification. Other pretreatment processes that are evaluated in the *Tank Waste Remediation System Program Environmental Impact Statement*¹⁴ are acid dissolution, advanced separations, and organic destruction.

Hanford's reference canister for HLW disposal has a diameter of 61 cm and a length of 4.5 m. The nominal glass volume is estimated at 1.1 m³ with a minimum waste oxide loading of 25 vol % (excluding sodium and silicon). Processing of the cesium and strontium capsules will be performed in the HLW vitrification facility concurrent with the HLW tank waste vitrification. Because the projected volume, radioactivity, and thermal power of the HLW final form have not been finalized, no data on the final LLW form are presented in Table 2.11.

An interim storage facility will be built at Hanford with sufficient capacity to store the entire HLW volume of glass produced by the HLW vitrification facility. Storage will continue until the HLW canisters are shipped to a geologic repository. It is assumed for planning purposes that shipment to the repository will commence no sooner than 2035. Thus values for glass volume, curies, watts and number of canisters given in Tables 2.4 through 2.7, respectively, represent the total accumulation of Hanford's HLW canisters.

2.5.2 INEL

In the baseline plan,¹⁵ the New Waste Calcining Facility is assumed to operate through 2012 and to complete calcining the SBW inventory as required by the Settlement Agreement. A new separations-vitrification facility is planned to be on line by 2020. Newly generated liquid waste and calcine will be processed to separate the high-activity radionuclides from the low-activity waste. In addition, the required land disposal restriction (LDR) treatments for the RCRA constituents in the waste will then be made as required. The high-activity waste will be vitrified in a new facility and stored until final disposition after 2035. The separated low-activity waste will be grouted and disposed. All HLW is projected to be processed by December 31, 2035, to meet the Settlement Agreement.

2.5.3 SRS

The plan to process SRS HLW into glass is detailed in *High Level Waste System Plan Revision 5(U)*¹⁶ (i.e., Rev. 5 baseline case, similar to Rev. 4), which was transmitted to DOE April 27, 1995. Briefly, Rev. 5 depicts three funding cases, and the data included in this report represent the baseline case with completion of the immobilization of the current inventory of HLW in FY 2021.

For SRS, canyon cleanout operations are scheduled to be completed by FY 2002. Additional HLW from canyon cleanout activities until then will represent a maximum

increase of about 14.5% of current inventory. Pretreatment (sludge-washing) of liquid HLW has been started, and the DWPF began producing canisters of solidified HLW in FY 1996. The HLW glass waste forms will be stored at SRS until a national repository is ready to accept them (see Fig. 2.7).

2.5.4 WVDP

Pretreatment at the WVDP is complete. In May 1988, the processing of liquid HLW was initiated. This alkaline liquid was decontaminated to LLW in the WVDP Supernatant Treatment System (STS) in preparation for the incorporation of all HLW at the WVDP into a glass. In the STS, an ion-exchange process that is operated in a batch mode is used to remove cesium from the alkaline liquid waste (see Fig. 2.8). The ion-exchange columns are located in the underground carbon-steel tank, which was originally installed as a backup tank for the storage of alkaline HLW. The sludge in the bottom of the tank has been mixed with the residual supernatant and an alkaline solution. Both sludge-wash processing cycles were completed in 1994. The wash solutions are also treated in the STS before they are incorporated in cement. The washed sludge, the acidic waste, and the loaded zeolite will be combined and incorporated into a glass. The primary vitrification campaign will begin in FY 1996 and be completed by FY 1998. Tank heels and residual material will then continue to be vitrified through mid-FY 2001. The glass will be stored on-site until it is transferred to a federal repository.

2.6 REFERENCES

1. DOE site HLW data submittal attachments, submitted to the IDB Program during September–October 1996. The following HLW submittals were received and reviewed by the IDB Program before analysis and integration. Preceding each submittal is the site (in parentheses) to which it refers.
 - a. (Hanford) William J. Taylor, DOE Richland Operations Office, Richland, Washington, correspondence to Robin L. Sweeney, High-Level Waste Program Manager, DOE-HQ, copy to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "High-Level Waste (HLW) Information Request for the 1996 Integrated Data Base Report," 96-WDD-098, dated July 15, 1996.
 - b. (INEL) D. A. Knecht, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho, correspondence to P. J. Dirkmaat, DOE-ID, Idaho Falls, Idaho, copy to S. Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "INEL HLW 1996 Integrated Data Base Submittal for 12/31/95 Waste Quantities," DAK-07-95, dated July 29, 1996.
 - c. (SRS) J. R. Hester, Westinghouse Savannah River Company, Aiken, South Carolina, correspondence to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "1996 DOE Integrated Data Base Input," dated June 17, 1996.

- d. (WVDP) P. E. Walters, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "Submittal of High-Level Waste Information for the 1996 Integrated Data Base Report," WZ:96:0070, dated Aug. 1, 1996.
2. U.S. Congress, Resource Conservation and Recovery Act of 1976, Pub. L. 94-580, 1976, as amended.
3. U.S. Congress, Atomic Energy Act of 1954, Pub. L. 83-703, Aug. 15, 1994.
4. U.S. Congress, The Federal Facility Compliance Act of 1992, Pub. L. 102-386, Oct. 6, 1992.
5. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, *Hanford Federal Facility Agreement and Consent Order*, EPA Docket Number 1089-03-040120, Ecology Docket Number 89-54, Richland, Washington (May 1989).
6. U.S. Department of Energy, *Integrated Data Base Report—1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 11, Oak Ridge National Laboratory, Oak Ridge, Tennessee (September 1995).
7. U.S. Department of Energy, Office of Civilian Radioactive Waste Management, *Waste Acceptance System Requirements Document*, DOE/RW-0351P, Rev. 1, Washington, D.C., (March 1994).
8. U.S. Department of Energy, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste, Hanford Site, Richland, Washington*, DOE/EIS-0113, DOE Richland Operations Office, Richland, Washington (December 1987).
9. U.S. Congress, The Nuclear Waste Policy Act of 1982, Pub. L. 97-425, Sect. 8, Jan. 7, 1983, as amended.
10. Ronald Reagan, President of the United States, Washington, D.C., letter to John S. Herrington, Secretary of Energy, "Disposal of Defense Waste in a Commercial Repository," dated Apr. 30, 1985.
11. U.S. Department of Energy, "Civilian Radioactive Waste Management: Calculating Nuclear Waste Fund Disposal Fees for Department of Energy Defense Program Waste; Notice," *Fed. Regis.* 56(161), 31508 (Aug. 20, 1987).
12. U.S. Congress, The Nuclear Waste Policy Amendments Act of 1987, Pub. L. 100-203, Title V, Subtitle A, Dec. 22, 1987.
13. U.S. Department of Energy, Office of Defense Waste and Transportation Management, *Defense Waste and Transportation Management Program Implementation Plan*, DOE/DP-0059, Washington, D.C. (August 1988).
14. U.S. Department of Energy and Washington State Department of Ecology, *Tank Waste Remediation System, Hanford Site, Richland, Washington—Final Environmental Impact Statement*, DOE/EIS-0189, DOE Richland Operations Office, Richland, Washington (August 1996).
15. U.S. Department of Energy, *Integration of EM Activities at the INEL*, Idaho National Engineering Laboratory, Idaho Falls, Idaho (March 31, 1995).
16. U.S. Department of Energy, *High-Level Waste System Plan Revision 5(U)*, HLW-OVP-95-0031, Savannah River Site, Aiken, South Carolina (April 26, 1995).

Fig. 2.1. Locations and total volumes of HLW through 1995.

Fig. 2.2. Total volume and radioactivity of solid and liquid HLW through 1995.

Fig. 2.3. Historical and projected cumulative volumes of untreated HLW in storage.

Fig. 2.4. Projected cumulative number of HLW canisters.

Fig. 2.5. Treatment methods for tank waste and capsules at Hanford.

Fig. 2.6. Treatment methods for HLW in tanks and bins at INEL.

Fig. 2.7. Treatment methods for HLW in tanks and canisters at SRS.

Fig. 2.8. Treatment methods for HLW in tanks and canisters at WVDP.

Table 2.1. Historical and projected cumulative volume of HLW stored in tanks, bins, and capsules, by site^{a,b}

End of calendar year	Volume, 10 ³ m ³				
	Hanford	INEL	SRS	WVDP	Total
1990	253.6	12.0	131.7	1.2	398.5
1991	256.4	10.4	127.9	1.7	396.5
1992	258.7	11.2	126.9	1.6	398.3
1993	261.7	10.5	129.3	2.0	403.5
1994	238.9	11.0	126.3	2.2	378.4
1995	233.5	11.2	126.5	2.2	373.4
1996	237.8	9.6	122.7	1.8	371.9
1997	221.0	9.4	118.9	0.8	350.0
1998	221.8	8.9	115.0	0.2	345.9
1999	220.9	8.2	111.2		340.2
2000	220.9	8.2	107.4		336.5
2001	221.3	8.3	103.5		333.1
2002	219.9	8.4	99.7		328.0
2003	218.4	8.5	95.9		322.8
2004	217.0	8.5	92.0		317.6
2005	215.6	8.3	88.2		312.1
2006	214.2	8.1	84.4		306.6
2007	212.8	7.9	80.5		301.2
2008	211.4	7.3	76.7		295.3
2009	209.9	7.2	72.8		289.9
2010	208.5	6.6	69.0		284.2
2011	207.1	6.5	65.2		278.7
2012	204.5	6.4	61.3		272.3
2013	196.3	6.5	57.5		260.3
2014	185.2	6.5	53.7		245.4
2015	169.8	6.6	49.8		226.2
2016	154.4	6.6	46.0		207.0
2017	138.9	6.7	42.2		187.8
2018	123.5	6.7	38.3		168.6
2019	108.1	6.2	34.5		148.8
2020	92.7	5.7	30.7		129.1
2021	77.2	5.3	26.8		109.4
2022	65.7	4.8	23.0		93.6
2023	54.2	4.4	19.2		77.8
2024	42.6	4.0	15.3		61.9
2025	31.1	3.5	11.5		46.1
2026	19.6	3.1	7.7		30.3
2027	8.0	2.7	3.8		14.5
2028	2.2 ^c	2.3	0.0		4.5
2029	2.2 ^c	1.9			4.1
2030	2.2 ^c	1.5			3.7
2031	2.2 ^c	1.1			3.3
2032	2.2 ^c	0.7			2.9
2033	2.2 ^c	0.5			2.7
2034	2.2 ^c	0.2			2.4
2035	2.2 ^c	0.0			2.2

^aHistorical inventories for HLW volume are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 10 (December 1994)]. The inventories for 1995 and the projections through 2030 are taken from ref. 1.

^bNumbers shown as 0.0 are less than 50 m³. Values of 0.0 or blank do not imply tank cleanout will be 100%.

^cThese volumes (2,200 m³) represent the residual amount (<1.0%) of HLW which will remain in tanks until 2035 or later, as per agreement between DOE, the Washington State Department of Ecology, and the EPA (see ref. 5).

Table 2.2. Historical and projected cumulative decayed radioactivity of HLW stored in tanks, bins, and capsules, by site^{a,b}

End of calendar year	Radioactivity, 10 ⁶ Ci				
	Hanford	INEL	SRS	WVDP	Total
1990	399.3	63.2	561.6	26.7	1,050.8
1991	384.2	59.4	537.6	26.2	1,007.4
1992	372.1	50.8	632.4	25.9	1,081.2
1993	361.4	52.5	606.0	25.3	1,045.3
1994	348.0	51.6	534.5	24.7	958.8
1995	339.9	49.3	502.2	24.1	915.4
1996	332.1	48.1	465.4	19.2	864.8
1997	324.4	45.9	440.2	8.5	819.0
1998	316.9	44.4	416.0	2.1	779.4
1999	309.6	43.3	392.8		745.7
2000	302.4	42.2	370.6		715.2
2001	295.4	41.2	349.2		685.8
2002	287.8	40.3	328.6		656.6
2003	280.4	39.3	308.8		628.4
2004	273.1	38.3	289.7		601.2
2005	266.0	37.5	271.4		575.0
2006	259.2	36.5	253.8		549.5
2007	252.5	35.7	236.8		525.0
2008	245.9	34.8	220.5		501.3
2009	239.6	34.0	204.8		478.4
2010	233.4	33.1	189.7		456.2
2011	227.3	32.3	175.2		434.8
2012	222.1	31.4	161.3		414.8
2013	189.8	30.7	147.9		368.4
2014	156.9	30.0	135.0		321.9
2015	122.4	29.3	122.6		274.3
2016	89.4	28.6	110.7		228.7
2017	79.7	27.9	99.3		206.9
2018	70.5	27.3	88.3		186.1
2019	61.6	26.7	77.7		166.0
2020	53.1	21.8	67.6		142.5
2021	45.0	18.4	57.9		121.3
2022	37.2	15.1	48.6		100.9
2023	29.7	12.2	39.7		81.6
2024	22.6	9.5	31.1		63.1
2025	15.8	6.9	22.9		45.5
2026	9.2	4.6	15.0		28.8
2027	3.0	2.9	7.5		13.4
2028	0.0	1.3	0.2		1.6
2029	0.0	0.7			0.7
2030	0.0	0.5			0.5
2031	0.0	0.2			0.2
2032	0.0	0.0			0.0
2033	0.0	0.0			0.0
2034	0.0	0.0			0.0
2035	0.0	0.0			0.0

^aHistorical inventories for HLW radioactivity are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 10 (December 1994)]. The inventories for 1995 and the projections through 2030 are taken from ref. 1.

^bNumbers shown as 0.0 are less than 5,000 Ci. Values of 0.0 or blank do not imply tank cleanout will be 100%.

Table 2.3. Historical and projected cumulative decayed thermal power of HLW stored in tanks, bins, and capsules, by site^{a,b}

End of calendar year	Thermal power, 10 ³ W				
	Hanford	INEL	SRS	WVDP	Total
1990	1,150.3	184.4	1,566.7	76.9	2,978.3
1991	1,106.5	172.0	1,509.3	75.9	2,863.7
1992	1,073.1	147.3	1,724.3	79.1	3,023.8
1993	1,043.1	153.7	1,615.3	74.1	2,886.3
1994	999.8	150.8	1,497.3	78.1	2,726.0
1995	976.7	142.8	1,406.0	69.7	2,595.2
1996	954.1	139.6	1,311.3	55.7	2,460.7
1997	932.1	132.7	1,248.5	24.8	2,337.9
1998	910.5	128.2	1,187.6	6.2	2,232.5
1999	889.5	125.0	1,128.0		2,142.5
2000	868.9	121.8	1,069.5		2,060.2
2001	848.9	118.7	1,012.2		1,979.7
2002	826.8	116.7	956.1		1,899.6
2003	805.4	113.6	901.5		1,820.5
2004	784.4	110.6	848.4		1,743.4
2005	764.1	108.4	796.9		1,669.4
2006	744.2	105.3	746.9		1,596.4
2007	724.9	103.2	698.5		1,526.6
2008	706.0	100.5	651.8		1,458.3
2009	687.7	98.2	606.6		1,392.4
2010	669.8	95.7	562.9		1,328.5
2011	652.4	93.0	520.8		1,266.3
2012	637.3	90.8	480.2		1,208.4
2013	548.3	88.7	441.0		1,078.1
2014	456.9	86.7	403.3		946.9
2015	360.5	84.7	366.9		812.1
2016	268.3	82.7	331.8		682.9
2017	239.4	80.8	298.0		618.2
2018	211.6	78.9	265.5		556.0
2019	185.0	77.0	234.2		496.2
2020	159.4	62.9	204.1		426.4
2021	135.0	53.1	175.1		363.2
2022	111.6	43.7	147.2		302.5
2023	89.2	35.3	120.3		244.9
2024	67.8	27.4	94.5		189.7
2025	47.3	19.8	69.7		136.8
2026	27.8	13.3	45.8		86.8
2027	9.1	8.5	22.8		40.4
2028	0.0	3.9	0.8		4.7
2029	0.0	2.0			2.1
2030	0.0	1.3			1.4
2031	0.0	0.7			0.7
2032	0.0	0.0			0.1
2033	0.0	0.0			0.1
2034	0.0	0.0			0.1
2035	0.0	0.0			0.0

^aHistorical inventories for HLW thermal power are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 10 (December 1994)]. The inventories for 1995 and the projections through 2030 are taken from ref. 1.

^bNumbers shown as 0.0 are less than 50 W. Values of 0.0 or blank do not imply tank cleanout will be 100%.

Table 2.4. Projected annual and cumulative volume (10³ m³) of HLW glass stored in canisters, by site^{a,b}

End of calendar year	Hanford ^c		INEL ^d		SRS ^e		WVDP ^f		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					0.044	0.044	0.050	0.050	0.094	0.094
1997					0.094	0.138	0.100	0.150	0.194	0.288
1998					0.125	0.263	0.060	0.210	0.185	0.473
1999					0.125	0.388	0.020	0.230	0.145	0.618
2000					0.125	0.513		0.230	0.125	0.743
2001					0.125	0.638		0.230	0.125	0.868
2002	0.069	0.069			0.125	0.764		0.230	0.194	1.062
2003	0.069	0.138			0.125	0.889		0.230	0.194	1.256
2004	0.069	0.207			0.125	1.014		0.230	0.194	1.450
2005	0.069	0.275			0.125	1.139		0.230	0.194	1.644
2006	0.069	0.344			0.125	1.264		0.230	0.194	1.839
2007	0.069	0.413			0.125	1.389		0.230	0.194	2.033
2008	0.069	0.482			0.125	1.515		0.230	0.194	2.227
2009	0.069	0.551			0.125	1.640		0.230	0.194	2.421
2010	0.069	0.620			0.125	1.765		0.230	0.194	2.615
2011	0.069	0.689			0.125	1.890		0.230	0.194	2.809
2012		0.689			0.125	2.015		0.230	0.125	2.934
2013	0.414	1.102			0.125	2.140		0.230	0.539	3.473
2014	0.643	1.745			0.125	2.266		0.230	0.768	4.241
2015	0.987	2.733			0.125	2.391		0.230	1.113	5.354
2016	0.987	3.720			0.125	2.516		0.230	1.113	6.466
2017	0.918	4.638			0.125	2.641		0.230	1.043	7.509
2018	0.918	5.556			0.125	2.766		0.230	1.043	8.553
2019	0.918	6.474	0.005	0.005	0.125	2.892		0.230	1.048	9.601
2020	0.918	7.392	0.051	0.056	0.125	3.017		0.230	1.094	10.695
2021	0.918	8.310	0.051	0.107	0.125	3.142		0.230	1.094	11.789
2022	0.918	9.228	0.051	0.158	0.125	3.267		0.230	1.094	12.883
2023	0.918	10.146	0.051	0.208	0.125	3.392		0.230	1.094	13.977
2024	0.918	11.064	0.051	0.259	0.125	3.517		0.230	1.094	15.071
2025	0.918	11.982	0.051	0.309	0.125	3.643		0.230	1.094	16.164
2026	0.918	12.900	0.050	0.359	0.078	3.720		0.230	1.045	17.210
2027	0.918	13.818	0.049	0.409		3.720		0.230	0.967	18.177
2028	0.459	14.277	0.050	0.458		3.720		0.230	0.509	18.686
2029		14.277	0.046	0.505		3.720		0.230	0.046	18.732
2030		14.277	0.045	0.550		3.720		0.230	0.045	18.777
2031		14.277	0.045	0.595		3.720		0.230	0.045	18.822

Table 2.4 (continued)

End of calendar year	Hanford ^c		INEL ^d		SRS ^e		WVDP ^f		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2032		14.277	0.045	0.640		3.720		0.230	0.045	18.868
2033		14.277	0.027	0.667		3.720		0.230	0.027	18.895
2034		14.277	0.027	0.694		3.720		0.230	0.027	18.922
2035		14.277	0.026	0.720		3.720		0.230	0.026	18.948

^aTaken from data given in ref. 1. Glass may be in storage at the site, in transit to a repository, or in a repository.

^bSee Table 2.7 for the projected number of canisters.

^cHanford's reference canister has a diameter of 61 cm and is 450 cm long (about 2 ft in diam by about 15 ft in length). The nominal glass volume is expected to be 1.1 m³ with a minimum waste oxide loading of 25 vol % (excluding sodium and silicon). Hanford values include HLW glass plus overpacked cesium and strontium capsule canisters, assuming capsules to be declared waste and treated as HLW.

^dINEL's canister projections assume the use of a canister containing 1.26 m³ of glass.

^eAt SRS, the DWPF canisters are 0.6 m in diam by 3 m in length (about 2 ft in diam by about 10 ft in length). Each canister is assumed to contain 0.625 m³ of glass [i.e., 85% of the usable capacity (0.735 m³)] made with HLW from the reprocessing of SNF at SRS. The glass incorporates 36 wt % oxides from waste (28 wt % from SNF and 8 wt % from processing chemicals) and 64 wt % oxides from nonradioactive glass frit. Volumes reported are for the glass waste form and not the canisters.

^fFor WVDP, it is assumed that 276 canisters 0.6 m in diam by 3 m in length (2 ft in diam by 10 ft in length) are filled with waste glass during 1996-1999 and that each canister contains 0.8 m³ of glass at the filling temperature. Tank heels and residual materials will continue to be vitrified through mid-FY 2001.

Table 2.5. Projected annual and cumulative decayed radioactivity (10⁶ Ci) of HLW glass stored in canisters, by site^{a,b}

End of calendar year	Hanford ^c		INEL		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					15.31	15.31	4.89	4.89	20.20	20.20
1997					14.96	29.90	9.56	14.45	24.52	44.35
1998					14.61	43.80	5.60	20.05	20.21	63.85
1999					14.28	57.05	1.83	21.88	16.11	78.93
2000					13.95	69.67		21.37	13.95	91.04
2001					13.64	81.69		20.87	13.64	102.56
2002	0.81	0.81			13.33	93.14		20.38	14.14	114.33
2003	0.79	1.58			13.03	104.03		19.91	13.82	125.52
2004	0.77	2.32			12.74	114.38		19.44	13.51	136.14
2005	0.75	3.02			12.46	124.22		18.99	13.21	146.23
2006	0.74	3.68			12.18	133.56		18.55	12.92	155.79
2007	0.72	4.32			11.91	142.43		18.12	12.63	164.86
2008	0.70	4.92			11.64	150.84		17.69	12.35	173.45
2009	0.69	5.49			11.39	158.80		17.28	12.07	181.57
2010	0.67	6.04			11.13	166.34		16.88	11.81	189.25
2011	0.66	6.55			10.89	173.46		16.48	11.54	196.50
2012		6.40			10.65	180.20		16.10	10.65	202.70
2013	27.13	33.39			10.42	186.55		15.72	37.55	235.66
2014	28.54	61.16			10.19	192.53		15.36	38.73	269.05
2015	30.87	90.62			9.96	198.17		15.00	40.83	303.79
2016	30.16	118.69			9.75	203.47		14.65	39.91	336.81
2017	7.59	123.55			9.54	208.44		14.31	17.13	346.29
2018	7.42	128.11			9.33	213.10		13.97	16.75	355.19
2019	7.25	132.41	0.04	0.04	9.13	217.46		13.65	16.41	363.56
2020	7.08	136.43	4.32	4.31	8.93	221.54		13.33	20.33	375.61
2021	6.91	140.20	2.95	7.12	8.74	225.33		13.02	18.60	385.67
2022	6.76	143.72	2.88	9.81	8.55	228.87		12.72	18.19	395.11
2023	6.60	147.00	2.57	12.10	8.37	232.14		12.42	17.54	403.67
2024	6.45	150.06	2.50	14.30	8.19	235.18		12.13	17.14	411.67
2025	6.30	152.90	2.43	16.40	8.02	237.98		11.85	16.74	419.12
2026	6.15	155.52	2.14	18.10	7.85	240.55		11.57	16.14	425.75
2027	6.01	157.95	1.57	19.30		235.23		11.30	7.58	423.78
2028	2.94	157.24	1.55	20.30		230.04		11.04	4.49	418.62
2029		153.61	0.62	20.50		224.97		10.78	0.62	409.86
2030		150.07	0.22	20.20		220.01		10.53	0.22	400.81
2031		d	0.22	20.00		d		d		d
2032		d	0.21	19.70		d		d		d

Table 2.5 (continued)

End of calendar year	Hanford ^c		INEL		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2033		d	0.01	19.30		d		d		d
2034		d	0.01	18.80		d		d		d
2035		d	0.01	18.40		d		d		d

^aTaken from data given in ref. 1.

^bRadioactive decay is taken into account by each site by means of radioisotope generation and depletion codes.

^cThe significant increase in annual radioactivity for the years 2013–2016 reflects the accelerated processing schedule for the strontium and cesium capsules at Hanford (see Sect. 2.5.1). Hanford values include HLW glass plus overpacked cesium and strontium capsule canisters, assuming capsules to be declared waste and treated as HLW.

^dNot available.

Table 2.6. Projected annual and cumulative decayed thermal power (10^3 W) of HLW glass stored in canisters, by site^{a,b}

End of calendar year	Hanford ^c		INEL		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					43.15	43.15	14.17	14.17	57.32	57.32
1997					42.42	84.81	27.71	41.88	70.13	126.69
1998					41.71	125.05	16.23	58.10	57.94	183.15
1999					41.00	163.82	5.30	63.40	46.30	227.22
2000					40.27	201.08		61.91	40.27	262.99
2001					39.54	236.82		60.46	39.54	297.28
2002	2.43	2.43			38.79	271.02		59.05	41.22	332.49
2003	2.37	4.74			38.05	303.72		57.66	40.42	366.12
2004	2.31	6.94			37.31	334.93		56.31	39.62	398.19
2005	2.26	9.05			36.57	364.70		54.99	38.83	428.74
2006	2.21	11.05			35.84	393.08		53.71	38.05	457.83
2007	2.16	12.95			35.12	420.10		52.45	37.28	485.49
2008	2.11	14.76			34.42	445.81		51.22	36.52	511.79
2009	2.06	16.48			33.72	470.26		50.02	35.78	536.76
2010	2.01	18.11			33.03	493.51		48.85	35.05	560.46
2011	1.97	19.66			32.36	515.58		47.71	34.33	582.94
2012		19.20			31.71	536.53		46.59	31.71	602.32
2013	74.34	93.10			31.06	556.40		45.50	105.41	695.00
2014	78.74	169.69			30.44	575.23		44.43	109.17	789.36
2015	85.87	251.65			29.82	593.07		43.39	115.69	888.11
2016	83.89	329.73			29.22	609.95		42.37	113.11	982.05
2017	22.79	344.91			28.63	625.90		41.38	51.42	1,012.20
2018	22.27	359.22			28.06	640.97		40.41	50.32	1,040.61
2019	21.75	372.69	0.12	0.12	27.50	655.19		39.47	49.37	1,067.47
2020	21.25	385.35	12.40	12.40	26.95	668.59		38.54	60.60	1,104.89
2021	20.76	397.23	8.49	20.50	26.41	681.21		37.64	55.67	1,136.59
2022	20.29	408.37	8.29	28.20	25.89	693.08		36.76	54.47	1,166.40
2023	19.82	418.78	7.41	34.90	25.38	704.22		35.90	52.61	1,193.80
2024	19.36	428.50	7.22	41.20	24.89	714.67		35.06	51.47	1,219.43
2025	18.92	437.55	7.01	47.20	24.40	724.46		34.24	50.33	1,243.45
2026	18.49	445.97	6.19	52.20	23.93	733.61		33.43	48.60	1,265.20
2027	18.06	453.76	4.54	55.50		718.68		32.65	22.60	1,260.59
2028	8.82	452.15	4.46	58.60		704.09		31.89	13.28	1,246.73
2029		441.75	1.79	59.00		689.84		31.14	1.79	1,221.73
2030		431.59	0.65	58.30		675.91		30.41	0.65	1,196.21
2031		d	0.63	57.60		d		d	0.63	d
2032		d	0.62	56.90		d		d	0.62	d

Table 2.6 (continued)

End of calendar year	Hanford ^c		INEL		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2033		d	0.02	55.60		d		d	0.02	d
2034		d	0.02	54.30		d		d	0.02	d
2035		d	0.01	53.00		d		d	0.01	d

^aTaken from data given in ref. 1.

^bThermal power is taken into account by each site by means of radioisotope generation and depletion codes.

^cThe significant increase in annual thermal power for the years 2013–2016 reflects the accelerated processing schedule for the strontium and cesium capsules at Hanford (see Sect. 2.5.1). Hanford values include HLW glass plus overpacked cesium and strontium capsule canisters, assuming capsules to be declared waste and treated as HLW.

^dNot available.

Table 2.7. Estimated potential number of HLW canisters, by site^a

End of calendar year	Hanford ^b		INEL ^c		SRS ^d		WVDP ^e		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					70	70	55	55	125	125
1997					150	220	118	173	268	393
1998					200	420	76	249	276	669
1999					200	620	27	276	227	896
2000					200	820		276	200	1,096
2001					200	1,020		276	200	1,296
2002	60	60			200	1,220		276	260	1,556
2003	60	120			200	1,420		276	260	1,816
2004	60	180			200	1,620		276	260	2,076
2005	60	240			200	1,820		276	260	2,336
2006	60	300			200	2,020		276	260	2,596
2007	60	360			200	2,220		276	260	2,856
2008	60	420			200	2,420		276	260	3,116
2009	60	480			200	2,620		276	260	3,376
2010	60	540			200	2,820		276	260	3,636
2011	60	600			200	3,020		276	260	3,896
2012		600			200	3,220		276	200	4,096
2013	361	961			200	3,420		276	561	4,657
2014	561	1,521			200	3,620		276	761	5,417
2015	861	2,382			200	3,820		276	1,061	6,478
2016	861	3,242			200	4,020		276	1,061	7,538
2017	800	4,042			200	4,220		276	1,000	8,538
2018	800	4,842			200	4,420		276	1,000	9,538
2019	800	5,642	4	4	200	4,620		276	1,004	10,542
2020	800	6,442	40	45	200	4,820		276	1,040	11,583
2021	800	7,242	40	85	200	5,020		276	1,040	12,623
2022	800	8,042	40	125	200	5,220		276	1,040	13,663
2023	800	8,842	40	165	200	5,420		276	1,040	14,703
2024	800	9,642	40	206	200	5,620		276	1,040	15,744
2025	800	10,442	40	246	200	5,820		276	1,040	16,784
2026	800	11,242	40	285	124	5,944		276	964	17,747
2027	800	12,042	39	324		5,944		276	839	18,586
2028	400	12,442	39	364		5,944		276	439	19,026
2029		12,442	37	400		5,944		276	37	19,062
2030		12,442	36	436		5,944		276	36	19,098
2031		12,442	36	472		5,944		276	36	19,134

Table 2.7 (continued)

End of calendar year	Hanford ^b		INEL ^c		SRS ^d		WVDP ^e		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2032		12,442	36	508		5,944		276	36	19,170
2033		12,442	21	530		5,944		276	21	19,192
2034		12,442	21	551		5,944		276	21	19,213
2035		12,442	21	572		5,944		276	21	19,234

^aTaken from ref. 1. The projected waste volume, radioactivity, and thermal power values (Tables 2.4–2.6) are consistent with the number of canisters reported. Canister projections may not be calculated by the site in whole numbers, as presented here. Due to round-off, numbers may not add exactly. The projections reported for Hanford and INEL reflect major changes in the HLW solidification schedule. These changes are mainly caused by current DOE funding guidance.

^bHanford's reference canister has a diameter of 61 cm and is 450 cm long (about 2 ft in diam by about 15 ft in length). The nominal glass volume is expected to be 1.1 m³ with a minimum waste oxide loading of 25 vol % (excluding sodium and silicon). Cesium and strontium capsules will also be disposed of in these canisters.

^cINEL canister projections assume the use of a canister containing 1.26 m³ of glass.

^dCanisters are 0.6 m in diam by 3 m in length (about 2 ft in diam by about 10 ft in length). Each canister is assumed to contain 0.625 m³ of glass made with HLW from the reprocessing of SNF at SRS. The glass incorporates 36 wt % oxides from waste (28 wt % from SNF and 8 wt % from processing chemicals) and 64 wt % oxides from nonradioactive glass frit.

^eCanisters are 0.6 m in diam by 3 m in length (about 2 ft in diam by 10 ft in length). Each canister is assumed to contain 0.8 m³ of a borosilicate glass incorporating waste solids.

Table 2.8. Current volume of HLW in storage by site through 1995^a

Site	Volume, 10 ³ m ³					Total
	Tank waste		Capsules		Canister material	
	Liquid ^b	Solid ^c	Sr	Cs		
Hanford	89.839	143.668	0.0011	0.0024		233.5
INEL	7.35	3.83				11.2
SRS	58.7	67.8				126.5
WVDP ^d	2.2					2.2
Total	158.1	215.3	0.0011	0.0024	0	373.4

^aTaken from ref. 1.^bLiquid tank waste consists of free tank supernatant and drainable interstitial liquid.^cSolid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate.^dWVDP liquid waste includes sludge and zeolite.Table 2.9. Current radioactivity of HLW in storage by site through 1995^a

Site	Radioactivity, 10 ⁶ Ci					Total
	Tank waste		Capsules		Canister material	
	Liquid ^b	Solid ^c	Sr	Cs		
Hanford	68.5	125.3	44.9	101.2		339.9
INEL	2.7	46.6				49.3
SRS	214.6	287.6				502.2
WVDP ^d	24.05					24.1
Total	309.8	459.5	44.9	101.2	0	915.4

^aTaken from ref. 1.^bLiquid tank waste consists of free tank supernatant and drainable interstitial liquid.^cSolid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate.^dWVDP liquid waste includes sludge and zeolite.

Table 2.10. Current thermal power of HLW in storage by site through 1995^a

Site	Thermal power, 10 ³ W					Total
	Tank waste		Capsules		Canister material	
	Liquid ^b	Solid ^c	Sr	Cs		
Hanford	166.7	414.24	150.3	245.4		976.7
INEL	7.8	135.0				142.8
SRS	476.2	929.84				1,406.0
WVDP ^d	69.7					69.7
Total	720.4	1,479.1	150.3	245.4	0	2,595.2

^aTaken from ref. 1.^bLiquid tank waste consists of free tank supernatant and drainable interstitial liquid.^cSolid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate.^dWVDP liquid waste includes sludge and zeolite.Table 2.11. Major radionuclides comprising HLW and associated wastes at Hanford^a

Radionuclides	Radioactivity (Ci) by waste category					
	Interim forms ^b		Final forms ^c			
	Tank waste	Other (capsules)	HLW glass canisters	LLW form (glass) ^d	Cumulative out of system	Other (capsule canisters)
³ H	e	e				
¹⁴ C	4.574E+03		4.555E+03			
⁹⁰ Sr	5.952E+07	2.246E+07	2.713E+07			1.024E+07
⁹⁰ Y	5.952E+07	2.246E+07	2.713E+07			1.024E+07
⁹⁹ Tc	3.210E+04		3.209E+04			
¹²⁹ I	2.980E-01		2.979E-01			
¹³⁷ Cs	3.772E+07	5.196E+07	1.760E+07			2.425E+07
^{137m} Ba	3.572E+07	4.921E+07	1.667E+07			2.296E+07
¹⁵¹ Sm	1.058E+06		8.205E+05			
²³⁸ Pu	1.415E+03		1.090E+03			
²³⁹ Pu	2.635E+04		2.632E+04			
²⁴⁰ Pu	6.692E+03		6.667E+03			
²⁴¹ Pu	9.316E+04		1.903E+04			
²⁴² Pu	2.802E-01		2.801E-01			
²⁴¹ Am	1.037E+05		1.007E+05			
²⁴² Am	6.247E+01		5.373E+01			
Total	1.938E+08	1.461E+08	8.955E+07			6.769E+07

^aData taken from ref. 1(a).^bAs of December 31, 1995.^cAs of December 31, 2028.^dRadionuclide distribution and decay power in LLW glass and emissions out of system are undefined, pending flowsheet development and regulatory decisions.^eEstimate of December 31, 1995, inventory for ³H is currently unavailable.

Table 2.12. Major radionuclides comprising HLW and associated wastes at INEL^a

Radionuclides	Radioactivity (Ci) by waste category			
	Interim forms ^b		Final forms ^c	
	Liquid	Calcine	Glass	Grout
⁹⁰ Sr	6.23E+05	1.10E+07	4.28E+06	4.28E+02
⁹⁰ Y	6.23E+05	1.10E+07	4.28E+06	4.28E+02
¹⁰⁶ Ru	3.03E+02	1.87E+03	8.90E-10	8.90E-10
¹⁰⁶ Rh	3.03E+02	1.87E+03	8.90E-10	8.90E-10
¹³⁴ Cs	4.48E+03	3.79E+04	5.95E-02	5.95E-06
¹³⁷ Cs	7.34E+05	1.26E+07	5.05E+06	5.05E+02
^{137m} Ba	6.96E+05	1.19E+07	4.79E+06	4.79E+02
¹⁴⁴ Ce	1.59E+03	7.17E+03	2.84E-12	2.84E-16
¹⁴⁴ Pr	1.59E+03	7.17E+03	2.84E-12	2.84E-16
¹⁴⁷ Pm		6.15E+04	1.71E+00	1.71E-04
¹⁵⁴ Eu	4.16E+03	4.76E+04	1.92E+03	1.92E-01
Total	2.69E+06	4.66E+07	1.84E+07	1.84E+03

^aData taken from ref. 1(b).

^bAs of December 31, 1995.

^cAs of December 31, 2035.

Table 2.13. Major radionuclides comprising HLW and associated wastes at SRS^a

Radionuclides	Radioactivity (Ci) by waste category			
	Interim form ^b	Final forms ^c		
	Tank waste	Canister material	Saltstone (LLW)	Outfall
³ H	8.06E+04	2.41E+03	7.82E-01	d
¹⁴ C	2.00E+01	5.99E-01	1.94E-04	d
⁹⁰ Sr	1.19E+08	3.57E+06	1.16E+03	d
⁹⁰ Y	1.19E+08	3.57E+06	1.16E+03	d
⁹⁹ Tc	2.28E+04	6.82E+02	2.21E-01	d
¹²⁹ I	3.68E+01	1.10E+00	3.57E-04	d
¹³⁷ Cs	1.16E+08	3.47E+06	1.12E+03	d
^{137m} Ba	1.10E+08	3.28E+06	1.06E+03	d
²³⁸ Pu	1.71E+06	5.13E+04	1.66E+01	d
²³⁹ Pu	3.64E+04	1.09E+03	3.54E-01	d
²⁴⁰ Pu	1.66E+04	4.96E+02	1.61E-01	d
²⁴¹ Pu	7.53E+05	2.26E+04	7.31E+00	d
²⁴² Pu	2.84E+01	8.51E-01	2.76E-04	d
²⁴¹ Am	6.06E+04	1.82E+03	5.88E-01	d
^{242m} Am	6.38E+01	1.91E+00	6.20E-04	d
²³² Th	1.47E+00	4.41E-02	1.43E-05	d
²³³ U	1.08E+02	3.25E+00	1.05E-03	d
²³⁴ U	3.01E+01	9.00E-01	2.92E-04	d
²³⁷ Np	7.04E+01	2.11E+00	6.83E-04	d
²⁴⁴ Cm	2.50E+03	7.50E+01	2.43E-02	d
Total	4.67E+08	1.40E+07	4.53E+03	d

^aData taken from ref. 1(c).

^bAs of December 31, 1995.

^cAs of December 31, 1996, the first year of glass production.

^dNegligible contribution.

Table 2.14. Major radionuclides comprising HLW and associated wastes at WVDP^a

Radionuclides	Radioactivity, Ci, by waste category			
	Interim form ^b	Final forms ^c		
		Tank waste	Canister material	LLW form Emissions
³ H	1.23E+00			
¹⁴ C	5.49E-01			
⁹⁰ Sr	5.81E+06			
⁹⁰ Y	5.81E+06			
⁹⁹ Tc	1.09E+02			
¹⁰⁶ Ru	2.30E-01			
¹⁰⁶ Rh	2.30E-01			
¹²⁹ I	1.81E-01			
¹³⁴ Cs	6.87E+02			
¹³⁵ Cs	1.61E+02			
¹³⁷ Cs	6.28E+06			
^{137m} Ba	5.94E+06			
¹⁴⁷ Pm	1.79E+04			
²³⁸ Pu	7.92E+03			
²³⁹ Pu	1.63E+03			
²⁴⁰ Pu	1.19E+03			
²⁴¹ Pu	6.04E+04			
²⁴² Pu	1.62E+00			
²⁴¹ Am	5.36E+04			
²⁴² Am	2.87E+02			
²⁴⁴ Cm	6.07E+03			
Total	2.40E+07			

^aData taken from ref. 1(d).

^bAs of December 31, 1995.

^cRadionuclide information for the final forms generated from HLW treatment is currently unavailable.

Table 2.15. Significant revisions and changes in the current values for HLW compared to the values in the previous year^{a,b}

Waste characteristics	Previous report values ^a	Significant revisions and changes	Updated values ^b	Explanation
<i>Hanford Site</i>				
Number of canisters	See Table 2.7	Canister production schedule updated	See Table 2.7	
<i>Idaho National Engineering Laboratory</i>				
Number of canisters	See Table 2.7	Canister production schedule updated	See Table 2.7	Based on current funding guidance from DOE and the INEL Full Treatment Alternative (see ref. 15)
<i>Savannah River Site</i>				
Number of canisters	See Table 2.7	Canister production schedule updated	See Table 2.7	Based on current funding guidance from DOE and the SRS <i>High-Level Waste System Plan Revision 6(U)</i> (see ref. 16)
<i>West Valley Demonstration Project</i>				
Volume, radioactivity, and thermal power	See Tables 2.8–2.10	Values reported are for liquid, sludge, and zeolite	See Tables 2.8–2.10	Wastes have been blended prior to vitrification

^aData are for December 31, 1994. See tables and text cited in Chapter 2 of ref. 6 (DOE/RW-0006, Rev. 11).

^bData are for December 31, 1995, as reported in this document (DOE/RW-0006, Rev. 12).

Table 2.16. Proposed representative chemical composition of future HLW glass to be generated at Hanford^a

Component	Wt %	Component	Wt %
Al ₂ O ₃	9.31	Na ₂ O	11.79
B ₂ O ₃	7.02	Na ₂ SO ₄	0.10
Bi ₂ O ₃	1.15	NiO	1.08
CaO	0.83	P ₂ O ₅	1.56
Ce ₂ O ₃	1.13	PbO ₂	0.14
Cr ₂ O ₃	0.36	SiO ₂	46.11
Fe ₂ O ₃	4.49	SrO	0.18
K ₂ O	0.17	ThO ₂	0.01
La ₂ O ₃	0.11	UO ₃	6.69
Li ₂ O	2.01	ZrO ₂	3.79
MnO ₂	1.17	Other	0.17
NaF	0.63		
		Total	100.00

^aData taken from ref. 1(a).

Table 2.17. Proposed representative chemical composition of future HLW glass to be produced at INEL^a

Chemical compound	Glass, wt %, formed from high-activity fraction from		
	Dissolved Zr calcine	Dissolved Al calcine	Na-bearing-waste
Al ₂ O ₃	0.5	12.7	17.2
AMP ^b	0.8	6.6	
B ₂ O ₃	12.2	8.1	11.3
CaF ₂	14.5		
CaO	0.4		
Cs ₂ O		0.1	
Fe ₂ O ₃		0.1	0.1
Na ₂ O	12.9	18.0	13.8
P ₂ O ₅	0.1		
SiO ₂	56.8	54.4	57.6
ZrO ₂	1.8		
Total	100.0	100.0	100.0

^aData taken from ref. 1(b); flowsheet estimate, not verified by laboratory tests.

^bAmmoniummolybdophosphate.

Table 2.18. Proposed representative chemical composition of future HLW glass to be generated at SRS^a

Component	Wt %	Component	Wt %
Al ₂ O ₃	3.9	MgO	2.0
B ₂ O ₃	7.3	MnO	1.2
CaO	0.6	Na ₂ O	8.7
Ca ₃ (PO ₄) ₂	1.1	NiO	0.1
Cr ₂ O ₃	0.2	SiO ₂	53.4
CuO	0.4	TiO ₂	0.3
FeO	1.1	U ₃ O ₈	0.9
Fe ₂ O ₃	11.1	ZnO	0.1
K ₂ O	2.4	Other	0.4
Li ₂ O	4.8		
		Total	100.0

^aData taken from ref. 1(c).

Table 2.19. Proposed representative chemical composition of future HLW glass to be generated at WVDP^a

Component	Wt %	Composition	Wt %
Al ₂ O ₃	6.00	Nd ₂ O ₃	0.14
B ₂ O ₃	12.89	NiO	0.25
BaO	0.16	P ₂ O ₅	1.20
CaO	0.48	PdO	0.03
Ce ₂ O ₃	0.31	Pr ₆ O ₁₁	0.04
CoO	0.02	Rh ₂ O ₃	0.02
Cr ₂ O ₃	0.14	RuO ₂	0.08
Cs ₂ O	0.08	SO ₃	0.23
CuO	0.03	SiO ₂	40.98
Fe ₂ O ₃	12.02	Sm ₂ O ₃	0.03
K ₂ O	5.00	SrO	0.02
La ₂ O ₃	0.04	ThO ₂	3.56
Li ₂ O	3.71	TiO ₂	0.80
MgO	0.89	UO ₃	0.63
MnO	0.82	Y ₂ O ₃	0.02
MoO ₃	0.04	ZnO	0.02
Na ₂ O	8.00	ZrO ₂	1.32
		Total	100.00

^aData taken from ref. 1(d).

3. TRANSURANIC WASTE

3.1 INTRODUCTION

This chapter presents information on the inventories and characteristics of transuranic waste (TRUW) at various DOE transuranic (TRU) waste sites in the United States. TRUW is a waste category specific to DOE; it does not apply to wastes regulated by the U.S. Nuclear Regulatory Commission. DOE Order 5820.2A defines TRUW as waste that (1) is contaminated with alpha-emitting transuranic (i. e., atomic numbers greater than 92) radionuclides with half-lives greater than 20 years and (2) contains a total concentration of such radionuclides in excess of 100 nCi/g of waste at the time of assay.¹

DOE Order 5820.2A also states that heads of field elements can determine that other alpha-contaminated waste at the site(s) may be managed as TRUW.¹ As a consequence of this provision, wastes containing radionuclides such as ²³³U and ²⁴⁴Cm, which do not meet the strict definition of TRU radionuclides because of their respective atomic numbers or half-lives, may be managed as TRUW at some sites.

Most TRUW exists in solid form (e.g., items such as protective clothing, paper, rags, glass, miscellaneous tools, and equipment that have become contaminated with TRU radionuclides).² Some TRUW is in the form of sludges or liquids resulting from chemical processing for recovery of plutonium or other TRU elements.² Some of the liquids have been solidified, and some sludges have been dewatered. All sludge and liquid wastes scheduled for disposal in the Waste Isolation Pilot Plant (WIPP) will be solidified prior to their shipment to meet the current WIPP waste acceptance criteria (WAC).³

Before 1970, TRUW was disposed of on-site in shallow, landfill-type, DOE-owned burial sites. TRUW disposed of in this manner is referred to as "buried" TRUW. In 1970, DOE's predecessor agency, the U.S. Atomic Energy Commission, concluded that waste containing long-lived alpha-emitting radionuclides should have greater confinement from the environment. Thus, TRUW generated since the early 1970s has been segregated from other waste types and placed in retrievable storage pending shipment and final disposal in a permanent

geologic repository.⁴ This waste is referred to as "retrievably stored" TRUW.

Retrievably stored waste is contained in a variety of packagings (e.g., metal drums and wooden and metal boxes) and is stored in various facilities such as earth-mounded berms, concrete culverts, buildings, and on outdoor pads. Many of these facilities have been upgraded and are now in compliance with applicable hazardous waste storage regulations.

TRUW packages are classified as either "contact handled" (CH) or "remote handled" (RH), depending on the radiation level at the surface of the package at the time of packaging. If this level equals or exceeds 200 mrem/h, the package is classified as RH TRUW.

CH TRUW contains relatively small quantities of fission and activation products that produce highly penetrating radiation. Typically, its emissions consists mostly of alpha particles, some neutrons and primarily low-energy gamma and X-rays. RH TRUW typically contains a greater proportion of fission and activation products that produce highly penetrating radiation and produce a higher level of radiation at the surface of the package.

Mixed TRUW is defined as TRUW which contains, in addition to radioactive constituents, hazardous constituents defined and regulated in accordance with the Resource Conservation and Recovery Act (RCRA). Examples of mixed TRUW are radionuclide-contaminated sludges from plutonium recovery, discarded materials contaminated with both solvents and radioactive materials, scintillation fluids, and discarded, contaminated lead shielding. Mixed TRUW must be managed to comply with both the applicable hazardous waste regulations (e.g., RCRA) and the regulations applying only to radioactive TRUW.

Some TRUW may also be contaminated with hazardous materials defined by regulations other than RCRA (e.g., Toxic Substances Control Act and state regulations). Once identified, DOE continues to manage these wastes appropriately to meet all other hazardous waste regulations in addition to RCRA (if applicable).

Under existing arrangements, retrievably stored TRUW is the responsibility of the DOE Office of Waste Management (EM-30). It is planned that the retrievably stored TRUW and newly generated TRUW from routine site operational activities will be shipped to WIPP for disposal; whereas, buried TRUW and TRUW generated from site remediation activities and decontamination and decommissioning (D&D) activities are the responsibility of the Office of Environmental Restoration (EM-40). (See Chapter 6 of this document for a discussion of environmental restoration wastes.)

3.2 TRUW INVENTORIES

3.2.1 Sources of Data

The vast majority of the quantitative information contained in this chapter is either derived or summarized from end of the calendar year data furnished by the DOE sites and published in the *Transuranic Waste Baseline Inventory Report (Revision 3)* (TWBIR).² In some cases, when no new data were made available by the sites (e.g., for TRU-contaminated soil volumes), the information presented in this chapter is the same as that presented in the previous revision of the IDB.⁵ As programs and plans evolve or are changed, modifications or additions will be made to the data and other information in this chapter. It is expected that the quality and accuracy of the data will improve with each annual revision of this document, thus improving the usefulness of the data for program planning and decision purposes.

Early TRUW inventory practices were not as stringent as current ones with regard to requirements for waste identification, categorization, and segregation. Consequently, early inventory data are based largely on process knowledge and on various studies and summaries related to site-specific practices.⁶ As these efforts continue and TRUW is further characterized, there may be revisions in the estimated overall quantities of TRUW.

3.2.2 Site Locations—Summarized Volumes and Radioactivity

TRUW management activities (generation, retrievable storage, etc.) are performed at 10 major sites and 15 small-quantity sites (SQS). Figure 3.1 shows the locations of the DOE's TRU waste sites. Tables 3.1–3.21, which are discussed later in this chapter, summarize the distribution of TRUW and their radioactivities at various DOE TRU waste sites. The volumes reported in this document reflect two waste conditions: as-generated and final form. For stored waste, the as-generated volumes reflect the waste volumes currently in storage at the site, whereas for

projected waste the as-generated volumes reflect the expected waste volumes at the time of generation. The final-form volumes reflect the expected volume of the waste following site processing, treatment, and repackaging of the as-generated waste for disposal at WIPP.

3.2.3 Development of Detailed Inventory Data

To optimize its resources and to enhance data quality, DOE integrated the TRUW data needs of the IDB report with those of the TWBIR and issued a joint data call to the sites in 1995. The information contained in this chapter is primarily a summary of the detailed data gathered through this integrated data-call process, supplemented by additional information received from some DOE sites after the original data submittals. The data reported in this document are based on both as-generated and final-form volumes of TRUW, and are derived from Rev. 3 of the TWBIR, which was published in June 1996 to document the TRUW inventory data used by Sandia National Laboratories for performance assessment calculations for the WIPP repository.

To meet the needs of the TWBIR, site data were collected at the waste-stream level in both their as-generated and final forms. The data were grouped by similar physical and chemical properties and aggregated to produce estimated total volumes of the waste.

The data reported in the tables in this chapter include both the as-generated and final-form volumes at the end of CY 1994, and the projected increase in these respective volumes from 1995 through 2022.

3.2.3.1 Site data submittal process

As stated previously, the vast majority of the quantitative TRUW information presented in this chapter is derived or summarized from Rev. 3 of the TWBIR, published in June 1996. The sites provided waste stream profiles for each waste stream in their respective current and projected inventories through 2022. The waste stream profiles included such information as waste stream description, as-generated and final-form volumes, specific container data, and estimates of the amount of various materials present in the waste (e.g., iron-based metals and alloys, cellulose, plastics, etc.). In addition, the sites were provided with a list of acceptable final waste forms for disposal at WIPP and asked to assign the appropriate final waste form to each waste stream that is eligible for disposal at WIPP. The assignment of final waste form helps to identify the general physical and chemical properties of the final form for each waste stream.

The sites provided radionuclide compositions and curies of each radionuclide added in each year of TRUW

accumulation from 1970 through the end of CY 1994. The annual radioactivities reported for the currently retrievable stored waste in the site submittals are on an as-stored basis; that is, they represent the curies of each radionuclide added each year at the end of the year in which the currently retrievable waste was placed in storage. Only the cumulative site radioactivities decayed to the end of 1995 have been included in this chapter.

3.2.3.2 Site data review and finalization

The site data submittals for TRUW were reviewed to make certain, to the greatest extent possible, that the data supplied met the requirements of completeness and consistency. The data review process included modifying the formats of the data so that they could be easily converted to input data files.

In support of the TWBIR, waste streams at each TRUW site that were assigned the same final waste form were grouped together to form site-specific waste profiles. These profiles provide a condensed summary of the volume and waste material information found in the waste stream profiles for each site. Site-specific waste profiles with the same final waste form were then combined for all the TRU waste sites to produce WIPP waste profiles. The summary tables and figures presented in this chapter for final form volumes are based on aggregation of detailed waste stream profile data reported in Rev. 3 of the TWBIR.

3.2.4 Volumes and Radioactivities of TRUW at DOE Sites

3.2.4.1 As-generated TRUW volumes

Table 3.1 shows the total estimated *as-generated* TRUW volumes in storage at the end of 1994 and projected through 2022 for each DOE site, and Tables 3.2–3.7 show the breakup of this total *as-generated* inventory into total CH TRUW (Table 3.2), mixed CH TRUW (Table 3.3), nonmixed CH TRUW (Table 3.4), total RH TRUW (Table 3.5), mixed RH TRUW (Table 3.6), and nonmixed RH TRUW (Table 3.7).

3.2.4.2 Final-form TRUW volumes

Table 3.8 shows the *expected final-form* volumes of the stored and projected TRUW reported earlier in Table 3.1 *after the waste is processed to its final form*. Tables 3.9–3.14 show the breakup of this expected final form volume into total CH TRUW (Table 3.9), mixed CH TRUW (Table 3.10), nonmixed CH TRUW (Table 3.11), total RH TRUW (Table 3.12), mixed RH TRUW (Table 3.13), and nonmixed RH TRUW (Table 3.14).

Tables 3.15 and 3.16 show the expected total final-form volumes of TRUW at each site distributed among each final waste form (e.g., combustible waste). Table 3.15 shows the final waste form distribution for the major sites, whereas Table 3.16 presents the same for the SQS.

3.2.4.3 Decayed radioactivities for retrievably stored TRUW

The yearly undecayed activity reported for each radionuclide by each TRU waste site for CH TRUW and RH TRUW generated from 1970 through 1994 was decayed to the end of CY 1995 using the ORNL computer code ORIGEN2.⁷ This code converts the annual as-stored activities to annual decayed activities and accumulates these quantities to produce tables showing cumulative decayed activity for each radionuclide at each site. Once the decayed activities were calculated, the decayed mass was estimated using standard values of the specific activity of each radionuclide as reported in Appendix B of Rev. 11 of the IDB. Waste volumes are assumed to be unaffected by radioactive decay.

Tables 3.17–3.20 show the distribution of the primary TRUW radionuclides for all the DOE sites (decayed to the end of CY 1995) for retrievably stored CH TRUW and RH TRUW both by radioactivity and by mass. As shown in these tables, ²⁴¹Pu, ²³⁸Pu, ²³⁹Pu, ²⁴¹Am, and ²⁴⁰Pu cumulatively contribute more than 99% of the total activity for retrievably stored CH TRUW (Table 3.17), whereas ²³⁸Pu, ²³⁹Pu, ²³²Th, ²³⁵U, and ²⁴⁰Pu contribute more than 98% of the total radionuclide mass for retrievably stored CH TRUW (Table 3.18). Similar information on RH TRUW and on the relative distribution of both the radioactivity and mass of the primary radionuclides for the various DOE sites can be derived from Tables 3.19 and 3.20.

For the purposes of this report, primary radionuclides are those that cumulatively contribute 98% of either the total radionuclide activity or mass. As compared to Rev. 11 of the IDB, the increase in the total activity of each of the primary radionuclides for CH TRUW is due to the inclusion of the residues from the Rocky Flats Environmental Technology Site that have been declared as TRUW and are planned to be disposed of in the WIPP repository.

Similarly, for RH TRUW, there has been an increase in the amount of ²³⁸U and a corresponding decrease in ²³⁵U activities and mass based on the results of RH TRUW sludge sampling data from ORNL. The new sludge sampling data indicated that the majority of the activity in the RH TRUW sludges at ORNL was due to the presence of ²³⁸U instead of ²³⁵U, as was originally reported. The new

data corrected the previously high estimates of ^{235}U in the RH TRUW sludges at ORNL.

3.2.4.4 Buried TRUW volumes and radioactivities

Table 3.21 summarizes the buried TRUW volumes and associated radioactivity, both as-stored and as-decayed. Buried TRUW volumes and radioactivities shown in Table 3.21 are based on data provided in the site submittals. The form of the site-submitted data for buried waste is identical to that of the retrievably stored waste—except that no distinction is made between CH and RH buried wastes. Table 3.21 shows both cumulative as-stored and as-decayed radioactivities for all nuclides as well as for TRU nuclides only.

3.3 PROJECTED FUTURE QUANTITIES OF TRUW

Tables 3.1–3.16 show the data submitted by the sites for estimated future volumes of TRUW generation. Tables 3.1–3.7 give projections for as-generated waste forms, and Tables 3.8–3.16 give projections for final waste forms. The sites were not requested to estimate the radioactivities or isotopic compositions of these wastes because it was believed that there would be little basis for such estimates. The estimated volumes are given in terms of average annual rates (m^3/year) for three time periods from 1995 to 1997 and for three cumulative time periods thereafter (1998–2002, 2003–2012, and 2013–2022).

3.4 TRUW DISPOSAL

The goals of the DOE TRUW Program are to terminate interim storage and achieve permanent disposal of DOE TRUW.⁸ As stated in Pub. L. 96-164,⁹ WIPP was to be constructed "... as a defense activity of the DOE for the purpose of providing a research and development facility to demonstrate the safe disposal of radioactive waste resulting from defense activities and programs of the United States." Construction of the facility is essentially complete, and WIPP is now the only facility specifically designed for isolation of TRUW. It is designed to contain about $175,000 \text{ m}^3$ (6.2 million ft^3)¹⁰ of TRUW 655 m (2,150 ft) below ground in a mined salt formation.

Waste received at WIPP must meet the WIPP WAC and associated quality assurance requirements specified in the WIPP WAC.³ A number of other approvals remain to be completed before DOE can begin disposal operations at the facility. DOE is committed to demonstrating compliance with all applicable regulations before the permanent disposal of TRUW in the WIPP repository. These regulations are the environmental standards for management and disposal of TRU wastes, as mandated in 40 CFR Part 191 (ref. 11) and Part 194 (ref. 12), and the RCRA regulations. Compliance will be demonstrated through performance assessment calculations based on the inventory of existing and currently projected waste streams as reported by the DOE TRU waste sites in the TWBIR, Rev. 3.²

In 1992 the WIPP Legislative Land Withdrawal Act¹⁰ was passed, confirming congressional intent to have DOE continue with development and permitting of the facility. Since then, DOE has stated its intent to accelerate processes leading to the start of waste disposal operations at the WIPP.

3.5 REFERENCES

1. U.S. Department of Energy, *Radioactive Waste Management*, DOE Order 5820.2A, Washington, D.C. (Sept. 26, 1988).
2. U.S. Department of Energy, *Transuranic Waste Baseline Inventory Report (Revision 3)*, CAO-95-1121, Carlsbad, New Mexico (June 1996).
3. U.S. Department of Energy, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Rev. 5, Carlsbad, New Mexico (April 1996).
4. K. S. Hollingsworth, *Policy Statement Regarding Solid Waste Burial*, AEC Directive IAD No. 0511-21, Washington, D.C. (Mar. 20, 1970).
5. U.S. Department of Energy, *Integrated Data Base Report—1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 11, Oak Ridge National Laboratory, Oak Ridge, Tennessee (September 1995).

6. U.S. Department of Energy, *Defense Waste Management Plan for Buried Transuranic-Contaminated Waste, Transuranic-Contaminated Soil, and Difficult-to-Certify Transuranic Waste*, DOE/DP-0044, Washington, D.C. (June 1987).
7. A. G. Croff, "ORIGEN2: A Versatile Computer Code for Calculating the Nuclide Compositions and Characteristics of Nuclear Materials," *Nuclear Technology*, **62**, 335-352 (November 1983).
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11. U.S. Environmental Protection Agency, *Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes*, 40 CFR Part 191, final rule, *Fed. Regist.* **58**, 66398 (Dec. 20, 1993).
12. U.S. Environmental Protection Agency, *Criteria for Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with 40 CFR 191 Disposal Regulations*, Final Rule, 40 CFR Part 194, *Fed. Regist.*, (Feb. 9, 1996).

Fig. 3.1. U.S. Department of Energy transuranic waste generator/storage sites.

AS-GENERATED WASTE FORM

Table 3.1. Summary of as-generated waste-form volumes (m³) of retrievably stored and projected TRUW (mixed and nonmixed CH and RH wastes)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	2.48E+01	0.00E+00	4.20E+01	3.33E+00	1.79E+01	3.33E+01	3.33E+01	1.55E+02
Hanford	1.12E+04	5.22E+02	2.01E+02	1.79E+02	2.56E+03	1.66E+04	2.86E+04	6.00E+04
INEL	3.95E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.95E+04
LANL	1.10E+04	2.63E+02	2.63E+02	2.63E+02	1.32E+03	2.63E+03	2.64E+03	1.84E+04
LLNL	2.30E+02	2.66E+01	1.32E+01	1.51E+01	6.99E+01	1.42E+02	4.44E+02	9.41E+02
Mound	2.74E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.74E+02
NTS	6.16E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E+00	2.77E+00	6.21E+02
ORNL	3.16E+03	2.14E+01	2.14E+01	2.14E+01	1.07E+02	2.14E+02	2.14E+02	3.76E+03
RFETS	1.87E+03	1.08E+02	9.37E+01	3.46E+01	1.73E+02	1.42E+03	1.35E+03	5.05E+03
SRS	6.55E+03	4.27E+02	8.84E+02	6.05E+02	3.48E+03	2.09E+03	1.46E+03	1.55E+04
Subtotal	7.45E+04	1.37E+03	1.52E+03	1.12E+03	7.73E+03	2.32E+04	3.48E+04	1.44E+05
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E–01	0.00E+00	4.16E–01
ANL–W	2.51E+01	0.00E+00	0.00E+00	0.00E+00	8.33E+01	1.12E+02	9.16E+01	3.12E+02
ARCO	4.00E–02	2.40E–03	2.40E–03	2.40E–03	1.20E–02	2.40E–02	2.08E–02	1.04E–01
BAPL	0.00E+00	7.28E–01	2.67E+01	1.73E+01	7.62E+01	3.88E+00	0.00E+00	1.25E+02
BCL	5.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E+02
ETEC	7.35E+00	0.00E+00	4.20E–01	4.20E–01	0.00E+00	0.00E+00	0.00E+00	8.19E+00
KAPL	2.40E–01	2.00E–01	2.00E–01	2.00E–01	1.00E+00	2.00E+00	2.00E+00	5.84E+00
LBL	6.24E–01	0.00E+00	0.00E+00	0.00E+00	2.08E–01	4.16E–01	4.16E–01	1.66E+00
MURR	2.08E–01	2.08E–01	2.08E–01	2.08E–01	2.08E–01	0.00E+00	0.00E+00	1.04E+00
PAD	2.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E+00
PANT	6.24E–01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E–01
SNL/NM	6.66E+00	2.08E–01	1.87E+00	2.08E–01	1.04E+00	2.08E+00	2.08E+00	1.41E+01
TBE	2.08E–01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E–01
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	6.24E+02	1.35E+00	2.94E+01	1.84E+01	1.62E+02	1.21E+02	9.62E+01	1.05E+03

AS-GENERATED WASTE FORM

Table 3.1 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	5.22E+02	4.98E+01	5.34E+00	5.34E+00	7.48E+01	5.34E+01	5.34E+01	5.34E+01
Total (all sites)	7.56E+04	1.42E+03	1.55E+03	1.15E+03	7.97E+03	2.34E+04	3.49E+04	1.46E+05

AS-GENERATED WASTE FORM

Table 3.2. Summary of as-generated waste-form volumes (m³) of retrievably stored and projected mixed and nonmixed CH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	2.48E+01	0.00E+00	4.20E+01	3.33E+00	1.79E+01	3.33E+01	3.33E+01	1.55E+02
Hanford	1.10E+04	4.50E+02	1.97E+02	1.68E+02	2.28E+03	1.22E+04	1.19E+04	3.82E+04
INEL	3.93E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E+04
LANL	1.10E+04	2.62E+02	2.62E+02	2.62E+02	1.31E+03	2.62E+03	2.63E+03	1.83E+04
LLNL	2.30E+02	2.66E+01	1.32E+01	1.51E+01	6.99E+01	1.42E+02	4.44E+02	9.41E+02
Mound	2.74E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.74E+02
NTS	6.16E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E+00	2.77E+00	6.21E+02
ORNL	1.33E+03	9.15E+00	9.15E+00	9.15E+00	4.58E+01	9.15E+01	9.15E+01	1.58E+03
RFETS	1.87E+03	1.08E+02	9.37E+01	3.46E+01	1.73E+02	1.42E+03	1.35E+03	5.05E+03
SRS	6.55E+03	4.27E+02	8.84E+02	6.05E+02	3.48E+03	2.09E+03	1.46E+03	1.55E+04
Subtotal	7.21E+04	1.28E+03	1.50E+03	1.10E+03	7.38E+03	1.86E+04	1.79E+04	1.20E+05
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	4.16E-01
ANL–W	3.47E+00	0.00E+00	0.00E+00	0.00E+00	7.65E+01	9.98E+01	8.51E+01	2.65E+02
ARCO	4.00E-02	2.40E-03	2.40E-03	2.40E-03	1.20E-02	2.40E-02	2.08E-02	1.04E-01
BAPL	0.00E+00	4.16E-01	2.65E+01	1.70E+01	7.56E+01	3.78E+00	0.00E+00	1.23E+02
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	6.24E-01	0.00E+00	0.00E+00	0.00E+00	2.08E-01	4.16E-01	4.16E-01	1.66E+00
MURR	2.08E-01	2.08E-01	2.08E-01	2.08E-01	2.08E-01	0.00E+00	0.00E+00	1.04E+00
PAD	2.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	6.66E+00	2.08E-01	1.87E+00	2.08E-01	1.04E+00	2.08E+00	2.08E+00	1.41E+01
TBE	2.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.56E+01	8.34E-01	2.85E+01	1.74E+01	1.54E+02	1.07E+02	8.76E+01	4.10E+02

AS-GENERATED WASTE FORM

Table 3.2 (continued)

Site	End of CY 1994	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	3.79E+01	5.34E+00	5.34E+00	5.34E+00	2.67E+01	5.34E+01	5.34E+01	1.87E+02
Total (all sites)	7.22E+04	1.29E+03	1.54E+03	1.12E+03	7.56E+03	1.88E+04	1.81E+04	1.21E+05

AS-GENERATED WASTE FORM

Table 3.3. As-generated waste-form volumes (m³) of retrievably stored and projected mixed CH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	6.48E+00	0.00E+00	0.00E+00	0.00E+00	1.29E+00	0.00E+00	0.00E+00	7.77E+00
Hanford	2.77E+02	6.94E+01	6.88E+01	7.35E+01	3.95E+02	6.34E+03	7.17E+03	1.44E+04
INEL	3.02E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E+04
LANL	7.67E+03	1.35E+02	1.35E+02	1.35E+02	6.73E+02	1.35E+03	1.35E+03	1.14E+04
LLNL	8.35E+00	2.52E+00	6.24E–01	2.52E+00	6.92E+00	1.57E+01	2.14E+01	5.80E+01
Mound	3.54E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E+00
NTS	6.15E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E+00	2.77E+00	6.20E+02
ORNL	6.97E+02	9.15E+00	9.15E+00	9.15E+00	4.58E+01	9.15E+01	9.15E+01	9.53E+02
RFETS	9.49E+02	5.87E+01	4.91E+01	2.19E+01	1.14E+02	1.06E+03	1.01E+03	3.26E+03
SRS	3.14E+03	6.18E+01	1.20E+02	8.05E+01	4.59E+02	3.09E+02	2.01E+02	4.37E+03
Subtotal	4.35E+04	3.36E+02	3.82E+02	3.22E+02	1.69E+03	9.16E+03	9.84E+03	6.53E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E–01	0.00E+00	4.16E–01
ANL–W	1.18E+00	0.00E+00	0.00E+00	0.00E+00	2.04E+00	0.00E+00	0.00E+00	3.22E+00
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	2.08E–01	2.08E–01	2.08E–01	2.08E–01	2.08E–01	0.00E+00	0.00E+00	1.04E+00
PAD	2.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	3.49E+00	2.08E–01	2.08E–01	2.08E–01	2.25E+00	4.16E–01	0.00E+00	6.78E+00

AS-GENERATED WASTE FORM

Table 3.3 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site								
WVDP	1.42E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E+01
Total	4.36E+04	3.36E+02	3.83E+02	3.22E+02	1.70E+03	9.16E+03	9.84E+03	6.53E+04

AS-GENERATED WASTE FORM

Table 3.4. As-generated waste-form volumes (m³) of retrievably stored and projected nonmixed CH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	1.83E+01	0.00E+00	4.20E+01	3.33E+00	1.66E+01	3.33E+01	3.33E+01	1.47E+02
Hanford	1.08E+04	3.81E+02	1.28E+02	9.47E+01	1.89E+03	5.86E+03	4.75E+03	2.39E+04
INEL	9.08E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.08E+03
LANL	3.28E+03	1.28E+02	1.28E+02	1.28E+02	6.40E+02	1.28E+03	1.28E+03	6.86E+03
LLNL	2.22E+02	2.40E+01	1.26E+01	1.26E+01	6.30E+01	1.26E+02	4.23E+02	8.83E+02
Mound	2.70E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E+02
NTS	9.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.00E-01
ORNL	6.29E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E+02
RFETS	9.19E+02	4.95E+01	4.46E+01	1.27E+01	5.94E+01	3.61E+02	3.43E+02	1.79E+03
SRS	3.42E+03	3.65E+02	7.64E+02	5.24E+02	3.02E+03	1.79E+03	1.26E+03	1.11E+04
Subtotal	2.86E+04	9.47E+02	1.12E+03	7.76E+02	5.69E+03	9.45E+03	8.08E+03	5.46E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	2.29E+00	0.00E+00	0.00E+00	0.00E+00	7.45E+01	9.98E+01	8.51E+01	2.62E+02
ARCO	4.00E-02	2.40E-03	2.40E-03	2.40E-03	1.20E-02	2.40E-02	2.08E-02	1.04E-01
BAPL	0.00E+00	4.16E-01	2.65E+01	1.70E+01	7.56E+01	3.78E+00	0.00E+00	1.23E+02
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	6.24E-01	0.00E+00	0.00E+00	0.00E+00	2.08E-01	4.16E-01	4.16E-01	1.66E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	6.66E+00	2.08E-01	1.87E+00	2.08E-01	1.04E+00	2.08E+00	2.08E+00	1.41E+01
TBE	2.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.21E+01	6.26E-01	2.83E+01	1.72E+01	1.51E+02	1.06E+02	8.76E+01	4.03E+02

AS-GENERATED WASTE FORM

Table 3.4 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	2.38E+01	5.34E+00	5.34E+00	5.34E+00	2.67E+01	5.34E+01	5.34E+01	1.73E+02
Total (all sites)	2.86E+04	9.53E+02	1.15E+03	7.98E+02	5.86E+03	9.61E+03	8.22E+03	5.52E+04

AS-GENERATED WASTE FORM

Table 3.5. Summary of as-generated waste-form volumes (m³) of retrievably stored and projected mixed and nonmixed RH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	2.01E+02	7.17E+01	4.05E+00	1.12E+01	2.82E+02	4.44E+03	1.67E+04	2.17E+04
INEL	2.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+02
LANL	9.32E+01	8.90E–01	8.90E–01	8.90E–01	4.45E+00	8.90E+00	1.78E+01	1.27E+02
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	1.83E+03	1.23E+01	1.23E+01	1.23E+01	6.14E+01	1.23E+02	1.23E+02	2.18E+03
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	2.33E+03	8.49E+01	1.72E+01	2.43E+01	3.48E+02	4.57E+03	1.69E+04	2.42E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL–W	2.17E+01	0.00E+00	0.00E+00	0.00E+00	6.82E+00	1.24E+01	6.57E+00	4.74E+01
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	3.12E–01	2.08E–01	3.12E–01	6.24E–01	1.04E–01	0.00E+00	1.56E+00
BCL	5.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E+02
ETEC	5.67E+00	0.00E+00	4.20E–01	4.20E–01	0.00E+00	0.00E+00	0.00E+00	6.51E+00
KAPL	2.40E–01	2.00E–01	2.00E–01	2.00E–01	1.00E+00	2.00E+00	2.00E+00	5.84E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	6.08E+02	5.12E–01	8.28E–01	9.32E–01	8.44E+00	1.45E+01	8.57E+00	6.42E+02

AS-GENERATED WASTE FORM

Table 3.5 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	4.84E+02	4.45E+01	0.00E+00	0.00E+00	4.81E+01	0.00E+00	0.00E+00	5.76E+02
Total (all sites)	3.42E+03	1.30E+02	1.80E+01	2.53E+01	4.04E+02	4.58E+03	1.69E+04	2.54E+04

AS-GENERATED WASTE FORM

Table 3.6. As-generated waste-form volumes (m³) of retrievably stored and projected mixed RH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	2.06E+00	4.05E+00	4.05E+00	1.12E+01	2.82E+02	4.08E+03	1.09E+04	1.53E+04
INEL	1.52E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E+02
LANL	1.64E+01	8.90E-01	8.90E-01	8.90E-01	4.45E+00	8.90E+00	1.78E+01	5.02E+01
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	1.77E+03	1.23E+01	1.23E+01	1.23E+01	6.14E+01	1.23E+02	1.23E+02	2.12E+03
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.94E+03	1.72E+01	1.72E+01	2.43E+01	3.48E+02	4.21E+03	1.10E+04	1.76E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	1.54E+01	0.00E+00	0.00E+00	0.00E+00	5.82E+00	1.04E+01	4.77E+00	3.64E+01
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	5.67E+00	0.00E+00	4.20E-01	4.20E-01	0.00E+00	0.00E+00	0.00E+00	6.51E+00
KAPL	0.00E+00	4.00E-02	4.00E-02	4.00E-02	1.40E-01	2.00E-01	2.00E-01	6.60E-01
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	2.11E+01	4.00E-02	4.60E-01	4.60E-01	5.96E+00	1.06E+01	4.97E+00	4.36E+01

AS-GENERATED WASTE FORM

Table 3.6 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total (all sites)	1.96E+03	1.73E+01	1.77E+01	2.48E+01	3.54E+02	4.22E+03	1.10E+04	1.76E+04

AS-GENERATED WASTE FORM

Table 3.7. As-generated waste-form volumes (m³) of retrievably stored and projected nonmixed RH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	1.99E+02	6.76E+01	0.00E+00	0.00E+00	0.00E+00	3.56E+02	5.83E+03	6.45E+03
INEL	4.87E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.87E+01
LANL	7.68E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.68E+01
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	5.94E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E+01
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	3.84E+02	6.76E+01	0.00E+00	0.00E+00	0.00E+00	3.56E+02	5.83E+03	6.64E+03
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	6.21E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	2.00E+00	1.80E+00	1.10E+01
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	3.12E-01	2.08E-01	3.12E-01	6.24E-01	1.04E-01	0.00E+00	1.56E+00
BCL	5.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E+02
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	2.40E-01	1.60E-01	1.60E-01	1.60E-01	8.60E-01	1.80E+00	1.80E+00	5.18E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	5.87E+02	4.72E-01	3.68E-01	4.72E-01	2.48E+00	3.90E+00	3.60E+00	5.98E+02

AS-GENERATED WASTE FORM

Table 3.7 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	4.84E+02	4.45E+01	0.00E+00	0.00E+00	4.81E+01	0.00E+00	0.00E+00	5.76E+02
Total (all sites)	1.45E+03	1.13E+02	3.68E-01	4.72E-01	5.06E+01	3.60E+02	5.84E+03	7.81E+03

FINAL WASTE FORM

**Table 3.8. Summary of final waste-form volumes (m³) of retrievably stored and projected TRUW
(mixed and nonmixed CH and RH wastes)**

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	2.48E+01	0.00E+00	4.20E+01	3.33E+00	1.79E+01	3.33E+01	3.33E+01	1.55E+02
Hanford	1.26E+04	4.57E+02	1.19E+02	1.31E+02	2.32E+03	1.96E+04	3.23E+04	6.75E+04
INEL	2.88E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E+04
LANL	1.11E+04	2.63E+02	2.65E+02	2.65E+02	1.33E+03	2.66E+03	2.67E+03	1.86E+04
LLNL	2.30E+02	3.74E+01	2.40E+01	2.59E+01	1.24E+02	2.50E+02	2.50E+02	9.41E+02
Mound	3.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E+02
NTS	6.19E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.21E+00	2.77E+00	6.28E+02
ORNL	3.80E+03	1.65E+01	2.54E+01	2.54E+01	1.27E+02	2.54E+02	2.54E+02	4.50E+03
RFETS	7.08E+02	1.05E+02	8.96E+01	3.24E+01	1.61E+02	1.75E+03	1.77E+03	4.61E+03
SRS	2.88E+03	2.50E-01	2.50E-01	2.50E-01	1.25E+00	2.50E+00	6.76E+03	9.65E+03
Subtotal	6.11E+04	8.79E+02	5.66E+02	4.84E+02	4.08E+03	2.46E+04	4.41E+04	1.36E+05
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	4.16E-01
ANL-W	2.58E+01	0.00E+00	0.00E+00	0.00E+00	5.47E+02	7.91E+02	6.68E+02	2.03E+03
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	0.00E+00	4.16E-01
BAPL	0.00E+00	1.75E+00	2.73E+01	1.83E+01	7.83E+01	4.22E+00	0.00E+00	1.30E+02
BCL	5.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E+02
ETEC	7.98E+00	0.00E+00	4.16E-01	4.16E-01	0.00E+00	0.00E+00	0.00E+00	8.81E+00
KAPL	2.50E+00	2.08E+00	2.08E+00	2.08E+00	1.04E+01	2.08E+01	2.08E+01	6.07E+01
LBL	6.24E-01	0.00E+00	0.00E+00	0.00E+00	2.08E-01	4.16E-01	4.16E-01	1.66E+00
MURR	2.08E-01	2.08E-01	2.08E-01	2.08E-01	2.08E-01	0.00E+00	0.00E+00	1.04E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.78E+00	3.78E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	6.66E+00	2.08E-01	1.87E+00	2.08E-01	1.04E+00	2.08E+00	2.08E+00	1.41E+01
TBE	2.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01
USAMC	2.50E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E+00
Subtotal	6.28E+02	4.25E+00	3.19E+01	2.13E+01	6.37E+02	8.19E+02	6.95E+02	2.84E+03

FINAL WASTE FORM

Table 3.8 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	3.42E+02	1.78E+01	4.18E+00	4.18E+00	5.38E+01	4.18E+01	4.18E+01	5.06E+02
Total (all sites)	6.21E+04	9.01E+02	6.02E+02	5.09E+02	4.77E+03	2.54E+04	4.48E+04	1.39E+05

FINAL WASTE FORM

Table 3.9. Summary of final waste-form volumes (m³) of retrievably stored and projected mixed and nonmixed CH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	2.48E+01	0.00E+00	4.20E+01	3.33E+00	1.79E+01	3.33E+01	3.33E+01	1.55E+02
Hanford	1.24E+04	3.85E+02	1.15E+02	1.20E+02	2.04E+03	1.52E+04	1.56E+04	4.58E+04
INEL	2.86E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E+04
LANL	1.11E+04	2.62E+02	2.62E+02	2.62E+02	1.31E+03	2.62E+03	2.63E+03	1.84E+04
LLNL	2.30E+02	3.74E+01	2.40E+01	2.59E+01	1.24E+02	2.50E+02	2.50E+02	9.41E+02
Mound	3.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E+02
NTS	6.19E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.21E+00	2.77E+00	6.28E+02
ORNL	1.33E+03	9.15E+00	9.15E+00	9.15E+00	4.58E+01	9.15E+01	9.15E+01	1.58E+03
RFETS	7.08E+02	1.05E+02	8.96E+01	3.24E+01	1.61E+02	1.75E+03	1.77E+03	4.61E+03
SRS	2.88E+03	2.50E-01	2.50E-01	2.50E-01	1.25E+00	2.50E+00	6.76E+03	9.65E+03
Subtotal	5.81E+04	7.99E+02	5.42E+02	4.53E+02	3.70E+03	1.99E+04	2.71E+04	1.11E+05
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	4.16E-01
ANL–W	6.54E+00	0.00E+00	0.00E+00	0.00E+00	2.14E+02	2.85E+02	2.42E+02	7.47E+02
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	0.00E+00	4.16E-01
BAPL	0.00E+00	4.16E-01	2.65E+01	1.70E+01	7.56E+01	3.78E+00	0.00E+00	1.23E+02
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	6.24E-01	0.00E+00	0.00E+00	0.00E+00	2.08E-01	4.16E-01	4.16E-01	1.66E+00
MURR	2.08E-01	2.08E-01	2.08E-01	2.08E-01	2.08E-01	0.00E+00	0.00E+00	1.04E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.78E+00	3.78E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	6.66E+00	2.08E-01	1.87E+00	2.08E-01	1.04E+00	2.08E+00	2.08E+00	1.41E+01
TBE	2.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01
USAMC	2.50E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E+00
Subtotal	1.90E+01	8.32E-01	2.85E+01	1.74E+01	2.91E+02	2.91E+02	2.49E+02	8.97E+02

FINAL WASTE FORM

Table 3.9 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site								
WVDP	3.90E+01	4.59E+00	4.18E+00	4.18E+00	2.09E+01	4.18E+01	4.18E+01	1.56E+02
Total (all sites)	5.82E+04	8.04E+02	5.75E+02	4.75E+02	4.01E+03	2.03E+04	2.74E+04	1.12E+05

FINAL WASTE FORM

Table 3.10. Final waste-form volumes (m³) of retrievably stored and projected mixed CH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	6.48E+00	0.00E+00	0.00E+00	0.00E+00	1.29E+00	0.00E+00	0.00E+00	7.77E+00
Hanford	2.78E+02	2.60E+01	2.53E+01	3.18E+01	1.84E+02	6.19E+03	7.09E+03	1.38E+04
INEL	2.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E+04
LANL	7.71E+03	1.35E+02	1.35E+02	1.35E+02	6.73E+02	1.35E+03	1.35E+03	1.15E+04
LLNL	8.34E+00	2.72E+00	8.32E-01	2.72E+00	7.94E+00	1.78E+01	1.76E+01	5.79E+01
Mound	3.54E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E+00
NTS	6.13E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.21E+00	2.77E+00	6.22E+02
ORNL	6.99E+02	9.15E+00	9.15E+00	9.15E+00	4.58E+01	9.15E+01	9.15E+01	9.55E+02
RFETS	4.37E+02	6.41E+01	5.37E+01	2.37E+01	1.23E+02	1.32E+03	1.31E+03	3.34E+03
SRS	1.48E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.87E+03	4.35E+03
Subtotal	3.45E+04	2.37E+02	2.24E+02	2.02E+02	1.03E+03	8.98E+03	1.27E+04	5.79E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	4.16E-01
ANL-W	4.25E+00	0.00E+00	0.00E+00	0.00E+00	2.04E+00	0.00E+00	0.00E+00	6.29E+00
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	2.08E-01	2.08E-01	2.08E-01	2.08E-01	2.08E-01	0.00E+00	0.00E+00	1.04E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.78E+00	3.78E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	4.46E+00	2.08E-01	2.08E-01	2.08E-01	2.25E+00	4.16E-01	3.78E+00	1.15E+01

FINAL WASTE FORM

Table 3.10 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	1.39E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E+01
Total (all sites)	3.45E+04	2.37E+02	2.24E+02	2.02E+02	1.04E+03	8.98E+03	1.27E+04	5.79E+04

FINAL WASTE FORM

Table 3.11. Final waste-form volumes (m³) of retrievably stored and projected nonmixed CH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	1.83E+01	0.00E+00	4.20E+01	3.33E+00	1.66E+01	3.33E+01	3.33E+01	1.47E+02
Hanford	1.21E+04	3.59E+02	8.95E+01	8.78E+01	1.85E+03	8.97E+03	8.51E+03	3.20E+04
INEL	5.33E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E+03
LANL	3.34E+03	1.28E+02	1.28E+02	1.28E+02	6.40E+02	1.28E+03	1.28E+03	6.92E+03
LLNL	2.22E+02	3.46E+01	2.32E+01	2.32E+01	1.16E+02	2.32E+02	2.32E+02	8.83E+02
Mound	3.17E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.17E+02
NTS	5.67E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.67E+00
ORNL	6.29E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E+02
RFETS	2.71E+02	4.10E+01	3.60E+01	8.68E+00	3.77E+01	4.28E+02	4.55E+02	1.28E+03
SRS	1.40E+03	2.50E-01	2.50E-01	2.50E-01	1.25E+00	2.50E+00	3.89E+03	5.30E+03
Subtotal	2.36E+04	5.62E+02	3.19E+02	2.51E+02	2.66E+03	1.09E+04	1.44E+04	5.28E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	2.29E+00	0.00E+00	0.00E+00	0.00E+00	2.12E+02	2.85E+02	2.42E+02	7.41E+02
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-01	0.00E+00	0.00E+00	4.16E-01
BAPL	0.00E+00	4.16E-01	2.65E+01	1.70E+01	7.56E+01	3.78E+00	0.00E+00	1.23E+02
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	6.24E-01	0.00E+00	0.00E+00	0.00E+00	2.08E-01	4.16E-01	4.16E-01	1.66E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	6.66E+00	2.08E-01	1.87E+00	2.08E-01	1.04E+00	2.08E+00	2.08E+00	1.41E+01
TBE	2.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01
USAMC	2.50E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E+00
Subtotal	1.46E+01	6.24E-01	2.83E+01	1.72E+01	2.89E+02	2.91E+02	2.45E+02	8.86E+02

FINAL WASTE FORM

Table 3.11 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	2.50E+01	4.59E+00	4.18E+00	4.18E+00	2.09E+01	4.18E+01	4.18E+01	1.42E+02
Total (all sites)	2.37E+04	5.68E+02	3.51E+02	2.73E+02	2.97E+03	1.13E+04	1.47E+04	5.38E+04

FINAL WASTE FORM

Table 3.12. Summary of final waste-form volumes (m³) of retrievably stored and projected mixed and nonmixed RH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	2.02E+02	7.21E+01	4.45E+00	1.16E+01	2.84E+02	4.44E+03	1.67E+04	2.17E+04
INEL	2.21E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E+02
LANL	9.43E+01	8.90E–01	2.67E+00	2.67E+00	1.33E+01	3.38E+01	4.54E+01	1.93E+02
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	2.47E+03	7.39E+00	1.63E+01	1.63E+01	8.14E+01	1.63E+02	1.63E+02	2.92E+03
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	2.99E+03	8.04E+01	2.34E+01	3.05E+01	3.79E+02	4.64E+03	1.69E+04	2.51E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL–W	1.93E+01	0.00E+00	0.00E+00	0.00E+00	3.33E+02	5.06E+02	4.25E+02	1.28E+03
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	1.33E+00	8.90E–01	1.33E+00	2.67E+00	4.45E–01	0.00E+00	6.67E+00
BCL	5.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E+02
ETEC	6.30E+00	0.00E+00	4.16E–01	4.16E–01	0.00E+00	0.00E+00	0.00E+00	7.13E+00
KAPL	2.50E+00	2.08E+00	2.08E+00	2.08E+00	1.04E+01	2.08E+01	2.08E+01	6.07E+01
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	6.09E+02	3.42E+00	3.39E+00	3.83E+00	3.46E+02	5.28E+02	4.46E+02	1.94E+03

FINAL WASTE FORM

Table 3.12 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	3.03E+02	1.32E+01	0.00E+00	0.00E+00	3.29E+01	0.00E+00	0.00E+00	3.50E+02
Total (all sites)	3.90E+03	9.70E+01	2.68E+01	3.44E+01	7.58E+02	5.16E+03	1.74E+04	2.73E+04

FINAL WASTE FORM

Table 3.13. Final waste-form volumes (m³) of retrievably stored and projected mixed RH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998–2002	2003–2012	2013–2022	
Major sites								
ANL–E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	2.67E+00	4.45E+00	4.45E+00	1.16E+01	2.84E+02	4.08E+03	1.09E+04	1.53E+04
INEL	1.95E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.95E+02
LANL	1.69E+01	8.90E–01	8.90E–01	8.90E–01	4.45E+00	8.90E+00	1.78E+01	5.07E+01
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	2.38E+03	7.39E+00	1.63E+01	1.63E+01	8.14E+01	1.63E+02	1.63E+02	2.83E+03
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	2.60E+03	1.27E+01	2.16E+01	2.87E+01	3.70E+02	4.26E+03	1.11E+04	1.84E+04
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL–W	1.78E+00	0.00E+00	0.00E+00	0.00E+00	8.90E+00	1.69E+01	8.90E+00	3.65E+01
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	6.30E+00	0.00E+00	4.16E–01	4.16E–01	0.00E+00	0.00E+00	0.00E+00	7.13E+00
KAPL	0.00E+00	4.16E–01	4.16E–01	4.16E–01	1.46E+00	2.08E+00	2.08E+00	6.86E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	8.08E+00	4.16E–01	8.32E–01	8.32E–01	1.04E+01	1.90E+01	1.10E+01	5.05E+01

FINAL WASTE FORM

Table 3.13 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total (all sites)	2.61E+03	1.31E+01	2.25E+01	2.96E+01	3.80E+02	4.27E+03	1.11E+04	1.84E+04

FINAL WASTE FORM

Table 3.14. Final waste-form volumes (m³) of retrievably stored and projected nonmixed RH TRUW

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Major sites								
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	1.99E+02	6.76E+01	0.00E+00	0.00E+00	0.00E+00	3.56E+02	5.83E+03	6.46E+03
INEL	2.61E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+01
LANL	7.74E+01	0.00E+00	1.78E+00	1.78E+00	8.90E+00	2.49E+01	2.76E+01	1.42E+02
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	8.54E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.54E+01
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	3.88E+02	6.76E+01	1.78E+00	1.78E+00	8.90E+00	3.81E+02	5.86E+03	6.71E+03
Small-quantity sites								
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	1.75E+01	0.00E+00	0.00E+00	0.00E+00	3.24E+02	4.89E+02	4.17E+02	1.25E+03
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	1.33E+00	8.90E-01	1.33E+00	2.67E+00	4.45E-01	0.00E+00	6.67E+00
BCL	5.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E+02
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	2.50E+00	1.66E+00	1.66E+00	1.66E+00	8.94E+00	1.87E+01	1.87E+01	5.39E+01
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	6.01E+02	3.00E+00	2.55E+00	3.00E+00	3.36E+02	5.09E+02	4.35E+02	1.89E+03

FINAL WASTE FORM

Table 3.14 (continued)

Site	End of CY 1994 total	Annual increase			Cumulative increase			End of CY 2022 total
		1995	1996	1997	1998-2002	2003-2012	2013-2022	
Commercial site WVDP	3.03E+02	1.32E+01	0.00E+00	0.00E+00	3.29E+01	0.00E+00	0.00E+00	3.50E+02
Total (all sites)	1.29E+03	8.39E+01	4.33E+00	4.78E+00	3.77E+02	8.90E+02	6.29E+03	8.95E+03

FINAL WASTE FORM

Table 3.15. Estimated final-form volume (m³) composition of retrievably stored and projected TRUW for major sites^a

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
ANL-E ^a	Lead/cadmium metal waste ^b	1.07	1.29	2.36	0.00	0.00	0.00
	Solidified inorganics	5.20	0.00	5.20	0.00	0.00	0.00
	Solidified organics	0.21	0.00	0.21	0.00	0.00	0.00
	Uncategorized metal	4.99	128.54	133.53	0.00	0.00	0.00
	Subtotal	11.47	129.83	141.30	0.00	0.00	0.00
Hanford ^c	Combustible	455.73	1,247.26	1,702.99	0.00	0.00	0.00
	Heterogeneous	11,190.75	6,271.29	17,462.04	199.36	4,066.41	3,006.87
	Lead/cadmium metal waste	14.17	34.53	48.69	2.67	60.52	0.00
	Soils	119.48	5,961.70	6,081.17	0.00	0.00	0.00
	Solidified inorganics	12.94	7.07	20.02	0.00	0.00	0.00
	Solidified organics	7.36	9.36	16.72	0.00	0.00	0.00
	Uncategorized metal	444.86	19,635.15	20,080.01	0.00	17,400.39	17,400.39
	Subtotal	12,280.03	33,235.41	45,515.44	202.03	21,527.32	21,729.35
INEL	Combustible	3,304.94	0.00	3,304.94	21.36	0.00	21.36
	Filter	131.05	0.00	131.05	0.00	0.00	0.00
	Graphite	498.19	0.00	498.19	0.00	0.00	0.00
	Heterogeneous	10,608.50	0.00	10,608.50	49.84	0.00	49.84
	Inorganic nonmetal	3,028.24	0.00	3,028.24	46.28	0.00	46.28
	Lead/cadmium metal waste	14.37	0.00	14.37	3.56	0.00	3.56
	Salt waste	20.52	0.00	20.52	0.00	0.00	0.00
	Solidified inorganics	4,344.44	0.00	4,344.44	65.27	0.00	65.27
	Solidified organics	789.67	0.00	789.67	3.56	0.00	3.56
	Uncategorized metal	5,866.82	0.00	5,866.82	30.85	0.00	30.85
	Subtotal	28,606.72	0.00	28,606.72	220.72	0.00	220.72
LANL	Combustible	1,821.45	2,464.60	4,197.64	15.13	48.95	64.08
	Heterogeneous	16.02	29.12	45.14	11.57	0.00	11.57
	Lead/cadmium metal waste	1.89	0.00	1.89	0.00	0.00	0.00
	Soils	110.57	29.12	139.69	0.00	0.00	0.00
	Solidified inorganics	4,888.20	2,033.82	6,922.02	0.00	0.00	0.00
	Solidified organics	1.46	29.12	30.58	0.00	0.00	0.00
	Uncategorized metals	4,214.43	2,853.76	7,068.19	67.64	49.84	117.48
	Subtotal	11,054.01	7,351.14	18,405.15	94.34	98.79	193.13
LLNL	Filter	15.54	32.28	47.82	0.00	0.00	0.00
	Heterogeneous	198.85	663.78	862.63	0.00	0.00	0.00
	Salt waste	0.62	3.02	3.64	0.00	0.00	0.00
	Solidified inorganics	14.35	5.82	20.18	0.00	0.00	0.00
	Solidified organics	1.04	5.82	6.86	0.00	0.00	0.00
	Subtotal	230.40	710.73	941.13	0.00	0.00	0.00

FINAL WASTE FORM

Table 3.15 (continued)

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
Mound ^d	Combustible	7.07	0.00	7.07	0.00	0.00	0.00
	Filter	0.83	0.00	0.83	0.00	0.00	0.00
	Heterogeneous	0.62	0.00	0.62	0.00	0.00	0.00
	Soils	177.18	0.00	177.18	0.00	0.00	0.00
	Solidified inorganics	6.03	0.00	6.03	0.00	0.00	0.00
	Uncategorized metal	82.48	0.00	82.48	0.00	0.00	0.00
	Subtotal	274.22	0.00	272.22	0.00	0.00	0.00
NTS	Heterogeneous	613.26	8.98	622.24	0.00	0.00	0.00
	Solidified inorganics	5.67	0.00	5.67	0.00	0.00	0.00
	Subtotal	618.93	8.98	627.91	0.00	0.00	0.00
ORNL ^e	Heterogeneous	1,304.16	256.26	1,560.42	1,432.01	240.30	1,672.31
	Solidified inorganics	0.00	0.00	0.00	1,036.85	206.48	1,243.33
	Subtotal	1,304.16	256.26	1,560.42	2,468.86	446.78	2,915.64
RFETS ^f	Combustible	185.54	861.08	1,046.62	0.00	0.00	0.00
	Filter	72.09	477.51	549.60	0.00	0.00	0.00
	Graphite	13.73	47.57	61.30	0.00	0.00	0.00
	Heterogeneous	3.86	0.00	3.86	0.00	0.00	0.00
	Inorganic nonmetal	58.29	866.74	925.03	0.00	0.00	0.00
	Lead/cadmium metal waste	3.95	298.27	302.22	0.00	0.00	0.00
	Salt waste	0.00	325.92	325.92	0.00	0.00	0.00
	Solidified inorganics	165.36	1,257.64	1,423.01	0.00	0.00	0.00
	Solidified organics	109.82	31.11	140.93	0.00	0.00	0.00
	Uncategorized metal	93.31	236.12	329.43	0.00	0.00	0.00
	Subtotal	1,133.13	5,901.46	7,034.59	0.00	0.00	0.00
SRS	Heterogeneous	2,611.61	5,475.85	8,087.46	0.00	0.00	0.00
	Solidified inorganics	200.19	1,169.61	1,369.80	0.00	0.00	0.00
	Uncategorized metal	70.35	120.54	190.89	0.00	0.00	0.00
	Subtotal	2,882.14	6,766.01	9,648.15	0.00	0.00	0.00
Total (major sites)		57,968.04	52,860.31	110,828.35	2,985.95	22,072.89	25,058.84

^aThe totals for ANL-E do not include 13.31 m³ of "as-generated" stored CH-TRU waste because final waste-form volumes have not been estimated at this time.

^bLead/cadmium metal wastes include materials that contain either lead or cadmium or both.

^cThe totals for Hanford do not include 94.82 m³ of "as-generated" stored CH-TRU waste and 459.49 m³ of "as-generated" projected CH-TRU waste because final waste-form volumes have not been estimated at this time.

^dThe totals for Mound do not include 30.57 m³ of "as-generated" stored CH-TRU waste because final waste-form volumes have not been estimated at this time.

^eThe totals for ORNL do not include 23 m³ of "as-generated" stored CH-TRU waste and 0.03 m³ of "as-generated" stored RH-TRU waste because final waste-form volumes have not been estimated at this time.

^fThe totals for RFETS do not include 0.83 m³ of "as-generated" stored CH-TRU waste because final waste-form volumes have not been estimated at this time.

FINAL WASTE FORM

Table 3.16. Estimated final-form volume (m³) composition of retrievably stored and projected TRUW for small-quantity and commercial sites^{a,b}

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
Small-quantity sites (SQS)							
Ames	Solidified inorganics	0.00	0.42	0.42	0.00	0.00	0.00
ANL-W ^a	Combustible	0.00	101.64	101.64	0.00	0.00	0.00
	Heterogeneous	6.54	345.35	351.89	0.00	1,208.62	1,208.62
	Inorganic nonmetal	0.00	0.00	0.00	0.00	21.36	21.36
	Lead/cadmium metal waste ^b	0.00	0.00	0.00	0.00	6.23	6.23
	Solidified inorganics	0.00	0.00	0.00	1.78	28.48	30.26
	Uncategorized metal	0.00	293.76	293.76	17.51	0.00	17.51
	Subtotal	6.54	740.76	747.30	19.29	1,264.69	1,283.98
ARCO	Heterogeneous	0.04 ^c	0.42	0.46	0.00	0.00	0.00
BCL	Heterogeneous	0.00	0.00	0.00	580.50	0.00	580.50
BAPL	Heterogeneous	0.00	123.27	123.27	0.00	6.67	6.67
ETEC ^d	Heterogeneous	1.68	0.00	1.68	0.00	0.00	0.00
	Lead/cadmium metal waste	0.00	0.00	0.00	0.89	0.00	0.89
	Subtotal	1.68	0.00	1.68	0.89	0.00	0.89
KAPL	Heterogeneous	0.00	0.00	0.00	2.50	58.24	60.74
LBL	Heterogeneous	0.62	1.04	1.66	0.00	0.00	0.00
MURR	Heterogeneous	0.21	0.83	1.04	0.00	0.00	0.00
PAD	Inorganic nonmetal	0.00	1.89	1.89	0.00	0.00	0.00
PANT ^e	Heterogeneous	0.62	0.00	0.62	0.00	0.00	0.00
SNL/NM	Heterogeneous	6.66	7.49	14.14	0.00	0.00	0.00
TBE	Inorganic nonmetal	0.21	0.00	0.21	0.00	0.00	0.00
USAMC	Heterogeneous	2.50	0.00	2.50	0.00	0.00	0.00
SQS subtotal		19.08	876.12	895.20	603.18	1,329.60	1,932.78

FINAL WASTE FORM

Table 3.16 (continued)

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
Commercial site							
WVDP ^f	Filter	0.00	0.00	0.00	48.95	46.15	95.10
	Heterogeneous	19.36	117.40	136.76	17.80	0.00	17.80
	Lead/cadmium metal waste	2.08	0.00	2.08	0.00	0.00	0.00
	Solidified inorganics	6.69	0.00	6.69	0.00	0.00	0.00
	Uncategorized metal	0.42	0.00	0.42	236.74	0.00	236.74
	Commercial site subtotal	28.55	117.40	145.95	303.49	46.15	349.64
	Total	47.63	993.52	1,041.15	906.67	1,375.75	2,282.42

^aThe totals for ANL-W do not include 14.76 m³ of "as-generated" stored RH-TRU waste because the final waste-form volumes have not been estimated at this time.

^bLead/cadmium metal wastes include materials that contain either lead or cadmium or both.

^cThe stored CH-TRU waste volume reported in this table is in "as-generated" form because final waste-form volumes have not been estimated at this time.

^dThe totals for ETEC do not include 5.46 m³ of "as-generated" stored RH-TRU waste and 0.84 m³ of "as-generated" projected RH-TRU waste because the final waste-form is unknown at this time.

^eThe totals for PANT do not include 0.90 m³ of "as-generated" stored CH-TRU waste and 3.78 m³ of "final form" projected CH-TRU waste because the final waste-form is unknown at this time.

^fThe totals for WVDP do not include 10.50 m³ of "as-generated" stored CH-TRU waste because the final waste-form volumes have not been estimated at this time.

Table 3.17. Summary of decayed radioactivity (Ci) isotopic content of retrievably stored CH TRUW^a

Site	²⁴¹ Pu	²³⁸ Pu	²³⁹ Pu	²⁴¹ Am	²⁴⁰ Pu	Total curies	Curies (%)
<i>Major sites</i>							
ANL-E	5.98E+01	2.14E+00	3.28E+01	5.73E+00	9.42E+00	1.10E+02	0.00
Hanford	3.78E+04	8.05E+04	2.63E+04	4.73E+03	6.15E+03	1.55E+05	6.19
INEL	1.50E+05	5.98E+04	4.01E+04	9.01E+04	9.82E+03	3.50E+05	13.93
LANL	1.62E+03	1.15E+05	7.69E+04	9.11E+03	1.00E+02	2.02E+05	8.06
LLNL	1.63E+03	7.65E+01	1.58E+02	1.44E+02	6.44E+01	2.07E+03	0.08
Mound	0.00E+00	1.53E+03	2.98E+01	0.00E+00	0.00E+00	1.56E+03	0.06
NTS	2.40E+02	1.95E+02	2.76E+03	2.84E+02	1.88E+01	3.50E+03	0.14
ORNL	4.79E+04	3.50E+03	1.01E+03	1.61E+03	9.48E+02	5.50E+04	2.19
RFETS	7.74E+05	8.43E+03	1.94E+05	1.30E+05	4.94E+04	1.16E+06	46.06
SRS	6.20E+04	4.87E+05	9.29E+03	3.70E+03	2.29E+03	5.64E+05	22.48
Subtotal	1.07E+06	7.55E+05	3.51E+05	2.40E+05	6.88E+04	2.49E+06	99.21
<i>Small-quantity sites (SQS)</i>							
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ANL-W	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ARCO	0.00E+00	3.70E+02	0.00E+00	0.00E+00	0.00E+00	3.70E+02	0.01
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ETEC	6.22E+00	1.11E-01	1.79E+00	5.19E-01	6.12E-01	9.25E+00	0.00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
LBL	4.48E-07	2.32E-04	8.45E-06	9.17E-02	5.14E-03	9.71E-02	0.00
MURR	6.32E-03	0.00E+00	2.46E-02	3.24E-01	0.00E+00	3.55E-01	0.00
PAD	0.00E+00	0.00E+00	5.57E+01	0.00E+00	0.00E+00	5.57E+01	0.00
PANT	0.00E+00	0.00E+00	5.55E-02	0.00E+00	0.00E+00	5.55E-02	0.00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
USAMC	0.00E+00	0.00E+00	1.80E+01	0.00E+00	0.00E+00	1.80E+01	0.00
Subtotal	6.22E+00	3.70E+02	7.56E+01	9.34E-01	6.17E-01	4.54E+02	0.02

Table 3.17 (continued)

Site	²⁴¹ Pu	²³⁸ Pu	²³⁹ Pu	²⁴¹ Am	²⁴⁰ Pu	Total curies	Curies (%)
<i>Commercial site</i>							
WVDP	3.43E+01	0.00E+00	0.00E+00	2.15E+00	0.00E+00	3.65E+01	0.00
Total (all sites)	1.07E+06	7.56E+05	3.51E+05	2.40E+05	6.88E+04	2.49E+06	99.23
Total curies, %	42.83	30.12	13.99	9.55	2.74		
Cumulative, %	42.83	72.96	86.94	96.49	99.23		

^aDecayed to the end of CY 1995.

Table 3.18. Summary of decayed mass (g) isotopic content of retrievably stored CH TRUW^a

Site	²³⁸ U	²³⁹ Pu	²³² Th	²³⁵ U	²⁴⁰ Pu	Total grams	Grams (%)
<i>Major sites</i>							
ANL-E	0.00E+00	5.29E+02	0.00E+00	0.00E+00	4.15E+01	5.70E+02	0.00
Hanford	1.74E+07	4.24E+05	6.12E+05	7.91E+05	2.71E+04	1.93E+07	65.49
INEL	3.44E+05	6.47E+05	3.01E+06	2.86E+04	4.33E+04	4.07E+06	13.84
LANL	7.03E+04	1.24E+06	2.09E+04	2.44E+05	4.42E+02	1.57E+06	5.35
LLNL	9.00E+04	2.55E+03	8.54E-09	2.74E+02	2.84E+02	9.31E+04	0.32
Mound	0.00E+00	4.81E+02	0.00E+00	1.24E-01	0.00E+00	4.81E+02	0.00
NTS	4.88E+02	4.45E+04	7.46E-09	2.84E+01	8.27E+01	4.51E+04	0.15
ORNL	1.27E+05	1.62E+04	7.82E+03	3.77E+03	4.18E+03	1.59E+05	0.54
RFETS	2.11E-02	3.13E+06	2.41E-05	7.43E+02	2.18E+05	3.35E+06	11.39
SRS	1.70E+04	1.50E+05	1.94E+05	2.70E+03	1.01E+04	3.74E+05	1.27
Subtotal	1.81E+07	5.66E+06	3.85E+06	1.07E+06	3.03E+05	2.89E+07	98.34
<i>Small-quantity sites (SQS)</i>							
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ANL-W	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ETEC	1.39E-07	2.89E+01	1.47E-10	4.89E-03	2.70E+00	3.16E+01	0.00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
LBL	5.48E-05	1.36E-04	4.86E-12	1.54E-08	2.26E-02	2.28E-02	0.00
MURR	3.46E-01	3.97E-01	0.00E+00	2.06E-05	0.00E+00	7.43E-01	0.00
PAD	0.00E+00	8.98E+02	0.00E+00	1.52E-01	0.00E+00	8.98E+02	0.00
PANT	0.00E+00	8.95E-01	0.00E+00	5.06E-05	0.00E+00	8.95E-01	0.00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
USAMC	0.00E+00	2.90E+02	0.00E+00	8.21E-03	0.00E+00	2.90E+02	0.00
Subtotal	3.46E-01	1.22E+03	1.52E-10	1.66E-01	2.72E+00	1.22E+03	0.00

Table 3.18 (continued)

Site	²³⁸ U	²³⁹ Pu	²³² Th	²³⁵ U	²⁴⁰ Pu	Total grams	Grams (%)
<i>Commercial site</i>							
WVDP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
Total (all sites)	1.81E+07	5.66E+06	3.85E+06	1.07E+06	3.03E+05	2.89E+07	98.35
Total grams, %	61.39	19.22	13.07	3.64	1.03		
Cumulative, %	61.39	80.62	93.68	97.32	98.35		

^aDecayed to the end of CY 1995.

Table 3.19. Summary of decayed radioactivity (Ci) isotopic content of retrievably stored RH TRUW^a

Site	⁹⁰ Sr	⁹⁰ Y	¹³⁷ Cs	^{137m} Ba	²⁴¹ Pu	¹⁵² Eu	¹⁵⁴ Eu	²⁴⁴ Cm	⁶⁰ Co	Total curies	Curies (%)
<i>Major sites</i>											
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
Hanford	6.46E+03	6.46E+03	6.98E+03	6.61E+03	4.67E+03	0.00E+00	0.00E+00	0.00E+00	3.36E+02	3.15E+04	22.68
INEL	1.70E+03	1.70E+03	1.90E+03	1.80E+03	4.82E+01	1.14E-01	7.92E-01	9.63E-02	1.31E+01	7.15E+03	5.14
LANL	1.24E+02	1.24E+02	1.35E+02	1.28E+02	0.00E+00	5.09E-04	3.50E-02	0.00E+00	4.17E+00	5.16E+02	0.37
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.60E-05	0.00E+00	0.00E+00	1.55E+02	0.00E+00	1.55E+02	0.11
ORNL	3.53E+04	3.53E+04	9.78E+03	9.25E+03	3.98E-07	3.66E+03	1.77E+03	9.44E+02	6.17E+02	9.65E+04	69.47
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
SRS	6.85E+00	6.85E+00	6.86E+00	6.49E+00	0.00E+00	0.00E+00	0.00E+00	4.68E+00	0.00E+00	3.17E+01	0.02
Subtotal	4.35E+04	4.36E+04	1.88E+04	1.78E+04	4.71E+03	3.66E+03	1.77E+03	1.10E+03	9.71E+02	1.36E+05	97.79
<i>Small-quantity sites (SQS)</i>											
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ANL-W	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
ETEC	2.62E+00	2.62E+00	2.62E+00	2.48E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+00	1.26E+01	0.01
KAPL	5.70E+01	5.70E+01	5.71E+01	5.40E+01	7.77E-01	0.00E+00	1.40E+00	0.00E+00	2.75E-01	2.28E+02	0.16
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00
Subtotal	5.96E+01	5.96E+01	5.97E+01	5.65E+01	7.77E-01	0.00E+00	1.40E+00	0.00E+00	2.58E+00	2.41E+02	0.17

Table 3.19 (continued)

Site	⁹⁰ Sr	⁹⁰ Y	¹³⁷ Cs	^{137m} Ba	²⁴¹ Pu	¹⁵² Eu	¹⁵⁴ Eu	²⁴⁴ Cm	⁶⁰ Co	Total curies	Curies (%)
<i>Commercial site</i>											
WVDP	1.96E+01	1.96E+01	5.35E+01	5.06E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E+02	0.10
Total (all sites)	4.36E+04	4.36E+04	1.89E+04	1.79E+04	4.71E+03	3.66E+03	1.77E+03	1.10E+03	9.73E+02	1.36E+05	98.07
Total curies, %	31.39	31.40	13.61	12.87	3.39	2.64	1.28	0.79	0.70	98.07	
Cumulative, %	31.39	62.79	76.40	89.27	92.66	95.30	96.57	97.37	98.07		

^aDecayed to the end of CY 1995.

Table 3.20. Summary of decayed mass (g) isotopic content of retrievably stored RH TRU^a

Site	²³⁸ U	Grams (%)
<i>Major sites</i>		
ANL-E	0.00E+00	0.00
Hanford	3.05E+04	0.03
INEL	4.11E+03	0.00
LANL	5.95E+01	0.00
LLNL	0.00E+00	0.00
Mound	0.00E+00	0.00
NTS	7.57E-12	0.00
ORNL	9.07E+07	98.52
RFETS	0.00E+00	0.00
SRS	0.00E+00	0.00
Subtotal	9.07E+07	98.56
<i>Small-quantity sites (SQS)</i>		
Ames	0.00E+00	0.00
ANL-W	0.00E+00	0.00
ARCO	0.00E+00	0.00
BCL	0.00E+00	0.00
BAPL	0.00E+00	0.00
ETEC	0.00E+00	0.00
KAPL	1.02E-08	0.00
LBL	0.00E+00	0.00
MURR	0.00E+00	0.00
PAD	0.00E+00	0.00
PANT	0.00E+00	0.00
SNL/NM	0.00E+00	0.00
TBE	0.00E+00	0.00
USAMC	0.00E+00	0.00
Subtotal	1.02E-08	0.00
<i>Commercial site</i>		
WVDP	0.00E+00	0.00
Total (all sites)	9.07E+07	98.56
Total grams, %	98.56	
Cumulative, %	9.86E-01	

^aDecayed to the end of CY 1995.

Table 3.21. Summary of buried TRUW volume and radioactivity
as of December 31, 1994^a

Site	Cumulative volume (m ³)	Cumulative as-stored radioactivity		Decayed radioactivity	
		All nuclides (10 ³ Ci)	TRU only (10 ³ Ci)	All nuclides (10 ³ Ci)	TRU only (10 ³ Ci)
Major sites					
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	6.36E+04	6.02E+02	1.14E+02	1.73E+02	9.38E+01
INEL	5.70E+04	2.49E+02	b	b	b
LANL	1.40E+04	c	d	c	c
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	1.76E+02	2.40E-01	1.00E-01	5.43E+02	2.00E-01
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	4.87E+03	3.37E+01	3.37E+01	3.05E+01	3.05E+01
Subtotal	1.40E+05	8.84E+02	1.48E+02	7.47E+02	1.25E+02
Small-quantity sites (SQS)					
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ARCO	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	1.33E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TBE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
USAMC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.33E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Commercial site					
WVDP	1.35E+03	6.52E+02	6.52E+02	0.00E+00	0.00E+00
Total	1.41E+05	1.54E+03	8.00E+02	7.47E+02	1.25E+02

^aAny small differences in volumes reported in this table and in TWBIR, Rev. 3 and in the numerical totals shown result from rounding.

^bINEL data did not include any isotopic compositions, so no TRU isotope or decay calculations could be made.

^cInformation not available.

^dAn estimate of 9230 Ci was reported for LANL as-stored TRU alpha radioactivity (as of the end of CY 1991) in *Integrated Data Base for 1992: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 8 (October 1992).

4. LOW-LEVEL WASTE

4.1 INTRODUCTION

As used in this chapter, LLW has the same meaning as in The Low-Level Waste Policy Act (Pub. L. 95-573, Dec. 22, 1980). Namely, LLW is radioactive waste not classified as high-level radioactive waste, transuranic waste (TRUW), spent nuclear fuel (SNF), or by-product material specified as uranium or thorium tailings and waste. Tailings (viz., mill tailings) are considered in Chapters 5 and 6. Another waste classification not delineated in this chapter is "mixed" low-level waste (MLLW), which contains both chemically hazardous and radioactive constituents (see Chapter 8). Specific definitions of these waste types (as defined by DOE Order 5820.2A) are given in the glossary of this report. DOE generates LLW through its defense activities, naval nuclear propulsion program, and various R&D activities. The data for DOE sites represent a summary of information obtained from each site.¹

Disposal of LLW at commercial sites accounted for about 21 vol % of the LLW disposed during 1995. In this chapter, commercial sites exclude the Envirocare site which is treated separately because it has not only commercial and DOE wastes, but also wastes from activities sponsored by other (non-DOE) federal agencies. Commercially disposed LLW is generally divided into five categories: academic, government, industrial, medical, and utility.² The academic category includes university hospitals and university medical and nonmedical research facilities. The government category includes state and non-DOE federal agencies. The industrial category is comprised of private entities such as R&D companies, manufacturers, nondestructive-testing operations, mining works, fuel fabrication facilities, and radiopharmaceutical manufacturers. The medical category includes hospitals and clinics, research facilities, and private medical offices. The utility category includes commercial nuclear reactors. In earlier revisions of the IDB report, commercially disposed waste was reported by fuel cycle and industrial/institutional (I/I) type activities. However, to achieve more consistency with other reporting agencies, the five categories previously described were used, starting with Rev. 9 of the IDB report.

Some LLW is also disposed of at the Envirocare facility located in Clive, Utah. Envirocare is a commercially operated facility that disposes of LLW, MLLW, NARM/NORM, and 11e(2) by-product material for both federal and private customers (see Table 0.8). The volume of LLW disposed of at Envirocare is presented in Table 4.1. Radioactivity data were not available. Envirocare accounted for about 27 vol % of the LLW disposed during 1995.

Some LLW is also generated by DOE environmental restoration programs (see Chapter 6). Other LLW will be generated in future years by nonroutine D&D operations. Waste from past commercial D&D operations is included in the disposed commercial waste inventories reported in this chapter.

The categorization of LLW according to DOE and commercial activities permits a comparison of the radioactivity levels and volumes of waste arising from each of these major sources (Figs. 4.1 and 4.2). Envirocare is not included in the comparisons presented in Fig. 4.1 since radioactivity data were not available. Summary data on LLW disposal are given in Table 4.1. Historical and projected data by year for DOE LLW disposal are presented in Table 4.2. In Table 4.3, similar data are shown for commercial LLW disposal.

4.2 DOE LLW

4.2.1 Inventories of LLW at DOE Sites

An abridged picture of DOE LLW inventories, projections, and characteristics through 1995 is given in Figs. 4.1-4.4, as well as Tables 4.1, 4.2, and 4.4-4.18. The data in these tables are derived from responses to questionnaires submitted to DOE sites.¹ As reflected in the tables, DOE LLW data can be grouped into three major areas: generation, storage, and disposal.

Summaries of DOE site-generated LLW volumes and associated radioactivity are presented in Tables 4.6, 4.9, and 4.10.

Tables 4.7, 4.11, and 4.12 provide summary volume and radioactivity data concerning LLW storage at DOE sites.

A summary of DOE LLW disposed volume and radioactivity is presented in Tables 4.1, 4.2, 4.4, 4.8, 4.13, 4.14, and 4.17. Before October 1979, some LLW generated by DOE contractors was shipped to commercial disposal sites. The volume and radioactivity data for DOE LLW that were shipped to commercial disposal sites are contained in the commercial LLW tables in this chapter. Currently, LLW generated by DOE activities is generally disposed of at DOE sites (see Figs. 4.3 and 4.4). It should be noted that the DOE Environmental Restoration Program (discussed in Chapter 6) is currently using, and will likely expand its use of, commercial LLW disposal facilities.

Small quantities of DOE LLW have been disposed of by dumping the LLW into the sea or by hydrofracture.³ Table 4.15 shows the estimated quantity and radioactivity of LLW disposed of by these methods. Dumping of LLW into the sea was halted by the United States in 1970, and hydrofracture was terminated in 1983.

4.2.2 Characterization of LLW at DOE Sites

Based on information reported in ref. 1, summaries of physical characteristics of DOE LLW are reported in Tables 4.6–4.14. Table 4.5 provides definitions of each of the physical forms used in the tables. For DOE site activities sponsored by the Office of Waste Management (EM-30), this set of physical forms provides a detailed description of the LLW that has been generated, stored, or disposed. However, the DOE Environmental Restoration Program (EM-40) has large volumes of LLW currently in storage (such as unsolidified sludges and resins) which, except for the “other” category, do not fit into the categories described in Table 4.5. Actual 1995 and projected generation, storage, and disposal volume and radioactivity data are presented in Tables 4.6–4.8, respectively. A more detailed breakdown of this data, by DOE site, is provided in Tables 4.9–4.14.

In addition to shallow-land burial, DOE LLW has been disposed by dumping wastes into the sea and hydrofracture (Table 4.15). Most of the DOE wastes that were dumped into the sea were incorporated into cement matrix material and packaged in steel drums (55- or 80-gal capacity). Hydrofracture was developed at ORNL for the permanent disposal of locally generated, low-level (approximately 0.25 Ci/L) liquid waste concentrates.⁴ Waste was mixed with a blend of cement and other additives, and the resulting grout was injected into shale at a depth of 200 to 300 m. The injected grout hardened into thin, horizontal sheets several hundred meters wide.

Significant changes in DOE LLW inventory and characteristics data from that reported in Rev. 11 of this report are summarized in Table 4.16.

4.2.3 DOE LLW Projections

Low-level waste generation, storage, and disposal projections reported by DOE sites are presented in Tables 4.6–4.8, respectively. Projections are provided for three time periods: 1996, 1997–2001, and 2002–2030. The data presented in Tables 4.6–4.8 represent the average annual generation, addition to storage, or disposal, respectively, during each of the three periods.

The projected disposal data (Table 4.8), combined with actual 1995 (Tables 4.8, 4.13, and 4.14) and historical (ref. 5) disposal data, were used to calculate historical and projected volume, radioactivity, and thermal power of DOE disposed LLW. LLW data were collected by a different breakdown in previous revisions of the IDB report (Revs. 1–10). Historical disposal data through 1993 were decayed from the year of addition through 2030 using the representative radionuclide compositions given in Table A.2 of Appendix A.⁶ Beginning with 1994, disposal data were decayed from the year of addition through 2030 using radionuclide compositions provided by each disposal site in the data call for Rev. 11 of this report.

Projected volume, radioactivity, and thermal power for disposed DOE LLW are presented in Tables 4.2, 4.17, and 4.18. Table 4.17 summarizes disposed DOE LLW excluding SRS saltstone. Table 4.18 summarizes projections of saltstone, an LLW by-product from the solidification of HLW at SRS. This saltstone (see Fig. 2.7 in Chapter 2) is to be stored in concrete vaults at SRS. Table 4.2 is the summation of Tables 4.17 and 4.18. Grout-immobilized LLW derived from processing double-shell waste at Hanford (see Fig. 2.5 in Chapter 2) is excluded from the projections in Table 4.2 because the schedule and formulation for immobilization are not yet firmly defined.

4.3 COMMERCIAL LLW

4.3.1 Inventories at Commercial LLW Disposal Sites

There are six commercial shallow-land disposal sites for LLW (Figs. 4.2, 4.5, and 4.6), but only two are currently in operation: Barnwell, South Carolina; and Richland, Washington. Commercial operations at the Maxey Flats, Kentucky; West Valley, New York; Sheffield, Illinois; and Beatty, Nevada, sites have been

halted. Until 1986, a second NRC-licensed burial ground at West Valley continued to receive wastes generated on-site from cleanup and water treatment operations. However, disposal operations at the WVDP have been suspended since 1986 pending the preparation of an environmental impact statement (EIS) report for the West Valley site closure. The historical data for annual additions and inventories of volume and radioactivity (undecayed) at each commercial disposal site through the end of 1995 are listed in Tables 4.19 and 4.20, respectively (compiled from refs. 5 and 7). The volumes are depicted in Figs. 4.2, 4.5, and 4.6. Sources of the historical reported data through 1984 are given in ref. 3, and those through 1994 are given in ref. 5. Quantities of LLW shipped to disposal sites during 1995 are listed in Table 4.21 on a state-by-state basis.⁷ Table 4.3 is a summary of historical and projected volumes, radioactivity (decayed), and thermal power for commercial LLW. Projections are made only through 2005 because of large uncertainties in commercial disposal facility operations. Not included in Table 4.3 are the drums of cemented LLW to be generated by the WVDP as a result of the vitrification of HLW. This LLW from the WVDP is described in Table A.5 of Appendix A. Table 4.3 also does not include 25,041 m³ (11,698 m³ from DOE generators, 12,860 m³ from commercial generators, and 483 m³ from other federal agency generators) of LLW disposed of at the Envirocare disposal facility near Clive, Utah. Additional information on Envirocare disposals can be found in Table 0.8 of Chapter 0.

4.3.2 Characterization of LLW at Commercial Disposal Sites

All of the LLW accepted for commercial disposal is categorized as Class A, B, or C in compliance with NRC specifications.⁸ The LLW that exceeds these specifications is currently in storage at the generator site or at a DOE site which has accepted it for study (see Sect. 4.3.3). A calculated representative radionuclide composition for disposed commercial LLW is given in Table A.3 of Appendix A. This composition is periodically updated to reflect changes in waste management practices and in the regulations governing LLW disposal.

4.3.3 Greater-Than-Class-C Low-Level Waste (GTCC LLW)

In 1980, federal law made each state responsible for providing the disposal capacity for LLW generated within its borders, except for certain waste generated by the federal government.⁹ In 10 CFR Part 61 (ref. 8), the NRC codifies disposal requirements for three classes of LLW, as

mentioned above, generally suitable for near-surface disposal, namely, Class A, B, and C (with Class C waste requiring the most rigorous disposal specifications). Waste with concentrations above Class C limits for certain short- and long-lived radionuclides (i.e., GTCC LLW) was found not generally suitable for near-surface disposal, except on a case-by-case evaluation of the waste and the proposed disposal method by NRC or state licensing agency. The Low-Level Radioactive Waste Policy Amendments Act (LLRWPA)¹⁰ made the states responsible for the disposal of Classes A, B, and C LLW and made the federal government (viz., DOE) responsible for disposal of GTCC LLW. The law also required that GTCC LLW generated by licensees of NRC be disposed of in a facility licensed by NRC. The projected amounts of GTCC LLW are uncertain, both because of regulatory uncertainties affecting the definition of HLW (i.e., a clearly defined all-inclusive list of wastes considered HLW may include more than those described in Chapter 2) and because of limited information on the sources, volumes, and characteristics of GTCC LLW.¹¹

In May 1989, NRC promulgated a rule that requires disposal of GTCC LLW in a deep geologic repository unless disposal elsewhere has been approved by NRC. The rule as amended states: "Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different and, in general, more stringent than those specified for Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in Part 60 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the Commission."¹² A disposal facility (other than a deep geologic repository) for GTCC LLW will probably not be available for several decades because of the complexities of siting and of NRC licensing. A generic description of estimated sources and forms of GTCC LLW is presented in Table A.4 of Appendix A.

DOE recently revised an earlier study to provide information about estimates of current and future GTCC LLW to the year 2035 (2055 in some instances). Information garnered during the study¹³ includes identification of generators, waste form characteristics, volumes, and radionuclide activities. The study categorizes GTCC LLW as (1) nuclear utilities waste, (2) sealed-sources waste, (3) DOE-held potential GTCC LLW, and (4) other generator waste. Various scenarios for data projection were used: (a) unpackaged volumes; (b) packaged volumes based on the application of packaging factors to the unpackaged volumes; and (c) concentration averaging, mixing, or blending of similar materials with different radionuclide concentration values

applied to the packaged volumes. Each of the three scenarios is treated for three cases: low, base, and high.

Based on base-case projections of after-concentration-averaged-packaged waste to the year 2035, the study determined that the largest volume of GTCC wastes (approximately 53%) is generated by nuclear power plants. The "other" generator waste category contributes approximately 31% of the total GTCC LLW volume projected to the year 2035. Sealed sources are about 16% of the total projected volume of GTCC LLW. A summary of historical and projected cumulative volume and radioactivity for GTCC LLW is presented in Table 4.22.

4.3.4 Commercial LLW Disposal Sites

Of the six commercial LLW disposal sites, only two remain open: Barnwell and Richland. Historical information regarding commercial LLW facilities can be found in previous editions of the IDB report. Closure dates for the four closed facilities are presented in the footnotes of Tables 4.19 and 4.20.

The Barnwell, South Carolina, disposal site is operated by Chem-Nuclear Systems, Inc. During 1995, Barnwell received about 70% of the total volume of commercial LLW shipped for disposal. Barnwell was scheduled to restrict access to Southeast compact members starting July 1, 1995; however, Barnwell withdrew from the Southeast compact. As a result, Barnwell is open for disposal to all states with the exception of North Carolina.

The Richland, Washington, disposal site is operated by U.S. Ecology, Inc. During 1995, Richland received about 30% of the total volume of commercial LLW shipped for disposal. Richland accepted wastes only from member states of the Northwest and Rocky Mountain compacts (Alaska, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Washington, and Wyoming).

Table 4.23 provides a breakdown of waste received at Barnwell and Richland in 1995 by category (i.e., academic, government, industrial, medical, or utility LLW).

4.3.5 Commercial LLW Projections

This report presents summary information for disposed commercial waste. Historical volume, radioactivity, and thermal power data through 1979 are taken from an earlier version of this report (DOE/RW-0006, Rev. 8). After 1979, the source term for commercial LLW in Table A.4 of Appendix A is used to decay the annual waste additions to the commercial sites.

Projections for disposed commercial LLW are made only through 2005 because of uncertainties in current facility operations and the availability of future sites. Neither Barnwell nor Richland have a published closure date.⁷ As a result, for projections, the disposal rates for 1996–2005 are assumed to be the same as the rates reported for 1995. Historical and projected volume, radioactivity, and thermal power for disposed commercial LLW are presented in Table 4.3.

4.4 REFERENCES

1. DOE site LLW data submittal attachments, submitted to the IDB Program during September–November 1996. The following LLW submittals were received and reviewed by the IDB Program before analysis and integration. Preceding each submittal is the site (in parentheses) to which it refers.
 - a. (Ames) Kay Lampe Hannasch, Ames Laboratory, Ames, Iowa, correspondence to Alan Icenhour or Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Low-Level Waste Data Request for Integrated Data Base Report," dated Sept. 10, 1996.
 - b. (ANL-E) R. F. Coley, Argonne National Laboratory, Argonne, Illinois, correspondence to Timothy S. Crawford, DOE Argonne Group Manager, Argonne, Illinois, "Low-Level Waste Data Request for the Integrated Data Base Report," dated Sept. 19, 1996.
 - c. (ANL-W) See reference for INEL.
 - d. (BNL) Angela C. Harvey, DOE Brookhaven Area Office, Upton, New York, correspondence to Steven Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Low-Level Waste Data for Brookhaven National Laboratory," dated Sept. 26, 1996.

- e. (ETEC) M. Lee, Rockwell International Corporation, Rocketdyne Division, Canoga Park, California, correspondence to Alan Icenhour or Steve Storch, IDB Program, ORNL, "ETEC/Rocketdyne Low-Level Waste Data for Integrated Data Base (IDB) Report," dated Sept. 12, 1996.
 - f. (FNAL) Andrew E. Mravca, DOE Fermi Group, Batavia, Illinois, correspondence to Alan Icenhour, IDB Program, ORNL, Oak Ridge, Tennessee, "Low-Level Waste Data Request for Integrated Data Base Report," dated Sept. 13, 1996.
 - g. (Hanford) D. E. McKenney, Westinghouse Hanford Company, Richland, Washington, correspondence to T. K. Teynor, DOE Richland Operations Office, Richland, Washington, "Low-Level Waste Data Request for the Integrated Data Base Report," 9602190 R1, dated Sept. 20, 1996.
 - h. (INEL) Roger R. Piscitella, Idaho National Engineering Laboratory, Idaho Falls, Idaho, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Idaho National Engineering Laboratory (INEL) Input to Integrated Data Base (IDB) Report (DOE/RW-0006, Rev. 12)," RRP-08-96, dated Sept. 20, 1996.
 - i. (ITRI) Stephen R. Rohrer, Lovelace Biomedical and Environmental Research Institute, Inc., Albuquerque, New Mexico, correspondence to Alan Icenhour, IDB Program, ORNL, Oak Ridge, Tennessee, transmitting updated ITRI LLW information and data, dated Aug. 28, 1996.
 - j. (K-25) A. L. Rivera, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, correspondence to S. N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "1996 Low-Level Waste (LLW) Management Data Call," dated Sept. 30, 1996.
 - k. (KCP) Margaret E. Stockdale, U.S. Department of Energy, Kansas City Area Office, Kansas City, Missouri, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "LLW Integrated Data Base," dated Nov. 14, 1996.
 - l. (LANL) I-Li Chen, Los Alamos National Laboratory, Los Alamos, New Mexico, correspondence to Alan Icenhour and Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "For 1996 Low-Level Waste," CST-14-96-139, Sept. 18, 1996.
 - m. (LBL) Robin Wendt, Lawrence Berkeley Laboratory, Berkeley, California, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "LLW Data Request for IDB," WM-96-256, dated Sept. 12, 1996.
 - n. (LLNL) Richard W. Crawford, Lawrence Livermore National Laboratory, Livermore, California, correspondence to Alan Icenhour or Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, transmitting updated LLNL LLW information and data, dated Sept. 20, 1996.
 - o. (MOUND) James J. Zahora, EG&G Mound Applied Technologies, Miamisburg, Ohio, correspondence to Robert S. Rothman, DOE Miamisburg Area Office, Miamisburg, Ohio, "Low-level Waste Management Data Call," dated Oct. 16, 1996.
 - p. (NR sites) E. D. Shollenberger, Pittsburgh Naval Reactors Office, West Mifflin, Pennsylvania, correspondence to Alan Icenhour, IDB Program, ORNL, Oak Ridge, Tennessee, "Low-Level Waste Information for the 1996 Integrated Data Base Report," dated Oct. 24, 1996.
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Fig. 4.1. Comparison of volume and radioactivity of LLW disposed at commercial and DOE facilities during 1995.

Fig. 4.2. Total volume of LLW disposed through 1995.

Fig. 4.3. Total volume of DOE LLW disposed through 1995.

Fig. 4.4. Locations and total volumes of DOE LLW disposed through 1995.

Fig. 4.5. Total volume of commercial LLW disposed through 1995.

Fig. 4.6. Locations and total volumes of commercial LLW disposed through 1995.

Table 4.1. Summary of characteristics for disposed LLW as of December 31, 1995

Category	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual ^a	Cumulative	Annual	Cumulative	Annual	Cumulative
DOE sites	48.5	3,011	422	12,550	2,378	22,195
Commercial sites ^b	19.5	1,538	172	5,376	869	20,815
Envirocare ^c	25.0	156	d	d	d	d
Total	93.0	4,705	594	17,926	3,247	43,010

^aAddition during 1995.

^bIncludes contributions from Beatty, West Valley, Maxey Flats, Richland, Sheffield, and Barnwell.

^cEnvirocare is a commercially operated facility that disposes of LLW, MLLW, NARM/NORM, and 11e(2) by-product material for both federal and private customers. See Table 0.8.

^dUnavailable.

Table 4.2. Historical and projected volume, radioactivity, and thermal power of disposed DOE LLW^a

End of calendar year	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative ^b	Annual	Cumulative
1990	60.0	2,759	545	13,516	2,013	17,844
1991	53.6	2,812	717	13,277	2,788	18,220
1992	48.3	2,860	1078	13,401	4,947	20,741
1993	50.5	2,911	894	13,147	3,263	20,398
1994	52.1	2,963	621	12,858	3,463	21,534
1995	48.5	3,011	422	12,550	2,378	22,195
1996	82.5	3,121	797	12,700	4,665	25,356
1997	76.5	3,197	744	12,786	4,383	27,911
1998	76.5	3,274	744	12,861	4,382	30,186
1999	76.5	3,350	745	12,922	4,381	32,186
2000	76.5	3,427	745	12,973	4,379	33,928
2001	76.5	3,503	745	13,015	4,375	35,435
2002	68.9	3,572	382	12,686	2,211	34,577
2003	68.9	3,641	382	12,399	2,209	33,831
2004	68.9	3,710	382	12,142	2,207	33,162
2005	68.9	3,779	382	11,910	2,206	32,561
2006	68.9	3,848	382	11,701	2,206	32,017
2007	68.9	3,917	382	11,511	2,206	31,524
2008	68.9	3,986	382	11,338	2,206	31,074
2009	68.9	4,055	382	11,180	2,206	30,661
2010	68.9	4,124	382	11,036	2,206	30,283
2011	68.9	4,193	382	10,905	2,206	29,936
2012	68.9	4,262	382	10,785	2,207	29,614
2013	68.9	4,331	382	10,675	2,207	29,316
2014	68.9	4,400	382	10,574	2,207	29,039
2015	68.9	4,469	382	10,483	2,207	28,782
2016	68.9	4,538	382	10,399	2,207	28,541
2017	68.9	4,607	382	10,324	2,208	28,317
2018	68.9	4,675	382	10,255	2,208	28,107
2019	68.9	4,744	381	10,193	2,208	27,909
2020	68.9	4,813	381	10,137	2,208	27,723
2021	68.9	4,882	381	10,087	2,208	27,548
2022	68.9	4,951	381	10,042	2,208	27,383
2023	68.9	5,020	381	10,003	2,209	27,226
2024	68.9	5,089	381	9,968	2,209	27,078
2025	68.9	5,158	381	9,938	2,209	26,939
2026	68.9	5,227	381	9,913	2,209	26,805
2027	68.9	5,296	381	9,891	2,210	26,679
2028	68.9	5,365	381	9,874	2,210	26,559
2029	68.9	5,434	381	9,859	2,210	26,445
2030	68.9	5,503	381	9,848	2,210	26,336

^aSummation of values in Tables 4.17 (buried DOE LLW, except SRS saltstone) and 4.18 (LLW saltstone at SRS).

^bThe radioactivity added each year for each waste type is decayed as described in the footnotes of Tables 4.17 and 4.18.

Table 4.3. Historical and projected volume, radioactivity, and thermal power of commercial LLW shipped for disposal^a

End of calendar year	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative ^b	Annual	Cumulative
1990	32.4	1,384	549	4,979	2,774	16,457
1991	38.8	1,423	800	5,272	4,044	18,424
1992	49.4	1,472	1,000	5,708	5,057	21,117
1993	22.4	1,495	643	5,709	3,252	21,627
1994	24.3	1,519	751	5,841	3,799	22,746
1995	19.5	1,538	172	5,376	869	20,815
1996 ^c	19.5	1,558	172	5,020	869	19,330
1997	19.5	1,577	172	4,726	869	18,093
1998	19.5	1,597	172	4,479	869	17,041
1999	19.5	1,617	172	4,268	869	16,140
2000	19.5	1,636	172	4,086	869	15,365
2001	19.5	1,656	172	3,928	869	14,697
2002	19.5	1,675	172	3,788	869	14,122
2003	19.5	1,695	172	3,665	869	13,626
2004	19.5	1,714	172	3,556	869	13,200
2005	19.5	1,734	172	3,459	869	12,834

^aIncludes LLW disposed of at the following commercial sites: Beatty, Nevada; West Valley, New York; Maxey Flats, Kentucky; Richland, Washington; Sheffield, Illinois; and Barnwell, South Carolina.

^bThe radioactivity through 1979 was decayed using a multiple source term methodology (see Tables 4.3 and 4.20–4.25 of Rev. 8 of this report for a description of this method). After 1979, the radioactivity is decayed from the year of addition using the representative compositions given in Table A.4 of Appendix A.

^cProjections were made based on disposal operations at Richland, Washington, and Barnwell, South Carolina, as described in Sect. 4.3.5. Projections were made only through 2005 because of large uncertainties in commercial disposal facility operations.

Table 4.4. Historical annual additions and total volume of LLW disposed at DOE sites^{a,b}

Year	Volume of waste disposed annually, 10 ³ m ³									Total annual addition	Total cumulative volume
	FEMP	Hanford	INEL	LANL	NTS	ORNL	SRS	Y-12 ^c	All others ^d		
1975 ^e	309.3	352.0	84.6	131.6	8.3	181.5	269.1	58.4	83.9	1,478.9	1,479
1976	14.4	4.1	6.2	8.8	0.0	3.8	8.1	2.7	0.9	49.0	1,528
1977	2.8	10.7	6.6	3.6	0.5	2.4	14.7	1.5	1.1	43.9	1,572
1978	1.9	9.8	5.9	7.5	10.0	2.0	15.5	1.4	3.2	57.2	1,629
1979	1.6	17.5	5.3	4.9	15.8	2.1	18.2	1.1	1.1	67.6	1,697
1980	1.3	10.4	5.1	4.8	13.3	2.0	19.6	1.4	0.7	58.6	1,755
1981	1.5	12.8	3.1	5.5	21.1	1.4	20.1	1.2	1.6	68.3	1,824
1982	2.8	11.7	3.2	4.5	57.0	1.3	22.4	2.2	2.0	107.1	1,931
1983	3.4	17.9	5.5	3.2	12.1	1.8	26.7	3.4	1.7	75.7	2,006
1984	3.5	18.8	3.9	5.4	36.0	2.2	26.1	7.2	10.6	113.7	2,120
1985	0.7	17.0	3.1	6.7	41.7	2.2	30.5	18.7	2.1	122.7	2,243
1986	0.0	21.1	3.4	4.5	27.9	1.8	30.1	15.0	1.0	104.8	2,348
1987	0.0	20.3	3.0	3.7	81.1	0.5	28.2	16.2	1.0	154.0	2,501
1988	0.0	16.8	2.0	4.3	39.1	0.6	30.2	10.6	1.0	104.6	2,606
1989	0.0	13.7	1.3	6.4	35.0	1.3	26.8	5.7	2.3	92.5	2,699
1990	0.0	13.4	1.8	4.5	9.1	0.3	26.6	4.4	0.0	60.1	2,759
1991	0.0	10.6	1.3	5.8	11.6	0.2	23.8	0.3	0.0	53.6	2,812
1992	0.0	10.9	0.8	2.3	20.1	1.1	13.0	0.0	0.0	48.2	2,860
1993	0.0	12.1	0.9	2.7	18.6	0.8	15.3	0.1	0.0	50.5	2,911
1994	0.0	13.7	1.9	1.9	22.9	0.3	11.4	0.0	0.0	52.1	2,963
1995	0.0	14.9	0.9	1.6	20.0	0.4	10.6	0.0	0.0	48.5	3,011
Total	343.2	630.2	149.8	224.2	501.3	210.0	687.0	151.3	114.2	3,011	

^aNo TRUW included; data from refs. 1 and 5. Slight differences in values shown and those actually reported result from round-off and truncation of numbers.

^bSee Tables 4.8 and 4.13 for breakdown of disposed volumes by physical form.

^cLand disposal of LLW at Y-12 was terminated July 1, 1991. A single exception was made in 1993 when waste was placed in the Bear Creek Burial Ground walk-in pits.

^dIncludes contributions from Ames, BNL, K-25, LLNL, PAD, PANT, PORTS, and SNL/NM.

^eValues for 1975 are cumulative volumes to this date (ref. 3).

Table 4.5. Description of physical forms used to characterize solid LLW from DOE activities^a

Physical form	Description
Debris waste	Waste that is at least 50% by volume solid materials that are intended for disposal and that are either manufactured objects, plant, or animal matter or that are natural geologic materials
Debris—combustible	Waste containing any material that will sustain combustion in air when exposed to an ignition source of 315°C (600°F) for a period of 5 min
Debris—noncombustible and compactible	Waste composed of materials that are capable of undergoing volume reduction or of being compacted and that are not capable of being burned or rapidly oxidized
Debris—noncombustible and combustible mixed	Waste composed of a mixture of materials that can and cannot sustain combustion
Activated metal/equipment/hardware	Waste materials that are contaminated with radionuclides generated through neutron activation of metal, equipment, and/or hardware. Metal waste includes slag generated from removal of dross from molten metal, activated aluminum ingots, and metal generated by the decontamination and decommissioning (D&D) of site structures and equipment. Other examples are activated reactor hardware, glove box parts, dehumidifiers, freezers, engines, pumps, and compressors
Contaminated metal/equipment/hardware	Waste materials that are externally contaminated with radioactive material. Metal waste includes slag generated from removal of dross from molten metal, nonreusable drums, and metal generated by the D&D of site structures and equipment
Reactor component/compartments	Reactor components are those components which have been removed from a reactor pressure vessel or reactor compartment. A reactor compartment is the section that contains the reactor that is separated and removed from a submarine
Elemental lead shielding	Wastes containing at least 50% by volume elemental lead. Examples include lead bricks, sheets, and pipes
Filter media	A category of solid waste that includes waste that is primarily (i.e., ≥50% by volume) filters constructed of one (or more than one) type of material. Examples of filter media waste are mechanical filters, cartridge-type filter media, and air filters
Biological waste and carcasses	Waste that consists of any plant or animal material such as shrubs, trees, animal carcasses, animal bedding and litter wastes, including any absorbent material and chemical agents such as lime, animal tissues in vials, and cultures
Asbestos-contaminated waste	Waste that contains about 80% by volume, or more, asbestos or asbestos-based material. The asbestos contained in the waste may be friable or nonfriable asbestos. Friable asbestos is a material that, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure. Nonfriable asbestos is that which is completely encapsulated or fixed in a matrix material that prevents the asbestos fibers from being released upon handling
Soil/sediment/rubble	A category of solid waste estimated to contain about 50% by volume soil and other ground media including, but not limited to, sand, silt, grass, rock, and gravel. The category also includes waste containing sediment which constitutes material in drainage and natural ponds and rubble which comprises waste material from building or demolition processes and concrete chunks and blocks from D&D activities

Table 4.5 (continued)

Physical form	Description
Solidified liquids/chelates/oils	Wastes that contain liquids, any polydentate ligand that will solubilize metal ions, and oils that have been immobilized or stabilized with agents, such as cement, polymers, and bitumen, and properly cured into a solidified form. The waste should not contain free liquids in excess of 1% of the volume of the waste when the waste is in a disposal container or 0.5% of the volume of the waste processed to a stable form. The waste should be in a form that meets stability requirements
Solidified sludge/resin	Sludge is any solid, semisolid, or liquid waste generated from any of a number of air- or water-treatment processes. Waste with a total suspended/settled solids (TSS) content of >30% is a sludge. The waste may be a mixture of sludge and stabilization agents cured into a solidified form Resin waste includes waste that is primarily (i.e., $\geq 50\%$ by volume) unused or spent inorganic or organic-based resins used in wastewater treatment or other applications. An example of this waste is inorganic/organic ion-exchange resins
Sources	Waste material composed of encapsulated radioactive material whose main purpose is to generate known amounts of radiation. Sealed sources are defined as a category of special-form radioactive material in 10 CFR Part 71.4. Special-form radioactive material is radioactive material which satisfies the following conditions: (1) it is either a single, solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule; (2) the piece or capsule has at least one dimension not less than 5 mm; and (3) it satisfies the test requirements of 10 CFR Part 71.75
Paint waste	Waste that is at least 50% by volume new, used, or removed paint. Examples of waste in this category are dried paint chips; containers filled with dried paint; and opened or unopened cans of heavy, viscous paint. This category does not include waste that is 50% by volume, or more, paint-related solids such as empty paint cans, depressurized spray paint cans, or other painting equipment (brushes, rollers, etc.)
Salt waste	Waste that is at least 50% by volume salts including interstitial liquids, if present. Chloride salts and sulfate salt wastes contain more than (i.e., >1000 ppm) levels of chlorides or other halogens and of sulfur compounds, respectively. Nitrate salts are predominantly (i.e., >50% by volume of salt) nitrates. Metal oxides/hydroxides waste is predominantly metal oxides or hydroxides
Incinerator ash	An inorganic particulate waste that is primarily (i.e., $\geq 50\%$ by volume) bottom or fly ash resulting from incineration
Activated carbon (charcoal)	An inorganic particulate waste that is primarily (i.e., $\geq 50\%$ by volume) spent or unused activated carbon including any residual liquids. The activated carbon may be in powdered (typically 50 to 100 μm) or granular (typically 0.1 to 1 mm) form
Other inorganic particulates	Waste that is at least 50% by volume inorganic particulates including any residual or absorbed liquids. Examples of other inorganic particulate waste are sandblasting media, inorganic particulate absorbent material (e.g., vermiculite), and ion-exchange media
Other	This category includes solid wastes that are not characterized sufficiently or that do not meet the criteria for assignment into one of the above categories

^aPatrice M. Bubar, DOE Office of Planning and Analysis, Office of Waste Management, Environmental Management, correspondence to DOE field offices and DOE site points of contact, "Low-Level Waste Data Request for Integrated Data Base Report," Attachment 1, dated Aug. 9, 1996.

Table 4.6. Actual 1995 generation and projected average annual generation of LLW at DOE sites

Physical form	Projections							
	1995 generation		1996		1997-2001		2002-2030	
	Volume (m ³)	Activity (Ci)	Volume (m ³)	Activity (Ci)	Volume (m ³ /year)	Activity (Ci/year)	Volume (m ³ /year)	Activity (Ci/year)
Debris								
Combustible	10,185	135	10,120	357	9,332	293	6,348	164
Noncombustible and compactible	1,781	1,599	922	8,146	873	4	4,430	2
Noncombustible and combustible mixed	7,577	23,925	8,512	7,294	7,778	137,796	5,084	136,698
Activated metal/equipment/hardware	690	69,015	848	159,142	1,396	153,384	164	78,639
Contaminated metal/equipment/hardware	3,546	36,537	4,813	11,263	3,679	11,718	2,107	5,319
Reactor component/compartment	275	56,902	126	40	531	295,500	1,242	796,000
Elemental lead shielding	5	<<1	0	0	0	0	0	0
Filter media (as-is, solidified, dewatered)	337	378	285	136	311	156	203	134
Biological waste and carcasses (as-is, solidified)	33	<<1	11	1	37	1	37	1
Asbestos-contaminated waste (as-is, solidified)	443	2	394	<1	255	<1	191	<1
Soil/sediment/rubble (as-is, solidified, dewatered)	527	12	1,545	16	2,627	12	296	9
Solidified liquids/chelates/oils	250	158,760	636	160,020	105	170,019	90	165,003
Solidified sludge/resin (dewatered, solidified)	727	221	543	560	700	186	498	141
Sources (sealed sources, devices, and gauges)	1 ^a	1,036 ^a	<1 ^b	124 ^b	<1 ^c	16 ^c	<1 ^d	2 ^d
Paint waste	5	<<1	11	<<1	11	<<1	11	<<1
Salt waste	1,501	23	2,771	41	174	<<1	145	<<1
Incinerator ash (solidified, as-is)	6	<<1	4	<<1	227	<<1	245	<<1
Activated carbon (charcoal)	3	865	2	6	4	1	1	1
Other inorganic particulates	160	245	592	20,777	671	15,912	458	12,129
Other	1,148	22,932	97	22,034	330	52	151	40
Total	29,199	372,586	32,232	389,956	29,040	785,051	21,701	1,194,283

^aTwo hundred fifty-six sources with no volume estimate are included in radioactivity value for sources.^bOne hundred sixty-four sources with no volume estimate are included in radioactivity value for sources.^cThirty-eight sources with no volume estimate are included in radioactivity value for sources.^dFifteen sources with no volume estimate are included in radioactivity value for sources.

Table 4.7. Actual 1995 cumulative storage inventory and projected average annual storage additions of LLW at DOE sites

Physical form	Cumulative ^b		Projected annual addition ^a					
			1996		1997-2001		2002-2030	
	Volume (m ³)	Activity (Ci)	Volume (m ³)	Activity (Ci)	Volume (m ³ /year)	Activity (Ci/year)	Volume (m ³ /year)	Activity (Ci/year)
Debris								
Combustible	9,656	43,044	2,625	-1,355	1,899	89	400	96
Noncombustible and compactible	4,443	31	-629	7,934	-446	-665	44	-159
Noncombustible and combustible mixed	10,391	801,424	2,105	-11,096	1,976	2,161	1,613	2,161
Activated metal/equipment/hardware	1,873	457,511	321	38,619	101	50	111	55
Contaminated metal/equipment/hardware	10,367	19,731	2,899	1,543	376	1,538	447	1,540
Reactor component/compartments	10	<1	0	0	0	0	0	0
Elemental lead shielding	15	<<1	0	0	0	0	0	0
Filter media (as-is, solidified, dewatered)	780	4	341	<1	42	2	36	2
Biological waste and carcasses (as-is, solidified)	13	<1	9	1	7	1	8	1
Asbestos-contaminated waste (as-is, solidified)	1,129	<<1	183	<<1	154	<<1	23	<<1
Soil/sediment/rubble (as-is, solidified, dewatered)	5,805	447	-215	-110	1,442	-66	71	<<1
Solidified liquids/chelates/oils	50	1,140,003	9	160,004	51	115,004	51	115,004
Solidified sludge/resin (dewatered, solidified)	8,291	220	6,296	305	140	-42	140	-9
Sources (sealed sources, devices, and gauges)	10 ^c	216 ^c	2 ^d	142 ^d	2 ^e	469 ^e	2 ^f	468 ^f
Paint waste	11	<<1	1	<<1	1	<<1	1	<<1
Salt waste	29	g	1	g	1	g	<1	g
Incinerator ash (solidified, as-is)	306	<<1	4	<<1	-1	<<1	2	<<1
Activated carbon (charcoal)	65	<<1	5	<<1	3	<<1	0	0
Other inorganic particulates	462	26	124	5	35	g	2	g
Other								
EM-30 program waste	12,068	501	5,806	666	-887	-189	<<1	<<1
EM-40 program waste	180,000 ^{h,i}	g	g	g	g	g	g	g
Total	245,775	2,463,158	19,888	196,659	4,895	118,351	2,950	119,159

^aNegative values indicate a decrease in stored volume or radioactivity.

^bCumulative storage as of December 31, 1995.

^cIncluded in radioactivity value for sources are 118 sources with no volume estimate.

^dIncluded in radioactivity value for sources are 91 sources with no volume estimate.

^eIncluded in radioactivity value for sources are 31 sources with no volume estimate.

^fIncluded in radioactivity value for sources are 30 sources with no volume estimate.

^gNot available.

^hFor EM-40 program LLW, data available only for cumulative storage volume for physical form "other." See Table 6.7 in Chapter 6. The physical form categories listed above do not apply to EM-40 program wastes.

ⁱTotal shown is rounded to two significant figures.

Table 4.8. Actual disposal during 1995 and projected average annual disposal of LLW at DOE sites

Physical form	Projections ^{a,b}							
	1995 disposal		1996		1997-2001		2002-2030	
	Volume (m ³)	Activity (Ci)	Volume (m ³)	Activity (Ci)	Volume (m ³ /year)	Activity (Ci/year)	Volume (m ³ /year)	Activity (Ci/year)
Debris-dry solids	25,258	27,002	23,323	3,496	20,395	232	6,322	199
Activated metal/equipment/hardware	568	51,495	300	136,600	567	90,350	89	38,790
Contaminated metal/equipment/hardware	10,607	37,123	2,806	12,234	1,844	8,172	951	5,486
Reactor component/compartment	9,047	256,100	8,120	484,200	7,654	520,500	3,529	240,317
Filter media (as-is, solidified, dewatered)	246	3	33	13	25	8	19	4
Biological waste and carcasses (as-is, solidified)	22	<<1	16	56	18	33	17	18
Asbestos-contaminated waste (as-is, solidified)	99	<1	57	<1	48	<<1	45	<<1
Soil/sediment/rubble (as-is, solidified, dewatered)	494	11	1,703	19	335	11	140	6
Solidified liquids/chelates/oils	252	31,270	700	19	102	17	20	15
Solidified sludge/resin (dewatered, solidified)	144	237	88	286	66	169	51	94
Sources (sealed sources, devices, and gauges)	<<1 ^c	1,033 ^c	<1 ^d	133 ^d	<1	12	<1	10
Paint waste	0	0	1	e	1	e	1	e
Salt waste	1,500	23	0	0	172	e	144	e
Incinerator ash (solidified, as-is)	6	<<1	10	<<1	6	<<1	3	<<1
Activated carbon (charcoal)	0	0	0	0	0	0	0	0
Other inorganic particulates	1	<<1	22	81	32	49	11	27
Other	259	17,622	323	24,840	230	14,620	102	8,128
Total	48,503	421,919	37,500	661,977	31,495	634,172	11,445	293,095

^aSome radioactivity projections unavailable from Hanford and SRS. Some volume and radioactivity projections unavailable from NTS.

^bVolume and radioactivity projections do not agree with those in Table 4.17. Projected values, shown in Table 4.17, were estimated for the unavailable data (from Hanford, SRS, and NTS).

^cIncluded in radioactivity value for sources are 105 sources with no volume estimate.

^dIncluded in radioactivity value for sources are 6 sources with no volume estimate.

^eUnknown.

Table 4.9. Breakdown by physical form of volumes of LLW generated during 1995 at DOE sites

Physical form	Volume, m ³									Total
	Hanford	INEL	K-25	LANL	Mound	NR sites ^a	ORNL	SRS	All others ^b	
Debris										
Combustible	1,111	1,357	2,115	558	47	223	0	4,070	704	10,185
Noncombustible and compactible	1,479	0	13	107	0	101	0	0	81	1,781
Noncombustible and combustible mixed	14	0	330	323	423	530	1,640	3,500	817	7,577
Activated metal/equipment/hardware	313	5	0	0	0	28	0	227	117	690
Contaminated metal/equipment/hardware	504	158	310	367	0	421	0	746	1,040	3,546
Reactor component/compartment	0	0	0	0	0	270	0	0	5	275
Elemental lead shielding	0	0	0	0	0	0	0	0	5	5
Filter media (as-is, solidified, dewatered)	101	6	3	15	0	46	0	0	166	337
Biological waste and carcasses (as-is, solidified)	9	0	0	<<1	0	0	13	0	11	33
Asbestos-contaminated waste (as-is, solidified)	18	1	129	40	7	182	12	0	55	443
Soil/sediment/rubble (as-is, solidified, dewatered)	181	107	4	107	0	2	0	0	126	527
Solidified liquids/chelates/oils	171	0	0	4	65	2	0	0	8	250
Solidified sludge/resin (dewatered, solidified)	0	1	0	61	145	12	0	0	508	727
Sources (sealed sources, devices, and gauges)	0	0 ^c	0	1	0	<<1 ^d	0	0	0 ^e	1
Paint waste	0	0	0	0	0	0	0	0	5	5
Salt waste	0	0	<1	0	0	0	0	1,500	<1	1,501
Incinerator ash (solidified, as-is)	1	0	0	0	0	0	0	0	5	6
Activated carbon (charcoal)	0	0	1	0	0	1	0	0	<1	3
Other inorganic particulates	0	63	9	0	0	0	0	0	88	160
Other	0	927	7	2	0	0	3	0	209	1,148
Total	3,902	2,625	2,921	1,585	687	1,818	1,668	10,043	3,950	29,199

^aNaval Reactors (NR) sites include KAPL, BAPL, and NRF.^bIncludes Ames, ANL-E, BNL, ETEC, FNAL, ITRI, KCP, LBL, LLNL, NTS, PANT, Pinellas, PPPL, RFETS, SLAC, SNL/CA, SNL/NM, WVDP and Y-12.^cINEL reported 63 sources for which a volume estimate was not available.^dNR sites reported 35 sources for which a volume estimate was not available.^eFour sites reported 158 sources for which a volume estimate was not available (38 at Ames, 9 at BNL, 100 at ETEC, and 11 at SNL/NM).

Table 4.10. Breakdown by physical form of radioactivity of LLW generated during 1995 at DOE sites

Physical form	Radioactivity, Ci									Total
	Hanford	INEL	K-25	LANL	Mound	NR sites ^a	ORNL	SRS	All others ^b	
Debris										
Combustible	22	5	c	24	24	<1	0	44	16	135
Noncombustible and compactible	1,595	0	c	<1	0	1	0	0	3	1,599
Noncombustible and combustible mixed	3,380	0	c	25	216	27	3,708	2,380	14,189	23,925
Activated metal/equipment/hardware	21,577	8,018	0	0	0	17,500	0	21,900	20	69,015
Contaminated metal/equipment/hardware	34,730	5	c	1,290	0	6	0	c	506	36,537
Reactor component/compartment	0	0	0	0	0	56,902	0	0	<<1	56,902
Elemental lead shielding	0	0	0	0	0	0	0	0	<<1	<<1
Filter media (as-is, solidified, dewatered)	3	<<1	c	<<1	0	372	0	0	3	378
Biological waste and carcasses (as-is, solidified)	<<1	0	0	<<1	0	0	<<1	0	<<1	<<1
Asbestos-contaminated waste (as-is, solidified)	<<1	<<1	c	<1	<<1	<1	0	0	1	2
Soil/sediment/rubble (as-is, solidified, dewatered)	<1	10	c	<<1	0	1	0	0	1	12
Solidified liquids/chelates/oils	1,760	0	0	<<1	157,000	<<1	0	0	<<1	158,760
Solidified sludge/resin (dewatered, solidified)	0	<1	0	2	<1	<1	0	0	218	221
Sources (sealed sources, devices, and gauges)	0	109	0	905	0	<<1	0	0	22	1,036
Paint waste	0	0	0	0	0	0	0	0	<<1	<<1
Salt waste	0	0	c	0	0	0	0	22	1	23
Incinerator ash (solidified, as-is)	<<1	0	0	0	0	0	0	0	<<1	<<1
Activated carbon (charcoal)	0	0	c	0	0	<<1	0	0	865	865
Other inorganic particulates	0	235	c	0	0	0	0	0	10	245
Other	0	17,620	c	2	0	0	<<1	0	5,310	22,932
Total	63,067	26,002	c	2,248	157,240	74,810	3,708	24,346	21,165	372,586

^aNaval Reactors (NR) sites include KAPL, BAPL, and NRF.^bIncludes Ames, ANL-E, BNL, ETEC, FNAL, ITRI, KCP, LBL, LLNL, NTS, PANT, Pinellas, PPPL, RFETS, SLAC, SNL/CA, SNL/NM, WVDP, and Y-12.^cUnknown.

Table 4.11. Breakdown by physical form of cumulative volumes of LLW stored at DOE sites^a

Physical form	Volume, m ³										Total
	FEMP	INEL	K-25	Mound	ORNL	RFETS	SRS	WVDP	Y-12	All others ^b	
Debris											
Combustible	0	4,102	1,777	282	0	2,380	0	121	869	125	9,656
Noncombustible and compactible	0	3,637	432	0	0	62	0	117	131	64	4,443
Noncombustible and combustible mixed	0	0	3,072	2,590	1,842	558	376	113	1,019	821	10,391
Activated metal/equipment/hardware	0	0	0	0	0	0	1,240	0	0	633	1,873
Contaminated metal/equipment/hardware	0	2,250	4,800	0	0	987	0	1,542	343	445	10,367
Reactor component/compartment	0	0	0	0	0	0	0	0	0	10	10
Elemental lead shielding	0	0	5	0	0	0	0	0	0	10	15
Filter media (as-is, solidified, dewatered)	0	0	76	0	0	504	0	5	51	144	780
Biological waste and carcasses (as-is, solidified)	0	0	0	0	0	6	0	1	0	6	13
Asbestos-contaminated waste (as-is, solidified)	0	0	856	42	0	0	0	30	192	9	1,129
Soil/sediment/rubble (as-is, solidified, dewatered)	0	4,016	816	0	0	100	0	455	234	184	5,805
Solidified liquids/chelates/oils	0	0	0	33	0	<1	0	3	0	14	50
Solidified sludge/resin (dewatered, solidified)	0	0	895	445	0	723	0	6,188	26	14	8,291
Sources (sealed sources, devices, and gauges)	0	0	0	0	0	<1	0	0	6	4 ^c	10
Paint waste	0	0	0	0	0	0	0	1	2	8	11
Salt waste	0	0	27	0	0	<1	0	0	1	1	29
Incinerator ash (solidified, as-is)	0	0	291	0	0	1	0	<1	0	14	306
Activated carbon (charcoal)	0	0	49	0	0	0	0	5	0	11	65
Other inorganic particulates	0	0	223	0	0	116	0	57	10	56	462
Other ^d											
EM-30 program waste	0	4,629	319	0	0	24	0	6,298	50	748	12,068
EM-40 program waste	140,000 ^e	0	0	0	0	0	0	0	0	40,000 ^e	180,000 ^e
Total	140,000	18,634	13,638	3,392	1,842	5,463	1,616	14,936	2,934	43,321	245,775

^aCumulative storage as of December 31, 1995.^bIncludes Ames, ANL-E, BNL, ETEC, FNAL, FUSRAP, GA, ITRI, KCP, LBL, LLNL, NRF, NTS, ORISE, PAD, PANT, Pinellas, RMI, SLAC, SNL/CA, and SNL/NM.^cThree sites reported 118 sources for which a volume estimate was not available (13 at BNL, 102 at ETEC, and 3 at ORISE).^dFor EM-40 program LLW, data available only for cumulative storage volume for physical form "other." The physical form categories listed above do not apply to EM-40 program wastes.^eSee Table 6.7 in Chapter 6. Reported volume rounded to two significant figures.

Table 4.12. Breakdown by physical form of total gross radioactivity of LLW stored at DOE sites^a

Physical form	Radioactivity, Ci										Total
	FEMP	INEL	K-25	Mound	ORNL	RFETS	SRS	WVDP	Y-12	All others ^b	
Debris											
Combustible	0	15	c	43,000	0	3	0	c	c	26	43,044
Noncombustible and compactible	0	27	c	0	0	<<1	0	c	c	4	31
Noncombustible and combustible mixed	0	0	c	384,000	400,519	<<1	1	c	c	16,904	801,424
Activated metal/equipment/hardware	0	0	0	0	0	0	318,000	c	0	139,511	457,511
Contaminated metal/equipment/hardware	0	4	c	0	0	3	0	c	c	19,724	19,731
Reactor component/compartment	0	0	0	0	0	0	0	0	0	<1	<1
Elemental lead shielding	0	0	0	0	0	0	0	0	0	<<1	<<1
Filter media (as-is, solidified, dewatered)	0	0	c	0	0	<1	0	c	c	3	4
Biological waste and carcasses (as-is, solidified)	0	0	0	0	0	c	0	c	0	<1	<1
Asbestos-contaminated waste (as-is, solidified)	0	0	c	<<1	0	0	0	c	c	<<1	<<1
Soil/sediment/rubble (as-is, solidified, dewatered)	0	443	c	0	0	3	0	c	c	1	447
Solidified liquids/chelates/oils	0	0	0	1,140,000	0	c	0	c	0	3	1,140,003
Solidified sludge/resin (dewatered, solidified)	0	0	c	1	0	<<1	0	c	c	219	220
Sources (sealed sources, devices, and gauges)	0	0	0	0	0	c	0	0	c	216	216
Paint waste	0	0	0	0	0	0	0	c	c	<<1	<<1
Salt waste	0	0	c	0	0	c	0	0	c	c	c
Incinerator ash (solidified, as-is)	0	0	c	0	0	c	0	c	c	<<1	<<1
Activated carbon (charcoal)	0	0	c	0	0	0	0	c	0	<<1	<<1
Other inorganic particulates	0	0	c	0	0	15	0	c	c	11	26
Other											
EM-30 program waste	0	c	c	0	0	<<1	0	c	c	501	501
EM-40 program waste	c	0	0	0	0	0	0	0	0	c	c
Total	c	489	c	1,567,001	400,519	25	318,001	c	c	177,123	2,463,158

^aTotal gross radioactivity is the total radioactivity, without decay, in storage as of December 31, 1995.^bIncludes Ames, ANL-E, BNL, ETEC, FNAL, ITRI, KCP, LBL, LLNL, NRF, NTS, ORISE, PANT, Pinellas, SLAC, SNL/CA, and SNL/NM. Radioactivity data not reported for EM-40 sites.^cNot available.

Table 4.13. Breakdown by physical form of volumes of LLW disposed during 1995 at DOE sites

Physical form	Volume, m ³						Total
	Hanford	INEL	LANL	NTS	ORNL	SRS	
Debris-dry solids	3,346	275	988	12,150	369	8,130	25,258
Activated metal/equipment/hardware	336	5	0	0	0	227	568
Contaminated metal/equipment/hardware	1,419	211	367	7,864	0	746	10,607
Reactor component/compartments	9,047	0	0	0	0	0	9,047
Filter media (as-is, solidified, dewatered)	225	6	15	0	0	0	246
Biological waste and carcasses (as-is, solidified)	8	0	<<1	0	14	0	22
Asbestos-contaminated waste (as-is, solidified)	35	1	40	0	22	0	99
Soil/sediment/rubble (as-is, solidified, dewatered)	281	106	107	0	0	0	494
Solidified liquids/chelates/oils	248	0	4	0	0	0	252
Solidified sludge/resin (dewatered, solidified)	0	63	61	20	0	0	144
Sources (sealed sources, devices, and gauges)	0	0 ^a	<<1	0	0	0	<<1
Paint waste	0	0	0	0	0	0	0
Salt waste	0	0	0	0	0	1,500	1,500
Incinerator ash (solidified, as-is)	6	0	0	0	0	0	6
Activated carbon (charcoal)	0	0	0	0	0	0	0
Other inorganic particulates	0	1	0	0	0	0	1
Other	0	257	2	0	0	0	259
Total	14,951	926	1,584	20,034	405	10,603	48,503

^aINEL reported 105 sources for which volume estimates were not available.

Table 4.14. Breakdown by physical form of radioactivity of LLW disposed during 1995 at DOE sites

Physical form	Radioactivity, Ci						Total
	Hanford	INEL	LANL	NTS	ORNL	SRS	
Debris-dry solids	24,008	11	49	300	94	2,540	27,002
Activated metal/equipment/hardware	21,577	8,018	0	0	0	21,900	51,495
Contaminated metal/equipment/hardware	35,570	5	1,290	258	0	^a	37,123
Reactor component/compartments	256,100	0	0	0	0	0	256,100
Filter media (as-is, solidified, dewatered)	3	<<1	<<1	0	0	0	3
Biological waste and carcasses (as-is, solidified)	<<1	0	<<1	0	<<1	0	<<1
Asbestos-contaminated waste (as-is, solidified)	<<1	<<1	<1	0	<<1	0	<1
Soil/sediment/rubble (as-is, solidified, dewatered)	1	10	<<1	0	0	0	11
Solidified liquids/chelates/oils	31,270	0	<<1	0	0	0	31,270
Solidified sludge/resin (dewatered, solidified)	0	236	1	<<1	0	0	237
Sources (sealed sources, devices, and gauges)	0	128	905	0	0	0	1,033
Paint waste	0	0	0	0	0	0	0
Salt waste	0	0	0	0	0	23	23
Incinerator ash (solidified, as-is)	<<1	0	0	0	0	0	<<1
Activated carbon (charcoal)	0	0	0	0	0	0	0
Other inorganic particulates	0	<<1	0	0	0	0	<<1
Other	0	17,620	2	0	0	0	17,622
Total	368,529	26,028	2,247	558	94	24,463	421,919

^aUnknown.

Table 4.15. DOE LLW disposed by methods other than shallow-land burial^a

Site	Location	Site use (year)	Waste containers buried ^b	Undecayed radioactive content (Ci)
<i>Atlantic Ocean</i>				
Atlantic	38°30'N 72°06'W	1951–1956; 1959–1962	14,300	74,400 ^c
Atlantic	37°50'N 70°35'W	1957–1959	14,500	2,100
Massachusetts Bay	42°25'N 70°35'W	1952–1959	4,008	2,440
Cape Henry	36°56'N 74°23'W	1949–1967	843	87
Central Atlantic	36°20'N 43°49'N 45°00'W	1959–1960	432	480
Subtotal			34,083	79,507
<i>Pacific Ocean</i>				
Farallon Islands (Subsite A)	37°38'N 123°08'W	1951–1953	3,500	1,100
Farallon Islands (Subsite B)	37°37'N 123°17'W	1946–1950; 1954–1956	44,000	13,400
Santa Cruz Basin	33°40'N 119°40'W	1946–1962	3,114	108
Cape Scot	50°56'N 136°03'W 52°25'N 140°12'W	1958–1969	360	124
San Diego	32°00'N 121°30'W	1959–1962	4,415	34
Subtotal (oceans)			55,389	14,766
Total			89,472	94,273
<i>Hydrofracture facility</i>				
ORNL	Bedded Conasauga shale underlying the ORNL site	1959–1965 1966–1980 ^d 1982 ^e 1983 ^e	Small experimental amounts of grout $8.0 \times 10^3 \text{ m}^3$ $3.8 \times 10^3 \text{ m}^3$ $5.5 \times 10^3 \text{ m}^3$	600,000 200,000 500,000
Total			$17.3 \times 10^3 \text{ m}^3$	1,300,000

^aRadioactivity is given at time of disposal. Data taken from Table 4.5 of ref. 3.^bEstimated number of containers.^cIncludes approximately 33,000 Ci of induced activity associated with the U.S.S. *Seawolf* reactor vessel.^dRetired after 18 injections.^eNew facility started up with four injections in 1982 and completed campaign with seven injections in 1983.

Table 4.16. Significant revisions and changes in the current values for LLW compared to the values in the previous year

Site	DOE/RW-0006, Rev. 11 (1995)	DOE/RW-0006, Rev. 12 (1996)	Significant revision or net change	Explanation
	Table No.	Table No.		
HANF	4.7 and 4.12	4.7 and 4.12	Large decrease in cumulative stored radioactivity at Hanford (from 205,200 Ci to 0 Ci)	Sources, which accounted for the 205,200 Ci, were redesignated as MLLW
INEL	4.7 and 4.12	4.7 and 4.12	Large decrease in cumulative stored radioactivity at INEL (from 1.2×10^6 Ci to 489 Ci)	Change was a result of revised reporting assumptions
ORNL	4.7, 4.11, and 4.12	4.7, 4.11, and 4.12	Large decrease in cumulative stored volume and radioactivity at ORNL (from 3,538 m ³ to 1,841 m ³ and from 7.6×10^5 Ci to 4.0×10^5 Ci)	Change was a result of revised reporting assumptions
ORNL	4.2, 4.4, and 4.17	4.2, 4.4, and 4.17	1994 disposed volume changed (from 397 m ³ to 318 m ³)	Revision to 1994 reported data

Table 4.17. Historical and projected volume, radioactivity, and thermal power characteristics of disposed DOE LLW, except SRS saltstone

End of calendar year	Volume ^{a,b} (10 ³ m ³)		Radioactivity ^{a,b} (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1990	60.0	2,759	545	13,516	2,013	17,844
1991	53.6	2,812	717	13,277	2,788	18,220
1992	48.3	2,860	1,078	13,401	4,947	20,741
1993	50.5	2,911	894	13,147	3,263	20,398
1994	52.1	2,963	621	12,858	3,463	21,534
1995	48.5	3,011	422	12,550	2,378	22,195
1996	37.5	3,049	792	12,695	4,621	25,312
1997	31.5	3,080	740	12,778	4,344	27,840
1998	31.5	3,112	740	12,850	4,344	30,092
1999	31.5	3,143	740	12,908	4,344	32,072
2000	31.5	3,175	740	12,955	4,344	33,799
2001	31.5	3,206	740	12,992	4,344	35,297
2002	23.9	3,230	377	12,659	2,184	34,433
2003	23.9	3,254	377	12,367	2,184	33,681
2004	23.9	3,278	377	12,106	2,184	33,002
2005	23.9	3,302	377	11,870	2,184	32,387
2006	23.9	3,326	377	11,656	2,184	31,825
2007	23.9	3,350	377	11,462	2,184	31,312
2008	23.9	3,374	377	11,285	2,184	30,841
2009	23.9	3,398	377	11,123	2,184	30,406
2010	23.9	3,422	377	10,975	2,184	30,005
2011	23.9	3,446	377	10,840	2,184	29,634
2012	23.9	3,470	377	10,716	2,184	29,288
2013	23.9	3,494	377	10,602	2,184	28,966
2014	23.9	3,518	377	10,498	2,184	28,665
2015	23.9	3,542	377	10,403	2,184	28,383
2016	23.9	3,566	377	10,316	2,184	28,118
2017	23.9	3,590	377	10,237	2,184	27,869
2018	23.9	3,613	377	10,165	2,184	27,633
2019	23.9	3,637	377	10,100	2,184	27,410
2020	23.9	3,661	377	10,041	2,184	27,198
2021	23.9	3,685	377	9,988	2,184	26,997
2022	23.9	3,709	377	9,940	2,184	26,805
2023	23.9	3,733	377	9,898	2,184	26,622
2024	23.9	3,757	377	9,860	2,184	26,447
2025	23.9	3,781	377	9,827	2,184	26,280
2026	23.9	3,805	377	9,799	2,184	26,119
2027	23.9	3,829	377	9,774	2,184	25,965
2028	23.9	3,853	377	9,754	2,184	25,817
2029	23.9	3,877	377	9,737	2,184	25,674
2030	23.9	3,901	377	9,723	2,184	25,536

^aHistorical (beginning of operations through 1994) annual values of volume and radioactivity for each site are from ref. 5. Similar values for 1995 are from ref. 1. See Tables 4.4, 4.8, 4.13, and 4.14 for more detail. For disposals prior to 1994, radioactivity (by waste type) is decayed from the year of addition using the representative compositions given in Table A.3 of Appendix A. Starting with 1994, representative compositions provided by the sites in the data call for Rev. 11 of this report are used to decay radioactivity.

^bBeginning in 1996, projected disposals are estimated for each active disposal site. Estimated values reported in this table may not agree with summary data reported in Table 4.8 because projections were reported as either unknown or unavailable by some sites.

Table 4.18. Projected volume, radioactivity, and thermal power characteristics of DOE LLW saltstone at SRS^a

End of calendar year	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996	45.0	72.0 ^b	4.7	4.7	43.5	43.5
1997	45.0	117.0	4.3	7.8	38.8	70.8
1998	45.0	162.0	4.4	10.9	37.8	93.9
1999	45.0	207.0	4.6	14.4	36.8	114.2
2000	45.0	252.0	4.9	18.3	34.5	129.3
2001	45.0	297.0	5.1	22.6	30.9	138.2
2002	45.0	342.0	5.1	27.0	27.3	143.6
2003	45.0	387.0	5.2	31.5	24.6	149.9
2004	45.0	432.0	5.2	36.0	22.9	159.9
2005	45.0	477.0	5.1	40.4	22.1	174.1
2006	45.0	522.0	5.1	44.8	21.7	191.6
2007	45.0	567.0	5.0	49.1	21.7	211.5
2008	45.0	612.0	5.0	53.2	21.8	232.8
2009	45.0	657.0	4.9	57.3	21.9	255.2
2010	45.0	702.0	4.9	61.3	22.1	278.2
2011	45.0	747.0	4.8	65.1	22.3	301.7
2012	45.0	792.0	4.8	68.9	22.5	325.5
2013	45.0	837.0	4.7	72.6	22.7	349.5
2014	45.0	882.0	4.7	76.2	22.9	373.9
2015	45.0	927.0	4.6	79.7	23.1	398.5
2016	45.0	972.0	4.6	83.2	23.3	423.3
2017	45.0	1,017.0	4.5	86.5	23.5	448.4
2018	45.0	1,062.0	4.5	89.8	23.6	473.7
2019	45.0	1,107.0	4.4	93.1	23.8	499.2
2020	45.0	1,152.0	4.4	96.2	24.0	525.1
2021	45.0	1,197.0	4.4	99.3	24.2	551.2
2022	45.0	1,242.0	4.3	102.4	24.4	577.6
2023	45.0	1,287.0	4.3	105.4	24.6	604.2
2024	45.0	1,332.0	4.3	108.3	24.9	631.2
2025	45.0	1,377.0	4.2	111.2	25.1	658.5
2026	45.0	1,422.0	4.2	114.0	25.3	686.1
2027	45.0	1,467.0	4.2	116.8	25.5	714.0
2028	45.0	1,512.0	4.1	119.6	25.7	742.2
2029	45.0	1,557.0	4.1	122.3	25.9	770.7
2030	45.0	1,602.0	4.1	124.9	26.2	799.6

^aSource: ref. 1 of Chapter 2.

^bReflects disposal, prior to 1996, of 27,000 m³ from processing of Effluent Treatment Facility concentrate.

Table 4.19. Historical annual additions and total volume of LLW at commercial disposal sites^a

Year	Volume, m ³						Annual total	Cumulative total
	Beatty ^b	West Valley ^c	Maxey Flats ^d	Richland	Sheffield ^e	Barnwell		
1962	1,861						1,861	1,861
1963	3,512	127	2,206				5,845	7,706
1964	2,836	5,940	3,872				12,648	20,354
1965	1,988	5,192	5,753	668			13,601	33,955
1966	3,533	3,951	5,557	2,402			15,443	49,398
1967	3,206	7,475	7,820	773	2,527		21,801	71,199
1968	3,576	3,490	8,178	1,359	2,713		19,316	90,515
1969	4,526	4,099	10,354	438	2,012		21,429	111,944
1970	5,152	4,906	12,521	423	2,825		25,827	137,771
1971	4,916	7,002	13,173	584	4,430	1,171	31,276	169,047
1972	4,301	9,045	15,578	654	5,956	3,757	39,291	208,338
1973	4,076	7,535	10,074	1,033	8,524	15,839	47,081	255,419
1974	4,103	8,866	8,898	1,411	12,373	18,244	53,895	309,314
1975	4,943	2,243	17,098	1,500	14,116	18,072	57,972	367,286
1976	3,864	427	13,775	2,867	13,480	40,227	74,640	441,926
1977	4,742	351	423	2,718	17,643	45,663	71,540	513,466
1978	8,874	144		7,422	1,735	61,554	79,729	593,195
1979	6,491	138		12,185		63,861	82,675	675,870
1980	12,717	141		24,819		54,723 ^f	92,400	768,270
1981	3,351	216		40,732		39,427 ^f	83,726	851,996
1982	1,505	632		39,606		34,779	76,522	928,518
1983	1,111	1,284		40,458		35,132	77,985	1,006,503
1984	2,067	966		38,481		34,879	76,393	1,082,896
1985	1,388	809		40,135		34,389	76,721	1,159,617
1986	2,668	2,095		18,833		29,612	53,208	1,212,825
1987	9,414			15,765		27,060	52,239	1,265,064
1988	2,645			11,430		26,391	40,466	1,305,530
1989	3,291			11,562		31,242	46,095	1,351,625
1990	1,684			8,362		22,315	32,361	1,383,986
1991	4,539			11,872		22,368	38,779	1,422,765
1992	14,575			11,271		23,518	49,364	1,472,129
1993				5,288		17,145	22,433	1,494,562
1994				3,533		20,783	24,316	1,518,878
1995				5,804		13,734	19,538	1,538,416
Total	137,455	77,074	135,280	364,388	88,334	735,885		1,538,416

^aFor a summary of historical additions (1962–1984), see Table 4.6 in ref. 3. For Beatty, Richland, and Barnwell, the additions for 1985–1994 are from Table 4.19 in ref. 5. Information for 1995 is taken from ref. 7.

^bBeatty ceased accepting LLW Dec. 31, 1992.

^cWest Valley includes a commercial state-licensed facility which opened Nov. 18, 1963, and closed Mar. 11, 1975, and an NRC-licensed facility (for on-site fuel reprocessing wastes) which opened in 1966 and continued to receive only on-site-generated LLW associated with water treatment and site cleanup until late 1986. This license is in abeyance. Disposal operations at the West Valley Demonstration Project (WVDP) have been suspended pending the preparation of an EIS report for the West Valley site closure. The WVDP began in 1980. The LLW volumes reported for 1982 through 1986 are for the WVDP only and are taken from ref. 5. Since the beginning of 1987, LLW generated at the WVDP is stored on-site in engineered facilities pending final disposal (ref. 5).

^dClosed Dec. 27, 1977. Small perturbations in waste volumes have occurred during site cleanup operations but are not included here since they are inconsequential.

^eClosed Apr. 8, 1978. No additional operations have taken place at the site.

^fThese values exclude almost 19,000 m³ (approximately 14,506 in 1980 and approximately 4,279 in 1981) of very low-level-activity settling pond sludge that was not included in the annual quota.

Table 4.20. Historical annual additions and total undecayed radioactivity of LLW at commercial disposal sites^a

Year	Radioactivity, Ci						Annual total	Cumulative total
	Beatty ^b	West Valley ^c	Maxey Flats ^d	Richland	Sheffield ^e	Barnwell		
1962	f						f	f
1963	5,690	100	22,556				28,346	28,346
1964	6,477	10,400	147,218				164,095	192,441
1965	6,377	22,600	63,828	144			92,949	285,390
1966	11,974	35,400	52,737	1,606			101,717	387,107
1967	10,894	123,100	23,273	5,378	3,850		166,495	553,602
1968	6,808	10,600	45,577	64,432	2,381		129,798	683,400
1969	9,761	36,000	31,028	55,964	2,192		134,945	818,345
1970	12,304	91,900	46,969	52,820	5,427		209,420	1,027,765
1971	4,316	436,700	720,146	23,916	7,895	4,151	1,197,124	2,224,889
1972	5,228	131,300	217,351	31,809	4,857	13,575	404,120	2,629,009
1973	5,704	346,000	118,359	57,037	2,834	48,212	578,146	3,207,155
1974	23,904	6,600	143,656	12,773	3,229	13,557	203,719	3,410,874
1975	18,388	11,600	289,570	113,341	6,103	17,428	456,430	3,867,304
1976	4,493	1,200	211,359	104,306	7,744	90,205	419,307	4,286,611
1977	23,811	900	267,063	7,465	11,147	390,121	700,507	4,987,118
1978	5,685	700		235,548	2,547	652,061	896,541	5,883,659
1979	8,897	400		164,787		314,938	489,022	6,372,681
1980	148,312	300		41,031		143,502	333,145	6,705,826
1981	52,214	229		43,905		183,744	280,092	6,985,918
1982	80,929	293		59,007		273,962	414,191	7,400,109
1983	1,356	255		120,534		383,450	505,595	7,905,704
1984	544	25		215,286		385,079	600,934	8,506,638
1985	453	39		287,849		460,571	748,912	9,255,550
1986	672	13		115,591		116,108	232,384	9,487,934
1987	3,353	0		42,734		211,026	257,113	9,745,047
1988	8,690	0		32,067		218,901	259,658	10,004,705
1989	42,678	0		99,056		725,164	866,898	10,871,603
1990	11,323	0		92,985		444,277	548,585	11,420,188
1991	29,679	0		158,784		611,348	799,811	12,219,999
1992	90,206	0		93,923		815,974	1,000,103	13,220,102
1993				31,422		611,785	643,207	13,863,309
1994				6,078		745,301	751,379	14,614,688
1995				2,836		168,981	171,817	14,786,505
Total	641,120	1,266,654	2,400,690	2,374,414	60,206	8,043,421		14,786,505

^aFor a summary of historical additions (1962–1984), see Table 4.6 in ref. 3. For Beatty, Richland, and Barnwell, the additions for 1985–1994 are from Table 4.20 in ref. 5. Information for 1995 is taken from ref. 7.

^bBeatty ceased accepting LLW Dec. 31, 1992.

^cWest Valley includes a commercial state-licensed facility which opened Nov. 18, 1963, and closed Mar. 11, 1975, and an NRC-licensed facility (for on-site fuel reprocessing wastes) which opened in 1966 and continued to receive only on-site-generated LLW associated with water treatment and site cleanup until late 1986. This license is in abeyance. Disposal operations at the West Valley Demonstration Project (WVDP) have been suspended pending the preparation of an EIS report for the West Valley site closure. The WVDP began in 1980. The LLW radioactivity values reported for 1982 through 1986 are for the WVDP only and are taken from ref. 5. Since the beginning of 1987, LLW generated at the WVDP is stored on-site in engineered facilities pending final disposal (ref. 5).

^dClosed Dec. 27, 1977.

^eClosed Apr. 8, 1978.

^fReported as 296 kg of source material (as defined in Title 10, *Code of Federal Regulations*, Part 40).

Table 4.21. Distribution of total volume and radioactivity, by state, of LLW shipped to commercial disposal sites in 1995^a

State	Volume (m ³)	Radioactivity (Ci)	State	Volume (m ³)	Radioactivity (Ci)
Alabama	398	78,340	Nebraska	68	407
Alaska	0	0	Nevada	2	<1
Arizona	<1	<1	New Hampshire	<1	<1
Arkansas	55	8	New Jersey	402	996
California	326	409	New Mexico	25	2
Colorado	1,954	553	New York	286	1,951
Connecticut	176	841	North Carolina	708	3,310
Delaware	2	<1	North Dakota	0	0
District of Columbia	4	<1	Ohio	250	553
Florida	174	2,444	Oklahoma	4	<1
Georgia	519	13,798	Oregon	2,119	1,279
Hawaii	75	1,821	Pennsylvania	997	5,692
Idaho	41	<1	Puerto Rico	0	0
Illinois	1,636	7,044	Rhode Island	<1	15
Indiana	3	36	South Carolina	2,465	4,418
Iowa	58	209	South Dakota	7	<1
Kansas	26	398	Tennessee	2,232	777
Kentucky	3	20	Texas	83	2,010
Louisiana	192	13,244	Utah	127	22
Maine	80	78	Vermont	3	135
Maryland	125	346	Virgin Islands	0	0
Massachusetts	311	24,903	Virginia	1,136	951
Michigan	579	1,438	Washington	1,461	923
Minnesota	70	365	West Virginia	<1	5
Mississippi	284	1,543	Wisconsin	30	348
Missouri	40	183	Wyoming	2	<1
Montana	<1	<1			
			Total	19,538	171,817

^aSource: ref. 7.

Table 4.22. Historical and projected cumulative volume and radioactivity summary of commercial GTCC LLW^a

Category	1993 ^b			2035 ^{c,d}		
	Volume (m ³)		Radioactivity (Ci)	Volume (m ³)		Radioactivity (Ci)
	Unpackaged	ACA packaged ^e		Unpackaged	ACA packaged	
Nuclear utility wastes						
• BWR operations	3.20	1.10	28,200	105.2	36.7	1,155,517
• PWR operations	2.82	0.12	18,300	77.7	10.0	573,510
LWR operations total	6.02	1.22	46,500	182.9	46.7	1,729,027
• BWR decommissioning	6.26	14.48	757,000	115.4	188.8	3,270,412
• PWR decommissioning	3.98	10.32	3,086,500	398.9	570.9	30,548,517
LWR decommissioning total	10.24	24.80	3,843,500	514.3	759.7	33,818,929
Nuclear utility total	16.26	26.02	3,890,000	697.2	806.4	35,547,956
Sealed sources						
• General license	0.007	0.474	1,119	0.123	8.09	18,440
• Specific license	0.125	38.22	354,000	0.87	234	1,560,000
Sealed sources total	0.13	38.69	355,119	0.99	242	1,578,440
DOE-held potential GTCC waste	0	0	0	0	0	0
Other generator waste ^f	46.9	74.2	2,738	235	465	12,680
Grand total	63.3	138.9	4,247,857	933	1,513	37,139,076

^aBased on the INEL study of ref. 13. Projected data reported represent base-case scenario projections.

^bReported cumulative inventory as of December 31, 1993.

^cProjected cumulative inventory for end of CY 2035.

^dReference 13 also projects quantities of nuclear utility GTCC LLW by the end of CY 2055. For the base case, these include an unpackaged volume of 1,144 m³, an after-concentration-averaged (ACA) packaged volume of 1,347 m³, and an associated radioactivity of 88,400,000 Ci.

^eACA packaged waste. This is the packaged volume of waste that is classified as GTCC LLW, after all other waste has been classified as Class A, B, or C LLW using concentration-averaging practices.

^fIncludes contributions from ¹⁴C users, irradiation laboratories, sealed source manufacturers, a nuclear fuel fabrication facility, and a university reactor.

**Table 4.23. Breakdown of 1995 low-level radioactive waste
by type, volume, and radioactivity received
by commercial disposal sites^a**

Commercial site	Type of waste	Volume (m ³)	Radioactivity (Ci)
Barnwell	Academic	132	39
	Government	3,171	74,834
	Industrial	3,200	24,995
	Medical	19	2
	Utility	7,212	69,111
		<hr/> 13,734	<hr/> 168,981
Richland	Academic	81	8
	Government	535	186
	Industrial	1,596	13
	Medical	36	4
	Utility	3,556	2,625
		<hr/> 5,804	<hr/> 2,836

^aSource: ref. 7.

5. URANIUM MILL TAILINGS

5.1 INTRODUCTION

Uranium mill tailings are the residual wastes of milled ore that remain after the uranium has been recovered. They are generated during the process of extracting uranium from the ore fed to the mill. Depending on the ore's chemical characteristics, uranium mills use either an acid leach or an alkaline leach process to recover uranium. Currently, all operable U.S. mills are designed to use the acid leach process. Mill tailings from both processes consist of slurries of sands and clay-like particles called slimes; the tailings slurries are pumped to tailings impoundment ponds for disposal.

5.2 BY-PRODUCT MATERIAL

Uranium mill tailings are part of a broad category of radioactive wastes called by-product materials. As defined in DOE Order 5820.2A, by-product material includes two major waste groups:

- (1) any radioactive material [except special nuclear material (SNM) such as plutonium or fissile uranium] yielded in, or made radioactive either by exposure to incident radiation or by the process of producing or utilizing SNM; and
- (2) the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material (i.e., uranium, thorium, or both) content. This excludes underground ores depleted by uranium solution extraction operations that continue to remain underground.

The basis for the definition of the second group of by-product materials is Section 11e(2) of the Atomic Energy Act (AEA) of 1954 (P.L. 83-703, as amended). For this reason, these wastes, which, of course, include uranium mill tailings, are referred to as 11e(2) by-product materials.

Uranium mill tailings are the only by-product materials considered in this chapter. Additional information and data on 11e(2) by-product materials from DOE Environmental Restoration Program activities are provided in Chapter 6. The Environmental Restoration Program chapter also reports the volumes of mixed DOE Environmental Restoration 11e(2) by-product materials, which have both hazardous and radioactive components. For this report, information on thorium mill tailings or other by-product materials is not considered.

5.3 COMMERCIAL URANIUM MILL TAILINGS

This section describes the inventories and characteristics of uranium mill tailings generated from uranium ore production at commercially licensed facilities.

5.3.1 Uranium Ore Production

U.S. uranium production from conventional milling has declined since 1980; as a consequence, the quantity of mill tailings generated each year has declined (see Table 5.1). During 1995, one conventional mill in the United States was commercially producing uranium concentrates from stockpiled ore mined prior to 1993. This mill accounted for sole generation of 134,000 t of mill tailings (see Table 5.2). At the end of 1995, one of the U.S. mills was operational. Five of the 26 mills were on standby status, and the rest were undergoing various stages of decommissioning. The location and status of each of these mills are indicated on the map shown in Fig. 5.1 (ref. 1). The nonutilization of U.S. uranium mill capacity can be attributed, in large part, to nuclear power plant cancellations and deferments. Since the late 1970s, these have led to lower uranium demand which, in turn, has contributed to lower uranium prices and a steady decline in domestic uranium mining. In addition, cost increases for domestic uranium mining and milling have led to increased reliance on imports of less expensive uranium.

In the history of U.S. uranium production, 1993 and 1994 were the only years with no production from

conventional milling of ore. Nonconventional concentrate production in 1995 increased to about 2,000 t U_3O_8 , or 34% above 1994 production.^{2,3} Nonconventional concentrate production includes by-product processing resulting from the mining of phosphate ore as well as the processing of in situ leach-mining solutions, heap-leach solutions, mine water, and other solutions from reclamation activities. In situ leaching (ISL) technology has been increasingly applied in recent years to mining operations. Of the total 1995 \$80/kg-U uranium reserves estimated by the Energy Information Administration (EIA), the amount for which ISL is the proposed mining method was about 42%. Because ISL mining generally is successful at lower costs as compared with conventional mining methods, it could gain even wider use in the near future. ISL and by-product (from phosphate ore) production methods do not generate uranium mill tailings. Residual wastes from nonconventional methods are not considered in this chapter.

5.3.2 Inventories

The status of the licensed mills, including their estimated commercial and government-related tailings inventories at the end of 1995, is shown in Table 5.2 (data based on refs. 1–11). For each mill, the amount of tailings generated depends on the amount of ore processed, the ore-feed grade (U_3O_8 assay), and the percentage of U_3O_8 recovered. Table 5.1 lists the annual milling rate, ore grade, and U_3O_8 recovery. Through 1995, 189.6×10^6 t (118.7×10^6 m³) associated mill tailings were generated.

5.3.3 Waste Characterization

Because the amount of uranium (by weight) extracted from the ore during milling is relatively small, the dry

weight of the tailings produced is nearly equal to the dry weight of the ore processed. Dry tailings typically are composed of 70 to 80 wt % sand-sized particles and 20 to 30 wt % finer-sized particles. Acid leaching is preferred for ores with low lime content (12% or less). Those with high lime content require excessive quantities of acid for neutralization and, for economic reasons, are best treated by alkaline leaching. In either leach process, most of the uranium is dissolved, together with the other materials present in the ore (e.g., iron, aluminum, and other impurities). After the ore is leached, the uranium-laden leach liquor is removed from the tailings solids by decantation. After thorough washing, the tailings are pumped as a slurry to a tailings pond. The waste liquid accompanying the tailings solids to the disposal pond is approximately 1 to 1.5 times the weight of the processed ore. Typical characteristics of the tailings solids and liquid are outlined in Table 5.3 (ref. 8).

The tailings pile must have a cover designed to control radiological hazards for a minimum of 200 years and for 1,000 years to the greatest extent reasonably achievable. It must also limit radon (^{222}Rn) releases to 20 pCi/m²/s averaged over the disposal area. Radon release limitation requirements apply to any portion of the tailings disposal site unless radium concentrates do not exceed 5 pCi/g in the first 15 cm below the surface and 15 pCi/g in layers more than 15 cm below the surface.¹¹

5.4 DOE URANIUM MILL TAILINGS

DOE uranium mill tailings include those resulting from uranium ore milled for defense purposes as well as existing tailings at inactive sites no longer licensed that are administered under the DOE site remedial action projects discussed in Chapter 6.

5.5 REFERENCES

1. U.S. Department of Energy, Energy Information Administration, "Comparison of Uranium Mill Tailings Reclamation in the United States and Canada," *Uranium Industry Annual 1994*, DOE/EIA-0478(94), Washington, D.C. (July 1995).
2. U.S. Department of Energy, Energy Information Administration, "Uranium Industry Annual Survey," Form EIA-858, Washington, D.C. (1995).
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5. U.S. Department of Energy, Grand Junction Office, and Bendix Field Engineering Corporation, *Commingled Uranium Tailings Study*, DOE/DP-0011, Vol. 2, Grand Junction, Colorado (June 1982).
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8. U.S. Nuclear Regulatory Commission, *Final Generic Environmental Impact Statement on Uranium Milling, Project M-25*, NUREG-0706, Washington, D.C. (September 1980).
9. U.S. Department of Energy, Grand Junction Office, *Statistical Data of the Uranium Industry*, GJO-100(73), Grand Junction, Colorado (Jan. 1, 1973).
10. U.S. Congress, House of Representatives, Committees on Energy and Commerce; Interior and Insular Affairs; Science, Space, and Technology; and Ways and Means, *Uranium Revitalization, Tailings Reclamation and Enrichment Act of 1988: Hearing on H.R. 4489*, 100th Congress, 2nd sess., pp. 19-21 (Apr. 28, 1988).
11. U.S. Department of Energy, Energy Information Administration, *Decommissioning of U.S. Uranium Production Facilities*, DOE-EIA-0592, Washington, D.C. (February 1995).

Active at the End of 1995

4. Malapai Resources, Christensen Ranch
6. Converse County Mining Venture, Highland
7. Crow Butte Resources, Crow Butte
9. Energy Fuels Nuclear, White Mesa
12. Malapai Resources, Holiday-El Mesquite
13. Uranium Resources, Rosita
18. IMC-Agrico, Sunshine Bridge
19. IMC-Agrico, Uncle Sam

Inactive at the End of 1995

1. Dawn Mining, Ford
2. Green Mountain Mining Venture, Sweetwater
3. Malapai Resources, Irigaray
5. Rio Algom Mining, Smith Ranch
8. U.S. Energy, Shootaring
10. Cotter Corp., Canon City
11. Rio Algom Mining, Ambrosia
14. Uranium Resources, Kingsville Dome
15. Everest Minerals, Hobson
16. COGEMA Mining, West Cole
17. Malapai Resources, O'Hem
20. IMC-Agrico, Plant City
21. IMC-Agrico, New Wales

Uranium Production Centers		
Active	Inactive	
●	○	Conventional Mills
■	□	In Situ Leach Plant
▲	△	Byproduct From Phosphate Processing
Major Uranium Reserve Areas		

Fig. 5.1. Location and status of uranium mills and plants at the end of 1995. Courtesy of U.S. Department of Energy, Energy Information Administration, Washington, D.C.

Table 5.1. Uranium ore processed, U_3O_8 recovery rate, and tailings generated through 1995^{a,b}

End of calendar year	Ore processed		U_3O_8		Tailings generated	
	Mass ^c (10^6 t)	Grade (% U_3O_8)	Recovery from ore (%)	Product ^d (10^3 t)	Mass ^e (10^6 t)	Volume ^f (10^6 m ³)
Prior to 1978	g	g	g	g	108.8	68.0
1978	12.5	0.134	91	15.6	12.6	7.9
1979	14.6	0.113	91	15.3	14.5	9.1
1980	15.3	0.118	93	17.2	15.2	9.5
1981	13.2	0.115	94	14.5	13.2	8.2
1982	7.9	0.119	96	9.9	8.1	5.0
1983	5.4	0.128	97	7.0	5.4	3.4
1984	3.9	0.112	95	4.4	4.0	2.5
1985	1.6	0.161	96	2.8	1.6	1.0
1986	1.2	0.338	97	4.0	1.2	0.7
1987	1.3	0.284	96	3.8	1.3	0.8
1988	1.1	0.288	95	3.2	1.1	0.7
1989	1.1	0.323	95	3.7	1.0	0.7
1990	0.7	0.293	94	2.1	0.7	0.4
1991	0.6	0.188	92	1.2	0.6	0.4
1992	0.2	0.229	96	0.6	0.2	0.2
1993	0.0	0.000	0	0.0	0.0	0.0
1994	0.0	0.000	0	0.0	0.0	0.0
1995	0.1 ^h	0.531	92	0.8	0.1	0.1
Total ⁱ					189.6	118.7

^aSources: Prior to 1984—U.S. Department of Energy, Grand Junction Area Office data files.
1984–1995—Energy Information Administration, "Uranium Industry Annual Survey," Form EIA-858.

^bThis table has been revised based on a detailed study of milling data from the Grand Junction Project Office and EIA files. The values shown include all tailings.

^cBefore in-process inventory adjustments.

^dConventional U_3O_8 concentrate production.

^eIncludes adjustments to ore-fed amounts for annual mill circuit inventory changes and uranium concentrate production.

^fCalculated assuming that the average density of tailings is 1.6 t/m³ (metric tons per cubic meter).

^gNot available.

^hStockpiled ore mined prior to 1993.

ⁱBecause of independent rounding, totals may not equal sum of components.

Table 5.2. Status of conventional uranium mill sites at the end of 1995^a

Location	Operator	Rated capacity ^b (t/d ore)	Status		Tailings storage area (ha) ^d	Total tailings		
			Operations ^b	Tailings ^c		Volume ^e (10 ⁶ m ³)	Mass (10 ⁶ t)	Government portion ^f (10 ⁶ t)
Colorado								
Canon City	Cotter	1,090	Shut down, 1987		66R ^g	1.3	2.0	0.3
Uravan	Umetco Minerals	1,180 ^h	Decommissioning	Partially stabilized	34R	5.9	9.5	5.2
Subtotal		1,090			100R	7.2	11.5	5.5
New Mexico								
Ambrosia Lake	Quivira Mining	6,350	Shut down, 1985	Fenced	131R	18.8	30.1	9.1
Bluewater	Anaconda	5,440 ^h	Decommissioning	Partially stabilized	199	13.6	21.7	8.0
Church Rock	United Nuclear	2,720 ^h	Decommissioning	i	40R	2.0	3.2	0
Grants	Homestake Mining	3,080 ^h	Decommissioning	Unstabilized	86R	12.7	20.2	10.4
L-Bar	Sohio Western Mining	1,450 ^h	Decommissioning	i	46R	1.2	1.9	0
Marquez	Bokum Resources	1,820 ^{h,j}	New (on standby)	Never operated	0	0	0	0
Subtotal		6,350			502R	48.3	77.1	27.5
South Dakota								
Edgemont	Tennessee Valley Authority	680 ^h	Decommissioned	Stabilized	50	1.2	1.8	1.5
Subtotal		0			50	1.2	1.8	1.5
Texas								
Falls City	Continental Oil/ Pioneer Nuclear	3,080 ^h	Decommissioned	Stabilized	89	6.5	10.5	0
Panna Maria	Rio Grande Resources	2,720 ^h	Decommissioned	Stabilized	101	3.9	5.9	0
Ray Point (Felder Facility)	Exxon	1,000 ^h	Decommissioned	Stabilized ^k	18	0.2	0.4 ^l	0
Subtotal		2,720			208	10.6	16.8	0

Table 5.2 (continued)

Location	Operator	Rated capacity ^b (t/d ore)	Status		Tailings storage area (ha) ^d	Total tailings		
			Operations ^b	Tailings ^c		Volume ^e (10 ⁶ m ³)	Mass (10 ⁶ t)	Government portion ^f (10 ⁶ t)
Utah								
Lisbon	Rio Algom	680	Decommissioning	i	14	2.2	3.5	0
Moab	Atlas	1,270 ^h	Decommissioning	Relocation sought	>80	6.0	9.6	5.4
Shooting	Plateau Resources	910	New (on standby)	Never operated	28	0	0	0
White Mesa	Energy Fuels	1,810	Shut down, 1990; restarted, 1995	Partially stabilized	135	2.0	3.3	0
Subtotal		3,400			>257	10.2	16.4	5.4
Washington								
Ford	Dawn Mining	410	Shut down, 1982	Wood chip covering	53R	1.8	2.8	1.1
Sherwood	Western Nuclear	1,810 ^h	Decommissioning	i	17	1.6	2.6	0
Subtotal		410			70R	3.4	5.4	1.1
Wyoming								
Bear Creek	Rocky Mountain Energy	1,810 ^h	Decommissioning	Unstabilized	61	2.7	4.3	0
Gas Hills	American Nuclear	860 ^h	Decommissioning	Unstabilized	47R	3.3	5.4	2.0
Gas Hills	Umetco	1,270 ^h	Decommissioning	Unstabilized	58R	4.6	7.3	1.9
Highland	Exxon	2,900 ^h	Decommissioning	Partially stabilized	116R	6.4	10.3	0
Lucky Mc	Pathfinder	2,540 ^h	Decommissioning	Unstabilized	99R	6.6	10.6	2.6
Petrotomics	Petrotomics	1,360 ^h	Decommissioning	Unstabilized	65	3.9	6.3	0.7
Shirley Basin	Pathfinder	1,630 ^h	Decommissioning	i	105R	4.7	7.4	0
Split Rock	Western Nuclear	1,540 ^h	Decommissioning	Interim stabilization	67R	4.4	7.0	3.0
Sweetwater	Minerals Exploration/ Union Energy Mining	2,720	Shut down, May 1983	Partially stabilized	121	1.3	2.1	0
Subtotal		4,350			739R	37.9	60.7	10.2
1995 total for all sites ^{b,m,n}		18,320 ^o			>1,926R	118.7	189.6	51.2 ^p

(Footnotes on next page.)

Table 5.2 (continued)

^aData based on refs. 1-11. Note: Subtotals and totals may not equal sum of components because of independent rounding. Ray Point, Texas (Felder Facility), site was stabilized during 1987 by Exxon Corporation. Historical data are revised based on detailed study of milling data from the Grand Junction Project Office and EIA files. The values shown include all tailings.

^bFrom refs. 2, 5, 9, and 11. Values rounded to nearest 10 t.

^cOn Aug. 15, 1986, EPA issued its final rules on ²²²Rn emissions from tailings piles. Mill owners have 6 years (subject to certain extensions) to phase out the use of large existing tailings piles. New tailings piles may be contained in small impoundments (less than 16 ha) or disposed of continuously by dewatering and burial (i.e., no more than 4 ha are uncovered at any one time). See ref. 7.

^dFrom refs. 6 and 11; 1 ha = 10,000 m² or approximately 2.5 acres.

^eCalculated from reported mass using density = 1.6 t/m³.

^fFrom ref. 5, Table 8.0. These tailings are from government contracts only and are included in the "Total tailings" column.

^gR = revised. From ref. 11.

^hEstimates provided are not included in the total. See column labeled "Operations" under "Status" for reason.

ⁱNot available.

^jMill construction has not been 100% complete.

^kFrom ref. 11.

^lFrom ref. 10.

^mThese values are cumulative totals that may not equal sum of components due to independent rounding. For annual totals see Table 5.3.

ⁿFrom ref. 2.

^oFrom ref. 2.

^pTotal at the end of government-contracted deliveries in 1970 (ref. 5).

Table 5.3. Typical characteristics of uranium mill tailings^a

Tailings component	Particle size (μm)	Chemical composition	Radioactivity characteristics
Sands	75 to 500	SiO ₂ with <1% complex silicates of Al, Fe, Mg, Ca, Na, K, Se, Mn, Ni, Mo, Zn, U, and V; also metallic oxides	0.004 to 0.01% U ₃ O ₈ ^b Acid leaching: ^c 26 to 100 pCi ²²⁶ Ra/g; 70 to 600 pCi ²³⁰ Th/g
Slimes	45 to 75	Small amounts of SiO ₂ , but mostly very complex clay-like silicates of Na, Ca, Mn, Mg, Al, and Fe; also metallic oxides	U ₃ O ₈ and ²²⁶ Ra are almost twice the concentration present in the sands Acid leaching: ^c 150 to 400 pCi ²²⁶ Ra/g; 70 to 600 pCi ²³⁰ Th/g
Liquids	d	Acid leaching: pH 1.2 to 2.0; Na ⁺ , NH ₄ ⁺ , SO ₄ ⁻² , Cl ⁻ , and PO ₄ ⁻³ ; dissolved solids up to 1% Alkaline leaching: pH 10 to 10.5; CO ₃ ⁻² and HCO ₃ ⁻ ; dissolved solids ~ 10%	Acid leaching: 0.001 to 0.01% U; 20 to 7,500 pCi ²²⁶ Ra/L; 2,000 to 22,000 pCi; ²³⁰ Th/L Alkaline leaching: 200 pCi ²²⁶ Ra/L; essentially no ²³⁰ Th (insoluble)

^aAdapted from information in ref. 8.^bU₃O₈ content is higher for acid leaching than for alkaline leaching.^cSeparate analyses of sands and slimes from the alkaline leaching process are not available. However, total ²²⁶Ra and ²³⁰Th contents of up to 600 pCi/g (of each) have been reported for the combined sands and slimes.^dParticle size does not apply. Up to 70% of the liquid may be recycled. Recycle potential is greater in the alkaline process.

6. ENVIRONMENTAL RESTORATION PROGRAM

6.1 INTRODUCTION

The overall mission of the DOE Office of Environmental Restoration (EM-40) is to protect human health and the environment from risks posed by inactive, surplus structures and contaminated environmental media. These structures and media contain radioactive and chemically hazardous contaminants as a result of previous activities conducted by DOE and its predecessor agencies. The EM-40 program is accomplishing its mission by remediating sites and facilities in the most cost-efficient and responsible manner possible to provide for future beneficial use of these contaminated areas while complying with applicable environmental regulations.

The environmental restoration program includes a bias for action to expedite actual cleanup wherever and whenever possible. Activities are prioritized based upon several factors, including the need to eliminate risks at sites not controlled by the federal government, the goal of reducing risks at all sites, and compliance with various laws, regulations and agreements. Most actions are designed to either remove or contain contamination in the environment (such as contaminated soil, debris, and ground water) or to decommission contaminated structures (including reactors, chemical processing buildings, and support facilities). Related activities to support remediation actions include treatment of contaminated materials and wastes, transportation of these materials and wastes to storage and disposal facilities, and disposal of wastes in permitted facilities.

Environmental restoration activities include cleanup of buildings and areas that supported defense-related activities (such as nuclear weapon component fabrication) and nondefense, civilian nuclear power activities (such as the development of heat sources for the space program and the operation of small test reactors). Remedial actions are concerned with all aspects of the assessment and cleanup of inactive sites at which releases of radioactive and chemically hazardous substances have occurred. These actions are not limited to the areas directly impacted by the release but also include additional areas to which contaminants may have migrated (such as to ground

water). Twenty-two DOE sites are on the U.S. Environmental Protection Agency (EPA) National Priorities List.

Cleanup goals and remedies for each contaminated area are developed through processes established by federal and state laws and other legal agreements. These processes involve decision-makers outside DOE, such as EPA and the impacted state, and include input from other stakeholders such as local citizens and national environmental groups. The principal regulatory requirements for remediation activities are derived from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Activities may be subject further to requirements associated with compliance with the National Environmental Policy Act (NEPA) and with regulatory requirements imposed by the states. Other requirements are set forth in various DOE Orders and standards and in other guidance documents.

Decommissioning activities, which occur after facilities have been stabilized and deactivated, address contamination within the structures. The objectives of decommissioning are to eliminate potential risks to human health and safety and the environment and to allow for the reuse of materials, equipment, and buildings to the greatest extent practicable. Most decommissioning activities are concerned with facilities such as reactors, hot cells, processing plants, storage tanks, and other structures from which, in general, few releases to the environment have occurred.

Decommissioning activities are carried out according to requirements set forth in various DOE Orders and standards and other guidance documents. State requirements also apply in certain instances. Based on a joint policy between DOE and EPA, provisions of CERCLA generally govern decommissioning activities, which are conducted as non-time-critical removal actions. Of the 3,500 contaminated facilities that are surplus, or projected to be surplus within the next 10 years, DOE has decommissioned 100 facilities to date. The EM-40 program has placed a priority on minimizing secondary

waste and has recycled 7,240 metric tons (t) (8,000 tons) of scrap metal from dismantled facilities and equipment (ref. 1). Only those decommissioning activities at facilities currently in the EM-40 program are addressed in this chapter.

The first steps in the remediation process for contamination in environmental media are to identify the contaminants of concern, determine the extent of contamination, and assess potential threats to human health and the environment. If a significant contamination problem is indicated and if a fast and limited cleanup or containment action could mitigate this problem, DOE may conduct an expedited response action or interim remedial action. To date, DOE has completed over 500 such limited actions (ref. 1).

Upon completion of characterization, a detailed analysis of remedial alternatives is conducted. This analysis is followed by a formal decision-making process, possibly including public meetings and a formal public comment period. If the results of the analysis indicate (a) that a contaminated area does not pose a threat to human health or the environment or (b) that a previously completed limited action adequately addressed the contamination condition, a determination that "no further action" is necessary may be made. Such a determination would be made in conjunction with EPA, the host state, and other stakeholders. However, if a threat is deemed to be present, the appropriate action would be identified and implemented.

A wide range of actions can be implemented to address environmental contamination problems that exist at DOE sites. Current and projected land use is a key component in the decision-making process. For example, in-situ remedies that rely on containment of contaminated materials would be appropriate for the large DOE reservations that are projected to remain under the control of the federal government. In contrast, ex-situ remedies in which contaminated materials are exhumed for treatment and disposal at off-site locations would likely be appropriate for small sites destined to be released for unrestricted or industrial (non-DOE) uses. The most appropriate action to be taken at any given area is site-specific and depends on the types of contaminants present, the medium in which they are found, and the likelihood of current or future exposures.

To support the planning process, EM-40 has established a database containing key information for the environmental restoration program, such as projected responses for each contaminated area and facility, milestones, projected costs, and anticipated wastes requiring active management. Information in the EM-40 Core Database was provided by the various field offices and was used to support the Baseline Environmental Management Report (BEMR) 1996. The EM-40 Core

Database also serves as the source of information for this chapter (ref. 2).

Waste management information included in the EM-40 Core Database includes data on all waste types that may result from environmental restoration activities including radioactive, sanitary, demolition, and hazardous wastes as regulated by RCRA and the Toxic Substances Control Act (TSCA). This information will assist DOE in planning, constructing, and operating appropriate treatment, storage, and disposal facilities to manage the wastes resulting from implementation of the EM-40 program.

6.2 OFFICE OF ENVIRONMENTAL RESTORATION

Environmental restoration activities under the auspices of EM-40 are managed in a decentralized manner. That is, much of the responsibility for program implementation rests with the various Operations and project offices. These field offices have the responsibility for determining the appropriate course of action to take at the various contaminated sites and then directing the remediation activities. The locations of the field offices responsible for directing the DOE environmental restoration program are shown in Fig. 6.1. A listing of the sites in the EM-40 program is given in Table 6.1.

The Headquarters element of the EM-40 program is responsible for establishing policy and providing programmatic guidance to the field offices in implementing this program and determining appropriate priorities. In addition, Headquarters is responsible for formulating and executing the EM-40 budget. Other Headquarters responsibilities include tracking progress on environmental restoration activities and responding to information requests from Congress, other federal agencies, and public-interest groups.

In general, the Operations offices directing the environmental restoration program in the field are the same offices that directed activities at these sites when facilities were operational. For example, the Chicago Operations Office directs energy research and development activities at Ames Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory as well as manages the environmental restoration program at these three laboratories.

Over half of the sites in the EM-40 program are managed under the Uranium Mill Tailings Remedial Action Project (UMTRAP) and the Formerly Utilized Sites Remedial Action Program (FUSRAP). The Albuquerque Operations Office is responsible for implementing UMTRAP, which was authorized in 1978, and involves the stabilization and control of (a) 24 inactive uranium-processing sites and associated vicinity properties located

in 10 states and 2 Indian tribal lands and (b) vicinity properties associated with the Edgemont, South Dakota, inactive uranium mill site, which is owned by the Tennessee Valley Authority (Fig. 6.2). All of the sites are located in the western United States, except for one in Canonsburg, Pennsylvania. Remedial actions have been completed at 20 of the 24 inactive uranium processing sites (ref. 3). The Department is seeking revocation, at the state's request, of the two sites in North Dakota. Remediation of the remaining two UMTRAP sites is expected to be completed in 1997. In addition to the surface contamination present at these sites (mill tailings, soil, and structures), the ground water is contaminated with metals (including uranium and radium) at all sites, except for Lowman, Idaho. Active remediation of contaminated ground water is expected to be necessary at only two of these sites [Monument Valley and Tuba City, Arizona (ref. 2)].

The Oak Ridge Operations Office is responsible for implementing FUSRAP, which is primarily concerned with the cleanup of sites that were formerly used to support the activities of the Manhattan Engineer District, established for the Manhattan Project, and the Atomic Energy Commission (AEC). Private firms and institutions were contracted by the federal government in the 1940s and 1950s to develop processes and perform research on radioactive materials. The storage and processing of uranium and thorium ores, concentrates, and residues were often involved. Although these sites were cleaned up to formerly acceptable levels, FUSRAP was established in 1974 to identify; reevaluate; and, if necessary, remediate these sites. Most FUSRAP sites are in the eastern half of the country. Currently, 46 sites have been identified in 14 states; 25 of these sites have already been remediated (Fig. 6.3). Remediation of the remaining FUSRAP sites is expected to be completed within the next ten years.

6.3 ENVIRONMENTAL RESTORATION WASTE CHARACTERISTICS

The volumes and types of wastes associated with DOE environmental restoration activities are a direct result of the remedy chosen. Waste associated with remediation of contaminated environmental media would occur only when such media are exhumed. For example, no waste would be produced at a site for which an in situ remedy was selected, such as capping an area containing contaminated soil. If a minimal remedial action were selected (e.g., pumping and treating a small pocket of contaminated ground water followed by construction of lateral barriers to minimize future migration), the site would have relatively small waste volumes. However, if large volumes of contaminated environmental media were removed, treated to provide a more suitable waste form for disposal, and

then disposed of in an engineered facility, the site would have very large waste volumes.

Environmental restoration wastes are different from those associated with processing operations in that restoration wastes generally have much lower concentrations of radioactive and chemically hazardous substances. Much of the material requiring remediation is a consequence of past activities (e.g., spills, waste disposal, and environmental releases such as liquid discharges to drainage basins). In addition, operations within structures resulted in the contamination of equipment, walls, and floors from routine material-handling activities and from off-normal incidents such as spills and equipment failure. Decommissioning of these facilities will result in wastes such as wipes, concrete, metal, personal protective clothing, and decontamination solvents that generally have low concentrations of radioactive and chemical contaminants.

Environmental restoration wastes also differ from those resulting from processing operations in that they are generally highly heterogeneous both in physical form and chemical constituency. For example, remediation of an abandoned waste pit could require the exhumation of all materials previously placed into the pit for disposal. This effort could involve any possible combination of objects ranging from small pieces of equipment and drums to entire vehicles such as trucks and forklifts. In addition, a full spectrum of contaminants could be present in these previously disposed materials including those associated with ordnance operations, processing of uranium and thorium ores and concentrates, and the operation of nuclear reactors and associated chemical processing plants. This potential variety is in contrast to waste streams associated with processing activities that have relatively consistent chemical and physical properties.

Because many DOE environmental restoration projects are still in the remedy-selection phase, it is not possible to project definitively the wastes that will result from all of these projects. However, reasonable waste projections can be made based on current site characterization information and planned restoration activities for sites and facilities in the EM-40 program, as reflected in the Core Database (ref. 2). These estimates are presented in Tables 6.2 through 6.6. In addition to waste projections, the volumes of contaminated materials associated with in-situ remedies are also provided in these tables. The information provided in Tables 6.2 through 6.6 is consistent with the base case presented in BEMR 1996 (ref. 1) and reflect proposed site-specific land use assumptions. These estimates do not include contaminated media outside the scope of the current EM-40 program, such as contaminated sediment in the Clinch River near Oak Ridge, Tennessee, and underground materials contaminated by past hydrofracture disposal and nuclear testing at the Oak Ridge Reservation and the Nevada Test Site, respectively.

Materials in inventory (i.e., those with potential economic value) are also not included in these estimates.

In addition to wastes to be generated, environmental media projected to be left in place have also been assigned a "waste" class in the EM-40 Core Database. This was done to simplify the tracking of all contaminated materials and support response planning, even though these media are technically not wastes unless or until they are removed. Three major radioactive waste classes are associated with environmental restoration activities: LLW, TRUW, and 11e(2) by-product material. As defined in DOE Order 5820.2A, LLW is waste that contains radioactivity and is not classified as HLW, TRUW, spent nuclear fuel (SNF), or 11e(2) by-product material. Environmental restoration activities are not expected to generate any HLW or SNF. TRUW is waste contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and at concentrations greater than 100 nCi/g at the time of assay.

As defined in Section 11e(2) of the AEA of 1954 (Pub. L. 83-703, as amended), 11e(2) by-product material is tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Materials being managed under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (Pub. L. 95-604) are defined as residual radioactive material distinct from 11e(2) by-product material. This residual radioactive material is largely uranium mill tailings (UMT), as well as soil and debris contaminated with UMT. Since this material has the same physical and radioactive properties as 11e(2) by-product material, it is included in this report with 11e(2) by-product material.

In addition to radioactive contaminants, these materials can also be contaminated with hazardous constituents as regulated by RCRA or TSCA; such wastes are considered mixed wastes. Thus, a total of six waste classes are relevant for radioactively contaminated material resulting from environmental restoration activities: LLW, mixed LLW (MLLW), TRUW, mixed TRUW (MTRUW), 11e(2) by-product material, and mixed 11e(2) by-product material.

The estimated volumes of radioactively contaminated materials being managed by the EM-40 program are given in Tables 6.2 through 6.5 for LLW, MLLW, TRUW, and 11e(2) by-product material, respectively. The volumes given in Tables 6.4 and 6.5 include the contribution of mixed wastes (the mixed waste volumes are identified in footnotes). The mixed wastes reported in these four tables are limited to RCRA mixed wastes and do not include the contribution of TSCA mixed wastes. TSCA mixed wastes are reported separately in Table 6.6. In addition, radioactive wastes currently in storage at EM-40 facilities are reported in Table 6.7.

The estimated volumes given in Tables 6.2 through 6.6 are grouped into the following six categories:

1. collection for treatment, storage, and/or disposal by EM-40;
2. collection for treatment, storage, and/or disposal by EM-30;
3. collection for disposition at a commercial facility;
4. in-situ treatment or containment;
5. access/institutional controls or no further action; and
6. not yet determined.

Contaminated materials will be removed and wastes generated under the first three categories (ex-situ responses) with responsibility for final disposition either maintained within the EM-40 program, transferred to the EM-30 program, or targeted for a commercial facility. Wastes will not be generated under the fourth or fifth category, which will involve such measures as capping, monitoring, and retention of land-use controls. The last category addresses materials for which the final disposition is not currently known. Estimates in this group represent the difference between the total volume of a given contaminated material for a specific waste class at a site and the volume projected to be addressed by the indicated responses.

The estimates represent the initial response volumes, that is, the amount collected, not the final waste forms. Thus, changes due to activities such as treatment have not been incorporated. Treatment can result in higher or lower final volumes depending on the specific process used (e.g., stabilization versus incineration). Treatment can also change the waste class (e.g., stabilizing a MLLW material could result in an LLW product). These changes are not reflected in the information provided in Tables 6.2 through 6.7.

The total volume of solid radioactively contaminated material being addressed by the EM-40 program is approximately 88 million cubic meters. The two waste classes that constitute the largest volumes of radioactively contaminated material are LLW and 11e(2) by-product material. Of the material classified as LLW, most (70%) is projected to be managed in-situ. Los Alamos National Laboratory and the Hanford Site account for most of this volume. The large volume of 11e(2) by-product material is mainly the result of the large volume of residual radioactive material associated with UMT being remediated under UMTRAP.

The other four waste classes combined contribute about 15% of the total volume of radioactively contaminated material being addressed by the EM-40 program. Most of this volume is associated with material currently classified as MLLW. In reality, much of this material is probably LLW; characterization of this material is ongoing. The contribution for material classified as

TRUW is very small, representing about 0.1% of the total volume of material being addressed by the EM-40 program.

Because environmental restoration information is currently in the initial stages of being compiled at a number of sites, much of the information included in Tables 6.2 through 6.6 is preliminary. In addition, these tables include information only for sites currently in the EM-40 program for which data are available. That is, zero (or very small) volumes may be reported in the EM-40 Core Database for areas of a site at which characterization activities have not been initiated, thus resulting in an underestimate of the total volume of radioactively contaminated media. Conversely, overly conservative assumptions may be incorporated into some estimates to ensure the adequate sizing of treatment and disposal facilities. These uncertainties will continue to be reduced with time as characterization and engineering studies become available to refine these volume estimates.

As described earlier, remedial actions are currently being conducted at a number of sites, especially those associated with the FUSRAP and UMTRAP projects. Many of these are small, interim actions. Wastes resulting from these activities are generally being managed at the site where the remedial action occurred. However, large volumes of UMT are being relocated (consolidated) for a number of UMTRAP sites. In addition, wastes resulting from remedial actions at some sites (such as those being remediated under FUSRAP) are being managed at commercial disposal facilities. One such commercial facility currently being utilized is the Envirocare Facility near Clive, Utah. A summary of radioactive wastes resulting from environmental restoration activities disposed of at this facility through the end of 1995 is given in Table 0.8. More than 44,000 m³ of wastes resulting from DOE environmental restoration activities has been disposed of at that site.

The information contained in this chapter is limited to radioactively contaminated environmental media and

wastes, consistent with the scope of this report. The volume estimates given in Tables 6.2 through 6.7 are also limited to solid materials. Liquids, such as contaminated surface water and ground water and liquid wastes currently in storage, are not included. It should not be concluded that sites for which no (or minimal) volumes are indicated in Tables 6.2 through 6.7 have no waste management concerns. Environmental restoration activities at such sites could generate hazardous wastes as regulated by RCRA and TSCA, as well as large volumes of sanitary and demolition wastes. Also, additional characterization activities at these sites may identify areas of radioactive contamination requiring remediation in the future. As it becomes available, such information will be included in future updates of this report.

The volumes of radioactively contaminated materials given in Tables 6.2 through 6.7 are limited to those sites and facilities currently in the EM-40 program. These data are summed across all elements of a site in Tables 6.2 through 6.6 including environmental media, wastes currently in storage, and radioactively contaminated materials that could result from future decommissioning activities. Stored wastes are reported separately in Table 6.7. At a number of sites, wastes resulting from EM-40 activities have been transferred to the Office of Waste Management (EM-30) for treatment, storage, and disposal. These wastes are no longer being managed by EM-40 and are therefore not included in this chapter. Additional information on the MLLW currently in storage at EM-40 sites and that projected to result from future environmental restoration activities are given in Chapter 8 of this report.

The DOE Office of Nuclear Material and Facility Stabilization (EM-60) is responsible for coordinating the transfer of facilities to the Office of Environmental Management (EM-1). As facilities are transferred to EM-1, environmental restoration and waste management information will be developed and included in future updates of this report.

6.4 REFERENCES

1. U.S. Department of Energy, Office of Strategic Planning and Analysis, Office of Environmental Management, *The 1996 Baseline Environmental Management Report*, DOE/EM-0290, Washington, D.C. (June 1996).
2. U.S. Department of Energy, Office of Environmental Restoration, Office of Environmental Management, EM-40 Core Database, electronic database accessed in July 1996, Washington, D.C.
3. U.S. General Accounting Office, *Uranium Mill Tailings—Cleanup Continues, but Future Costs Are Uncertain*, GAO/RCED-96-37, Washington, D.C. (December 1995).

Fig. 6.1. Locations of field offices that direct the DOE environmental restoration program.

Fig. 6.2. Locations and status of UMTRAP sites.

Fig. 6.3. Locations and status of FUSRAP sites.

Table 6.1. List of sites in the DOE Environmental Restoration Program

Field office ^a	Site
Albuquerque	Inhalation Toxicology Research Institute Kansas City Plant Los Alamos National Laboratory Pantex Plant Pinellas Plant Sandia National Laboratories/California Sandia National Laboratories/New Mexico South Valley Superfund Site Uranium Mill Tailings Remedial Action Project ^b
Chicago	Ames Laboratory Argonne National Laboratory—East Argonne National Laboratory—West Brookhaven National Laboratory Hallam Site Piqua Site Princeton Plasma Physics Laboratory Site A/Plot M
Grand Junction	Grand Junction Projects Office Site Monticello Remedial Action Project
Idaho	Idaho National Engineering Laboratory
Nevada	Nevada Test Site Nevada off-site locations ^c
Oak Ridge	Formerly Utilized Sites Remedial Action Program ^d Oak Ridge Reservation ^e Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant
Oakland	Energy Technology Engineering Center General Atomics Site General Electric Vallecitos Nuclear Center Laboratory for Energy-Related Health Research Lawrence Berkeley Laboratory Lawrence Livermore National Laboratory Stanford Linear Accelerator Center
Ohio	Battelle Columbus Laboratories Fernald Environmental Management Project Mound Plant Reactive Metals, Inc., Site Separations Process Research Unit
Richland	Hanford Site

Table 6.1 (continued)

Field office ^a	Site
Rocky Flats	Rocky Flats Environmental Technology Site
Savannah River	Savannah River Site
Weldon Spring	Weldon Spring Site Remedial Action Project

^aAll of the field offices listed here are Operations offices except for Grand Junction (which reports to Albuquerque Operations) and Weldon Spring (which reports to Oak Ridge Operations). The locations of these field offices is shown in Fig. 6.1.

^bA listing of sites being addressed under UMTRAP is given in Fig. 6.2.

^cConsists of Amchitka Island, Alaska; the Rio Blanco and Rulison Test sites in Colorado; the Gnome and Gasbuggy Test sites in New Mexico; the Salmon Test Site in Mississippi; and the Shoal and Central Nevada Test sites in Nevada.

^dA listing of sites being addressed under FUSRAP is given in Fig. 6.3.

^eConsists of K-25 Site, Y-12 Plant, Oak Ridge National Laboratory, and contaminated areas in the vicinity of Oak Ridge, Tennessee, beyond the boundaries of these three facilities.

Table 6.2. Projected disposition of radioactively contaminated solid materials classified as LLW^a

Site	Response volume, ^b m ³					
	Ex-situ			In-situ treatment/ containment	Access control or no further action	Not yet determined
	Managed by EM-40	Transferred to EM-30	Commercial disposal			
Argonne National Laboratory-East		8,700	23			
Argonne National Laboratory-West	150		6			
Battelle Columbus Laboratories		710	1,400			
Brookhaven National Laboratory		400	120,000			
Energy Technology Engineering Center		1,600				
Fernald Environmental Management Project	1,800,000	180,000	480,000			5,800
Formerly Utilized Sites Remedial Action Program ^c						
Missouri sites	160,000					
New Jersey sites	6,300					
New York sites	9,400		930			
Other sites	79,000		15,000			
General Atomics Site	1,200					
General Electric Vallecitos Nuclear Center	20					
Hanford Site	3,900,000	700		20,000,000		
Idaho National Engineering Laboratory	420,000	140,000		79,000		
Inhalation Toxicology Research Institute		9,100				
Laboratory for Energy-Related Health Research		3,800				
Lawrence Berkeley Laboratory		9,400				
Los Alamos National Laboratory		15,000		200,000	8,900,000	110,000
Mound Plant		3,100	120,000			
Nevada off-site locations ^d				26,000		
Nevada Test Site		1,100,000		1,200		
Oak Ridge Reservation	30,000	9,800	850,000	51,000		
Paducah Gaseous Diffusion Plant	770,000	150			56	
Pantex Plant	54					
Portsmouth Gaseous Diffusion Plant	730,000	190				
Reactive Metals, Inc., Site		30,000				
Rocky Flats Environmental Technology Site	61,000	36,000				
Sandia National Laboratories/New Mexico		36,000			14,000	
Savannah River Site		400,000		310,000	1,800	1,800,000

Table 6.2 (continued)

Site	Response volume, ^b m ³						
	Ex-situ			In-situ treatment/ containment	Access control or no further action	Not yet determined	Total
	Managed by EM-40	Transferred to EM-30	Commercial disposal				
Separations Process Research Unit			15,000				15,000
Site A/Plot M			40				40
Total	8,000,000	1,900,000	1,600,000	21,000,000	8,900,000	1,900,000	43,000,000

^aInformation obtained from the EM-40 Core Database (July 1996). Volume estimates include environmental media such as soil, sediment, sludge, and intermixed rubble/debris; stored wastes; and standing structures and equipment. Sites not listed in this table do not have any radioactively contaminated solid material classified as LLW. The stored waste volumes are also provided separately in Table 6.7.

^bThese volume estimates represent the initial response volumes, not final waste forms. Changes in volumes and waste classes due to treatment are not reflected in this table. All values are preliminary and are being updated as site characterization and engineering studies continue. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^cA listing of the sites being addressed under FUSRAP is given in Fig. 6.3. The radioactively contaminated material classified as LLW in the EM-40 Core Database for those FUSRAP sites (Latty Avenue Properties in Missouri and the Luckey and Painesville sites in Ohio) may be reclassified as 11e(2) by-product material.

^dConsists of Amchitka Island, Alaska; the Rio Blanco and Rulison Test sites in Colorado; the Gnome and Gasbuggy Test sites in New Mexico; the Salmon Test Site in Mississippi; and the Shoal and Central Nevada Test sites in Nevada.

Table 6.3. Projected disposition of radioactively contaminated solid materials classified as MLLW^a

Site	Response volume, ^b m ³						Total
	Ex-situ			In-situ treatment/ containment	Access control or no further action	Not yet determined	
	Managed by EM-40	Transferred to EM-30	Commercial disposal				
Argonne National Laboratory-East	160	0.4		140,000			140,000
Battelle Columbus Laboratories		12	1				13
Brookhaven National Laboratory	3,200		16,000				19,000
Fernald Environmental Management Project		2,200	2,400				4,600
Formerly Utilized Sites Remedial Action Program ^c							
New York sites			12,000				12,000
Other sites	7,200						7,200
General Atomics Site	96						96
Hanford Site	220	100					320
Idaho National Engineering Laboratory	100,000		65	99,000			200,000
Laboratory for Energy-Related Health Research		4,400					4,400
Lawrence Berkeley Laboratory				42,000			42,000
Los Alamos National Laboratory			980		500,000		500,000
Nevada off-site locations ^d				11,000			11,000
Nevada Test Site		50					50
Oak Ridge Reservation		3,900			450,000	1,900	460,000
Paducah Gaseous Diffusion Plant	210,000				240,000		450,000
Portsmouth Gaseous Diffusion Plant	380				270,000		270,000
Reactive Metals, Inc., Site		11	17				28
Rocky Flats Environmental Technology Site	140,000	42,000		9,900	180,000		380,000
Sandia National Laboratories/New Mexico			1,700		2,600		4,300
Savannah River Site		150,000		3,900,000		6,600,000	11,000,000
Site A/Plot M			500				500
Total	470,000	200,000	34,000	4,200,000	1,600,000	6,600,000	13,000,000

^aInformation obtained from the EM-40 Core Database (July 1996). Volume estimates include environmental media such as soil, sediment, sludge, and intermixed rubble/debris; stored wastes; and standing structures and equipment. Sites not listed in this table do not have any radioactively contaminated solid material classified as MLLW. The stored waste volumes are also provided separately in Table 6.7.

^bThese volume estimates represent the initial response volumes, not final waste forms. Changes in volumes and waste classes due to treatment are not reflected in this table. All values are preliminary and are being updated as site characterization and engineering studies continue. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^cA listing of the sites being addressed under FUSRAP is given in Fig. 6.3.

^dConsists of Amchitka Island, Alaska; the Rio Blanco and Rulison Test sites in Colorado; the Gnome and Gasbuggy Test sites in New Mexico; the Salmon Test Site in Mississippi; and the Shoal and Central Nevada Test sites in Nevada.

Table 6.4 Projected disposition of radioactively contaminated solid materials classified as TRUW^a

Operations office	Response volume, ^b m ³					Total
	Ex-situ		In-situ treatment/ containment	Access control or no further action	Not yet determined	
	Managed by EM-40	Transferred to EM-30				
Argonne National Laboratory-East	20 ^c	190				190
Battelle Columbus Laboratories		95				95
General Electric Vallecitos Nuclear Center						20
Hanford Site		1,800			84	1,900
Idaho National Engineering Laboratory		9,700 ^d				9,700
Los Alamos National Laboratory			4,400			4,400
Oak Ridge Reservation	12 ^c	1,500	130			1,600 ^e
Paducah Gaseous Diffusion Plant	7 ^{c,d}					7
Portsmouth Gaseous Diffusion Plant						
Rocky Flats Environmental Technology Site		1,900			3,000	4,900 ^f
Sandia National Laboratories/New Mexico				4,000 ^d		4,000
Savannah River Site		65,000				65,000
Separations Process Research Unit		36				36
Total	39	80,000	4,500	4,000	3,100	91,000

^aInformation obtained from the EM-40 Core Database (July 1996). Volume estimates include environmental media such as soil, sediment, sludge, and intermixed rubble/debris; stored wastes; and standing structures and equipment and include the contribution of material classified as MTRUW. Sites not listed in this table do not have any radioactively contaminated solid material classified as TRUW. The stored waste volumes are provided separately in Table 6.7.

^bThese volume estimates represent the initial response volumes, not final waste forms. Changes in volumes and waste classes due to treatment are not reflected in this table. All values are preliminary and are being updated as site characterization and engineering studies continue. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^cThese wastes are expected to be packaged and eventually transferred to the Waste Isolation Pilot Plant for final disposition.

^dMTRUW.

^eAt Oak Ridge National Laboratory, 45 m³ of the TRUW is MTRUW.

^fAt the Rocky Flats Environmental Technology Site, 4,100 m³ of the TRUW is MTRUW.

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CHAPTER 6: TABLE 6.5 ERRATA

NOTE: Table 6.5 was revised to correct a couple of erroneous entries and to delete those materials that have been disposed of already in EM-40-managed facilities. These materials are included in Table 6.7. Table 6.5 was revised on January 28, 1997.

(over)

Table 6.5. Projected disposition of radioactively contaminated solid materials classified as 11e(2) by-product material^{a,b}

Operations office	Response volume, ^c m ³						Total
	Ex-situ			In-situ treatment/ contaminant	Access control or no further action	Not yet determined	
	Managed by EM-40	Transferred to EM-30	Commercial disposal				
Fernald Environmental Management Project Formerly Utilized Sites Remedial Action Program ^e		11,000 ^d					11,000
Missouri sites	340,000			190,000			530,000
New Jersey sites	68,000		390,000				460,000 ^f
New York sites	280,000 ^g		460				280,000
Other sites	28,000						28,000
Grand Junction Projects Office Site	3,200						3,200
Monticello Remedial Action Project	1,900,000				14,000		1,900,000
Uranium Mill Tailings Remedial Action Program ^h	3,200,000						3,200,000
Weldon Spring Site Remedial Action Project	670,000 ⁱ						670,000
Total	6,500,000	11,000	390,000	190,000	14,000		7,100,000

^aInformation obtained from the EM-40 Core Database (July 1996). Volume estimates include environmental media such as soil, sediment, sludge, and intermixed rubble/debris; stored wastes; and standing structures and equipment and include the contribution of material classified as mixed 11e(2) by-product material. Sites not listed in this table do not have any radioactively contaminated solid material classified as 11e(2) by-product material. The stored waste volumes are provided separately in Table 6.7.

^bBy-product material as defined in Section 11e(2) of the Atomic Energy Act of 1954 (P.L. 83-703), as amended. Materials being managed under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (Pub. L. 95-604) are defined as residual radioactive material. Since this material has the same physical and radioactive properties as 11e(2) by-product material, it is reported here under 11e(2) by-product material.

^cThese volume estimates represent the initial response volumes, not final waste forms. Changes in volumes and waste classes due to treatment are not reflected in this table. All values are preliminary and are being updated as site characterization and engineering studies continue. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^dResidues in storage in four concrete silos.

^eA listing of the sites being addressed under FUSRAP is given in Fig. 6.3.

^fIncludes 83,000 m³ of 11e(2) by-product material soil in bulk storage at the Middlesex Sampling Plant and the Wayne and Maywood Interim Storage sites and 24,000 m³ of mixed 11e(2) by-product soil in bulk storage at the Middlesex Sampling Plant.

^gAdditional 190,000 m³ of contaminated soil and residues have been disposed of in a containment cell at the Niagara Falls Storage Site (see Table 6.7).

^hA listing of the sites being addressed under UMTRAP is given in Fig. 6.2. The volume of mill tailings and debris associated with the 20 sites for which remedial actions have been completed is 27,000,000 m³ (see Table 6.7).

ⁱIncludes 160,000 m³ of 11e(2) by-product material soil and debris and 20,000 m³ of mixed 11e(2) by-product material soil and debris in interim storage at the chemical plant area of the Weldon Spring Site.

Table 6.5. Projected disposition of radioactively contaminated solid materials classified as 11e(2) by-product material^{a,b}

Operations office	Response volume, ^c m ³						Total
	Ex-situ			In-situ treatment/ contaminant	Access control or no further action	Not yet determined	
	Managed by EM-40	Transferred to EM-30	Commercial disposal				
Fernald Environmental Management Project Formerly Utilized Sites Remedial Action Program ^d		11,000					11,000
Missouri sites	340,000			190,000			530,000
New Jersey sites	68,000 ^e		390,000				460,000
New York sites	280,000		460		190,000 ^f		540,000
Other sites	28,000						28,000
Grand Junction Projects Office Site	3,200						3,200
Monticello Remedial Action Project	1,900,000				14,000		1,900,000
Uranium Mill Tailings Remedial Action Program ^g	30,000,000						30,000,000
Weldon Spring Site Remedial Action Project	670,000 ^h						670,000
Total	31,000,000	11,000	390,000	190,000	190,000		32,000,000

^aInformation obtained from the EM-40 Core Database (July 1996). Volume estimates include environmental media such as soil, sediment, sludge, and intermixed rubble/debris; stored wastes; and standing structures and equipment and include the contribution of material classified as mixed 11e(2) by-product material. Sites not listed in this table do not have any radioactively contaminated solid material classified as 11e(2) by-product material. The stored waste volumes are provided separately in Table 6.7.

^bBy-product material as defined in Section 11e(2) of the Atomic Energy Act of 1954 (P.L. 83-703), as amended. Materials being managed under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604) are defined as residual radioactive material. Since this material has the same physical and radioactive properties as 11e(2) by-product material, it is reported here under 11e(2) by-product material.

^cThese volume estimates represent the initial response volumes, not final waste forms. Changes in volumes and waste classes due to treatment are not reflected in this table. All values are preliminary and are being updated as site characterization and engineering studies continue. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^dA listing of the sites being addressed under FUSRAP is given in Fig. 6.3.

^eIncludes 24,000 m³ of mixed 11e(2) by-product material soil in bulk storage at the Middlesex Sampling Plant. The storage pile is covered with a tarp.

^fConsists of soil and residues disposed of in a containment cell at the Niagara Falls Storage Site.

^gA listing of the sites being addressed under UMTRAP is given in Fig. 6.2. The volume of mill tailings and debris associated with the 20 sites for which remedial actions have been completed is 27,000,000 m³, leaving 3,200,000 m³ of mill tailings and debris for which remedial actions are currently ongoing.

^hIncludes 20,000 m³ of mixed 11e(2) by-product material soil and debris in interim storage at the chemical plant area of the Weldon Spring Site.

Table 6.6. TSCA mixed waste associated with EM-40 activities^a

Site	Response volume ^b , m ³	
	RASB ^c	RPCB ^d
Argonne National Laboratory-East	5 ^e	
Grand Junction Projects Office Site	38 ^f	46 ^{f,g}
Mound Plant	870 ^h	
Oak Ridge Reservation	75 ^e	1 ^e
Paducah Gaseous Diffusion Plant	430 ^{f,g}	3,500 ^{f,g}
Portsmouth Gaseous Diffusion Plant		3,600 ^{f,g}
Reactive Metals, Inc., Site	580 ^e	
Separative Process Research Unit	2 ^h	
Weldon Spring Site Remedial Action Project	7,500 ^{f,g}	

^aInformation obtained from the EM-40 Core Database (July 1996). Volume estimates include environmental media such as soil, sediment, sludge, and intermixed rubble/debris; stored wastes; and standing structures and equipment. Sites not listed in this table do not have any radioactively contaminated solid material classified as mixed TSCA wastes. The stored waste volumes are also provided separately in Table 6.7.

^bThese volume estimates represent the initial response volumes, not final waste forms. Changes in volumes and waste types due to treatment are not reflected in this table. All values are preliminary and are being updated as site characterization and engineering studies continue. Values are given to two significant figures or the nearest integer (for volumes less than 10 m³).

^cRadioactive asbestos, i.e., materials contaminated with both radionuclides and asbestos.

^dRadioactive PCBs, i.e., materials contaminated with both radionuclides and polychlorinated biphenyls.

^eProjected to be transferred to EM-30 for final disposition.

^fProjected to be managed by EM-40 through final disposition.

^gWastes currently in storage.

^hProjected to be transferred to a commercial facility for final disposition.

Table 6.7. Volumes (m³) of solid radioactive wastes in storage at EM-40 facilities^a

Site	Waste type							Total
	TRUW	MTRUW	LLW	MLLW ^b	11e(2) by-product material	Mixed 11e(2) by-product material	RASB ^c	RPCB ^d
Battelle Columbus Laboratories	41							41
Fernald Environmental Management Project			140,000	3,500	11,000 ^e			150,000
Formerly Utilized Sites Remedial Action Program ^f								
Missouri sites			24,000 ^g					24,000
New Jersey sites					83,000 ^h	24,000 ⁱ		110,000
New York sites					190,000 ^j			190,000
Other sites			1,500 ^k					1,500
General Atomics Site			35	5				40
Grand Junction Projects Office Site								46 ^l
Paducah Gaseous Diffusion Plant	2		5,200	1,000			430	3,500
Portsmouth Gaseous Diffusion Plant			9,000	6,800				3,600
Reactive Metals, Inc., Site			550	28				
Uranium Mill Tailings Remedial Action Program					27,000,000 ^m			
Weldon Spring Site Remedial Action Project					160,000	20,000	7,500 ^l	

^aInformation obtained from the EM-40 Core Database (July 1996). Waste volumes are limited to solid wastes and do not include EM-40-generated wastes that are currently in storage facilities managed by EM-30. Volumes are given to two significant figures or the nearest integer (for volumes less than 10 m³). Some totals may not equal sum of components, due to independent rounding.

^bManagement plans for these wastes are provided in site treatment plans developed to meet the requirements of the Federal Facility Compliance Act.

^cRadioactive asbestos, i.e., materials contaminated with both radionuclides and asbestos.

^dRadioactive PCBs, i.e., materials contaminated with both radionuclides and polychlorinated biphenyls.

^e11e(2) by-product material residues in storage in four concrete silos.

^fA listing of sites being addressed under FUSRAP is given in Fig. 6.3.

^gLow-level waste soil in bulk storage at the Hazelwood Interim Storage Site. The storage pile is covered with a tarp.

^h11e(2) by-product material soil in bulk storage at the Middlesex Sampling Plant and the Wayne and Maywood Interim Storage Sites. All of the storage piles are covered with tarps.

ⁱMixed 11e(2) by-product material soil in bulk storage at the Middlesex Sampling Plant. The storage pile is covered with a tarp.

^j11e(2) by-product material residues and soil disposed of in a containment cell at the Niagara Falls Storage Site.

^kLow-level waste soil in bulk storage at the CE Site.

^lThe radioactive classification of this waste is 11e(2) by-product material.

^mWaste volume associated with the 20 completed UMTRAP sites (see Fig. 6.2).

7. NATURALLY OCCURRING AND ACCELERATOR-PRODUCED RADIOACTIVE MATERIAL

7.1 INTRODUCTION

Naturally occurring and accelerator-produced radioactive material (NARM) is a broad category that includes accelerator-produced radioactive material (ARM) and naturally occurring radioactive material (NORM) and is not source, special nuclear, or by-product material. ARM wastes include materials generated by accelerators used in subatomic particle physics research.

The term NORM refers to materials not covered under the AEA whose radioactivity has been enhanced (i.e., materials whose radionuclide concentrations are either increased or redistributed compared to typical background levels either naturally or as the result of human intervention or processes). Examples are exploration and production wastes from the oil and natural gas industries and phosphate slag piles from the phosphate mining industry. NORM is not used to describe or discuss the natural radioactivity of rocks and soils or background radiation.

NARM wastes are currently not regulated by any federal agency. Responsibility for regulating the disposal of NARM is not addressed in the Atomic Energy Act (AEA).¹ Regulation of NARM disposal currently rests with the states as part of their authority for ensuring the protection of public health and safety.^{2,3} However, currently a few states do not have regulatory programs for NARM wastes.

7.2 WASTE CHARACTERIZATION

The accelerator wastes (ARM) that comprise NARM include accelerator targets, wastes from accelerator maintenance and D&D, and wastes from radiopharmaceutical manufacture. Table 7.1 (based on ref. 4) lists the radionuclides found in ARM wastes. Except for ⁸¹Kr, ¹⁴⁵Pm, and ²²Na, most of these radionuclides have short half-lives that are measured in days, hours, or minutes.

Compared to radioactive wastes associated with most research, industrial, and medical applications, NARM

wastes have low radioactivity concentrations. NARM waste with more than 2 nCi/g of ²²⁶Ra or equivalent is commonly referred to as discrete NARM waste; below this threshold, the waste is referred to as diffuse NARM waste.

7.2.1 Discrete Wastes

Discrete wastes have a relatively small volume but large radioactivity; these include industrial gauges, old radium watch and industrial dials, radium needles in medical equipment, and resins (filters) that remove radioactive radium and other NORM from ground water.

7.2.2 Diffuse Wastes

Diffuse wastes are characterized by a relatively large volume with small radioactivity.⁵ These materials result from industrial processes and include:

- coal ash and slag from utility electrical generation;
- solid wastes from geothermal energy production;
- slag, leachate, and tailings from the mining and processing of metals other than uranium or thorium (e.g., copper);
- sludge from drinking water treatment;
- scale, sludge, produced water, and equipment from oil and natural-gas production containing NORM; and
- wastes (phosphogypsum and slag) from mining phosphate ores for fertilizer (ammonium phosphate) production.

A summary of domestic processes that generate NORM wastes are given in Table 7.2 (based on refs. 6–9). Levels of specific activity for these wastes typically vary from 2–200 pCi/g.^{6,10} Table 7.3 (adapted from refs. 9 and 11) lists major radionuclides found in diffuse NORM wastes. Estimated radionuclide concentrations reported by the Environmental Protection Agency (EPA) in ref. 9 for each diffuse NORM category are provided in Tables 7.4–7.9.

Descriptions of the specific characteristics of diffuse NORM wastes are given in the following and are based on

the EPA waste characterization and preliminary risk assessment study of ref. 9.

7.2.2.1 Coal combustion

Fossil fuels such as coal contain naturally occurring radioactivity from uranium, thorium, radium, and their daughter products. The combustion of coal as a fossil fuel for electric power and industrial applications results in the generation of ash, which is collected at the bottom of power plant boilers and in exhaust stack filters. Consisting mostly of aluminum, iron, calcium, and silicon, coal ash is retained either as bottom ash and boiler slag or as fly ash trapped in exhaust stack filtration devices. Most of the waste is generated as fly ash, which is entrained with the hot flue gases of the combustion process. The remainder of the ash is heavier and settles to the bottom of the boiler to form what is referred to as bottom ash. Liquid boiler slag is formed when some of the bottom ash melts under the intense heat.⁹ Table 7.4 (based on ref. 9) gives a breakdown of the radionuclide concentrations found in NORM wastes from coal combustion. These concentrations, however, can vary widely depending on the mineral content of the coal which, in turn, can vary with mining location and region of the country.

7.2.2.2 Geothermal energy production

Geothermal energy is heat produced and stored in the earth. This energy can be economically extracted from high-temperature crustal rocks, sediments, volcanic deposits, water, steam, and other gases found at accessible depths from the earth's surface. Concentrations of NORM are found in the solid wastes generated by the exploration and development of geothermal systems and the extraction of the earth's geothermal energy for use in either producing electric power or supplying direct heat. These NORM wastes include minerals that precipitate out of solution and form scale or sludge on the inside surfaces of the drilling and production equipment (e.g., steam turbines, heat exchangers, process lines, valves, turbines, and fluid-handling equipment) used to extract geothermal heat. Such wastes contain barium, calcium, and strontium salts (carbonates, sulfates, and silicates) and silica as well as significant concentrations of radium and radium decay products. Radium is slightly soluble and, consequently, can be brought to the surface and coprecipitated with barium and calcium salts onto the inside surfaces of drilling and production equipment. The principal wastes of concern are the scales in piping and production equipment and the filter cake produced from treatment of spent geothermal fluids prior to reinjection. Scales are hard, insoluble sulfate deposits that form on the inside of pipes, tubulars, filters, pumps, well heads, and other water-handling equipment.⁸ Concentrations of NORM in geothermal wastes will vary

with the geology and mineralogy of a geothermal resource area along with the physical and chemical changes that occur during energy extraction.⁹ Table 7.5 (based on ref. 9) gives a breakdown of typical radionuclide concentrations found in NORM wastes from geothermal energy production.

7.2.2.3 Metal mining and processing

The mining and processing of metal ores, other than uranium and phosphate, generates large quantities of NORM wastes. These wastes include ore tailings and smelter slag, some of which contain elevated concentrations of uranium, thorium, radium, and their decay products that were originally part of the process feed ore. The extraction process for some ores can yield a waste product (e.g., tailings or slag) that has a higher radionuclide concentration than the original ore. Tailings are the solid materials remaining after physical or chemical beneficiation (washing, flotation, grinding, and drying) removes the valuable metal constituents from the ore. Slag is the vitreous residue mass left from the smelting (blast furnace melting and conversion) of metal ore for extraction and purification.⁹

The EPA study of ref. 9 describes NORM wastes from the mining and processing of three categories of metals: rare earth metals, special application metals, and metals produced in bulk quantities (i.e., large volumes) by industrial extraction processes. Rare earth (or lanthanide) metals comprise 16 chemical elements, including those with atomic numbers 57 (lanthanum) through 71 (lutetium) as well as yttrium (atomic number 39), which has similar chemical properties. Special application metals are regarded as metals that have unique commercial and industrial uses and include hafnium, tin, titanium, and zirconium. Metals mined and processed in bulk for industrial applications include aluminum, copper, iron, lead, zinc, and precious metals like gold and silver.⁹

The level of NORM found in metal ores depends more on the geologic formation or region than on the particular mineral being mined. Table 7.6 (based on ref. 9) gives a breakdown of typical radionuclide concentrations found in NORM wastes from each of the three categories of mined metals.⁹

7.2.2.4 Municipal water treatment

A small portion of the public water supply systems in the United States treat water containing elevated NORM radionuclide concentrations—most significantly, uranium and radium. Radionuclides are leached into ground or surface water when the water comes in contact with uranium- and thorium-bearing geologic media. The predominant radionuclides found in water include those of uranium, radium, radon, and their decay products. Many

water treatment technologies typically used for removing solids from water for softening and purification can significantly reduce the level of NORM radioactivity. NORM wastes from municipal water treatment consist of radioactive-contaminated sludges and solids that include filter sludges, spent ion-exchange resins, spent granular activated carbon, and water from filter backwash. Radium-selective ion-exchange resins generate wastes at much higher concentrations than those found in sludge, but in smaller quantities. In fact, some of these wastes fall into the discrete NARM waste category because their concentrations exceed 2 nCi/g.⁹ Table 7.7 (based on ref. 9) gives estimated typical radionuclide concentrations of NORM wastes from municipal water treatment. These concentrations can vary significantly from location to location because of the varying geologic characteristics of different water sources in different regions of the country.

7.2.2.5 Oil and natural gas production and processing

Some oil and natural gas production and processing activities generate NORM wastes. Radium is a major contributor to the radioactivity found in these wastes, which are found in pipe scale and sludge from production and processing operations. Uranium and thorium compounds are mostly insoluble, and as oil and natural gas are brought to the surface, these compounds tend to remain embedded in underground geologic formations. However, some radium and radium daughter products are slightly soluble in water and can become mobilized when ground water (containing dissolved mineral salts) is brought to the surface from production and processing. When this occurs, some radium and its daughters may precipitate out of solution because of geologic chemical changes and reduced temperature and pressure. Radium concentrations from geologic formations can precipitate out in sludges and on the interior surfaces of oil and natural gas piping and production and processing equipment. The solid scale residue typically consists mainly of barium, calcium, and strontium sulfates, silicates, and carbonates along with smaller portions of radium compounds. Sludge deposits, consisting of barium and silica compounds, are generally in the form of oily, loose material. NORM radionuclide concentrations in scales that accumulate in process piping and surface equipment may vary from background soil levels (about 1 pCi/g) to several hundred thousand picocuries per gram—with an average activity of about 1000–2000 pCi/g.¹² Concentrations in sludges range from background levels to several hundred picocuries per gram. Radium and its decay products are also found in elevated concentrations in ground water extracted to the surface from oil drilling. However, these concentrations are much less than those found for the scale or sludge wastes.⁹

NORM wastes from natural gas plant deposits differ from oil production NORM wastes and typically consist of

radon decay products plated out on the interior surfaces of pipes, valves, filters, and other gas production and processing equipment.⁹

Table 7.8 (based on ref. 9) gives estimated radionuclide concentrations of NORM wastes from both oil and natural gas production and processing. As with other NORM wastes, the radioactivity concentrations for the scale and sludge wastes are strongly influenced by the natural abundance of radionuclides, the geologic formation conditions where the oil and natural gas are produced, and the characteristics of the production process.^{9,13}

7.2.2.6 Phosphate mining and fertilizer production

NORM wastes are generated from the mining and processing of phosphate rock (phosphorite) needed to produce phosphate fertilizers, detergents, animal feed, food products, pesticides, and other phosphorous chemicals. These wastes include ferrophosphorus, phosphogypsum (a hydrated calcium sulfate slurry), piping scale, and slag (calcium silicate).⁹

Phosphogypsum and scale are the principal waste by-products generated during the production of phosphoric acid and fertilizers. Scale is deposited in small quantities in process piping and in filtration receiving tanks. Phosphate scale wastes are generally regarded as discrete NORM because ²²⁶Ra concentrations in small volumes of these materials have been found to be as high as 100,000 pCi/g.^{9,14}

Ferrophosphorus and phosphate slag are the principal waste by-products from the production of elemental phosphorous, which is produced by the reduction of phosphate rock in large electric furnaces that use carbon and silica as catalysts. Both ferrophosphorus and slag are found in the residual solids that remain from the furnace processing.⁹

Table 7.9 (based on ref. 9) gives estimated radionuclide concentrations in the principal NORM wastes from phosphate mining and fertilizer production. These concentrations include contributions from uranium, thorium, radium, and their radioactive decay products, which are found in mined phosphate ores and have become concentrated in the waste by-products. Actual radionuclide concentrations will vary in location because of varying geological characteristics of phosphate ores in different regions of the country as well as variations in the processes used for phosphate mining and production.⁹

7.3 GENERATION, INVENTORIES AND PROJECTIONS

Limited information is available on the generation, inventories, and projections of domestic NARM wastes. Table 7.10 reports the inventories of radium disposed of in recent years by New York State generators.⁶ Currently

NARM wastes are shipped for disposal to either the Envirocare Facility near Clive, Utah, or the U.S. Ecology, Inc. site near Richland, Washington. As Table 0.8 in Chapter 0 shows, nearly 280,000 m³ of NARM wastes were disposed of at the Envirocare Facility by the end of CY 1995. Most of these wastes were generated from programs sponsored by DOD and EPA. Only a small portion (4.5%) of the cumulative volume of NARM wastes disposed of at the Envirocare Facility resulted from commercial activities.

Like inventories, projections of NARM (and NORM) are limited and vary according to the region of the country. Table 7.11 (adapted from refs. 9 and 11) reports a summary of estimates of domestic diffuse NORM waste generation, material density, cumulative inventory, and radioactive (²²⁶Ra) concentration. These estimates are reported in refs. 9 and 11 and pertain to wastes from commercial rather than DOE activities. EPA information and data reported from ref. 9 are, in turn, based on refs. 13–26. It should be cautioned that the large quantities reported in Table 7.11 for cumulative NORM inventories are preliminary estimates associated with large ranges of

uncertainty. Consequently, caution should be used in trying to extrapolate any of the referenced information and data for purposes such as risk assessment or determining needed disposal facilities. The estimates given in Table 7.11 also do not reflect possible opportunities for the reuse and recycling of NORM materials in commercial and industrial applications. Such applications are further discussed in ref. 9.

The ubiquitous nature of NORM wastes accounts for the apparent enormous inventory of these materials. Even allowing for uncertainties, the estimated cumulative volume of these materials is much larger than the cumulative volume of DOE and commercial radioactive waste and SNF being managed through CY 1995 (see the tables of Chapter 0 and Chapter 6).

The total inventory that should be associated with NORM will depend on what regulatory concentration standards can be applied to these materials on a national basis. Future updates of this document will include additional and updated information and data on both accelerator-produced waste and NORM waste inventories, projections, and characteristics as they become available.

7.4 REFERENCES

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Table 7.1. Radionuclides found in accelerator-produced radioactive materials^a

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c
¹¹ C	6	20.4 min	β^+	⁸¹ Rb	37	4.6 h	EC
¹³ N	7	10.0 min	β^+	⁸² Rb	37	6.4 h	β^+ , γ
¹⁵ O	8	2.0 min	β^+	⁸⁴ Rb	37	34.0 d	EC
¹⁸ F	9	1.8 h	β^+	⁸² Sr	38	25.0 d	EC
²² Na	11	2.6 y	β^+ , γ	^{87m} Sr	38	2.8 h	IT
²⁸ Mg	12	21.1 h	β , γ	⁸⁷ Y	39	80.3 h	EC
²⁸ Al	13	2.2 min	β , γ	^{97m} Tc	43	90.0 d	IT
³³ P	15	25.3 d	β	¹¹¹ In	49	2.83 d	EC, γ
³⁷ Ar	17	34.8 d	EC	¹²³ I	53	13.1 h	EC, γ
⁴³ K	19	22.2 h	β , γ	¹²⁴ I	53	4.2 d	EC, γ
⁴⁹ Sc	21	57.3 min	β , γ	¹²⁵ I	53	59.7 d	EC, γ
⁵² Mn	25	5.7 d	β^+ , γ	¹²⁶ I	53	13.0 d	EC, γ
⁵² Fe	26	8.3 h	β^+ , γ	¹²⁷ Xe	54	36.4 d	EC, γ
⁵⁷ Co	27	271 d	EC	¹³¹ Cs	55	9.7 d	EC
⁵⁸ Co	27	71 d	EC	¹⁴⁵ Pm	61	18 y	EC
⁶² Cu	29	9.8 min	β^+ , γ	¹⁵⁷ Dy	66	8.1 h	EC, γ
⁶⁷ Cu	29	61.7 h	β , γ	¹⁹⁰ Os	76	9.9 min	IT
⁶² Zn	30	9.2 h	EC, γ	¹⁹⁰ Ir	77	12.2 d	EC, γ
⁶⁶ Ga	31	9.5 h	β^+ , γ	^{190m} Ir	77	1.2 h	IT
⁶⁸ Ge	32	287 d	EC, γ	^{193m} Pt	78	4.3 d	IT
⁷³ As	33	80.3 d	EC	¹⁹⁵ Au	79	184.0 d	EC, γ
⁷³ Se	34	7.1 h	β^+	¹⁹⁷ Hg	80	64.1 h	EC, γ
⁷⁷ Br	35	56.0 h	β^+ , γ	¹⁹⁹ Tl	81	7.4 h	EC, γ
⁷⁷ Kr	36	1.2 h	β^+	²⁰³ Pb	82	52.1 h	EC, γ
⁸¹ Kr	36	2.1×10^5 y	EC	²⁰⁴ Bi	83	11.3 h	EC, γ

^aBased on ref. 4.^by—years, d—days, h—hours, and min—minutes.^c α —alpha decay, β —negative beta decay, β^+ —positive beta decay, γ —gamma emission, EC—electron capture, and IT—*isomeric transition*.

Table 7.2. Domestic processes that generate NORM waste^a

Process	Waste generated	Classification by specific activity ^b	Major generator locations(s)
Coal combustion	Fly ash	Diffuse	Midwestern and South Atlantic states
	Bottom ash and slag	Diffuse	
Geothermal energy production	Solid wastes	Diffuse	California
Manufacturing	Old/used products: industrial gauges, radium watches and industrial dials, and radium needles in medical equipment	Discrete	Various commercial sites
Metal mining and processing	Slag, leachate, and tailings from the following: Rare earth metals	Diffuse	California, Florida, and North Carolina
	Special-application metals (zirconium, hafnium, titanium, and tin)	Diffuse	Ohio, Delaware, and Florida
	Large-volume metal-processing industries (copper, iron, etc.)	Diffuse	Ohio, Pennsylvania, Indiana, Illinois, Michigan, and some western states
Municipal water treatment	Sludge	Diffuse	North central (e.g., Illinois) and coastal plain (e.g., North Carolina) states and other states
	Radium selective resins	Discrete	
Oil and natural gas production and processing	Scale	Discrete or diffuse	In all petroleum and natural gas states having production and processing facilities ^c
	Sludge	Diffuse	
	Contaminated water and production/processing equipment	Diffuse	
Phosphate mining and fertilizer production	Ferrophosphorous	Diffuse	Florida, Idaho, and other states in the West and Southeast
	Phosphogypsum ^d	Diffuse	
	Scale	Discrete	
	Slag	Diffuse	

^aBased on ref. 6 (p. 13-9), and refs. 7-8.

^bIn fact, many of the wastes generated can be either diffuse or discrete. What is listed in this column is the classification most typically associated with a particular waste generated.

^cAs yet, the geographic distribution of NORM from oil and natural gas production/processing has not been well characterized statistically. See refs. 7 and 8.

^dCalcium sulfate.

Table 7.3. Major radionuclides found in diffuse NORM wastes^a

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Natural decay series ^d	Principal source(s) ^e
²³⁸ U	92	4.468E+09 y	α	U	1, 2, 4, 5, 7
²³⁵ U	92	7.037E+08 y	α	A	1, 5, 7
²³⁴ U	92	2.454E+05 y	α	U	1, 2, 4, 5, 7
²³¹ Pa	91	3.276E+04 y	α	A	1, 5
²³² Th	90	1.405E+10 y	α	T	1, 5, 7
²³⁰ Th	90	7.54E+04 y	α	U	1, 2, 4, 5, 7
²²⁸ Th	90	1.913 y	α	T	1, 5, 6, 7
²²⁷ Ac	89	2.177E+01 y	α, β	A	1, 5
²²⁸ Ra	88	5.75 y	β	T	1, 5, 6
²²⁶ Ra	88	1.600E+03 y	α	U	1, 2, 3, 4, 5, 6, 7
²²⁴ Ra	88	3.66 d	α	T	1, 5, 6, 7
²²² Rn	86	3.825 d	α	U	1, 2, 3, 4, 5, 6, 7
²¹⁰ Po	84	1.383E+02 d	α	U	1, 2, 4, 5, 6, 7
²¹⁰ Pb	82	1.94E+01 y	β	U	1, 2, 4, 5, 6, 7
⁴⁰ K	19	1.277E+09 y	β	—	1, 2, 4, 6, 7

^aBased on refs. 9 and 11.^by—years and d—days.^cα—alpha decay and β—negative beta decay.^dU—uranium series (²³⁸U parent, ²⁰⁶Pb stable end daughter); A—actinium series (²³⁵U parent, ²⁰⁷Pb stable end daughter); and T—thorium series (²³²Th parent, ²⁰⁸Pb stable end daughter).^e1—coal combustion; 2—geothermal energy production; 3—manufacturing (industrial gauges, watches, etc., and medical needles); 4—metal mining and processing; 5—municipal water treatment; 6—oil and gas production; and 7—phosphate mining and fertilizer production.

Table 7.4. Radionuclide concentrations in coal combustion wastes^a

Nuclide	Concentration (pCi/g)	
	Fly ash	Bottom ash and slag
²³⁸ U	2.6	0.7
²³⁵ U	0.13	0.03
²³⁴ U	2.6	0.7
²³¹ Pa	0.13	0.03
²³² Th	1.7	0.4
²³⁰ Th	1.8	0.5
²²⁸ Th	2.6	0.6
²²⁷ Ac	0.13	0.03
²²⁸ Ra	1.4	0.4
²²⁶ Ra	3.0	0.7
²¹⁰ Po	5.6	1.4
²¹⁰ Pb	5.4	1.4
Total ^b	27.1	6.9

^aBased on ref. 9, which assumes that 80 wt % of the concentration is fly ash.

^bExcludes contributions from other (short-lived) radionuclides in decay chains.

Table 7.5. Radionuclide concentrations in geothermal energy production waste^a

Nuclide	Waste concentration (pCi/g)
²²⁸ Th	25
²²⁸ Ra	93
²²⁶ Ra	132
²¹⁰ Po	96
²¹⁰ Pb	96
Total ^b	442

^aBased on ref. 9.

^bExcludes contributions from other (short-lived) radionuclides in decay chains.

Table 7.6. Radionuclide concentrations in metal mining and processing wastes^a

Nuclide	Waste concentration, pCi/g		
	Rare earth metals	Special-application metals	Large-volume industry metals
²³⁸ U	900	43	10.0
²³⁵ U	45	2.2	0.5
²³⁴ U	900	43	10.0
²³¹ Pa	45	2.2	0.5
²³² Th	2,000	22	10.0
²³⁰ Th	900	43	10.0
²²⁸ Th	2,000	22	10.0
²²⁷ Ac	45	2.2	0.5
²²⁸ Ra	2,000	22	10.0
²²⁶ Ra	900	43	5.0
²¹⁰ Po	630	30	3.5
²¹⁰ Pb	630	30	3.5
Total ^b	10,995	305	73.5

^aBased on ref. 9.

^bExcludes contributions from other (short-lived) radionuclides in decay chains.

Table 7.7. Radionuclide concentrations in municipal water treatment wastes^a

Nuclide	Concentration (pCi/g)	
	Sludges	Radium selective resins
²³⁸ U	4.0	b
²³⁵ U	0.03	b
²³⁴ U	4.0	b
²³¹ Pa	0.03	b
²³² Th	0.2	b
²³⁰ Th	0.2	b
²²⁸ Th	9.0 ^c	b
²²⁷ Ac	0.03	b
²²⁸ Ra	16 ^c	b
²²⁶ Ra	16	35,000 ^d
²¹⁰ Po	11.0	b
²¹⁰ Pb	11.0	b
Total ^e	71.5	b

^aBased on ref. 9.^bUnknown.^cConcentration after 2 years of decay and ingrowth.^dRough estimate.^eExcludes contributions from other (short-lived) radionuclides in decay chains.**Table 7.8. Radionuclide concentrations in oil and natural gas production and processing wastes^a**

Nuclide	Concentration (pCi/g)	
	Scale	Sludge
²²⁸ Th	120	19
²²⁸ Ra	120	19
²²⁶ Ra	360	56
²¹⁰ Po	360	56
²¹⁰ Pb	360	56
Total ^b	1,320	206

^aBased on ref. 9.^bExcludes contributions from other (short-lived) radionuclides in decay chains.

Table 7.9. Radionuclide concentrations in phosphate wastes^a

Nuclide	Concentration (pCi/g)			
	Ferrophosphorous	Phosphogypsum	Scale	Slag
²³⁸ U	b	6.0	b	25
²³⁵ U	b	0.3	b	1.3
²³⁴ U	b	6.2	b	24
²³¹ Pa	b	0.3	b	1.3
²³² Th	b	0.27	b	0.77
²³⁰ Th	b	13	b	32
²²⁸ Th	b	1.4	b	0.77
²²⁷ Ac	b	0.3	b	1.3
²²⁸ Ra	b	0.27	b	0.77
²²⁶ Ra	1.2 ^c	33	1000 ^d	35
²¹⁰ Po	b	26	b	35
²¹⁰ Pb	b	26	b	35
Total ^e	b	113	b	192

^aBased on ref. 9.^bUnknown.^cAverage for Florida plants.^dRough estimate for purposes of illustration and comparison.^eExcludes contributions from other (short-lived) radionuclides in decay chains.Table 7.10. Quantities of radium disposed of by
New York State generators
during 1987-91^a

CY	Volume (m ³)	Radioactivity (Ci)
1987	16.1	1.32
1988	4.0	4.23
1989	26.7	123
1990	6.4	0.08
1991	6.7	1.28
Totals	59.9	129.91

^aBased on ref. 6 (p. 13-9).

Table 7.11. Estimates of domestic diffuse NORM waste generation, material density, cumulative inventory, and radioactive concentration^a

Process/waste material	Current annual generation (10 ⁶ t/year)	Waste material density (t/m ³)	Cumulative inventory			Average ²²⁶ Ra concentration (pCi/g)
			Mass (10 ⁶ t)	Volume ^b (10 ⁶ m ³)	Radioactivity ^c (Ci)	
Coal combustion						
Bottom ash and slag	17	(1.50) ^d	>337 ^e	>225	2,300	(3.1)
Fly ash	44	1.20	>959 ^e	>800	26,000	(3.9)
Geothermal energy production (scale and filter cake)	0.054	1.80	0.74	0.41	330	132
Metal mining and processing—slag, leachate, and tailings from the following:						
• Large bulk metal industries (e.g., aluminum, copper, iron, and steel)	1,000	2.00	50,000 ^f	25,000	3,700,000	(5)
• Rare earths	0.021	2.00	1 ^f	0.5	11,000	900
• Special-application metals (zirconium, hafnium, titanium, and tin)	0.47	2.00	20 ^f	10	6,100	43
Municipal water treatment						
Radium selective resins	0.04	(1.50)	2 ^g	>1	>35,000	(35,000)
Sludges	0.26	1.60	10 ^g	6	700	16
Oil and gas production waste (scale and sludge) ^h	0.056	1.70	4	2.3	1,210	84
Phosphate production						
Ferrophosphorous	i	(1.50)	i	i	i	1.2 ^j
Phosphogypsum	48	1.44	8,200	5,700	930,000	33
Scale	0.003	(2.00)	<<1	<<1	<1,000	(1,000)
Slag	1.6	1.90	324 ^k	171	62,200	35
Total	1,112	1.88	>59,857	>31,917	>4,775,840	9.6

(Footnotes on next page)

Table 7.11 (continued)

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- ^aBased on refs. 9 and 11. Information and data from ref. 9 are, in turn, based on refs. 13–26.
- ^bEstimated from listed waste material density.
- ^cEstimated from total radionuclide concentrations listed in Tables 7.4–7.9. Excludes contributions from ⁴⁰K.
- ^dData listed in parentheses represent rough estimates developed for purposes of illustration and comparison.
- ^eBased on cumulative ash production rate from 1966 through 1990. Assumes that 74% of cumulative production is fly ash.
- ^fBased on average annual generation applied to a 50-year period.
- ^gBased on the average annual generation applied to a 40-year period.
- ^hBased on ref. 26.
- ⁱUnknown.
- ^jAverage for Florida plants.
- ^kMidpoint value in a range based on ref. 25.

8. MIXED LOW-LEVEL WASTE

8.1 INTRODUCTION

This chapter reports estimated inventories and generation rates of mixed low-level waste (MLLW) from DOE site and commercial operations. Mixed wastes are radioactive wastes that are also considered hazardous. MLLW are mixed wastes which, radiologically, are low level as defined in Chapter 4.

Other types of radioactive wastes may also be mixed. All high-level wastes (HLWs) are regarded as mixed and are discussed in Chapter 2. Mixed transuranic wastes are not included in this chapter, but are addressed in the TRUW inventories and projections reported in Chapter 3.

The radioactive components of mixed wastes are subject to the Atomic Energy Act (AEA), as amended,¹ which, for government sources, is administered by DOE, and, for commercial sources, by NRC (unless a state has obtained agreement-state status). As defined for this report, the hazardous components of mixed wastes are subject to either of two federal statutes that are administered by the U.S. Environmental Protection Agency (EPA) (unless a state has obtained authorization status). These statutes are the Resource Conservation and Recovery Act (RCRA), as amended,² and the Toxic Substances Control Act (TSCA).³ Table 8.1 (based on ref. 4) lists those states and territories designated by EPA as having mixed waste authorization. The management of RCRA- and TSCA-regulated mixed wastes are subject to the regulations of EPA^{5,6} and NRC (or the authorized and agreement states), or DOE.

8.2 SCOPE

This chapter summarizes the quantities (inventory and generation) and associated characteristics of MLLW from both DOE site and commercial site operations. The DOE MLLW include MLLW for which the hazardous component of the waste is subject to regulation under either RCRA or TSCA (hereafter referred to as either RCRA MLLW or TSCA MLLW, respectively). MLLW which is subject to regulation under both RCRA and TSCA are considered RCRA MLLW.

Relative to the previous issue of this report (DOE/RW-0006, Rev. 11), a key scope change is the exclusion of the Middlesex, Weldon Spring, and Grand Junction sites from this chapter. Radiologically, the mixed waste at these sites is considered 11e(2) by-product material. Mixed 11e(2) wastes are addressed exclusively in Chapter 6 (Environmental Restoration Program) of this report. This scope change accounts for most of the difference in the total nationwide inventory of DOE RCRA MLLW from the previous issue of this report (see Sect. 8.4.1).

A significant volume of MLLW is associated with environmental restoration activities. For example, most of the radioactive asbestos results from decommissioning and/or renovation of old structures. In addition, remediation of former landfills used for disposal of radioactively contaminated materials can result in large quantities of RCRA MLLW. MLLW resulting from such activities are provided in Chapter 6 within pertinent tables. The environmental restoration program is a very dynamic program in which wastes are currently being generated by ongoing remedial action activities and certain stored wastes are being treated either on-site or off-site prior to disposal. As such, waste volumes can change significantly in very short periods of time. There may be some discrepancies with MLLW volumes reported in this chapter with those reported in Chapter 6. These variances occur as a result of differences in (a) the sources of information (e.g., the information in Chapter 6 is limited to environmental restoration activities) and (b) when the information was last updated.

For commercial MLLW, this chapter reports a summary of the cumulative stored inventories and generation documented for a baseline CY (1990) in a national profile study (NUREG/CR-5938, ref. 7) made for the NRC and EPA. The wastes in that study are grouped by facility categories and by major hazardous waste classifications.

Unless otherwise noted, the inventories and projections reported for MLLW in this chapter are separate from those reported for strictly radioactive LLW in Chapter 4. Inventories of MLLW currently stored at DOE

sites are being thoroughly characterized. As a result, the waste at some sites could require future reclassification, thereby causing significant changes in current inventory data that are currently reported.

8.3 DOE MLLW DATA SOURCES

The information and data on DOE RCRA MLLW contained in the previous issue of this report (DOE/RW-0006, Rev. 11) was based on the 1995 update to the DOE Mixed Waste Inventory Report (MWIR)⁸ data base. In this issue, DOE RCRA MLLW information and data are based on the DOE Site Treatment Plan (STP) Data Base, as updated through December 1996.⁹ These data bases differ with respect to certain details of the information and data that are maintained on DOE RCRA MLLW streams. The MWIR data base contains greater detail on the characteristics of the waste streams, whereas the STP data base contains more detail on their planned management. While there was no update to the MWIR data in 1996, the DOE sites have continued to provide updates to the STP data base as part of ongoing efforts to finalize their STPs as required under the Federal Facility Compliance Act (FFCA).¹⁰

DOE TSCA MLLW information and data reported in this chapter are based on DOE site submittals recently provided to the IDB Program and cited in ref. 11.

8.4 DOE MLLW

Figure 8.1 summarizes the estimated MLLW (RCRA and TSCA) volume inventory for major sites in the DOE complex. A corresponding illustration of the estimated annual volume generation is shown in Fig. 8.2. For comparison, Table 8.2 summarizes estimated nationwide volume inventory and annual volume generation of DOE MLLW (RCRA and TSCA) and commercial MLLW.

8.4.1 DOE RCRA MLLW

There is approximately 108,000 m³ of RCRA MLLW in storage throughout the DOE complex with an estimated 28,600 m³ anticipated to be generated over the next 5 years. Table 8.3 summarizes the distribution of the inventory and projected generation across the DOE sites. Most (>90%) of the inventory is stored at 7 sites (Hanford, INEL, K-25, PORTS, RFETS, SRS, and Y-12).

Table 8.5 summarizes the distribution of RCRA MLLW inventories and projected generation for the DOE sites according to physical form categories. Definitions of the physical form categories are provided in Table 8.4.

The complex-wide aggregate of the site distributions is provided in Table 8.6. Complex-wide, most (~90%) of the inventory consists of inorganic homogeneous solids, debris (inorganic, organic, heterogeneous), and soil/gravel.

The previous edition of this document (DOE/RW-0006, Rev. 11) reported that approximately 138,000 m³ RCRA MLLW was stored throughout the DOE complex. As discussed above, approximately 108,000 m³ are reported in this edition. The majority of the 30,000 m³ decrease in this edition is due to the exclusion of mixed 11e(2) waste, particularly that stored at Middlesex (see Sect. 8.2). Table 8.7 summarizes the major contributions to the change in the DOE complex-wide inventory.

8.4.2 DOE TSCA MLLW

This section highlights the major ground rules and assumptions associated with the DOE site information and data reported in Tables 8.8–8.14. Most of the information and data reported in the subsections that follow describes the TSCA MLLW inventory, generation, and projection ground rules and assumptions documented in the specific DOE site submittals of ref. 11. Corresponding site information associated with RCRA MLLW data are reported in the MWIR (ref. 8) and STP Data Base (ref. 9).

The site inventories and generation rates of DOE TSCA MLLW are given in this chapter for two major categories of hazardous materials: polychlorinated biphenyls (PCBs) and asbestos. A third category, "Other," has been added to include TSCA MLLWs that contain either mixtures of PCBs and asbestos, other TSCA-regulated materials, or both.

Tables 8.8 and 8.9, respectively, report the mass and volume inventory of TSCA MLLW at each DOE site. A volume inventory of about 23,500 m³ is reported for TSCA MLLW throughout the DOE complex. Current annual generation levels for these wastes are reported in mass units in Table 8.10 and in volume units in Table 8.11. Projected TSCA MLLW mass and volume generation levels are given in Tables 8.12 and 8.13, respectively. Significant changes in site reported TSCA MLLW volume inventories from those reported in the previous edition of this report (Rev. 11) are noted in Table 8.14.

The following subsections give some of the significant features of the TSCA MLLW data at each DOE site that are reported in Tables 8.8–8.13.

8.4.2.1 Ames Laboratory (Ames)

Materials containing radioactively-contaminated PCBs and asbestos comprise the TSCA MLLW inventories and projections for Ames.

8.4.2.2 Argonne National Laboratory-East (ANL-E)

ANL-E TSCA MLLW inventories are comprised of PCBs. ANL-E projections for TSCA MLLW are not available.

8.4.2.3 Argonne National Laboratory-West (ANL-W)

TSCA MLLW inventories for ANL-W include both PCBs and asbestos. During 1995, TSCA MLLW generation included only asbestos.

8.4.2.4 Brookhaven National Laboratory (BNL)

Both PCBs and solid asbestos materials comprise BNL TSCA MLLW inventories and generation. Projected wastes reported in Tables 8.12 and 8.13 assume that small quantities will continue to be generated as a result of maintenance activities.

8.4.2.5 Energy Technology Engineering Center (ETEC)

The ETEC site reported no TSCA MLLW inventory for the end of CY 1995, but some asbestos was generated during 1995, and was shipped off site. TSCA MLLW projections anticipated over the next few years include only contributions from asbestos.

8.4.2.6 Fernald Environmental Management Project (FEMP)

Information for this site is not available.

8.4.2.7 Fermi National Accelerator Laboratory (FNAL)

Currently, FNAL has no inventories of TSCA MLLW.

8.4.2.8 Hanford Site (Hanford)

Hanford Site TSCA MLLWs consist of inventories of PCBs. Site projections for PCBs are included in the projections for RCRA MLLW. Hanford inventories and projections for asbestos are not included in this chapter but are included in the site's data for LLW in Chapter 4.

8.4.2.9 Idaho National Engineering Laboratory (INEL)

Inventories of INEL TSCA MLLWs consist solely of PCBs and do not include contributions from ANL-W. It is likely that PCB wastes will continue to be generated at

INEL; however, estimates of specific future quantities are not yet available. There are also inventories and projections of asbestos wastes at INEL; however, these are not included in this chapter but are included in the site data for LLW in Chapter 4.

8.4.2.10 Inhalation Toxicology Research Institute (ITRI)

Currently, ITRI has no TSCA MLLW.

8.4.2.11 K-25 Site

For the K-25 Site, projections of annual TSCA MLLW generation reported in Tables 8.12 and 8.13 are based on 1995 generation levels. Both the reported TSCA MLLW inventories and projections for this site include only contributions from PCBs.

8.4.2.12 Kansas City Plant (KCP)

Currently, KCP does not have any inventories of TSCA MLLW, and no quantities of TSCA MLLW are anticipated for the future.

8.4.2.13 Lawrence Berkeley Laboratory (LBL)

LBL TSCA MLLW inventories represent contributions from asbestos during 1995.

8.4.2.14 Lawrence Livermore National Laboratory (LLNL)

Inventories of TSCA-regulated MLLW at LLNL include PCBs and asbestos. No TSCA MLLW is projected from future LLNL activities. Current inventories resulted from either the removal of PCB-containing transformers from service or from renovation or closure of buildings containing asbestos.

8.4.2.15 Los Alamos National Laboratory (LANL)

Inventories of TSCA MLLW at LANL are based on limited records kept of asbestos and PCB wastes during the early operating years. A significant increase occurred during 1993 from the addition of contaminated equipment to the asbestos inventory.

8.4.2.16 Mound Plant (Mound)

TSCA MLLW inventories at Mound include contributions from PCBs and asbestos. After CY 1995, no major generation of PCB wastes is anticipated. Projected levels for asbestos are based on 1995 generation.

8.4.2.17 Naval Reactor (NR) Sites

Tables 8.8–8.13 report the total inventories of NR sites. Most of these include contributions from the Bettis Atomic Power Laboratory (BAPL). Projected wastes reported for NR sites in Tables 8.12 and 8.13 include contributions from the INEL Naval Reactors Facility (NRF), BAPL, Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site. These wastes are anticipated to result from a variety of site activities, including facility D&D, plant lay-up, ship inactivation, and asbestos removal and replacement.

8.4.2.18 Nevada Test Site (NTS)

Inventories of TSCA MLLW at NTS include only PCB wastes. Future volumes of TSCA MLLW may be generated from NTS D&D and environmental restoration activities, however no estimates are available at this time.

8.4.2.19 Oak Ridge National Laboratory (ORNL)

PCBs comprise the inventories of TSCA MLLW at ORNL. Site-generated projections reported in Tables 8.12 and 8.13 are based on 1995 generation levels.

8.4.2.20 Oak Ridge Institute of Science and Education (ORISE)

Currently, ORISE does not have any inventories of TSCA MLLW, and no quantities of TSCA MLLW are anticipated for the future.

8.4.2.21 Paducah Gaseous Diffusion Plant (PAD)

PAD site TSCA MLLW inventories include both PCBs and asbestos. Projections for generated TSCA wastes are not currently available.

8.4.2.22 Pantex Plant (PANT)

TSCA MLLW inventories at PANT include contributions from both PCBs and asbestos. The site normally ships these waste materials as soon as a shipping increment is accumulated. TSCA MLLW materials are not stored at PANT for the long term. Current inventories listed in Tables 8.8–8.11 are materials temporarily on hand awaiting shipment. TSCA MLLW projections reported in Tables 8.12 and 8.13 for PANT do not include asbestos materials from future site D&D activities.

8.4.2.23 Pinellas Plant (Pinellas)

Pinellas currently has no inventories of TSCA MLLW.

8.4.2.24 Portsmouth Gaseous Diffusion Plant (PORTS)

At PORTS, TSCA-regulated MLLW is comprised of both PCBs and asbestos. Reported inventories of these wastes pertain to CY 1994. Projections of generated TSCA wastes from PORTS site activities are currently not available.

8.4.2.25 Princeton Plasma Physics Laboratory (PPPL)

PPPL currently has no inventories of TSCA MLLW.

8.4.2.26 Rocky Flats Environmental Technology Site (RFETS)

Both radioactive PCBs and asbestos are included in the RFETS TSCA MLLW inventories reported in Tables 8.8–8.11. TSCA MLLW projections for RFETS are not currently available.

8.4.2.27 Stanford Linear Accelerator Center (SLAC)

SLAC currently has no inventories of TSCA MLLW.

8.4.2.28 Sandia National Laboratory/California (SNL/CA)

SNL/CA currently has no inventories of TSCA MLLW.

8.4.2.29 Sandia National Laboratory/New Mexico (SNL/NM)

SNL/NM currently has no inventories of TSCA MLLW.

8.4.2.30 Savannah River Site (SRS)

PCBs comprise the TSCA MLLW inventories reported for SRS. Additional PCB wastes are not anticipated for 1996, and projections are unavailable for 1997 and beyond. No information and data are available on SRS inventories and projections for radioactive asbestos.

8.4.2.31 West Valley Demonstration Project (WVDP)

TSCA MLLW inventories reported for WVDP in Tables 8.8–8.11 include both PCBs and asbestos. Projections reported in Tables 8.12 and 8.13 for TSCA MLLW at WVDP apply only through CY 2001.

8.4.2.32 Y-12 Plant (Y-12)

Y-12 Plant TSCA MLLW inventories reported in Tables 8.8–8.11 are radioactive PCBs. Contributions from asbestos are not reported because asbestos is considered to be a sanitary waste at the Y-12 Plant. Projections for Y-12 are based on 1995 generation levels for PCB wastes.

8.5 COMMERCIAL MLLW

In recent years, the NRC and EPA cosponsored a survey study to compile a national profile of the volumes, characteristics, and treatability of commercially generated MLLW. Such a profile was designed to provide the following:

- states and compacts with information to assist in planning and developing adequate disposal capacity for low-level radioactive waste, including MLLW, as mandated by the Low-Level Radioactive Waste Policy Amendments Act;¹³
- private developers with a clearer idea of the characteristics and volumes of mixed waste and the technical capability and capacity needed to treat this waste; and
- a reliable national data base of the volumes, characteristics, and treatability of commercial mixed waste.

In addition, the data were collected to provide a basis for possible federal actions that would effectively manage and regulate the treatment and disposal of mixed waste. Results from this investigation are documented in ref. 7 and summarized in this report.

The study identified the types and volumes of MLLW generated from five groups of facilities: nuclear utilities, medical facilities, academic institutions, industrial facilities, and NRC-licensed government facilities. The study selected a random sample of 1323 facilities out of a total target population of 2936 facilities. Data from the 1016 completed mixed waste survey questionnaires (77% response rate) received and the use of appropriate weighting factors indicate that approximately 3950 m³ of MLLW—of which 72% was liquid scintillation fluids—were generated in the United States in 1990.

The study divided the MLLW into several hazardous stream categories, including the following:

- Liquid scintillation fluids from laboratory counting activities.
- Waste oil from various pumps, equipment, and maintenance activities.
- Chlorinated or fluorinated organics and chlorinated fluorocarbons, including sludges and contaminated filters from dry cleaning, refrigeration, degreasing, and decontamination operations. Chloroform and a number of pesticides are also included.
- Other organics, including miscellaneous solvents, reagents, expired products, and other organic compounds (or materials like rags, wipes, etc., contaminated with such) from research and manufacturing activities, experimental procedures, and laboratory and process equipment cleaning.
- Lead wastes, including lead shielding and lead solutions for research and industrial facilities.
- Mercury wastes, including equipment and debris contaminated with mercury.
- Chromate wastes, including chromium-contaminated solutions for research, maintenance, and waste treatment (ion exchange) operations.
- Cadmium wastes from decontamination activities.
- Aqueous corrosive wastes, including inorganic acids, or, in some instances, bases from cleanup and decontamination activities.
- Other hazardous materials, including materials (a) either not readily assignable to any one of the previous categories or (b) containing a number of different hazardous materials.

Summaries of estimated generation rates, amounts in storage, and amounts treated for each of the five facility categories and each of the hazardous waste stream categories are shown in Tables 8.15 and 8.16, respectively (data from ref. 7). Upper and lower bounds were also set for the volume of mixed waste that is untreatable under current technologies by making the simplifying assumption that liquid scintillation fluids, oil, nonhalogenated organics, and corrosive wastes are treatable. Deducting their total contribution from the estimated total mixed waste generation rate leaves residues of about 524 m³. This upper bound for untreatable mixed waste is about 13% of the estimated 1990 national generation rate of 3950 m³. However, it was noted that the capacity to treat *all* of the so-called treatable mixed waste may not be available.

8.6 REFERENCES

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 - b. (ANL-E) R. F. Coley, Argonne National Laboratory, Argonne, Illinois, correspondence to Timothy S. Crawford, DOE Argonne Group Manager, Argonne, Illinois, "Low-Level Waste Data Request for the Integrated Data Base Report," dated Sept. 19, 1996.
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 - d. (BNL) Angela C. Harvey, DOE Brookhaven Area Office, Upton, New York, correspondence to Steven Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Low-Level Waste Data for Brookhaven National Laboratory," dated Sept. 26, 1996.
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- n. (LLNL) Richard W. Crawford, Lawrence Livermore National Laboratory, Livermore, California, correspondence to Alan Icenhour or Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, transmitting updated LLNL LLW information and data, dated Sept. 20, 1996.
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 - ac. (WVDP) E. B. Martin, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Steven N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Submittal of Low-Level Waste Data Call for the 1995 (sic) Integrated Data Base," WZ:96:0100, dated Sept. 26, 1996.
 - ad. (Y-12) A. L. Rivera, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, correspondence to S. N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "1996 Low-Level Waste (LLW) Management Data Call," dated Sept. 30, 1996.
12. U.S. Department of Energy, Office of Waste Management, *DOE Waste Treatability Group Guidance*, Washington, D.C., DOE/LLW-217, Rev. 0 (January 1995).
 13. U.S. Congress, Low-Level Radioactive Waste Policy Amendments Act of 1985, Pub. L., 99-240, Jan. 15, 1986.

Fig. 8.1. Estimated volume inventory of DOE MLLW (RCRA and TSCA) at the end of 1995.

Fig. 8.2. Estimated volume generation of DOE MLLW (RCRA and TSCA) during 1995.

Table 8.1. Thirty-nine states and territories with EPA mixed waste authorization as of the end of 1995^a

State or territory	Effective date	State or territory	Effective date
Alabama	11/23/93	Nebraska	12/03/88
Arizona	01/22/93	Nevada	06/29/92
Arkansas	05/29/90	New Hampshire	11/14/94
California	08/01/92	New Mexico	07/25/90
Colorado	11/07/86	New York	05/07/90
Connecticut	12/31/90	North Carolina	11/21/89
Florida	02/12/91	North Dakota	08/24/90
Georgia	09/26/88	Ohio	06/30/89
Guam	10/10/89	Oklahoma	11/27/90
Idaho	04/09/90	Oregon	05/29/90
Illinois	04/30/90	South Carolina	09/13/87
Indiana	09/30/91	South Dakota	06/17/91
Kansas	06/25/90	Tennessee	08/11/87
Kentucky	12/19/88	Texas	03/15/90
Louisiana	10/26/91	Utah	03/07/89
Michigan	12/26/89	Vermont	08/06/93
Minnesota	06/23/89	Washington	11/23/87
Mississippi	05/28/91	Wisconsin	04/24/92
Missouri	03/12/93	Wyoming	10/18/95
Montana	03/21/94		

^aBased on ref. 4. Information as of February 14, 1996.

Table 8.2. Summary of estimated MLLW inventories and annual generation as of 1995

Category	Volume, m ³	
	Inventory	Annual generation
DOE sites		
RCRA/state MLLW	107,911 ^a	5,725 ^b
TSCA MLLW ^c	23,468	2,234
DOE MLLW total	131,379	7,959
Commercial sites ^d	2,116	3,949
Envirocare ^e	20,143	0

^aBased on ref. 9. The currentness of these data for the various DOE sites ranges from January 1995 to June 1996.

^bBased on an annual average of site-reported five-year projections.

^cReported for CY 1995.

^dReported for CY 1990.

^eWastes from commercial- and government-sponsored (DOE, EPA, DOD) activities that are disposed of at the Envirocare Facility near Clive, Utah. DOE wastes include LLW, MLLW, and 11e(2) by-product material. See Table 0.8 in Chapter 0, which is based on ref. 19 of Chapter 0.

Table 8.3. Estimated volume (m³) inventories and five-year projections of DOE RCRA MLLW as of 1995, by site^a

Site	Inventory	Five-year projection	Total
Ames	0.0	b	b
ANL-E	33.7	107.5	141.2
ANL-W	411.9	368.9	780.8
BNL	24.0	2.8	26.8
ETEC	1.4	3.4	4.8
FEMP	2,390.2	153.6	2,543.8
FNAL	b	b	b
Hanford	8,169.5	4,200.4	12,370.0
INEL ^c	25,734.4	899.4	26,633.8
ITRI	0.0	b	b
K-25	23,076.1	1,345.1	24,421.2
KCP	0.0	b	b
LANL	608.6	107.4	716.0
LBL	6.3	7.0	13.3
LLNL	454.0	1,765.1	2,219.1
Mound	97.1	4.5	101.6
NR sites ^d	77.2	157.2	234.4
NTS	306.0	2,652.0	2,958.0
ORISE	b	b	b
ORNL	2,840.5	562.6	3,403.1
PAD	1,032.2	0.0	1,032.2
PANT	132.3	918.5	1,050.8
Pinellas	0.0	b	b
PORTS	8,011.4	3,544.2	11,555.6
PPPL	0.0	b	b
RFETS	13,558.4	4,005.1	17,563.5
RMI	21.5	7.5	29.0
SLAC	b	b	b
SNL/CA	0.0	b	b
SNL/NM	69.8	339.0	408.8
SRS	6,939.5	5,674.7	12,614.2
WVDP	147.8	39.0	186.8
Y-12	13,729.6	1,732.3	15,461.9
Others ^e	37.9	27.0	64.9
Total (DOE complex)	107,911.3	28,624.2	136,535.5

^aBased on the STP Data Base, ref. 9. The currentness of these data for the various DOE sites ranges from January 1995 to June 1996.

^bInformation not available or unknown.

^cIncludes contributions from the Idaho Naval Reactors Facility.

^dIncludes contributions, if any, from Bettis Atomic Power Laboratory (BAPL), Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site. Also includes contributions, if any, from the Charleston, Mare Island, Norfolk, Pearl Harbor, Portsmouth, and Puget Sound Naval shipyards.

^eIncludes contributions, if any, from Battelle Columbus Laboratory (BCL), Colonial Interim Storage Site (CISS), General Atomics (GA), Laboratory for Energy Related Health Research (LEHR), and Missouri University.

Table 8.4. Treatability group matrix parameter categories used to characterize DOE RCRA MLLW^a

Matrix parameter category	Description
<i>Liquids^b</i>	
Aqueous liquids/slurries	Liquids and slurries containing less than 1% total organic carbon (TOC)
Organic liquids	Liquids and slurries containing $\geq 1\%$ TOC
Unknown/other liquids	Liquids and slurries which can not be categorized as aqueous liquids/slurries or organic liquids because it is not known if the TOC level is less or greater than 1%
<i>Solids^c</i>	
Inorganic homogeneous solids	Wastes that are at least 50 vol % inorganic homogeneous solids. Homogeneous solids are defined as solid waste materials, excluding soil/gravel, that do not meet the Environmental Protection Agency (EPA) land disposal restrictions (LDR) criteria for classification as debris. Inorganic homogeneous solids are further defined as those with sufficient inorganic solids content such that a minimum of approximately 20 wt % would remain as residue (i.e., ash/solids) following incineration
Organic homogeneous solids	Wastes that are at least 50 vol % organic homogeneous solids. Homogeneous solids are defined as solid waste materials, excluding soil/gravel, that do not meet the EPA LDR criteria for classification as debris. Organic homogeneous solids are further defined as those with a base structure that is primarily organic such that a maximum of approximately 20 wt % would remain as residue (i.e., ash/solids) following incineration
Unknown/other homogeneous solids	Wastes that are at least 50 vol % homogeneous solids, but: <ul style="list-style-type: none"> • are insufficiently characterized to enable categorization as either inorganic or organic homogeneous solids, or • do not meet the criteria for categorization as either inorganic or organic homogeneous solids
Soil/gravel	Wastes that are at least 50 vol % soil, including sand and silt or rock and gravel, that do not meet EPA LDR criteria for classification as debris
Inorganic debris	Wastes that are at least 80 vol % inorganic materials that meet the EPA LDR criteria for classification as debris. Examples include scrap metal, concrete, glass, and brick
Organic debris	Wastes that are at least 80 vol % organic materials that meet the EPA LDR criteria for classification as debris. Examples include plastic, rubber, wood, paper, cloth, and biological materials
Heterogeneous debris	Wastes that are at least 50 vol % debris materials that meet the EPA LDR criteria for classification as debris but are not dominant (i.e., at least 80 vol %) in either inorganic or organic debris materials
Unknown/other debris	Wastes that are at least 50 vol % materials that meet the EPA LDR criteria for classification as debris but lack adequate characterization information to enable categorizing as inorganic, organic, or heterogeneous debris
Unknown/other solids	Wastes with physically solid matrices for which insufficient characterization information exists to enable categorizing as a homogeneous solid, soil/gravel, or debris

Table 8.4 (continued)

Matrix parameter category	Description
<i>Specific waste forms^d</i>	
Lab packs	Wastes packaged in lab pack configurations. A lab pack configuration is defined as two or more waste containers packaged within a larger outer container. Typically, the inner containers are surrounded by absorbent materials. If present, the absorbents can be homogeneous solids or debris materials
Reactive metals	Reactive metal wastes that meet the criteria for classification as water-reactive or ignitable-reactive per the Third Third LDR rule (55 FR 22545 and 22553). Typically, this waste is sodium metal or sodium metal alloys, but can also include particulate fines of aluminum, uranium, zirconium, or other pyrophoric materials
Explosives/propellants	Wastes consisting of substances which undergo rapid chemical transformations that produce large amounts of gases and heat. The gases rapidly expand at velocities exceeding the speed of sound (due to the heat of reaction), which creates a shock wave and explosion. Waste that meets this definition is categorized as an explosive/propellant regardless of the specific physical form
Compressed gases/aerosols	Wastes consisting of pressurized gas cylinders or aerosol cans
Elemental mercury	Wastes that are bulk, pourable liquid mercury. The liquid mercury may be packaged in a lab pack configuration
Elemental hazardous metals	Wastes that are at least 50 vol % solid, bulk elemental hazardous metals that meet the EPA LDR size criteria for classification as debris. Typical examples of solid elemental hazardous metals are lead and cadmium
Beryllium dust	Wastes that are subject to the metal recovery treatment standard for beryllium dust as specified in the Third Third LDR rule (55 FR 22545)
Batteries	Wastes consisting of lead acid, cadmium, or other batteries. The batteries may be packaged with absorbent materials
Unknown/other matrix	Wastes for which insufficient characterization information is known to enable categorization as a liquid or solid or as one of the specific waste forms
<i>Final waste forms^e</i>	
Immobilized forms	Wastes that have been immobilized. These include wastes considered to be either micro- or macro-encapsulated
Decontaminated solids	Waste that has been decontaminated and is ready for disposal or recycling
Other final forms	Final waste forms other than immobilized forms and decontaminated solids

^aBased on ref. 9.

^bThis category addresses wastes that are liquid, including slurries, and are packaged in bulk, free form (i.e., excludes lab packs). Slurries are defined as liquids with a total suspended/settled solids (TSS) content of $\geq 1\%$ and $\leq 30\%$.

^cThis category addresses waste with physically solid matrices, including sludges. Sludges are defined as having a TSS $> 30\%$. Certain waste with physically solid matrices are excluded from this category (see the "specific waste forms" and "final waste forms" categories above).

^dThis category addresses lab packs and other specific waste forms. The other specific waste forms include waste that (a) is inherently hazardous (i.e., the bulk material itself is RCRA hazardous), or (b) presents unique treatment or management concerns.

^eThis category addresses waste that is in final form and meets applicable disposal criteria, including applicable LDR and PCB treatment standards.

Table 8.5. Estimated volume (m³) inventories and five-year projections of DOE RCRA MLLW as of 1995, by site and physical form^a

Site	Physical form ^b	Inventory	Five-year projection	Total
Ames	Not applicable	0.00	c	c
ANL-E	Aqueous liquids/slurries	0.02	0.00	0.02
	Elemental hazardous metals	17.53	71.74	89.27
	Inorganic debris	0.67	5.19	5.86
	Inorganic homogeneous solids	5.12	15.00	20.12
	Lab packs	8.59	9.65	18.24
	Organic debris	0.79	3.97	4.76
	Reactive metals	0.53	0.44	0.97
	Soil/gravel	0.40	1.50	1.90
	ANL-E total	33.63	107.49	141.14
ANL-W	Aqueous liquids/slurries	0.42	0.08	0.50
	Elemental hazardous metals	0.52	0.09	0.61
	Heterogeneous debris	2.94	1.87	4.81
	Inorganic debris	d	d	0.01
	Organic debris	0.16	0.08	0.24
	Organic homogeneous solids	20.82	23.50	44.32
	Reactive metals	387.03	343.31	730.33
	ANL-W total	411.90	368.94	780.82
BNL	Organic liquids	17.33	0.78	18.11
	Elemental hazardous metals	1.18	0.73	1.91
	Elemental mercury	0.65	0.10	0.75
	Inorganic homogeneous solids	2.50	0.20	2.70
	Lab packs	1.02	0.46	1.48
	Unknown/other matrix	1.30	0.50	1.80
	BNL total	23.98	2.77	26.75
ETEC	Aqueous liquids/slurries	0.13	0.00	0.13
	Inorganic debris	0.10	0.84	0.94
	Inorganic homogeneous solids	0.99	2.51	3.49
	Organic liquids	0.15	0.00	0.15
	Reactive metals	d	0.00	d
	ETEC total	1.37	3.35	4.72
FEMP	Aqueous liquids/slurries	940.19	26.99	967.18
	Batteries	5.00	14.09	19.09
	Compressed gases/aerosols	0.59	0.30	0.89
	Elemental hazardous metals	2.00	5.10	7.10
	Elemental mercury	0.20	0.00	0.20
	Heterogeneous debris	62.80	10.90	73.70
	Inorganic debris	22.60	16.70	39.30
	Inorganic homogeneous solids	612.00	15.70	627.70
	Lab packs	0.40	0.00	0.40
	Organic debris	12.80	0.29	13.09
	Organic homogeneous solids	96.20	0.00	96.20
	Organic liquids	460.22	63.50	523.72
	Reactive metals	0.40	0.00	0.40
	Soil/gravel	170.50	0.00	170.50

Table 8.5 (continued)

Site	Physical form ^b	Inventory	Five-year projection	Total
FEMP (contd.)	Unknown/other homogeneous solids	3.40	0.00	3.40
	Unknown/other liquids	0.10	0.00	0.10
	Unknown/other solids	0.80	0.00	0.80
	FEMP total	2,390.20	153.57	2,543.77
FNAL	Not applicable	c	c	c
Hanford	Batteries	1.86	2.27	4.13
	Elemental hazardous metals	240.03	134.50	374.53
	Elemental mercury	1.45	0.66	2.11
	Explosives/propellants	0.00	1.14	1.14
	Heterogeneous debris	808.78	1,678.04	2,486.82
	Immobilized forms	86.47	0.00	86.47
	Inorganic debris	535.31	1,145.29	1,680.60
	Inorganic homogeneous solids	3,779.41	260.65	4,040.06
	Lab packs	291.35	123.67	415.02
	Organic debris	1,690.50	585.92	2,276.42
	Organic liquids	1.04	0.00	1.04
	Reactive metals	5.43	0.00	5.43
	Soil/gravel	476.38	244.01	720.39
	Unknown/other debris	145.45	0.00	145.45
	Unknown/other homogeneous solids	25.32	24.30	49.61
	Unknown/other matrix	60.15	0.00	60.15
	Unknown/other solids	20.62	0.00	20.62
	Hanford total	8,169.54	4,200.44	12,369.98
INEL ^c	Aqueous liquids/slurries	10.73	14.50	25.24
	Elemental hazardous metals	433.38	119.23	552.61
	Elemental mercury	0.00	0.01	0.01
	Heterogeneous debris	19,654.13	80.11	19,734.23
	Immobilized forms	2.28	9.20	11.98
	Inorganic debris	508.02	332.90	840.92
	Inorganic homogeneous solids	3,828.39	86.28	3,914.67
	Lab packs	3.28	2.91	6.19
	Organic debris	709.21	189.09	898.30
	Organic homogeneous solids	350.41	58.82	409.23
	Organic liquids	10.45	6.33	16.79
	Reactive metals	0.93	0.00	0.93
	Soil/gravel	222.67	0.05	222.72
	INEL total	25,734.38	899.43	26,633.82
ITRI	Not applicable	0.00	c	c
K-25	Aqueous liquids/slurries	357.16	169.02	526.18
	Batteries	17.56	7.09	24.65
	Beryllium dust	0.16	0.00	0.16
	Compressed gases/aerosols	4.91	1.45	6.36
	Elemental hazardous metals	90.83	1.63	92.46
	Elemental mercury	2.80	0.25	3.05
	Heterogeneous debris	147.88	153.12	301.00
	Inorganic debris	190.38	60.82	251.19
	Inorganic homogeneous solids	20,956.75	674.13	21,630.88

Table 8.5 (continued)

Site	Physical form ^b	Inventory	Five-year projection	Total
K-25 (contd.)	Lab packs	31.97	4.55	36.52
	Organic debris	162.58	103.10	265.68
	Organic homogeneous solids	440.77	2.26	443.03
	Organic liquids	352.13	117.55	469.68
	Reactive metals	0.08	0.00	0.08
	Soil/gravel	278.78	49.37	328.15
	Unknown solids	41.42	0.77	42.19
	K-25 total	23,076.16	1,345.09	24,421.26
KCP	Not applicable	0.00	c	c
LANL	Aqueous liquids/slurries	3.34	1.51	4.85
	Compressed gases/aerosols	1.68	2.20	3.88
	Elemental hazardous metals	66.91	12.70	79.61
	Elemental mercury	0.50	0.05	0.55
	Inorganic debris	15.60	1.00	16.60
	Organic debris	42.14	8.50	50.64
	Organic liquids	55.42	23.21	78.63
	Reactive metals	0.20	0.05	0.25
	Soil/gravel	49.85	2.00	51.85
	Unknown/other debris	19.47	11.20	30.67
	Unknown/other matrix	353.49	45.00	398.49
	LANL total	608.60	107.42	716.02
LBL	Aqueous liquids/slurries	2.16	2.90	5.06
	Elemental hazardous metals	0.43	0.00	0.43
	Elemental mercury	0.11	0.00	0.11
	Heterogeneous debris	0.11	0.15	0.26
	Lab packs	0.20	0.12	0.32
	Organic liquids	3.30	3.80	7.10
	LBL total	6.31	6.97	13.28
LLNL	Elemental mercury	0.09	0.05	0.14
	Heterogeneous debris	62.40	72.00	134.40
	Inorganic debris	19.10	10.00	29.10
	Inorganic homogeneous solids	250.00	240.00	490.00
	Lab packs	6.30	6.50	12.80
	Organic homogeneous solids	1.20	5.00	6.20
	Organic liquids	92.80	1,389.50	1,482.30
	Soil/gravel	16.70	40.00	56.70
	Reactive metals	5.43	2.00	7.43
	LLNL total	454.02	1,765.05	2,219.07
Mound	Batteries	0.00	0.79	0.79
	Elemental hazardous metals	5.00	0.65	5.65
	Elemental mercury	0.02	d	0.02
	Lab packs	43.47	3.00	46.47
	Organic debris	0.02	0.02	0.04

Table 8.5 (continued)

Site	Physical form ^b	Inventory	Five-year projection	Total
Mound (contd.)	Organic liquids	28.73	0.00	28.73
	Unknown/other matrix	19.90	0.00	19.90
	Mound total	97.13	4.46	101.60
NR Sites ^f	Aqueous liquids/slurries	2.10	0.63	2.73
	Elemental hazardous metals	3.53	9.59	13.11
	Elemental mercury	0.03	0.08	0.11
	Heterogeneous debris	39.78	14.25	54.03
	Inorganic debris	2.30	5.52	7.82
	Inorganic homogeneous solids	4.97	8.88	13.85
	Lab packs	0.03	3.42	3.45
	Organic debris	13.23	26.57	39.80
	Organic homogeneous solids	4.02	5.48	9.50
	Organic liquids	2.61	3.85	6.96
	Soil/gravel	1.49	28.50	29.99
	Unknown/other debris	0.23	0.10	0.33
	Unknown/other homogeneous solids	1.74	46.00	47.74
	Unknown/other liquids	0.55	0.00	0.55
	Unknown/other solids	0.55	4.34	4.89
	NR Sites total	77.16	157.21	234.36
NTS	Aqueous liquids/slurries	0.00	652.00	652.00
	Elemental hazardous metals	8.18	0.00	8.18
	Inorganic homogeneous solids	260.00	0.00	260.00
	Lab packs	0.30	0.00	0.30
	Organic homogeneous solids	1.61	0.00	1.61
	Organic liquids	0.21	0.00	0.21
	Soil/gravel	35.71	2,000.00	2,035.71
	NTS total	306.01	2,652.00	2,958.01
ORISE	Not applicable	c	c	c
ORNL	Aqueous liquids/slurries	2,682.97	429.36	3,112.34
	Batteries	1.21	1.43	2.65
	Beryllium dust	0.01	0.00	0.01
	Elemental hazardous metals	0.30	0.02	0.32
	Elemental mercury	0.69	0.27	0.96
	Explosives/propellants	0.00	0.01	0.01
	Heterogeneous debris	2.53	4.80	7.33
	Inorganic debris	1.76	10.38	12.14
	Inorganic homogeneous solids	51.86	2.97	54.83
	Lab packs	25.36	2.66	28.02
	Organic debris	2.52	6.51	9.04
	Organic homogeneous solids	0.46	1.46	1.92
	Organic liquids	59.49	61.95	121.44
	Reactive metals	0.62	0.01	0.63
	Soil/gravel	4.15	7.66	11.80
	Unknown/other liquids	3.06	4.55	7.61
	Unknown/other matrix	0.15	1.78	1.93
	Unknown/other solids	3.36	26.74	30.10
	ORNL total	2,840.50	562.55	3,403.08

Table 8.5 (continued)

Site	Physical form ^b	Inventory	Five-year projection	Total
PANT	Aqueous liquids/slurries	1.75	24.40	26.15
	Batteries	0.05	1.31	1.36
	Elemental hazardous metals	0.06	0.15	0.21
	Elemental mercury	d	0.00	d
	Heterogeneous debris	3.81	13.85	17.66
	Inorganic debris	12.85	569.85	582.70
	Inorganic homogeneous solids	19.26	7.86	27.12
	Lab packs	7.25	1.82	9.07
	Organic debris	80.06	105.94	186.00
	Organic homogeneous solids	0.00	1.95	1.95
	Organic liquids	2.20	1.40	3.60
	Soil/gravel	0.00	190.00	190.00
	Unknown/other debris	0.21	0.00	0.21
	Unknown/other solids	4.79	0.00	4.79
	PANT total	132.28	918.53	1,050.82
PAD	Aqueous liquids/slurries	61.43	0.00	61.43
	Batteries	4.99	0.00	4.99
	Compressed gases/aerosols	15.40	0.00	15.40
	Elemental hazardous metals	4.25	0.00	4.25
	Elemental mercury	0.52	0.00	0.52
	Explosives/propellants	0.21	0.00	0.21
	Heterogeneous debris	4.63	0.00	4.63
	Inorganic debris	541.85	0.00	541.85
	Inorganic homogeneous solids	86.95	0.00	86.95
	Lab packs	7.44	0.00	7.44
	Organic debris	79.11	0.00	79.11
	Organic homogeneous solids	20.97	0.00	20.97
	Organic liquids	173.21	0.00	173.21
	Soil/gravel	5.01	0.00	5.01
	Unknown/other matrix	26.25	0.00	26.25
	PAD total	1,032.22	0.00	1,032.22
Pinellas	Not applicable	0.00	c	c
PORTS	Aqueous liquids/slurries	119.92	83.50	203.42
	Batteries	17.65	0.00	17.65
	Compressed gases/aerosols	7.91	0.00	7.91
	Elemental mercury	2.66	0.00	2.66
	Heterogeneous debris	1,425.46	3,167.20	4,592.66
	Inorganic debris	5.64	0.00	5.64
	Inorganic homogeneous solids	634.64	2.00	636.64
	Lab packs	30.88	0.00	30.88
	Organic debris	404.55	77.50	482.05
	Organic homogeneous solids	286.56	105.00	391.56
	Organic liquids	236.31	9.00	245.31
	Soil/gravel	4,837.73	100.00	4,937.73
	Reactive metals	0.62	0.00	0.62
	Unknown/other matrix	0.85	0.00	0.85
	PORTS total	8,011.38	3,544.20	11,555.58
PPPL	Not applicable	0.00	c	c

Table 8.5 (continued)

Site	Physical form ^b	Inventory	Five-year projection	Total
RFETS	Aqueous liquids/slurries	533.26	11.17	544.43
	Beryllium dust	3.15	0.00	3.15
	Elemental hazardous metals	34.69	0.00	34.69
	Heterogeneous debris	1,241.85	822.17	2,064.02
	Inorganic debris	180.95	1,096.38	1,277.33
	Inorganic homogeneous solids	10,965.67	1,582.69	12,548.36
	Lab packs	47.38	40.47	87.85
	Organic debris	14.59	38.98	53.57
	Organic liquids	130.80	27.23	158.03
	Soil/gravel	406.05	386.00	792.05
	RFETS total	13,558.39	4,005.09	17,563.48
RMI	Aqueous liquids/slurries	1.80	4.73	6.53
	Inorganic debris	0.00	0.23	0.23
	Inorganic homogeneous solids	1.35	0.69	2.04
	Organic debris	5.87	0.46	6.33
	Organic homogeneous solids	4.93	0.69	5.62
	Organic liquids	7.50	0.69	8.19
	RMI total	21.45	7.49	28.94
SLAC	Not applicable	c	c	c
SNL/CA	Not applicable	0.00	c	c
SNL/NM	Aqueous liquids/slurries	0.03	160.00	160.03
	Elemental hazardous metals	0.04	1.00	1.04
	Elemental mercury	d	1.00	1.00
	Heterogeneous debris	29.00	155.00	184.00
	Inorganic debris	9.74	17.00	26.74
	Organic debris	28.06	2.00	30.06
	Organic liquids	2.90	1.00	3.90
	Reactive metals	0.02	1.00	1.02
	Unknown/other solids	0.01	1.00	1.01
	SNL/NM total	69.80	339.00	408.80
SRS	Aqueous liquids/slurries	157.60	1,556.80	1,714.40
	Elemental hazardous metals	155.70	45.00	200.70
	Elemental mercury	2.70	2.50	5.20
	Heterogeneous debris	2,753.60	1,450.60	4,204.20
	Inorganic debris	16.40	261.40	277.80
	Inorganic homogeneous solids	2,724.40	154.50	2,878.90
	Organic debris	13.90	1,612.20	1,626.10
	Organic liquids	147.40	591.70	739.10
	Soil/gravel	16.80	0.00	16.80
	Unknown/other debris	951.00	0.00	951.00
	SRS total	6,939.50	5,674.70	12,614.20
WVDP	Aqueous liquids/slurries	3.27	1.23	4.49
	Batteries	0.20	0.14	0.34
	Elemental hazardous metals	1.26	0.10	1.36
	Elemental mercury	d	0.00	d
	Heterogeneous debris	125.54	0.07	125.61

Table 8.5 (continued)

Site	Physical form ^b	Inventory	Five-year projection	Total
WVDP (contd.)	Inorganic debris	0.29	0.00	0.29
	Inorganic homogeneous solids	10.01	32.11	42.12
	Lab packs	0.10	0.16	0.26
	Organic debris	1.93	2.57	4.50
	Organic homogeneous solids	0.07	0.00	0.07
	Organic liquids	2.27	2.62	4.89
	Unknown/other matrix	2.86	0.00	2.86
	Unknown/other solids	0.02	0.02	0.04
WVDP total		147.82	39.01	186.83
Y-12	Aqueous liquids/slurries	81.38	122.97	204.35
	Batteries	5.20	2.54	7.74
	Beryllium dust	d	0.00	d
	Compressed gases/aerosols	1.01	0.99	2.00
	Elemental hazardous metals	2.26	1.30	3.56
	Elemental mercury	1.24	0.06	1.29
	Heterogeneous debris	30.73	20.17	50.90
	Inorganic debris	13.84	37.24	51.08
	Inorganic homogeneous solids	6,620.26	1,293.13	7,913.39
	Lab packs	0.05	0.00	0.05
	Organic debris	66.22	62.68	128.90
	Organic homogeneous solids	51.25	7.06	58.31
	Organic liquids	300.92	172.88	473.80
	Reactive metals	0.83	0.00	0.83
	Soil/gravel	6,476.39	11.24	6,487.64
	Unknown/other liquids	22.16	0.00	22.16
	Unknown/other matrix	0.03	0.04	0.06
	Unknown/other solids	55.81	0.00	55.81
Y-12 total		13,729.58	1,732.32	15,461.87
Other ^g	Aqueous liquids/slurries	12.83	0.00	12.83
	Elemental hazardous metals	1.26	1.30	2.55
	Heterogeneous debris	8.93	10.83	19.76
	Inorganic debris	12.00	3.50	15.50
	Inorganic homogeneous solids	2.13	0.00	2.13
	Lab packs	0.02	0.02	0.04
	Organic liquids	0.01	0.00	0.01
	Soil/gravel	0.71	11.40	12.11
Other total		37.89	27.05	64.93
Grand total (DOE complex)		107,911.20	28,624.11	136,535.30

^aBased on the STP Data Base, ref. 9. The currentness of these data for the various DOE sites ranges from January 1995 to June 1996.

^bAs described in Table 8.4.

^cInformation not available or unknown.

^dValue <0.005 m³.

^eIncludes contributions from the Idaho Naval Reactors Facility.

^fIncludes contributions, if any, from Bettis Atomic Power Laboratory (BAPL), Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site. Also includes contributions, if any, from the Charleston, Mare Island, Norfolk, Pearl Harbor, Portsmouth, and Puget Sound Naval Shipyards.

^gIncludes contributions, if any, from Battelle Columbus Laboratory (BCL), Colonie Interim Storage Site (CISS), General Atomics (GA), Laboratory for Energy Related Health Research (LEHR), and Missouri University.

Table 8.6. Estimated volume (m³) inventories and five-year projections of DOE RCRA MLLW as of 1995, by physical form^a

Physical form ^b	Inventory	Five-year projection	Total
Liquids			
Aqueous liquids/slurries	4,972.48	3,261.80	8,234.28
Organic liquids	2,087.40	2,476.99	4,564.39
Unknown/other liquids	25.87	4.55	30.41
Solids			
Heterogeneous debris	26,404.90	7,655.13	34,060.03
Inorganic debris	2,089.40	3,574.23	5,663.63
Inorganic homogeneous solids	50,816.66	4,379.29	55,195.95
Organic debris	3,328.24	2,826.39	6,154.63
Organic homogeneous solids	1,279.28	211.22	1,490.50
Soil/gravel	12,999.32	3,071.73	16,071.05
Unknown/other debris	1,116.36	11.30	1,127.66
Unknown/other homogeneous solids	30.46	70.30	100.75
Unknown/other solids	127.37	32.87	160.24
Specific waste forms			
Batteries	53.72	29.66	83.39
Beryllium dust	3.32	0.00	3.32
Compressed gases/aerosols	31.49	4.94	36.43
Elemental hazardous metals	1,069.32	404.82	1,474.14
Elemental mercury	13.65	5.02	18.67
Explosives/propellants	0.21	1.15	1.36
Lab packs	505.36	199.41	704.77
Reactive metals	401.12	346.81	748.92
Final waste forms	89.25	9.20	98.45
Unknown/other matrix	464.96	47.32	512.28
Total	107,911.15	28,624.11	136,535.26

^aBased on the STP Data Base, ref. 9.

^bAs described in Table 8.4.

Table 8.7. Significant revisions and changes in historical volume (m³) inventory data for DOE RCRA MLLW compared to volume (m³) inventory data reported previously

Site	Values in current report ^a	Values in previous report ^b	Explanation
Hanford	8,170	6,331	The increase in Hanford inventory is due to on-site generation and receipts of off-site shipments
K-25	23,076	29,473	The decrease in K-25 inventory is primarily due to the shipment of stabilized pond sludge wastes to Envirocare for disposal
Middlesex	NA	24,480	The previous report included mixed 11e(2) wastes at part of the RCRA MLLW inventories. In this current report, mixed 11e(2) wastes are addressed exclusively in Chapter 6
WSSRAP	NA	2,022	The previous report included mixed 11e(2) wastes at part of the RCRA MLLW inventories. In this current report, mixed 11e(2) wastes are addressed exclusively in Chapter 6

^aDOE/RW-0006, Rev. 12 (December 1996).

^bDOE/RW-0006, Rev. 11 (September 1995).

Table 8.8. Mass (kg) inventories through 1995, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0	140	0	140
ANL-E	55,636	0	0	55,636
ANL-W	333	6,114	0	6,447
BNL	1,300	1,000	0	2,300
ETEC	0	0	0	0
FEMP	0	0	0	0
FNAL	0	0	0	0
Hanford ^b	117,100	c	0	117,100
INEL ^d	850	0	0	850
ITRI	0	0	0	0
K-25	5,998,200	0	0	5,998,200
KCP	0	0	0	0
LANL	65,570	79,840	0	145,410
LBL	0	307	0	307
LLNL	780	58	0	838
Mound	2,750	20,600	0	23,350
NR sites ^e	9,240	0	0	9,240
NTS	165	0	0	165
ORISE	0	0	0	0
ORNL	16,534	0	0	16,534
PAD	f	f	0	f
PANT	365	1,262	0	1,627
Pinellas	0	0	0	0
PORTS	f	0	0	f
PPPL	0	0	0	0
RFETS	192,000	101,000	0	293,000
SLAC	0	0	0	0
SNL/CA	0	0	0	0
SNL/NM	0	0	0	0
SRS	1,540	f	f	1,540
WVDP	11,086	15,727	0	26,813
Y-12	460,190	0	0	460,190
Total	6,933,639	226,048	0	7,159,687

^aBased on the DOE site data submittals of ref. 11. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.2.

^bIncludes contributions from PNNL.

^cIncluded in the Hanford LLW inventories reported in Chapter 4.

^dExcludes contributions from ANL-W.

^eIncludes only contributions from Bettis Atomic Power Laboratory (BAPL).

^fInformation not available or unknown.

Table 8.9. Volume (m³) inventories through 1995, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0.0	0.7	0.0	0.7
ANL-E	57.0	0.0	0.0	57.0
ANL-W	0.3	12.5	0.0	12.8
BNL	1.3	2.1	0.0	3.4
ETEC	0.0	0.0	0.0	0.0
FEMP	0.0	0.0	0.0	0.0
FNAL	0.0	0.0	0.0	0.0
Hanford ^b	102.5	c	0.0	102.5
INEL ^d	2.2	0.0	0.0	2.2
ITRI	0.0	0.0	0.0	0.0
K-25	8,159.3	0.0	0.0	8,159.3
KCP	0.0	0.0	0.0	0.0
LANL	2,105.0	4,087.0	0.0	6,192.0
LBL	0.0	0.8	0.0	0.8
LLNL	0.5	<0.1	0.0	0.6
Mound	3.9	41.2	0.0	45.1
NR sites ^e	18.3	0.0	0.0	18.3
NTS	0.1	0.0	0.0	0.1
ORISE	0.0	0.0	0.0	0.0
ORNL	16.3	0.0	0.0	16.3
PAD	3,500.0	430.0	0.0	3,930.0
PANT	0.3	2.4	0.0	2.7
Pinellas	0.0	0.0	0.0	0.0
PORTS	3,600.0	0.0	0.0	3,600.0
PPPL	0.0	0.0	0.0	0.0
RFETS	128.0	62.9	0.0	190.9
SLAC	0.0	0.0	0.0	0.0
SNL/CA	0.0	0.0	0.0	0.0
SNL/NM	0.0	0.0	0.0	0.0
SRS	110.0	f	f	110.0
WVDP	13.0	69.2	0.0	82.2
Y-12	940.8	0.0	0.0	940.8
Total	18,758.8	4,708.9	0.0	23,467.7

^aBased on the DOE site data submittals of ref. 11. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.2.

^bIncludes contributions from PNNL.

^cIncluded in the Hanford LLW inventories reported in Chapter 4.

^dExcludes contributions from ANL-W.

^eIncludes only contributions from Bettis Atomic Power Laboratory (BAPL).

^fInformation not available or unknown.

Table 8.10. 1995 mass (kg) generation, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0	100	0	100
ANL-E	0	0	0	0
ANL-W	0	17	0	17
BNL	230	230	0	460
ETEC	0	18,000	0	18,000
FEMP	0	0	0	0
FNAL	0	0	0	0
Hanford ^b	6,900	c	0	6,900
INEL ^d	54	0	0	54
ITRI	0	0	0	0
K-25	175,500	0	0	175,500
KCP	0	0	0	0
LANL	16	18,390	0	18,406
LBL	0	125	0	125
LLNL	53	7	0	60
Mound	15	3,500	0	3,515
NR sites ^e	505	28,161 ^f	0	28,666
NTS	0	0	0	0
ORISE	0	0	0	0
ORNL	16,492	0	0	16,492
PAD ^g	224,470	187,794	0	412,264
PANT	1,017	146,288	0	147,305
Pinellas	0	0	0	0
PORTS ^g	79,990	11,500	0	91,490
PPPL	0	0	0	0
RFETS	h	h	h	h
SLAC	0	0	0	0
SNL/CA	0	0	0	0
SNL/NM	0	0	0	0
SRS	0	h	h	0
WVDP	10,090	4,877	0	14,967
Y-12	27,227	0	0	27,227
Total	542,559	418,989	0	961,548

^aBased on the DOE site data submittals of ref. 11. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.2.

^bIncludes contributions from PNNL.

^cIncluded in the Hanford LLW generation reported in Chapter 4.

^dExcludes contributions from ANL-W.

^eIncludes contributions from Bettis Atomic Power Laboratory (BAPL), Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site.

^fExcludes contributions from asbestos wastes generated at BAPL. These are reported as LLW in Chapter 4.

^gInformation for CY 1994. Information for CY 1995 not available.

^hInformation not available or unknown.

Table 8.11. 1995 volume (m³) generation, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0.0	0.2	0.0	0.2
ANL-E	0.0	0.0	0.0	0.0
ANL-W	0.0	<0.1	0.0	<0.1
BNL	0.2	0.4	0.0	0.6
ETEC	0.0	18.5	0.0	18.5
FEMP	0.0	0.0	0.0	0.0
FNAL	0.0	0.0	0.0	0.0
Hanford ^b	6.9	c	0.0	6.9
INEL ^d	0.3	0.0	0.0	0.3
ITRI	0.0	0.0	0.0	0.0
K-25	321.8	0.0	0.0	321.8
KCP	0.0	0.0	0.0	0.0
LANL	0.3	68.6	0.0	68.9
LBL	0.0	0.3	0.0	0.3
LLNL	<0.1	<<0.1	0.0	<0.1
Mound	<0.1	7.0	0.0	7.1
NR sites ^e	0.4	21.8 ^f	0.0	22.2
NTS	0.0	0.0	0.0	0.0
ORISE	0.0	0.0	0.0	0.0
ORNL	20.1	0.0	0.0	20.1
PAD ^g	286.1	774.7	0.0	1,060.8
PANT	0.8	357.4	0.0	358.2
Pinellas	0.0	0.0	0.0	0.0
PORTS ^g	250.0	9.9	0.0	259.9
PPPL	0.0	0.0	0.0	0.0
RFETS	h	h	h	h
SLAC	0.0	0.0	0.0	0.0
SNL/CA	0.0	0.0	0.0	0.0
SNL/NM	0.0	0.0	0.0	0.0
SRS	0.0	h	h	0.0
WVDP	10.4	25.2	0.0	35.6
Y-12	52.1	0.0	0.0	52.1
Total	949.6	1,284.1	0.0	2,233.7

^aBased on the DOE site data submittals of ref. 11. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.2.

^bIncludes contributions from PNNL.

^cIncluded in the Hanford LLW generation reported in Chapter 4.

^dExcludes contributions from ANL-W.

^eIncludes contributions from Bettis Atomic Power Laboratory (BAPL), Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site.

^fExcludes contributions from asbestos wastes generated at BAPL. These are reported as LLW in Chapter 4.

^gInformation for CY 1994. Information for CY 1995 not available.

^hInformation not available or unknown.

Table 8.12. Historical and projected annual mass (kg) generation rates for TSCA-regulated MLLW from DOE site activities^a

Site	1995 ^b	1996	1997-2001 ^c	2002-2030 ^c
Ames	100	100	100	100
ANL-E	0	d	d	d
ANL-W	17	d	d	d
BNL	460	180	400	400
ETEC	18,000	145,000	18,000	0
FEMP	0	d	d	d
FNAL	0	0	0	0
Hanford ^e	6,900	f	f	f
INEL ^g	54	d	d	d
ITRI	0	0	0	0
K-25	175,500	175,500	175,500	175,500
KCP	0	0	0	0
LANL	18,406	118,400	118,400	94,750
LBL	125	0	125	125
LLNL	60	0	0	0
Mound	3,515	3,500	3,500	3,500
NR sites ^{h,i}	28,666	42,919	72,656	19,500
NTS	0	d	d	d
ORISE	0	0	0	0
ORNL	16,492	16,492	16,492	16,492
PAD	412,264	d	d	d
PANT	147,305	82,199	43,722	4,893
Pinellas	0			
PORTS	91,490	d	d	d
PPPL	0	0	0	0
RFETS	d	d	d	d
SLAC	0	0	0	0
SNL/CA	0	0	0	0
SNL/NM	0	0	0	0
SRS	0	0	d	d
WVDP	14,967	7,500	d	d
Y-12	27,227	27,227	27,227	27,227
Total	961,548	619,017	476,122	342,487

^aBased on the DOE site data submittals of ref. 11. Specific site information is provided in Sect. 8.4.2.

^bActual data, as reported in Table 8.10.

^cAverage annual generation rate anticipated for this period.

^dInformation not available or unknown.

^eIncludes contributions from PNNL.

^fHanford projections for PCB's are included in the RCRA/state category of this chapter. Hanford projections for asbestos are included in the Hanford LLW projections of Chapter 4.

^gExcludes contribution from ANL-W.

^hIncludes contributions from INEL Naval Reactors Facility (NRF), Bettis Atomic Power Laboratory (BAPL), Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site.

ⁱExcludes contributions from asbestos wastes generated at BAPL. These are reported as LLW in Chapter 4.

Table 8.13. Historical and projected annual volume (m³) generation rates for TSCA-regulated MLLW from DOE site activities^a

Site	1995 ^b	1996	1997–2001 ^c	2002–2030 ^c
Ames	0.2	0.2	0.2	0.2
ANL–E	0.0	d	d	d
ANL–W	<0.1	d	d	d
BNL	0.6	0.7	0.7	0.7
ETEC	18.5	147.0	18.4	0.0
FEMP	0.0	d	d	d
FNAL	0.0	0.0	0.0	0.0
Hanford ^e	6.9	f	f	f
INEL ^g	0.3	d	d	d
ITRI	0.0	0.0	0.0	0.0
K-25	321.8	321.8	321.8	321.8
KCP	0.0	0.0	0.0	0.0
LANL	68.9	146.8	146.8	117.5
LBL	0.3	0.0	0.3	0.3
LLNL	<0.1	0.0	0.0	0.0
Mound	7.1	7.0	7.0	7.0
NR sites ^{h,i}	22.2	36.7	64.4	14.9
NTS	0.0	d	d	d
ORISE	0.0	0.0	0.0	0.0
ORNL	20.1	20.1	20.1	20.1
PAD	1,060.8	d	d	d
PANT	358.2	200.3	106.5	44.9
Pinellas	0.0			
PORTS	259.9	d	d	d
PPPL	0.0	0.0	0.0	0.0
RFETS	d	d	d	d
SLAC	0.0	0.0	0.0	0.0
SNL/CA	0.0	0.0	0.0	0.0
SNL/NM	0.0	0.0	0.0	0.0
SRS	0.0	0.0	d	d
WVDP	35.6	6.6	d	d
Y-12	52.1	52.1	52.1	52.1
Total	2,233.7	939.3	738.3	579.5

^aBased on the DOE site data submittals of ref. 11. Specific site information is provided in Sect. 8.4.2.

^bActual data, as reported in Table 8.11.

^cAverage annual generation rate anticipated for this period.

^dInformation not available or unknown.

^eIncludes contributions from PNNL.

^fHanford projections for PCB's are included in the RCRA/state category of this chapter. Hanford projections for asbestos are included in the Hanford LLW projections of Chapter 4.

^gExcludes contribution from ANL–W.

^hIncludes contributions from INEL Naval Reactors Facility (NRF), Bettis Atomic Power Laboratory (BAPL), Knolls Atomic Power Laboratory (KAPL), Kesselring Site, and Windsor Site.

ⁱExcludes contributions from asbestos wastes generated at BAPL. These are reported as LLW in Chapter 4.

**Table 8.14. Significant revisions and changes in historical inventory data for DOE
TSCA MLLW compared to inventory data reported previously**

Site	Waste characteristics	Values in current report ^a	Values in previous report ^b	Significant revisions and changes	Explanation
Y-12	Inventory of radioactive PCB wastes	941 m ³ (460,190 kg)	150 m ³ (204,544 kg)	+791 m ³ (+255,646 kg)	Large increase is mainly due to wastes from site reroofing activities during CY 1995

^aDOE/RW-0006, Rev. 12 (December 1996).

^bDOE/RW-0006, Rev. 11 (September 1995).

**Table 8.15. National commercially generated MLLW profile
volume summary, by facility category^a**

Facility category	Waste volume, m ³		
	Generated in 1990	Stored as of Dec. 31, 1990 ^b	Treated in 1990 ^c
Academic	820.7	154.2	1,581.9
Government	750.4	78.9	612.5
Industrial	1,428.0	1,197.3	1,115.1
Medical	563.6	63.1	466.3
Nuclear power plants	385.8	622.5	216.9
Total ^d	3,948.5	2,116.0	3,992.6

^aBased on ref. 7.

^bThis is not the amount of mixed waste requiring disposal. Some of this waste was being accumulated for treatment.

^cTreated wastes may include mixed wastes generated in years prior to 1990.

^dTotal reported in this table may not equal the sum of component entries because of round-off and truncation of numbers.

Table 8.16. National commercially generated MLLW profile volume summary, by hazardous waste stream^a

Hazardous stream	Waste volume, m ³		
	Generated in 1990	Stored as of Dec. 31, 1990 ^b	Treated in 1990 ^c
Organics			
Liquid scintillation fluids	2,837.2	363.4	3,371.8
Waste oil	148.9	178.1	139.4
Chlorinated organics	70.9	27.0	23.2
Fluorinated organics	0	3.5	0
Chlorinated fluorocarbons (CFCs)	113.2	254.7	3.7
Other organics	274.6	117.9	258.9
Total organics ^d	3,444.8	944.6	3,797.0
Metals			
Lead	81.6	138.7	6.1
Mercury	12.5	81.1	1.5
Chromium	28.4	53.3	3.9
Cadmium	0.3	745.2	0.1
Total metals ^d	122.8	1,018.3	11.6
Aqueous corrosives	80.4	12.2	2.6
Other hazardous materials	300.5	141.0	181.4
Grand totals ^d	3,948.5	2,116.0	3,992.6

^aBased on ref. 7.

^bThis is not the amount of mixed waste requiring disposal. Some of this waste was being accumulated for treatment.

^cTreated wastes may include mixed wastes generated in years prior to 1990.

^dTotals reported in this table may not equal the sum of component entries because of round-off and truncation of numbers.

**APPENDIX A. RADIOACTIVE WASTE SOURCE TERMS
AND CHARACTERISTICS**

APPENDIX A. RADIOACTIVE WASTE SOURCE TERMS AND CHARACTERISTICS

A.1 DISCUSSION

In this report, a number of engineering estimates, assumptions, and ground rules are used to determine radioactive waste and spent nuclear fuel projections through the year 2030. Many of these involve parameters that characterize certain types of waste (e.g., see Table A.1). In other instances, estimates were made of the waste volume generated per unit of product throughput for each step in the fuel cycle. This appendix is a compilation of source terms and characteristics used for making radioactive waste projections. Source terms are used to describe quantitative and qualitative characteristics of radioactive wastes. As used in this report, the source term for a particular waste is comprised of two components unique to that waste: (1) the number of curies of radioactivity expressed either per unit of facility production or per unit of waste volume or mass and (2) a listing of the relative radioactivity contributions of component radioisotopes.

The source terms used in the analysis of this report are based on reported historical data, engineering estimates, calculations, and/or experimental data. Documentation of the source terms and key waste-modeling parameters is provided in the following sets of figures and tables (based primarily on refs. 1 through 6). Detailed information on how these source terms and modeling parameters were derived is available, mainly in ref. 1 and its update (ref. 2).

Representative DOE LLW radionuclide compositions are described in Table A.2 (based on ref. 1). Average concentrations for representative radionuclides in LLW disposed of at commercial sites are given in Table A.3. This information was adapted from ref. 3. Table A.4 gives a summary of major sources and estimated characteristics of commercial greater-than-Class-C LLW (data from refs. 4 and 5). Inventories of the LLW incorporated in cement by the West Valley Demonstration Project Radwaste Treatment System are given in Table A.5, which is based on ref. 6.

A.2 REFERENCES

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Table A.1. Estimated representative unit activity and thermal power characteristics of various types of radioactive materials and wastes

Radioactive material/ waste type	Unit activity (Ci/m ³)	Unit thermal power (W/m ³)
Spent nuclear fuel ^a		
BWR	1,000,000–10,000,000	3,500–40,000
PWR	2,000,000–20,000,000	7,500–65,000
High-level waste	1,500–15,000	5–50
Transuranic waste		
Remote-handled, stored	1,000	1–2
Contact-handled, stored	25–50	0.5–1.5
Buried	0.25–0.50	0.005–0.010
Low-level waste ^b		
DOE sites	9–27	0.012–0.054
Commercial sites ^c	4.6–6.4	0.30–1.60
Class A	0.5–0.7	0.03–0.10
Class B	55–60	14–15
Class C	0.1–>7,000 ^d	0.003–115 ^d
GTCC ^e	>0.1–No limit	>0.003–No limit
Uranium mill tailings	0.010	0.00020

^aLower-bound levels are based on cumulative spent nuclear fuel discharged; upper-bound levels are based on annual discharges.

^bBased on 1986–1988 Solid Waste Information Management System (SWIMS) and the National Low-Level Waste Management Program (LLWMP) data access system, both of which were maintained by EG&G, Idaho, Inc., Idaho Falls, Idaho.

^cWaste classification is defined by the NRC in 10 CFR Part 61.55 on the basis of concentration of certain long- and short-lived radionuclides. The classification system is designed to minimize potential exposures in both the short and long term. The gross Ci/m³ shown above are representative of typical LLW shipped to commercial disposal sites. Nuclear power plant wastes account for most of the radioactivity (~96%) and include Class A, B, and C. Essentially all medical wastes are Class A. Industrial wastes are largely Class A, but they contain some Class B and C.

^dMaximum for ⁶³Ni in activated metal or ⁹⁰Sr. There is no limit on concentration of ³H, ⁶⁰Co, or nuclides with half-lives < 5 years. The maximum thermal power shown is based on the highest reported gross Ci/m³ analysis for irradiated core components (1986–1988) and assumes all the activity is due to ⁶⁰Co, which would yield the greatest heat output. If the activity is due to activation products, such as ⁵⁴Mn, ⁵⁸Co, etc., the Ci/m³ could be much higher for individual shipments, and the total W/m³ could exceed the value shown.

^eIn temporary storage. The concentration of actinides and ¹²⁹I determines the lower activity boundary. There is no limit on concentrations of ³H, ⁶⁰Co, or nuclides with half-lives < 5 years.

Table A.2. Representative DOE LLW radionuclide composition by percent activity^a

Uranium/thorium		Fission product		Induced activity		Alpha, <100 nCi/g		Other	
Nuclide	Composition	Nuclide	Composition	Nuclide	Composition	Nuclide	Composition	Nuclide	Composition
²⁰⁸ Tl	0.0017	⁶⁰ Co	0.08	⁵¹ Cr	4.95	²³⁸ Pu	2.62	³ H	1.22
²¹² Pb	0.0045	⁹⁰ Sr	7.77	⁵⁴ Mn	38.10	²³⁹ Pu	0.20	¹⁴ C	0.06
²¹² Bi	0.0045	⁹⁰ Y	7.77	⁵⁸ Co	55.40	²⁴⁰ Pu	0.70	⁵⁴ Mn	6.76
²¹² Po	0.0029	⁹⁵ Zr	1.27	⁵⁹ Fe	0.49	²⁴¹ Pu	96.4	⁵⁸ Co	6.24
²¹⁶ Po	0.0045	⁹⁵ Nb	2.83	⁶⁰ Co	0.87	²⁴¹ Am	0.004	⁶⁰ Co	18.03
²²⁴ Ra	0.0045	⁹⁹ Tc	0.02	⁶⁵ Zn	0.19	²⁴² Cm	0.056	⁹⁰ Sr	8.48
²²⁸ Ra	0.0269	¹²⁵ Sb	2.93			²⁴⁴ Cm	0.020	⁹⁰ Y	8.48
²²⁸ Ac	0.0269	^{125m} Te	0.73		100.00			⁹⁹ Tc	0.12
²²⁸ Th	0.0045	¹⁰⁶ Ru	6.39				100.000	¹³⁴ Cs	13.98
²³¹ Th	0.0259	¹⁰⁶ Rh	6.39					¹³⁷ Cs	18.45
²³² Th	0.273	¹³⁴ Cs	0.38					^{137m} Ba	17.45
²³⁴ Th	33.197	¹³⁷ Cs	17.31					²³⁸ U	0.73
^{234m} Pa	33.197	^{137m} Ba	16.38						
²³⁴ Pa	0.0034	¹⁴⁴ Ce	14.67						100.00
²³⁵ U	0.0258	¹⁴⁴ Pr	14.67						
²³⁸ U	33.197	¹⁴⁷ Pm	0.06						
		¹⁵¹ Sm	0.11						
	100.0000	¹⁵² Eu	0.09						
		¹⁵⁴ Eu	0.09						
		¹⁵⁵ Eu	0.06						
			100.00						

^aBased on ref. 1.

Table A.3. Average concentrations for representative radionuclides in LLW at commercial disposal sites^a

Radionuclide	Half-life ^b	Concentration (Ci/m ³)
³ H	1.228E+01 y	1.083E+00
¹⁴ C	5.730E+03 y	5.079E-03
²⁶ Al	7.300E+05 y	2.980E-10
³² Si	1.000E+02 y	3.725E-11
³² P	1.428E+01 d	9.292E-04
³⁵ S	8.751E+01 d	2.208E-03
³⁶ Cl	3.010E+05 y	6.143E-06
⁴⁰ K	1.280E+09 y	1.766E-07
⁵¹ Cr	2.770E+01 d	7.137E-02
⁵⁴ Mn	3.122E+02 d	3.895E-01
⁵⁵ Fe	2.730E+00 y	3.112E+00
⁵⁹ Fe	4.445E+01 d	5.081E-03
⁵⁸ Co	7.092E+01 d	2.047E-01
⁶⁰ Co	5.271E+00 y	2.242E+00
⁵⁹ Ni	7.500E+04 y	1.364E-03
⁶³ Ni	1.001E+02 y	2.692E-01
⁶⁵ Zn	2.441E+02 d	1.174E-01
⁸⁵ Kr	1.072E+01 y	8.147E-04
⁸⁹ Sr	5.055E+01 d	6.032E-03
⁹⁰ Sr	2.850E+01 y	6.987E-02
⁹⁰ Y	2.671E+01 d	6.987E-02
⁹¹ Y	5.851E+01 d	8.859E-03
⁹⁵ Zr	6.402E+01 d	1.036E-02
⁹⁴ Nb	2.030E+04 y	1.659E-05
⁹⁵ Nb	3.497E+01 d	1.916E-02
⁹³ Mo	3.500E+03 y	9.273E-12
⁹⁹ Tc	2.130E+05 y	1.949E-04
¹⁰³ Ru	3.925E+01 d	5.900E-04
^{108m} Ag	1.300E+02 y	5.534E-06
^{110m} Ag	2.498E+02 d	3.600E-02
¹¹³ Cd	9.000E+15 y	4.223E-12
¹²⁴ Sb	6.020E+00 d	2.621E-03
¹²⁵ Sb	2.730E+00 y	1.901E-02
¹²³ Te	1.300E+13 y	5.710E-07
¹²⁵ I	6.014E+00 d	4.570E-04
¹²⁹ I	1.570E+07 y	2.101E-05
¹³¹ I	8.040E+00 d	5.299E-03
¹³⁴ Cs	2.062E+00 y	8.661E-02
¹³⁵ Cs	3.000E+06 y	1.105E-05
¹³⁷ Cs	3.017E+01 y	2.431E-01
^{137m} Ba	2.552E+00 min	2.300E-01
¹⁴¹ Ce	3.250E+01 d	1.649E-03
¹⁴⁴ Ce	2.849E+02 d	1.463E-02

Table A.3 (continued)

Radionuclide	Half-life ^b	Concentration (Ci/m ³)
¹⁴⁴ Pr	1.728E+01 min	1.463E-02
¹⁴⁴ Nd	2.100E+15 y	1.689E-10
¹⁴⁷ Pm	2.623E+00 y	1.317E-02
¹⁵⁷ Tb	1.100E+02 y	1.012E-10
¹⁵⁸ Tb	1.800E+02 y	3.768E-10
¹⁷⁵ Hf	7.000E+01 d	1.427E-03
¹⁸¹ Hf	4.240E+01 d	3.235E-03
¹⁸⁷ Re	4.100E+10 y	1.772E-11
²⁰⁹ Po	3.253E+00 h	1.284E-10
²²⁶ Ra	1.600E+03 y	2.852E-04
²²⁹ Th	7.340E+03 y	1.310E-10
²³⁰ Th	7.540E+04 y	1.721E-08
²³² Th	1.405E+10 y	8.482E-03
²³¹ Pa	3.276E+04 y	1.016E-10
²³³ U	1.592E+05 y	2.308E-07
²³⁴ U	2.454E+05 y	5.368E-05
²³⁵ U	7.037E+08 y	3.179E-05
²³⁶ U	2.432E+07 y	7.886E-07
²³⁸ U	4.468E+09 y	9.970E-03
²³⁷ Np	2.140E+06 y	2.210E-07
²³⁹ Pu	2.413E+04 y	1.021E-05 ^c
²⁴⁰ Pu	6.563E+03 y	2.504E-06 ^c
²⁴² Pu	3.763E+05 y	6.148E-07 ^c
²⁴¹ Am	4.322E+02 y	4.053E-05
²⁴³ Am	7.380E+03 y	1.398E-08
²⁴⁸ Cm	3.400E+05 y	6.220E-07
Total		8.380E+00

^aAdapted from ref. 3.^by = years; d = days; h = hours; min = minutes; and s = seconds.^cIsotopes of plutonium are omitted when this list is applied to waste disposed at Barnwell, South Carolina, because this site has not permitted disposal of plutonium (even though traces of plutonium could have entered with other wastes).

Table A.4. Estimated sources and characteristics of commercial Greater-Than-Class-C LLW^a

Waste source	Physical form	Primary isotopes of concern for disposal
Utilities		
Reactor operations	Activated metals, instruments, filters, ion-exchange resins, sludges	⁵⁹ Ni, ⁶³ Ni, ⁹⁴ Nb, and TRU isotopes
Reactor decommissioning	Activated metals	⁵⁹ Ni, ⁶³ Ni, and ⁹⁴ Nb
Fuel testing labs		
Burnup lab operation	Solidified liquids, metal cuttings, glassware, equipment, ion-exchange resins	⁹⁰ Sr and TRU isotopes
Burnup lab decommissioning	Solidified liquids, metals, glassware, equipment	⁹⁰ Sr and TRU isotopes
Sealed sources		
Manufacturer operations	Trash, metal, foils	¹⁴ C, ⁹⁰ Sr, ¹³⁷ Cs, ²⁴¹ Am, and Pu isotopes
Manufacturer decommissioning	Trash, metal, foils	¹⁴ C, ⁹⁰ Sr, ¹³⁷ Cs, ²⁴¹ Am, and Pu isotopes
Sources designated as waste	Sealed sources	¹³⁷ Cs, ²³⁸ Pu, ²³⁹ Pu, and ²⁴¹ Am
Other		
¹⁴ C users	Solidified process liquids	¹⁴ C
Test and research reactors	Activated metals	⁵⁹ Ni, ⁹⁴ Nb, and TRU isotopes
Other	Soil, trash	²⁴¹ Am

^aGleaned from information given in refs. 4 and 5.

Table A.5. Historical number and volume of drums and classes of LLW incorporated in cement generated in the WVDP Low-Level Radwaste Treatment System^{a,b,c,d}

End of calendar year	Number of drums			Total volume of drums (m ³)
	Class A ^c	Class B	Class C ^e	
1987	726 ^f	g	—	189
1988		g	2,009	523
1989		g	4,523	1,177
1990 ^h		g	3,862	1,055
1991		g	0	0
1992	1,268	g	268	399
1993	2,387	g	1,298	959
1994		g	2,641	687
1995 ⁱ		g	1,632	425
Total number	4,381	g	16,238	
Total volume, m ³	1,140	g	4,225	5,414

^aThe so-called square drums used are parallelepipeds of square cross sections (~0.6 m × 0.6 m × 0.8 m) with a volume of 71 gal (0.27 m³).

^bThe classes are in accordance with the Classes (A, B, or C) as set by requirements of the NRC in 10 CFR Part 61.55.

^cTaken from ref. 6.

^dAlkaline HLW liquid is processed (see Chapter 2) to yield a loaded ion-exchange material (zeolite), which is HLW, and an effluent, which is LLW. This effluent is solidified with cement.

^eStored in a shielded drum cell.

^fGenerated in 1987 during equipment testing campaigns.

^gNo Class-B LLW is expected to be generated with the effluent mentioned in footnote "d."

^hProcessing of alkaline supernatant HLW liquid was completed in November 1990.

ⁱProcessing of residual supernatant, sludge waste solutions, and Thorex waste were completed in January 1995.

APPENDIX B. CHARACTERISTICS OF IMPORTANT RADIONUCLIDES

APPENDIX B. CHARACTERISTICS OF IMPORTANT RADIONUCLIDES

B.1 DISCUSSION

The following Table B.1 lists radionuclides whose characteristics are most often referenced in the variety of studies and evaluations discussed in Chapters 1–7. It includes isotopes for HLW, TRUW, LLW, and UMT as defined by EPA,¹ NRC,^{2,3} and DOE.^{4,5} The data in Table B.1 were obtained from refs. 6–9.

B.2 REFERENCES

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Table B.1. Characteristics of important radionuclides^a

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
³ H	1	1.233E+01 y	β		0.00568		5.68E-03	3.37E-05	9.650E+03	³ He
¹⁴ C	6	5.730E+03 y	β		0.0495		4.95E-02	2.93E-04	4.457	¹⁴ N
²⁶ Al	13	7.2E+05 y	EC		0.4451	2.6758	3.079	1.825E-02	1.91E-02	²⁶ Mg
³² Si	14	650 y	β		0.0647		2.10E-01	1.245E-03	1.719E+01	³² P
³² P	15	14.282 d	β		0.6947		6.95E-01	4.12E-03	2.853E+05	³² S
³⁵ S	16	87.51 d	β		0.0486		4.86E-02	2.88E-04	4.263E+04	³⁵ Cl
³⁶ Cl	17	3.01E+05 y	β (98.1%); EC (1.9%)		0.2460		2.460E-01	1.458E-03	3.299E-02	³⁶ Ar, ³⁶ S
⁴⁰ K	19	1.277E+09 y	β (89.33%); EC (10.67%)		0.4545	0.1559	6.104E-01	3.62E-03	6.983E-06	⁴⁰ Ca, ⁴⁰ Ar
⁴⁵ Ca	20	163.8 d	β		0.0770		7.70E-02	4.56E-04	1.780E+04	⁴⁵ Sc
⁴⁶ Sc	21	83.83 d	β	0.1120	2.0095		2.122	1.257E-02	3.381E+04	⁴⁶ Ti
⁵¹ Cr	24	27.704 d	EC		0.0031	0.0325	3.56E-02	2.11E-04	9.240E+04	⁵¹ V
⁵⁴ Mn	25	312.20 d	EC		0.0034	0.8360	8.394E-01	4.975E-03	7.738E+03	⁵⁴ Cr
⁵⁵ Fe	26	2.73 y	EC		0.0038	0.0016	5.4E-03	3.2E-05	2.500E+03	⁵⁵ Mn
⁵⁹ Fe	26	44.496 d	β		0.1174	1.1882	1.3056	7.741E-03	4.918E+04	⁵⁹ Co
⁵⁷ Co	27	271.77 d	EC		0.0176	0.1252	1.428E-01	8.464E-01	8.456E+03	⁵⁷ Fe
⁵⁸ Co	27	70.92 d	EC		0.0336	0.9758	1.0094	5.99E-03	3.181E+04	⁵⁸ Fe
⁶⁰ Co	27	5.271 y	β		0.0958	2.5058	2.6016	1.541E-02	1.131E+03	⁶⁰ Ni
^{60m} Co	27	10.47 min	IT (99.75%); β (0.25%)		0.0536	0.0066	6.02E-02	3.57E-04	2.993E+08	⁶⁰ Co; ⁶⁰ Ni
⁵⁹ Ni	28	7.5E+04 y	EC		0.0043	0.0024	6.72E-03	3.98E-05	8.079E-02	⁵⁹ Co
⁶³ Ni	28	1.001E+02 y	β		0.0171		1.71E-02	1.01E-04	6.168E+01	⁶³ Cu

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
⁶⁵ Zn	30	244.1 d	EC		0.0066	0.5838	5.90E-01	3.51E-03	8.237E+03	⁶⁵ Cu
⁶⁷ Ga	31	3.261 d	EC		0.0333	0.1549	1.882E-01	1.115E-03	5.975E+05	⁶⁷ Zn
⁷⁵ Se	34	119.77 d	EC		0.0134	0.3924	4.06E-01	2.41E-03	1.453E+04	⁷⁵ As
⁷⁹ Se	34	<6.5E+04 y			0.0529		5.29E-02	3.13E-04	6.966E-02	⁷⁹ Br
⁸⁵ Kr	36	1.072E+01 y	β		0.2505	0.0022	2.53E-01	1.50E-03	3.923E+02	⁸⁵ Rb
⁸⁶ Rb	37	18.66 d	β		0.6670	0.0945	7.62E-01	4.52E-03	8.138E+04	⁸⁶ Sr
⁸⁹ Sr	38	50.55 d	β		0.5829	0.0001	5.83E-01	3.46E-03	2.905E+04	⁸⁹ Y
⁹⁰ Sr	38	2.85E+01 y	β		0.1958		1.96E-01	1.16E-03	1.364E+02	⁹⁰ Y
⁹⁰ Y	39	2.671 d	β		0.9332		9.33E-01	5.54E-03	5.441E+05	⁹⁰ Zr
⁹¹ Y	39	58.51 d	β		0.6039	0.0036	6.07E-01	3.60E-03	2.452E+04	⁹¹ Zr
⁹³ Zr	40	1.53E+06 y	β		0.0471	0.0018	4.89E-02	2.90E-04	2.513E-03	⁹³ Nb
⁹⁵ Zr	40	64.02 d	β		0.1200	0.7337	8.54E-01	5.06E-03	2.148E+04	⁹⁵ Nb
^{93m} Nb	41	1.36E+01 y	IT		0.0281	0.0018	2.99E-02	1.77E-04	2.826E+02	⁹³ Nb
⁹⁴ Nb	41	2.03E+04 y	β		0.1454	1.5715	1.7169	1.018E-02	1.873E-01	⁹⁴ Mo
⁹⁵ Nb	41	34.97 d	β		0.0435	0.7643	8.078E-01	4.788E-03	3.910E+04	⁹⁵ Mo
⁹³ Mo	42	3500 y	EC		0.0051	0.0107	1.58E-02	9.37E-05	1.10	⁹³ Nb
⁹⁹ Mo	42	2.748 d	β		0.4076	0.2723	6.799E-01	4.028E-03	4.796E+05	⁹⁹ Tc
⁹⁹ Tc	43	2.13E+05 y	β		0.0846		8.46E-02	5.01E-04	1.695E-02	⁹⁹ Ru
^{99m} Tc	43	6.006 h	IT		0.0142	0.1240	1.382E-01	8.186E-04	5.271E+06	⁹⁹ Tc
¹⁰³ Ru	44	39.254 d	β		0.1105	0.4851	5.96E-01	3.53E-03	3.227E+04	¹⁰³ Rh
¹⁰⁶ Ru	44	1.020 y	β		0.1004		1.004E-01	5.951E-04	3.346E+03	¹⁰⁶ Rh
^{103m} Rh	45	56.12 min	IT		0.0375	0.0017	3.92E-02	2.32E-04	3.253E+07	¹⁰³ Rh
¹⁰⁶ Rh	45	2.17 h	β		0.3144	2.8826	3.197	1.894E-02	3.560E+09	¹⁰⁶ Pd

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
¹⁰⁷ Pd	46	6.5E+06 y	β			0.0093	9.3E-03	5.5E-05	5.143E-04	¹⁰⁷ Ag
¹¹⁰ Ag	47	24.6 s	β (99.70%); EC (0.30%)		1.1842	0.0316	1.216	7.208E-03	4.169E+09	¹¹⁰ Cd; ¹¹⁰ Pd
^{110m} Ag	47	249.76 d	β (98.64%); IT (1.36%)		0.0755	2.7392	2.815	1.669E-02	4.750E+03	¹¹⁰ Cd; ¹¹⁰ Ag
¹¹³ Cd	48	9.3E+15 y	β		0.0933		9.13E-02	5.412E-04	3.402E-13	¹¹³ In
^{113m} Cd	48	1.37E+01 y	β (99.9%); IT (0.1%)			0.1834	1.83E-01	1.08E-03	2.168E+02	¹¹³ In; ¹¹³ Cd
^{115m} Cd	48	44.6 d	β		0.6029	0.0329	6.36E-01	3.76E-03	2.546E+04	¹¹⁵ In
¹¹¹ In	49	2.807 d	EC		0.0340	0.4053	4.393E-01	2.604E-03	4.157E+05	¹¹¹ Cd
^{113m} In	49	1.658 h	IT		0.1340	0.2555	3.89E-01	2.31E-03	1.673E+07	¹¹³ In
^{114m} In	49	49.51 d	IT (95.7%); EC (4.3%)		0.1431	0.0943	2.37E-01	1.40E-03	2.313E+04	¹¹⁴ In; ¹¹⁴ Cd
¹¹³ Sn	50	115.09 d	EC		0.1394	0.2808	4.20E-01	2.48E-03	1.004E+04	¹¹³ In
^{117m} Sn	50	13.61 d	IT		0.1613	0.1580	3.19E-01	1.89E-03	7.969E+04	¹¹⁷ Sn
^{119m} Sn	50	293.0 d	IT		0.0783	0.0114	8.97E-02	5.32E-04	4.478E+03	¹¹⁹ Sn
^{121m} Sn	50	5.5E+01 y	IT (77.6%); β (22.4%)		0.0352	0.0050	4.02E-02	2.43E-04	5.912E+01	¹²¹ Sn; ¹²¹ Sb
¹²³ Sn	50	129.2 d	β		0.5222	0.0069	5.29E-01	3.14E-03	8.219E+03	¹²³ Sb
¹²⁵ Sn	50	9.64 d	β		0.8110	0.3124	1.123	6.656E-03	1.084E+05	¹²⁵ Sb
¹²⁶ Sn	50	~1E+05 y	β		0.1249	0.0573	1.82E-01	1.08E-03	2.837E-02	¹²⁶ Sb
¹²⁴ Sb	51	60.20 d	β		0.3897	1.8523	2.242	1.329E-02	1.749E+04	¹²⁴ Te
¹²⁵ Sb	51	2.73 y	β		0.1257	0.4434	5.69E-01	3.37E-03	1.032E+03	¹²⁵ Te
¹²⁶ Sb	51	12.4 d	β		0.3527	2.7496	3.102	1.839E-02	8.360E+04	¹²⁶ Te
^{126m} Sb	51	19.0 min	β (86%); IT (14%)		0.6323	1.5484	2.181	1.292E-02	7.854E+07	¹²⁶ Te; ¹²⁶ Sb
^{123m} Te	52	119.7 d	IT		0.1020	0.1482	2.502E-01	1.482E-03	8.870E+03	¹²³ Te
^{125m} Te	52	58 d	IT		0.1106	0.0361	1.467E-01	8.690E-04	1.801E+04	¹²⁵ Te
¹²⁷ Te	52	9.35 h	β		0.2248	0.0048	2.30E-01	1.36E-03	2.639E+06	¹²⁷ I

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
^{127m} Te	52	109 d	IT (97.6%); β (2.4%)		0.0821	0.0111	9.32E-02	5.52E-04	9.432E+03	¹²⁷ Te; ¹²⁷ I
¹²⁹ Te	52	1.160 h	β		0.5422	0.0624	6.05E-01	3.58E-03	2.094E+07	¹²⁹ I
^{129m} Te	52	33.6 d	IT (64%); β (36%)		0.2663	0.0370	3.03E-01	1.80E-03	3.013E+04	¹²⁹ Te; ¹²⁹ I
¹²³ I	53	13.2 h	EC		0.0276	0.1729	2.005E-01	1.188E-03	1.940E+06	¹²³ Te
¹²⁵ I	53	60.14 d	EC		0.0179	0.0423	6.02E-02	3.57E-04	1.737E+04	¹²⁵ Te
¹²⁹ I	53	1.57E+07 y	β		0.0556	0.0248	8.04E-02	4.77E-04	1.765E-04	¹²⁹ Xe
¹³¹ I	53	8.040 d	β		0.1913	0.3826	5.74E-01	3.40E-03	1.240E+05	¹³¹ Xe
¹³³ Xe	54	5.245 d	β		0.1363	0.0459	1.82E-01	1.08E-03	1.872E+05	¹³³ Cs
¹³⁴ Cs	55	2.062 y	β		0.1639	1.5555	1.719	1.019E-02	1.294E+03	¹³⁴ Ba
¹³⁵ Cs	55	3.0E+06 y	β		0.0563		5.63E-02	3.32E-04	1.151E-03	¹³⁵ Ba
¹³⁷ Cs	55	3.017E+01 y	β (94.6%); β (5.4%)			0.1708	1.71E-01	1.01E-03	8.698E+01	^{137m} Ba; ¹³⁷ Ba
¹³³ Ba	56	1.054E+01 y	EC		0.0547	0.4045	4.592E-01	2.722E-03	2.500E+02	¹³³ Cs
^{137m} Ba	56	2.552 min	IT		0.0652	0.5991	6.64E-01	3.94E-03	5.379E+08	¹³⁷ Ba
¹⁴¹ Ce	58	32.50 d	β		0.1707	0.0770	2.48E-01	1.47E-03	2.848E+04	¹⁴¹ Pr
¹⁴⁴ Ce	58	284.9 d	β		0.0918	0.0192	1.11E-01	6.58E-04	3.190E+03	¹⁴⁴ Pr
¹⁴³ Pr	59	13.58 d	β		0.3156		3.16E-01	1.87E-03	6.731E+04	¹⁴³ Nd
¹⁴⁴ Pr	59	17.28 min	β		1.2091	0.0289	1.238	7.338E-03	7.555E+07	¹⁴⁴ Nd
^{144m} Pr	59	7.2 min	IT (99.96%); β (0.04%)		0.0464	0.0121	5.85E-02	3.43E-04	1.814E+08	¹⁴⁴ Pr; ¹⁴⁴ Nd
¹⁴⁶ Pm	61	5.53 y	EC (66.1%); β (33.9%)		0.0928	0.7542	8.47E-01	5.02E-03	4.428E+02	¹⁴⁶ Nd; ¹⁴⁶ Sm
¹⁴⁷ Pm	61	2.6234 y	β		0.6196		6.20E-02	3.67E-04	9.270E+02	¹⁴⁷ Sm
¹⁴⁸ Pm	61	5.370 d	β		0.7235	0.5747	1.298	7.691E-03	1.643E+05	¹⁴⁸ Sm
^{148m} Pm	61	41.29 d	β (95.4%); IT (4.6%)		0.1695	1.9861	2.156	1.278E-02	2.136E+04	¹⁴⁸ Sm; ¹⁴⁸ Pm

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
¹⁵¹ Sm	62	9.0E+01 y	β		0.1251		1.25E-01	7.41E-04	2.631E+01	¹⁵¹ Eu
¹⁵² Eu	63	1.333E+01 y	EC (72.08%); β (27.92%)		0.1275	1.1628	1.290	7.646E-03	1.729E+02	¹⁵² Sm; ¹⁵² Gd
¹⁵⁴ Eu	63	8.8 y	β		0.2794	1.2531	1.532	9.081E-03	2.699E+02	¹⁵⁴ Gd
¹⁵⁵ Eu	63	4.96 y	β		0.0650	0.0633	1.28E-01	7.59E-04	4.651E+02	¹⁵⁵ Gd
¹⁵³ Gd	64	241.6 d	EC		0.0399	0.1015	1.414E-01	8.381E-04	3.526E+03	¹⁵³ Eu
¹⁵⁷ Tb	65	150 y	EC		0.0031	0.0050	8.10E-03	4.802E-05	1.519E+01	¹⁵⁷ Gd
¹⁵⁸ Tb	65	150 y	EC (82%) β (18%)				9.02E-01	5.347E-03	1.508E+01	¹⁵⁸ Gd; ¹⁵⁸ Dy
¹⁶⁰ Tb	65	72.3 d	β		0.2535	1.1271	1.381	8.186E-03	1.129E+04	¹⁶⁰ Dy
¹⁶⁹ Yb	70	32.02 d	EC		0.1117	0.3121	4.238E-01	2.512E-03	2.414E+04	¹⁶⁹ Tm
¹⁷⁵ Hf	72	70.0 d	EC		0.0439	0.3646	4.085E-01	2.422E-03	1.066E+04	¹⁷⁵ Lu
¹⁸¹ Hf	72	42.39 d	β		0.1943	0.5441	7.54E-01	4.47E-03	1.702E+04	¹⁸¹ Ta
¹⁸² Ta	73	115.0 d	β		0.2073	1.3011	1.508	8.940E-03	6.253E+03	¹⁸² W
¹⁸⁷ Re	75	4.6E+10 y	β		0.0007		2.59	1.535E-02	3.823E-08	¹⁸⁷ Os
¹⁹² Ir	77	73.831 d	β (95.4%); EC (4.6%)		0.2162	0.8137	1.030	6.105E-03	9.211E+03	¹⁹² Pt; ¹⁹² Os
²⁰¹ Tl	81	3.046 d	EC		0.0481	0.0924	1.40E-01	8.30E-04	2.132E+05	²⁰¹ Hg
²⁰⁷ Tl	81	4.77 min	β		0.4931	0.0022	4.95E-01	2.93E-03	1.904E+08	²⁰⁷ Pb
²⁰⁸ Tl	81	3.053 min	β		0.5979	3.3742	3.972	2.354E-02	2.945E+08	²⁰⁸ Pb
²⁰⁹ Pb	82	3.253 h	β		0.1980		1.98E-01	1.17E-03	4.544E+06	²⁰⁹ Bi
²¹⁰ Pb	82	2.232E+01 y	β		0.0343		3.43E-02	2.029E-04	7.630E+01	²¹⁰ Bi
²¹¹ Pb	82	36.1 min	β		0.4523	0.0678	5.20E-01	3.083E-03	2.468E+07	²¹¹ Bi
²¹² Pb	82	10.64 h	β		0.1752	0.1453	3.20E-01	1.90E-03	1.389E+06	²¹² Bi
²¹¹ Bi	83	2.14 min	α (99.727%); β (0.273%)	6.5505	0.0099	0.0467	6.607	3.916E-02	4.184E+08	²⁰⁷ Tl; ²¹¹ Po

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
²¹² Bi	83	1.0092 h	α (35.94%); β (64.06%)	2.1740	0.5025	0.1061	2.783	1.649E-02	1.465E+07	²⁰⁸ Tl; ²¹² Po
²¹³ Bi	83	45.59 min	α (2.16%); β (97.84%)	0.1268	0.4563	0.0825	6.66E-01	3.95E-03	1.934E+07	²⁰⁹ Tl; ²¹³ Po
²⁰⁹ Po	84	102 y	α (99.74%) EC (0.26%)				4.9645	2.943E-01	1.68E+01	²⁰⁵ Pb; ²⁰⁹ Bi
²¹⁰ Po	84	138.4 d	α	5.3044			5.304	3.144E-02	4.493E+03	²⁰⁶ Pb
²¹² Po	84	2.98E-07 s	α	8.7844			8.784	5.207E-02	1.774E+17	²⁰⁸ Pb
²¹³ Po	84	4.2E-06 s	α	8.3757			8.375	4.964E-02	1.261E+16	²⁰⁹ Pb
²¹⁵ Po	84	1.780E-03 s	α	7.3864			7.386	4.378E-02	2.948E+13	²¹¹ Pb
²¹⁶ Po	84	1.50E-02 s	α	6.7785			6.779	4.018E-02	3.482E+11	²¹² Pb
²¹⁷ At	85	3.23E-02 s	α	7.0657		0.0002	7.066	4.189E-02	1.610E+12	²¹³ Bi
²¹⁹ Rn	86	3.96 s	α	6.8122	0.0064	0.0560	6.875	4.076E-02	1.301E+10	²¹⁵ Po
²²⁰ Rn	86	55.6 s	α	6.2878		0.0005	6.288	3.727E-02	9.223E+08	²¹⁶ Po
²²² Rn	86	3.825 d	α	5.4892		0.0004	5.490	3.255E-02	1.538E+05	²¹⁸ Po
²²¹ Fr	87	4.9 min	α	6.3571	0.0084	0.0277	6.393	3.789E-02	1.772E+08	²¹⁷ At
²²³ Fr	87	21.8 min	β		0.3805	0.0542	4.35E-01	2.85E-03	3.868E+07	²²³ Ra
²²³ Ra	88	11.43 d	α	5.6972	0.0731	0.1348	5.905	3.500E-02	5.121E+04	²¹⁹ Rn
²²⁴ Ra	88	3.66 d	α	5.6751	0.0022	0.0103	5.688	3.372E-02	1.593E+05	²²⁰ Rn
²²⁵ Ra	88	14.2 d	β		0.1057	0.0137	1.19E-01	7.08E-04	3.920E+04	²²⁵ Ac
²²⁶ Ra	88	1.600E+03 y	α	4.7741	0.0035	0.0067	4.784	2.836E-02	9.887E-01	²²² Rn
²²⁸ Ra	88	5.75 y	β		0.0116		1.16E-02	6.88E-05	2.340E+02	²²⁸ Ac
²²⁵ Ac	89	10.0 d	α	5.7501	0.0257	0.0176	5.793	3.434E-02	5.803E+04	²²¹ Fr
²²⁷ Ac	89	2.177E+01 y	β (98.62%); α (1.38%)	0.0673	0.0125	0.0002	8.00E-02	4.74E-04	7.233E+01	²²⁷ Th; ²²³ Fr
²²⁸ Ac	89	6.13 h	β		0.4292	0.9269	1.356	8.038E-03	2.242E+06	²²⁸ Th
²²⁷ Th	90	18.718 d	α	5.9022	0.0543	0.1113	6.068	3.597E-02	3.073E+04	²²³ Ra
²²⁸ Th	90	1.913 y	α	5.3992	0.0201	0.0034	5.423	3.214E-02	8.196E+02	²²⁴ Ra
²²⁹ Th	90	7.340E+03 y	α	4.8620		0.0343	4.896	2.902E-02	2.127E-01	²²⁵ Ra

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			"Q" value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
²³⁰ Th	90	7.54E+04 y	α	4.6651		0.0004	4.665	2.765E-02	2.109E-02	²²⁶ Ra
²³¹ Th	90	1.0633 d	β	0.1732		0.0295	2.03E-01	1.21E-03	5.316E+05	²³¹ Pa
²³² Th	90	1.405E+10 y	α	4.0056		0.0002	4.006	2.375E-02	1.097E-07	²²⁸ Ra
²³⁴ Th	90	24.10 d	β		0.0158	0.0094	2.52E-02	1.49E-04	2.316E+04	²³⁴ Pa
²³¹ Pa	91	3.276E+04 y	α	4.9230	0.0483	0.0399	5.011	2.970E-02	4.723E-02	²²⁷ Ac
²³³ Pa	91	27.0 d	β		0.1941	0.2042	3.98E-01	2.36E-03	2.075E+04	²³³ U
^{234m} Pa	91	1.17 min	β (99.87%); IT (0.13%)		0.8227	0.0121	8.35E-01	4.95E-03	6.868E+08	²³⁴ U; ²³⁴ Pa
²³² U	92	6.89E+01 y	α	5.3065		0.0002	5.307	3.146E-02	2.140E+01	²²⁸ Th
²³³ U	92	1.592E+05 y	α	4.8141	0.0055	0.0013	4.821	2.857E-02	9.680E-03	²²⁹ Th
²³⁴ U	92	2.454E+05 y	α	4.7732		0.0001	4.773	2.829E-02	6.248E-03	²³⁰ Th
²³⁵ U	92	7.037E+08 y	α	4.3785	0.0426	0.1561	4.577	2.713E-02	2.161E-06	²³¹ Th
²³⁶ U	92	2.342E+07 y	α	4.4793	0.0108	0.0015	4.492	2.662E-02	6.469E-05	²³² Th
²³⁸ U	92	4.468E+09 y	α	4.1945	0.0095	0.0013	4.205	2.492E-02	3.362E-07	²³⁴ Th
²³⁶ Np	93	1.550E+05 y	EC (91%); β (8.9%); α (0.20%)		0.1967	0.1411	3.38E-01	2.00E-03	1.317E-02	²³⁶ U; ²³⁶ Pu; ²³² Pa
²³⁷ Np	93	2.140E+06 y	α	4.7604	0.0640	0.0327	4.857	2.879E-02	7.049E-04	²³³ Pa
²³⁹ Np	93	2.355 d	β		0.2521	0.1740	4.26E-01	2.53E-03	2.320E+05	²³⁹ Pu
²³⁶ Pu	94	2.851 y	α	5.7521	0.0126	0.0020	5.767	3.418E-02	5.313E+02	²³² U
²³⁸ Pu	94	8.774E+01 y	α	5.4871	0.0099	0.0018	5.499	3.2593E-02	1.712E+01	²³⁴ U
²³⁹ Pu	94	2.411E+04 y	α	5.1011		0.0001	5.101	3.024E-02	6.216E-02	²³⁵ U
²⁴⁰ Pu	94	6.563E+03 y	α	5.1549			5.155	3.056E-02	2.279E-01	²³⁶ U
²⁴¹ Pu	94	1.44E+01 y	β	0.0001		0.0052	5.3E-03	3.2E-05	1.030E+02	²⁴¹ Am
²⁴² Pu	94	3.763E+05 y	α	4.8901	0.0081	0.0014	4.900	2.904E-02	3.818E-03	²³⁸ U
²⁴⁴ Pu	94	8.26E+07 y	α (99.875%); SPF (0.125%)	4.5751	0.0007	0.0001	4.576	2.712E-02	1.774E-05	²⁴⁰ U; (fission products)
²⁴¹ Am	95	4.327E+02 y	α	5.4801	0.0304	0.0287	5.539	3.283E-02	3.432	²³⁷ Np
²⁴² Am	95	16.01 h	β (82.7%); EC (17.3%)		0.1781	0.0180	1.96E-01	1.16E-03	8.084E+05	²⁴² Cm; ²⁴² Pu

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ε	γ and X	(MeV/dis)	(W/Ci)		
^{242m} Am	95	1.41E+02 y	IT (99.55%); α (0.45%)	0.0232	0.0403	0.0049	6.84E-02	4.05E-04	9.718	²⁴² Am; ²³⁸ Np
²⁴³ Am	95	7.380E+03 y	α	5.2656		0.0481	5.3137	3.1496E-02	1.993E-01	²³⁹ Np
²⁴² Cm	96	162.94 d	α	6.0434	0.0090	0.0018	6.0542	3.5886E-02	3.306E+03	²³⁸ Pu
²⁴³ Cm	96	2.85E+01 y	α (99.76%); EC (0.24%)	5.8380	0.1129	0.1316	6.083	3.605E-02	5.162E+01	²³⁹ Pu; ²⁴³ Am
²⁴⁴ Cm	96	1.811E+01 y	α	5.7965		0.0016	5.798	3.437E-02	8.090E+01	²⁴⁰ Pu
²⁴⁵ Cm	96	8.5E+03 y	α	5.3631	0.1342	0.1178	5.615	3.329E-02	1.717E-01	²⁴¹ Pu
²⁴⁶ Cm	96	4.73E+03 y	α	5.3764	0.0072	0.0014	5.385	3.192E-02	3.072E-01	²⁴² Pu
²⁴⁷ Cm	96	1.56E+07 y	α	4.9475		0.3152	5.263	3.119E-02	9.278E-05	²⁴³ Pu
²⁴⁸ Cm	96	3.40E+05 y	α (91.74%); SPF (8.26%)	4.6524			4.6524	2.7577E-02	4.251E-03	²⁴⁴ Pu; (fission products)
²⁵² Cf	98	2.645 y	α (96.908%); SPF (3.092%)	5.9308	0.0051	0.0011	5.9370	3.5191E-02	5.378E+02	²⁴⁸ Cm; (fission products)

^aBased on refs. 6-9.^by—years; d—days; h—hours; min—minutes; and s—seconds.^cα—alpha decay; β—negative beta decay; EC—electron capture; IT—*isomeric transition* (radioactive transition from one nuclear isomer to another of lower energy); and SPF—*spontaneous fission*.^dα—alpha decay; ε—total electron emissions; and γ and X—gamma and X-ray photons.^eThe sum of the average energies for different radiation types in MeV/disintegration or W/Ci (includes alpha and beta particles, discrete electrons, and photons). The “value” indicates the amount of energy (heat) that could be deposited in a radioactive material from each decay event if none of the radiation escaped from the material. Neutrinos are not included.

APPENDIX C. REFERENCE SITES AND FACILITIES

APPENDIX C. REFERENCE SITES AND FACILITIES

This appendix provides information on the major DOE and commercial sites and facilities discussed in this report. The DOE operations and special site offices are identified in Table C.1, along with the sites for which they have responsibility. This is followed by Table C.2, which lists DOE Naval Reactors Program (NE-60) offices and sites. Table C.3 lists major DOE sites and facilities referred to in this report, and major commercial radioactive waste disposal sites are given in Table C.4. For each site or facility listed in Tables C.3 and C.4, additional information is provided, including reference symbol or label, location, operations contractor, and, for DOE sites, the supervisory DOE operations and area office.

Table C.1. DOE operations and special site offices

DOE office	Symbol/label	General mailing address (Phone number) ^a	Radioactive waste sites for which DOE office has responsibility
Albuquerque Operations Office ^b	DOE/AL	P.O. Box 5400 Albuquerque, NM 87115-5400 (505/845-4154)	Grand Junction Projects Office sites Inhalation Toxicology Research Institute Kansas City Plant Los Alamos National Laboratory Pantex Plant Pinellas Plant Sandia National Laboratories/California Sandia National Laboratories/New Mexico Uranium Mill Tailings Remedial Action Project sites Waste Isolation Pilot Plant
Chicago Operations Office ^c	DOE/CH	Building 201 9800 South Cass Avenue Argonne, IL 60439 (630/252-2001)	Ames Laboratory Argonne National Laboratory—East Argonne National Laboratory—West Brookhaven National Laboratory Fermi National Accelerator Laboratory Princeton Plasma Physics Laboratory
Idaho Operations Office	DOE/ID	785 DOE Place Idaho Falls, ID 83402 (208/526-0111)	Idaho National Engineering Laboratory
Nevada Operations Office	DOE/NV	P.O. Box 98518 Las Vegas, Nevada 89193-8518 (702/295-1212)	Nevada Test Site
Oakland Operations Office	DOE/OAK	1301 Clay Street Oakland, CA 94612-5208 (510/273-6383)	Energy Technology Engineering Center (Santa Susana Field Laboratory) Laboratory for Energy-Related Health Research (Institute of Toxicology and Environmental Health) Lawrence Berkeley Laboratory Lawrence Livermore National Laboratory Stanford Linear Accelerator Center

Table C.1 (continued)

DOE office	Symbol/label	General mailing address (Phone number) ^a	Radioactive waste sites for which DOE office has responsibility
Oak Ridge Operations Office ^d	DOE/OR	P.O. Box 2001 Oak Ridge, TN 37831 (423/576-5454)	Formerly Utilized Sites Remedial Action Program (FUSRAP) sites Oak Ridge Institute for Science and Education Oak Ridge K-25 Site Oak Ridge National Laboratory Oak Ridge Y-12 Plant Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant Weldon Spring Site Remedial Action Project
Ohio Field Office	DOE/OH	P.O. Box 3020 Miamisburg, OH 45343-3020 (513/865-3977)	Battelle Columbus Laboratories Decommissioning Project Fernald Environmental Management Project Mound Plant Reactive Metals, Inc., Extrusion Plant West Valley Demonstration Project
Richland Operations Office	DOE/RL	P.O. Box 550 825 Jadwin Avenue Richland, WA 99352 (509/376-7411)	Hanford Site Pacific Northwest National Laboratory
Rocky Flats Office	DOE/RF	P.O. Box 928 Golden, CO 80401-0928 (303/966-7000)	Rocky Flats Environmental Technology Site
Savannah River Operations Office	DOE/SR	P.O. Box A Aiken, SC 29802 (803/725-6211)	Savannah River Site

^aAccess to main organizations.

^bThe Albuquerque Operations Office also has the following area offices (monitoring activities of the sites indicated) under its purview: Amarillo (Pantex Plant), Grand Junction (Grand Junction Projects Office), Kansas City (Kansas City Plant), Los Alamos (Los Alamos National Laboratory), and Pinellas (Pinellas Plant).

^cThe Chicago Operations Office has the following area offices (monitoring activities of the sites indicated) under its purview: Argonne (Argonne National Laboratory-East), Batavia (Fermi National Accelerator Laboratory), Upton (Brookhaven National Laboratory), and Princeton (Princeton Plasma Physics Laboratory).

^dThe Oak Ridge Operations Office has a separate site office located at the following: Oak Ridge K-25 Site, Oak Ridge National Laboratory, Oak Ridge Y-12 Plant, Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, and the Weldon Spring Site Remedial Action Project.

Table C.2. DOE Naval Reactors Program offices and sites

DOE office	Symbol/label	General mailing address (Phone number) ^a	Radioactive waste sites for which DOE office has responsibility
DOE/HQ, Office of Naval Reactors	DOE/HQ/NE-60	Route Symbol NE-60 2521 Jefferson Davis Hwy Arlington, VA 22202 (703/603-7321)	Oversees Pittsburgh and Schenectady area offices and their sites; oversees the following shipyards: <ul style="list-style-type: none"> • Charleston Naval Shipyard, Charleston, SC • Mare Island Naval Shipyard, Mare Island, CA • Norfolk Naval Shipyard, Norfolk, VA • Pearl Harbor Naval Shipyard, Pearl Harbor, HI • Portsmouth Naval Shipyard, Portsmouth, ME • Puget Sound Naval Shipyard, Puget Sound, WA
Pittsburgh Naval Reactors Offices	DOE/PNRO	P.O. Box 109 West Mifflin, PA 15122-0109 (412/476-5000)	Bettis Atomic Power Laboratory Naval Reactors Facility (Idaho Falls, ID)
Schenectady Naval Reactors Office	DOE/SNRO	P.O. Box 1069 Schenectady, NY 12301-1069 (518/395-4000)	Knolls Atomic Power Laboratory

^aAccess to main organizations.

Table C.3. Major DOE sites and facilities referred to in this report

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Ames Laboratory	Ames	Iowa State University Technical Administration Services Facility Ames, IA 50011-3020 (515/294-2680)	Chicago (630/252-2001)
Argonne National Laboratory-East	ANL-E	University of Chicago 9700 South Cass Avenue Argonne, IL 60439 (630/252-2000)	Chicago Argonne Area Office (630/252-2001)
Argonne National Laboratory-West ^b	ANL-W	University of Chicago Idaho Site P.O. Box 2528 Idaho Falls, ID 83403-2528 (208/533-7000)	Chicago (630/252-2001)
Battelle Columbus Laboratories Decommissioning Project	BCLDP	Battelle Memorial Institute 505 King Avenue Columbus, OH 43201-2693 (614/424-3989)	Ohio Field Office (513/865-3977)
Brookhaven National Laboratory	BNL	Associated Universities, Inc. 16 South Railroad Street Upton, NY 11973-2310 (516/282-2123)	Chicago Brookhaven Area Office (516/282-3427)
Colonie Interim Storage Site	CISS	Bechtel National, Inc. P.O. Box 5169 Albany, NY 12205 (518/482-0237)	Oak Ridge (423/576-5454)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Energy Technology Engineering Center (Santa Susana Field Laboratory)	ETEC (SSFL)	Rockwell International Rocketdyne Division 6633 Canoga Avenue P.O. Box 1449 Canoga Park, CA 91304 (818/586-5326)	Oakland (510/273-6383)
Fermi National Accelerator Laboratory	FNAL	University Research Association P.O. Box 500 Batavia, IL 60510 (630/840-3000)	Chicago Batavia Area Office (630/840-3281)
Fernald Environmental Management Project	FEMP	Fluor Daniel Fernald Environmental Restoration Management Corporation P.O. Box 398704 7400 Wiley Road Cincinnati, OH 45239-8704 (513/738-6200)	Ohio Field Office Fernald Area Office (513/648-3119)
Grand Junction Projects Office	GJPO	Chem-Nuclear Geotech, Inc. P.O. Box 14000 Grand Junction, CO 81502-5504 (303/248-6200)	Albuquerque (505/845-4154)
Hanford Site	Hanford	Fluor Daniel Hanford, Inc. P.O. Box 1970 Richland, WA 99352 (509/376-7411)	Richland (509/376-7411)
Idaho National Engineering Laboratory	INEL	Lockheed Martin Idaho Technologies P.O. Box 1625 Idaho Falls, ID 83415-4201 (208/526-0111)	Idaho (208/526-0111)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Inhalation Toxicology Research Institute	ITRI	Lovelace Biomedical and Environmental Research Institute, Inc. P.O. Box 5890 Albuquerque, NM 87185 (505/845-1037)	Albuquerque (505/845-4154)
Kansas City Plant	KCP	Allied-Signal Aerospace Company Kansas City Division Bannister Federal Complex Kansas City, MO 64141 (816/997-2000)	Albuquerque Kansas City Area Office (816/997-3348)
Laboratory for Energy-Related Health Research (Institute of Toxicology and Environmental Health)	LEHR (ITEH)	University of California-Davis Old Davis Road Davis, CA 95616-8615 (916/752-1340)	Oakland (510/273-6383)
Lawrence Berkeley Laboratory	LBL	University of California One Cyclotron Road Berkeley, CA 94720 (510/486-4000)	Oakland Lawrence Berkeley Laboratory Site Office (510/486-4363)
Lawrence Livermore National Laboratory	LLNL	University of California 7000 East Avenue P.O. Box 808, L-1 Livermore, CA 94550 (510/422-1100)	Oakland (510/273-6383)
Los Alamos National Laboratory	LANL	University of California P.O. Box 1663 Los Alamos, NM 87545 (505/667-5061)	Albuquerque Los Alamos Area Office (505/667-5061)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Mound Plant	Mound	EG&G Mound Applied Technologies P.O. Box 3000 Miamisburg, OH 45343-3000 (513/865-4020)	Ohio Field Office Miamisburg Area Office (513/865-3271)
Naval Reactors Program Facilities Bettis Atomic Power Laboratory	BAPL	Westinghouse Electric Corporation P.O. Box 79 West Mifflin, PA 15122-0079 (412/476-5000)	DOE/HQ Office of Naval Reactors (NE-60) Pittsburgh Naval Reactors Office (412/476-5000)
Knolls Atomic Power Laboratory	KAPL	Lockheed Martin Services Group P.O. Box 1072 Schenectady, NY 12301-1072 (518/395-4000)	DOE/HQ Office of Naval Reactors (NE-60) Schenectady Naval Reactors Office (518/395-4000)
Naval Reactors Facility (INEL)	NRF	Lockheed Martin Idaho Technologies P.O. Box 2068 Idaho Falls, ID 83403-2068 (208/526-5526)	DOE/HQ Office of Naval Reactors (NE-60) Pittsburgh Naval Reactors Office (412/476-5000)
Nevada Test Site	NTS	Bechtel Nevada Corporation P.O. Box 98521 Mail Stop 738 Las Vegas, NV 89193-8521 (702/295-9060)	Nevada (702/295-1212)
Oak Ridge Institute for Science and Education	ORISE	Oak Ridge Associated Universities 246 Laboratory Road P.O. Box 117 Oak Ridge, TN 37831-0117 (423/576-3000)	Oak Ridge (423/576-5454)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Oak Ridge K-25 Site	K-25	Lockheed Martin Energy Systems, Inc. P.O. Box 2003 Oak Ridge, TN 37831-7358 (423/576-5454)	Oak Ridge (423/576-5454)
Oak Ridge National Laboratory	ORNL	Lockheed Martin Energy Research Corporation P.O. Box 2008 Oak Ridge, TN 37831-6235 (423/576-5454)	Oak Ridge (423/576-5454)
Oak Ridge Y-12 Plant	Y-12	Lockheed Martin Energy Systems, Inc. P.O. Box 2009 Oak Ridge, TN 37831-8010 (423/576-5454)	Oak Ridge (423/576-5454)
Pacific Northwest National Laboratory ^c	PNNL	Battelle Memorial Institute Battelle Boulevard P.O. Box 999 Richland, WA 99352 (509/375-2121)	Richland (509/376-7411)
Paducah Gaseous Diffusion Plant	PAD	Lockheed Martin Utility Systems, Inc. P.O. Box 1410 Paducah, KY 42001 (502/441-6000)	Oak Ridge Paducah Site Office (502/441-6800)
Pantex Plant	PANT	Mason & Hanger—Silas Mason Company, Inc. P.O. Box 30020 Amarillo, TX 79177 (806/477-3000)	Albuquerque Amarillo Area Office (806/477-3000)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Pinellas Plant	Pinellas	Lockheed Martin Specialty Components, Inc. P.O. Box 2908 Largo, FL 34649-2908 (813/541-8001)	Albuquerque Pinellas Area Office (813/541-8196)
Portsmouth Gaseous Diffusion Plant	PORTS	Lockheed Martin Utility Systems, Inc. P.O. Box 628 Piketon, OH 45661 (614/897-2331)	Oak Ridge Portsmouth Site Office (614/897-2331)
Princeton Plasma Physics Laboratory	PPPL	Princeton University P.O. Box 451 Princeton, NJ 08543 (609/243-2000)	Chicago Princeton Area Office (609/243-3700)
Reactive Metals, Inc., Extrusion Plant	RMI	RMI Titanium Company P.O. Box 579 Ashtabula, OH 44004 (216/992-7442)	Ohio Field Office RMI Decommissioning Project Office (216/992-7442)
Rocky Flats Environmental Technology Site	RFETS	EG&G Rocky Flats, Inc. P.O. Box 464 Golden, CO 80401-0464 (303/966-7000)	Rocky Flats Office (303/966-7000)
Sandia National Laboratories California	SNL/CA	Lockheed Martin Sandia Corporation P.O. Box 969 Livermore, CA 94551-0969 (510/294-3000)	Albuquerque (505/845-4154)
New Mexico	SNL/NM	Lockheed Martin Sandia Corporation P.O. Box 5800 Albuquerque, NM 87185-5800 (505/844-5678)	Albuquerque (505/845-4154)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations/field office (Phone number) ^a
Savannah River Site	SRS	Westinghouse Savannah River Company P.O. Box 616 Aiken, SC 29802 (803/725-6211)	Savannah River (803/725-6211)
Stanford Linear Accelerator Center	SLAC	Stanford University P.O. Box 4349 Palo Alto, CA 94309 (415/926-3300)	Oakland Stanford Site Office (415/926-3208)
Three Mile Island—Unit 2 Reactor	TMI—Unit 2	General Public Utilities P.O. Box 480 Middletown, PA 17057 (717/944-7621)	Idaho Three Mile Island Site Office (717/944-7621)
Waste Isolation Pilot Plant	WIPP	Westinghouse Electric Corporation WIPP Project Office P.O. Box 2078 Carlsbad, NM 88221 (505/885-7500)	Albuquerque Carlsbad Area Office (505/234-7327)
Weldon Spring Site Remedial Action Project	WSSRAP	Jacobs Engineering Group, Inc. MK-Ferguson Company 7295 Highway 94 South St. Charles, MO 63304 (314/441-8978)	Oak Ridge Weldon Spring Site Office (314/441-8978)
West Valley Demonstration Project	WVDP	Westinghouse Electric Corporation West Valley Nuclear Services Company, Inc. 10282 Rock Springs Road P.O. Box 191 West Valley, NY 14171-0191 (716/942-3235)	Ohio Field Office West Valley Area Office (716/942-4313)

^aPhone number for access to main organization.^bPart of the Idaho National Engineering Laboratory Reservation.^cPart of the Hanford Site.

Table C.4. Major commercial radioactive waste disposal sites included in this report^a

Site	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^b
Barnwell	BARN	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, SC 29210 (803/256-0450)
Beatty	BETY	U.S. Ecology, Nuclear P.O. Box 578 Beatty, NV 89003 (702/553-2203)
Envirocare ^c	ENVR	Envirocare of Utah, Inc. 46 West Broadway Suite 240 Salt Lake City, Utah 84101 (801/532-1330)
Maxey Flats	MFKY	Commonwealth of Kentucky ^d Department of Environmental Protection/Superfund Branch Maxey Flats Project 14 Reilly Road Frankfort, KY 40601-1190 (502/564-6716) <u>Site address:</u> Maxey Flats Project Route 2 P.O. Box 238A Hillsboro, KY 41049 (606/784-6612)
Richland	RICH	U.S. Ecology, Nuclear P.O. Box 638 Richland, WA 99352 (509/377-2411)
Sheffield	SHEF	U.S. Ecology, Nuclear P.O. Box 158 Sheffield, IL 61361 (815/454-2342)
West Valley	WVNY	Westinghouse Electric Corporation West Valley Nuclear Services Company, Inc. 10282 Rock Springs Road P.O. Box 191 West Valley, NY 14171-0191 (716/942-3235)

Table C.4 (continued)

Site	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^b
West Valley (contd.)	WVNY	New York State Energy Research and Development Authority 2 Rockefeller Plaza Albany, NY 12223 (518/465-6251)

^aDoes not include uranium mill tailings sites. See Table 5.2.

^bPhone number for access to main organizations.

^cAlso contains disposed wastes from DOE site activities.

^dThe Commonwealth of Kentucky assumed operating contractor responsibilities for the Maxey Flats site in 1992.

**APPENDIX D. INTEGRATED DATA BASE DOCUMENT
ACCESS ON THE INTERNET**

APPENDIX D. INTEGRATED DATA BASE DOCUMENT ACCESS ON THE INTERNET

A copy of this document (IDB Rev. 12) will be accessible via the Internet on the DOE Office of Environmental Management World Wide Web (EM WWW) Server at the Uniform Resource Locator (URL) <http://www.em.doe.gov/idb96>.

This document may also be accessed from the EM WWW home page at <http://www.em.doe.gov>. From the home page menu, select **Waste Management**. The IDB reports are listed on the Waste Management menu.

The EM WWW Server provides a collection of documents and other information and data relating to DOE/EM's mission. It was established as an EM-wide information resource available to DOE employees, other federal agencies, Congress, state and tribal governments, and the general public. The EM WWW Server is updated and maintained to provide historical and current DOE/EM information.

APPENDIX E. INTEGRATED DATA BASE READER COMMENT FORM

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GLOSSARY OF TERMS

This glossary gives definitions of some terms commonly used in the main body of this report.

Actinides: Elements with atomic numbers from 89 (actinium) or 90 (thorium) to 103 (lawrencium) inclusive.

Activation product: A radioactive material produced by bombardment with neutrons, protons, or other nuclear particles.

Agreement State: A state that has entered into an agreement with the U.S. Nuclear Regulatory Commission (as specified by the Atomic Energy Act of 1954) and has authority to regulate the disposal of low-level radioactive waste under such an agreement. This term is used in the Low-Level Radioactive Waste Policy Act (Public Law 99-240).

Alpha decay: Radioactive decay in which an alpha particle (^4He nucleus) is emitted.

Beta decay: Radioactive decay in which a beta particle (negative or positive electron) is emitted.

Borosilicate glass: A type of glass containing at least 5 wt % boric oxide. It is used in glassware that resists heat and is a leading candidate for use in high-level waste immobilization and disposal.

Branching ratio: In branching radioactive decay, the fraction of nuclei that disintegrates in a specific way. (It is usually expressed as a percentage.)

Burnup, specific: The total energy released per initial unit mass of reactor fuel as a result of the fission process occurring. The unit commonly used for specific burnup is megawatt-days per metric ton of initial heavy metal, MWd/MTIHM.

By-product material: (1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material.

For purposes of determining the applicability of the Resource Conservation and Recovery Act of 1976 to any radioactive waste, the term "any radioactive material" refers only to the actual radionuclides dispersed or suspended in the waste substance. The nonradioactive hazardous waste component of the waste substance will be subject to regulation under the Resource Conservation and Recovery Act; (2) the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute by-product material.

Calcine: A form of high-level waste produced from defense reactor fuel reprocessing waste (at the Idaho Chemical Processing Plant) by heating to a temperature below the melting point to bring about loss of moisture and nonradioactive volatile oxides, thus producing a chemically stable granular powder.

Canister: A metal container used for the storage or disposal of heat-producing, solid, high-level radioactive waste.

Capacity factor, plant: The ratio of the electrical energy actually supplied by a power plant in a given time interval to the electrical energy that could have been produced at continuous full-power operation during the same time period.

Capsules: Encapsulated strontium and cesium high-level wastes produced from defense reactor fuel reprocessing at the Hanford Site. For purposes of this report, inventories of encapsulated strontium and cesium are included in a separate table in the high-level waste section (Chapter 2).

Cladding: A corrosion-resistant tube (commonly aluminum, zirconium alloy, or stainless steel) surrounding the reactor fuel pellets which provides protection from a

chemically reactive environment and containment of fission products.

Code of Federal Regulations: A documentation of the general rules by the executive departments of the federal government. The code is divided into 50 titles that represent broad areas subject to federal regulation. Each title is divided into chapters that usually bear the name of the issuing agency. Each chapter is further subdivided into parts covering specific regulatory areas.

Control rod: A movable part of the reactor core that is adjusted to regulate the degree of fuel fissioning in the core.

Conversion, fuel: Chemical treatment of yellowcake (U_3O_8) to uranium hexafluoride (UF_6) in preparation for enrichment.

Core, nuclear reactor: That part of the reactor which contains the nuclear fuel and in which most or all of the nuclear fissions occur.

Daughter product(s): The nuclide(s) formed by the radioactive decay of the parent radionuclide.

Decay, radioactive: The transition of a nucleus from one energy state to a lower one, usually involving the emission of a photon, electron, neutron, or alpha particle.

Decay chain, radioactive: A series of nuclides in which each member decays to the next member of the chain through radioactive decay until a stable nuclide has been formed.

Decommissioning: Activities taken to reduce the potential health and safety impacts of commercial and DOE-contaminated facilities, including removing a unit from operation, decontamination, entombment, dismantlement, or conversion of the site to another use.

Decommissioning wastes: Wastes (generally low-level) collected or resulting from facility decommissioning activities.

Decontamination: Activities taken to remove unwanted (typically radioactive) material from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other (treatment) techniques.

Deep bed plant: A boiling-water reactor facility using a demineralizer vessel for water purification which contains an ion-exchange resin that is 3 ft or more deep.

Disintegration energy (Q-value): The amount of energy released in a particular nuclear disintegration. This is usually expressed in MeV/disintegration.

DOE waste: Radioactive waste produced from activities supported by the Department of Energy and/or U.S. government defense programs.

Double-shell tank wastes: High-level wastes, generated from defense reactor fuel reprocessing at Hanford, which are stored in double-shelled tanks. These wastes consist of a mixture of liquid and suspended solids referred to as slurry. See also "single-shell tank wastes."

Electron capture: Radioactive decay in which an orbital electron is captured by the nucleus of the radionuclide.

Enrichment, fuel: A nuclear fuel cycle process which increases the concentration of fissionable uranium (i.e., ^{235}U) in uranium ore above its natural level of 0.71%. (The method currently used in the United States is gaseous diffusion.)

Environmental Impact Statement: A report that documents the information required to evaluate the environmental impact of a project. Such a report informs decision-makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the environment.

Environmental restoration: Cleanup and restoration of sites contaminated with radioactive and/or hazardous substances during past production, accidental releases, or disposal activities.

Equilibrium cycle: An assumed nuclear fuel cycle in which the feed and waste materials of a facility have constant compositions. In a reactor this condition typically results after the third or fourth fuel-loading schedule.

Fabrication, fuel: Conversion of enriched uranium hexafluoride (UF_6) into pellets of ceramic uranium dioxide (UO_2). These pellets are then sealed into corrosion-resistant tubes of zirconium alloy or stainless steel. The loaded tubes, called fuel elements or rods, are then mounted into special assemblies for loading into the reactor core.

Fertile nuclide: A nuclide capable of being transformed into a fissile nuclide by neutron capture.

Filter/demineralizer plant: A facility that combines filtration and ion-exchange processing using non-regenerable powered resins.

Fissile nuclide: A nuclide capable of undergoing nuclear fission with thermal neutrons.

Fission, nuclear: The division of a heavy atomic nucleus into two or more isotopes, usually accompanied by the emission of neutrons and gamma radiation.

Fission products: Nuclides produced either by fission or by the subsequent decay of the nuclides thus formed.

Fission, spontaneous: Nuclear fission that occurs without the addition of particles or energy to the nucleus.

Formerly utilized site: A site contaminated with radioactive wastes which was previously used for supporting nuclear activities of the DOE's predecessor agencies, the Manhattan Engineer District (Manhattan Project) and the Atomic Energy Commission.

Fuel assembly: A grouping of nuclear fuel rods that remains integral during the charging and discharging of a reactor core.

Fuel cycle, nuclear: The complete series of steps involved in supplying fuel for nuclear reactors. It includes mining, refining, UF_6 conversion, enrichment, fabrication of fuel elements, use in a reactor, and management of radioactive waste. It may also involve chemical processing to recover the fissionable material remaining in the spent nuclear fuel, reenrichment of the fuel material, and/or refabrication of new fuel elements.

Generation (electricity): The process of producing electric energy from other forms of energy; also, the amount of electric energy produced, commonly expressed in kilowatt-hours (kWh) or megawatt-years [MW(e)-years].

Generation (gross): The total amount of electric energy produced by the generating units in a generating station or stations, measured at the generator terminals.

Generation (net): Gross generation less the electric energy consumed at the generating station for station use.

Generation (waste): The origination of new wastes from various facility operations (including production, rework, decontamination and decommissioning, and environmental restoration), including the recovery of pre-1970 transuranic-produced wastes, should their recovery be determined necessary.

Glass frit: A fusible ceramic mixture used to make glass for use in the immobilization and disposal of high-level wastes.

Greater-than-Class-C low-level waste: Waste from commercial sources containing concentrations of radionuclides that exceed U.S. Nuclear Regulatory Commission limits for Class C low-level radioactive waste, as defined in 10 CFR Part 61.55.

Grout: A mortar or cement mixture used to immobilize radioactive wastes.

Half-life, radioactive: For a single radioactive decay process, the time required for the activity to decrease to one-half of its initial value by that process.

Hazardous waste: Nonradioactive waste that has at least one of the following characteristics: (1) is listed as a hazardous waste in Subpart D of 40 CFR Part 261, (2) exhibits any of the characteristics identified in Subpart C of 40 CFR Part 261, or (3) contains PCB-containing wastes subject to regulation under the Toxic Substances Control Act and 40 CFR Parts 702-799.

High-level waste: As defined by the Nuclear Waste Policy Act, high-level waste is (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including the liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations and (2) other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule to require permanent isolation.

Hydrofracture: A process formerly used for permanent disposal of low-level (approximately 0.25 Ci/L) liquid waste at the Oak Ridge National Laboratory. The process involved mixing the waste with a blend of cement and other additives with the resulting grout being injected into shale at a depth of 200 to 300 m. The injected grout hardened into thin, horizontal sheets several hundred meters wide.

Industrial waste: Commercial low-level waste resulting from nonnuclear fuel cycle sources. These include the commercial producers of radiochemicals and radiopharmaceuticals, luminous dial manufacturers, and instruments that incorporate sealed source components (e.g., smoke detectors).

Institutional waste: Commercial low-level waste resulting from bioresearch, medical, and certain

nonbioresearch sources. Bioresearch wastes include wastes from animal studies at universities. Medical wastes include those generated from diagnostic and therapeutic procedures on humans at hospitals. Nonbioresearch wastes include research reactor wastes; small-volume, sealed radiation sources; and accelerator targets.

Leaching: The process of removal or separation of soluble components from a solid by percolating water or other liquids through the solid.

Low-level waste: As specified in the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240), radioactive waste not classified as high-level waste, spent nuclear fuel, or by-product material specified as uranium or thorium tailings and waste.

Mill tailings, uranium: Earthen residues that remain after the extraction of uranium from ores. Tailings may also contain other minerals or metals not extracted in the process.

Mixed low-level waste: Waste that satisfies the definition of low-level radioactive waste (LLW) in the Low-Level Radioactive Waste Policy Amendments Act of 1985 and that contains hazardous waste that has at least one of the following characteristics: (1) is listed as a hazardous waste in Subpart D of 40 CFR Part 261, (2) exhibits any of the hazardous waste characteristics identified in Subpart C of 40 CFR Part 261, or (3) contains PCB-containing wastes subject to regulation under the Toxic Substances Control Act and 40 CFR Parts 702-799.

Mixed-oxide fuel: Nuclear reactor fuel composed of plutonium and uranium in oxide form.

Mixed waste: Waste that includes concentrations of both radionuclides and hazardous chemicals.

Moderator: A material used to reduce neutron energy (for fissioning if in a reactor) by elastic scattering.

MRS facility: A proposed facility for the monitored retrievable storage of spent nuclear fuel from commercial power plants. Such a facility would permit continuous monitoring, management, and maintenance of these wastes and provide for their ready retrieval for further processing or disposal.

Naturally occurring and accelerator-produced radioactive materials: Radioactive materials that are considered either naturally occurring and are not source, special nuclear, or by-product material or are produced in a charged particle accelerator.

Neutron activation: The process of irradiating a material with neutrons so that the material itself is transformed into a radioactive nuclide.

Nonfuel components: Nuclear reactor core parts and hardware, excluding the nuclear fuel itself. Such components include shrouds, control rods, fuel channels, in-core chambers, support tubes, and dummy fuel rods.

Parent: A radionuclide that upon decay yields a specified nuclide (the daughter) either directly or as a later member of a radioactive decay series.

Pressure vessel, reactor: A strong-walled container housing the core of most types of power reactors. It usually also contains other core components such as the moderator and control rods.

PUREX™ process: A solvent extraction process that may be used in the reprocessing of uranium/plutonium-based nuclear fuels.

Radioactivity: The property possessed by certain nuclides of spontaneously emitting alpha or beta particles and, sometimes, gamma radiation by the disintegration of atomic nuclei. The units for the rate of decay of radioactive nuclides are the curie, Ci (3.7×10^{10} disintegrations per second exactly), or, in SI units, the becquerel, Bq (1 disintegration per second).

Reactor, boiling-water: A light-water reactor in which water, used as both coolant and moderator, is allowed to boil in the core. The resulting steam is used directly to drive a turbine.

Reactor, breeder: A reactor that produces more fissionable fuel than it consumes. The new fissionable material is created by a process (breeding) in which fission neutrons are captured in fertile materials.

Reactor, fast flux: A reactor in which fission is induced predominantly by fast neutrons.

Reactor, high-temperature, gas-cooled: A nuclear reactor that uses an inert gas (helium) as the primary coolant and graphite as the moderator.

Reactor, light-water: A nuclear reactor that uses light water (H_2O) as the primary coolant and moderator and slightly enriched uranium as the fuel. There are two types of commercial light-water reactors: boiling-water and pressurized-water.

Reactor, naval propulsion: A reactor used to power a U.S. Navy vessel.

Reactor, pressurized-water: A light-water reactor in which heat is transferred from the core to a heat exchanger via water kept under high pressure, so that high temperatures can be maintained in the primary coolant system without boiling the water. Steam is generated in a secondary circuit.

Reactor, production: A reactor whose primary purpose is to produce fissile or other materials or to perform irradiations on an industrial scale. Unless otherwise specified, the term usually refers to either a tritium- or plutonium-production facility used to produce materials for nuclear weapons.

Reactor, research: A reactor whose nuclear radiations are used primarily as a tool for basic or applied research. Typically, it has a thermal power of 10 MW(t) or less and may include facilities for testing reactor materials.

Reactor, test: A reactor associated with an engineering-scale test program conducted to develop basic design information or demonstrate safety characteristics of nuclear reactor systems.

Reinserted fuel: Irradiated reactor fuel that is discharged in one cycle and inserted into the same reactor during a subsequent refueling. In a few cases, fuel discharged from one reactor has been used to fuel a different reactor.

Repository, geologic: A facility that has an excavated subsurface system for the permanent disposal of spent nuclear fuel and high-level waste.

Reprocessing, fuel: The chemical/mechanical processing of irradiated nuclear reactor fuel to remove fission products and recover fissile and fertile material.

Salt cake: A salt form of high-level waste stored in tanks, which is produced from neutralizing acidic liquid waste from defense reactor fuel reprocessing with an alkaline agent (caustic soda).

Saltstone: A low-level waste by-product from the solidification of high-level waste at the Savannah River Site. Saltstone is retained in trenches at the Savannah River Site.

Sea-bed disposal: Placement of waste packages in deep ocean sediments.

Sea dumping (disposal): The practice of periodically dumping shiploads of drummed, solidified waste into the ocean at specified locations. (No longer performed.)

Separative work unit: The standard measure of enrichment services. The separative work unit (SWU) is expressed as a unit of mass. For example, 1 kilogram of separative work is expressed as 1 kg SWU.

Single-shell tank wastes: High-level wastes, generated from defense reactor fuel reprocessing at Hanford, which are stored in single-shelled tanks that contain liquid, sludge, and salt cake. See also "double-shell tank wastes."

Slurry, high-level waste: A watery mixture of highly radioactive, insoluble matter.

Solvent extraction: The separation of materials of different chemical types by exploiting the relative chelating ability of different chemicals which preferentially dissolve in one of the two phases. In spent nuclear fuel reprocessing, liquid-liquid contact of two immiscible solvents (one aqueous, one organic) permits recovery and separation of uranium and plutonium in one phase and fission products in the other phase.

Source material: (1) material containing any combination of uranium or thorium in any physical or chemical form, or (2) ores containing 0.05 wt % or more of uranium, thorium, or both. Source material excludes special nuclear material (see below).

Source term (IDB Program usage): A set of qualitative and quantitative features used to describe the origin and concentration of radioactive waste. The qualitative features include a flowchart of waste streams generated by a facility or an activity. Quantitative features include (1) the number of curies of radioactivity expressed either per unit of facility production or per unit of waste volume or mass and (2) a listing of the relative concentrations of component radioisotopes per curie of waste activity.

Special nuclear material: Plutonium or fissile uranium (i.e., ^{233}U , ^{235}U) enriched to a higher-than-natural assay.

Spent nuclear fuel: Nuclear fuel that has been permanently discharged from a reactor after it has been irradiated. Typically, spent nuclear fuel is measured in terms of either the number of discharged fuel assemblies or the quantity of discharged fuel mass. The latter is measured either in metric tons of heavy metal (i.e., only the heavy-metal content of the spent nuclear fuel is considered) or in metric tons of initial heavy metal (essentially, the initial heavy-metal mass of the fuel before irradiation).

The difference between these two quantities is the weight of the fission products produced during irradiation.

Standard Contract: A contract between DOE and each commercial owner and/or generator of irradiated nuclear fuel. As indicated in 10 CFR Part 961, the contract specifies the terms and methods of payment, how fees are to be calculated, and how spent nuclear fuel is to be transferred to DOE custody.

Thermal power: A measure of the rate of heat-energy emission that results from the radioactive decay of a material. A unit of thermal power commonly used is the watt (W).

THOREX process: A solvent extraction process developed to reprocess thorium-based nuclear fuels.

Transuranic waste: As defined and used by the U.S. Department of Energy (DOE Order 5820.2A), radioactive waste that, at the time of assay, contains more than 100 nCi/g of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years.

Transuranic waste acceptance criteria: A set of requirements/criteria that must be satisfied prior to transport to and emplacement in the Waste Isolation Pilot Plant for disposal.

Transuranic waste certification: The process for verifying that waste meets the applicable requirements/criteria for transport to and emplacement in a repository for disposal.

Transuranic waste, contact-handled: Transuranic waste with a surface dose rate of less than 200 mrem/h.

Transuranic waste nondestructive assay/nondestructive examination: Nondestructive test procedures performed on suspect transuranic wastes to determine their transuranic isotope concentration. From these tests such wastes can be properly classified (certified) as transuranic or low-level.

Transuranic waste, remote-handled: Transuranic waste with a surface dose rate of greater than 200 mrem/h.

Vitrification: The conversion of high-level waste materials into a glassy or noncrystalline solid for subsequent disposal.

Waste Isolation Pilot Plant: A facility, located near Carlsbad, New Mexico, to be used for demonstrating the safe disposal of transuranic wastes from DOE defense-related activities.

Yellowcake: A uranium oxide concentrate that results from milling (concentrating) uranium ore. It typically contains 80 to 90% U_3O_8 .

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University Research Association, P.O. Box 500, Batavia, IL 60510

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DOE Fernald Area Office, P.O. Box 398705, 7400 Wiley Road, Cincinnati, OH 45239-8705

Fluor Daniel, Fernald Environmental Restoration Management Corporation, P.O. Box 398704, 7400 Wiley Road, Cincinnati, OH 45239-8704

Formerly Utilized Sites Remedial Action Program:

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Department of Energy, Grand Junction Projects Office, P.O. Box 2567, Grand Junction, CO 81502

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Naval Reactors Facility, P.O. Box 2068, Idaho Falls, ID 83403-2068

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Mound Plant:

DOE Miamisburg Area Office, P.O. Box 66, Miamisburg, OH 45343-0066

EG&G Mound Applied Technologies, Inc., P.O. Box 3000, Miamisburg, OH 45343-3000

Naval Reactors Program (DOE/HQ, NE-60) Facilities:

Bettis Atomic Power Laboratory, Westinghouse Electric Corporation, P.O. Box 79, West Mifflin, PA 15122-0079

DOE Pittsburgh Naval Reactors Office, P.O. Box 109, West Mifflin, PA 15122-0109

DOE Schenectady Naval Reactors Office, P.O. Box 1069, Schenectady, NY 12301-1069

Knolls Atomic Power Laboratory, General Electric Company, P.O. Box 1072, Schenectady, NY 12301-1072

Naval Reactors Facility (see Idaho National Engineering Laboratory)

Nevada Test Site:

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Mason and Hanger—Silas Mason Co., P.O. Box 30020, Amarillo, TX 79177

Pinellas Plant:

DOE Pinellas Area Office, P.O. Box 2900, Largo, FL 34649

Lockheed Martin Specialty Components, P.O. Box 2908, Largo, FL 34649-2908

Portsmouth Gaseous Diffusion Plant, Lockheed Martin Utility Systems, P.O. Box 628, Piketon, OH 45661

Princeton Plasma Physics Laboratory, Princeton University, P.O. Box 451, Princeton, NJ 08543

Reactive Materials Incorporated (RMI) Extrusion Plant, P.O. Box 579, Ashtabula, OH 44004

Rocky Flats Environmental Technology Site:

DOE Rocky Flats Office, P.O. Box 928, Golden, CO 80401-0928

EG&G Rocky Flats, Inc., P.O. Box 464, Golden, CO 80401-0464

Sandia National Laboratories/California, Lockheed Martin Sandia Corporation, P.O. Box 969, Livermore, CA 94551-0969

Sandia National Laboratories/New Mexico, Lockheed Martin Sandia Corporation, P.O. Box 5800, Albuquerque, NM 87185-5800

Savannah River Site, Westinghouse Savannah River Company, P.O. Box 616, Aiken, SC 29802

Stanford Linear Accelerator Center, P.O. Box 4349, Palo Alto, CA 94309

Uranium Mill Tailings Remedial Action Program (UMTRAP):

DOE Albuquerque Operations Office, UMTRA Project Office, P.O. Box 5400, Albuquerque, NM 87115

Jacobs Engineering Group, Inc., Suite 1700, 5301 Central Ave., NE, Albuquerque, NM 87108

Waste Isolation Pilot Plant:

Department of Energy, Waste Isolation Pilot Plant Project Office, P.O. Box 3090, Carlsbad, NM 88221

Westinghouse Electric Corporation, Waste Isolation Pilot Plant Project Office, P.O. Box 2078, Carlsbad, NM 88221

West Valley Demonstration Project:

DOE West Valley Area Office, 10282 Rock Springs Road, P.O. Box 191, West Valley, NY 14171-0191

West Valley Nuclear Services Company, Inc., 10282 Rock Springs Road, P.O. Box 191, West Valley, NY 14171-0191

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