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U.S. Department of Energy
Office of
Environmental Restoration and
Waste Management

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Environmental Restoration and Waste Management (EM) Program

An Introduction

MASTER

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Foreword

This booklet introduces the reader to the mission and functions of a major new unit within the U.S. Department of Energy (DOE): the Office of Environmental Restoration and Waste Management (EM). The Secretary of Energy established EM in November 1989, implementing a central purpose of DOE's first annual Environmental Restoration and Waste Management Five-Year Plan, which had appeared three months earlier. The contents of this booklet, and their arrangement, reflect (and will, it is hoped, serve as a kind of appetizer for) the annual update of the Five-Year Plan.

Over 2000 feet beneath a desert in New Mexico, a technician inspects a borehole in salt rock. This DOE demonstration facility will assess the suitability of underground salt formations for the safe disposal of certain radioactive waste.

EM Organization

The Five-Year Plan Characterizes the Evolution and Future of EM's Program

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Our nation has entered an era in which the public is demanding cleanup and restoration of its environment, understandable information, and participation in decision making. DOE's culture, which grew out of the Atomic Energy Commission's culture of classification, compartmentalization, and strict-need-to-know dissemination of information, was in direct conflict with this demand for public involvement. DOE recognized this situation as outdated, and committed to changing its culture into one of more openness and public involvement in decision making and policy direction. One of the results of this commitment to an open culture--dedicated to the restoration of the Nation's environment--was the creation of the Environmental Restoration and Waste Management (EM) Five-Year Plan.

In March 1989, the Secretary promised Congress he would soon deliver a comprehensive plan outlining specific actions DOE intended to undertake over the next five years to achieve compliance with national environmental laws and to begin cleanup and restoration of sites contaminated over the past 40 years. Although the development and production schedule seemed nearly impossible for such an important document, the Secretary recognized the need to take immediate charge of DOE's problems.

First published in August 1989, and updated annually, the Environmental Restoration and Waste Management Five-Year Plan contains the framework for EM to characterize, prioritize, and consolidate cleanup activities for every site. Under the Five-Year Plan, immediate problems are to be confined and corrected. The priorities of a 30-year compliance and cleanup effort are based on credible science and technology.

In November 1989, DOE issued a Draft Applied Research, Development, Demonstration, Testing, and Evaluation (RDDT&E) Plan. The RDDT&E Plan is a real attempt to get results from research and technology demonstrations within a timetable driven by a hard assessment of need and risk. Decisions will be made based on performance, and return on the dollar spent. DOE is building a methodology that applies tough cost/benefit criteria to all waste-related activities. DOE is using industry and peer academic input to determine what's really useful and achievable. Thus, time won't be wasted on evaluating competing proposals that have limited value. The RDDT&E Plan is now a full-fledged section of the Five-Year Plan.

The Five-Year Plan Characterizes the Evolution and Future of EM's Program

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The Five-Year Plan supports DOE's strategy for meeting its 30-year compliance and cleanup goal. This strategy involves: (1) focusing DOE's activities on eliminating or reducing known or recognized potential risks to worker and public health and the environment, (2) containing or isolating, removing, or detoxifying onsite and offsite contamination, and (3) developing technology to achieve DOE's environmental goals.

Why the New EM Organization?

In its Five-Year Plan, DOE has committed to a 30-year goal of compliance and cleanup. That is, by the year 2019, DOE's goal is to have cleaned up its current inventory of inactive sites and facilities and, on a much faster track, bring its nuclear-related sites and facilities into compliance with applicable Federal, State, and local laws and regulations. Before the creation of EM, no single DOE focal point existed for such activities; programs responsible for these activities were spread among three distinct management elements--Defense Programs, Nuclear Energy, and Energy Research. The lack of a consolidated management approach reflected a less than top priority for waste-related compliance and cleanup. It also hampered DOE from responding effectively and efficiently to increasingly numerous and strict environmental requirements.

However, on June 27, 1989, as part of his 10-point initiative, the Secretary announced that environmental compliance and cleanup were now a higher priority than nuclear materials and weapons production. Clearly, a new age was dawning for DOE. There would no longer be nuclear materials or weapons production without environmental compliance. And just as clearly, new strategic planning would have to emerge; and a new, large, dedicated organization would have to take responsibility for implementing the Secretary's vision of environmental stewardship. Thus, DOE created the Office of EM to consolidate DOE-wide responsibility for compliance and cleanup and to give it the attention of top-level management.

EM as the Cornerstone of DOE's Emerging New Culture

The Secretary has mandated that the "trust-me" culture that pervaded DOE and its predecessor agencies for more than 40 years must yield to a "watch-me" culture. As waste and contamination from DOE's defense-related nuclear activities have taken the brunt of increasing congressional, regulatory, and public concern and scrutiny, so must EM take the lead in conducting its compliance and cleanup efforts with excellence, timeliness, and cost-effectiveness. It's impossible to redress, all at once, the effects of decades of activities now determined to be hazardous to human health and safety and the environment.

Likewise, it's impossible to change overnight the culture--the motivational structure--of tens of thousands of DOE and contractor employees across the nation. DOE's largely closed, hands-off posture reflected prevailing executive, congressional, and public concerns for national security. The Secretary's new vision recognizes that, though DOE's purely defense-related activities must remain classified, its activities in environmental restoration and waste management must be open and openly communicated. They must be subject not merely to applicable laws and regulations but to the invited participation of affected parties at all levels of government and the private sector.

An example of this new openness is the State and Tribal Government Working Group (STGWG), which DOE created in early 1989 to review formulative drafts of the Five-Year Plan. Made up of representatives appointed by governors and tribal leaders from State and tribal lands hosting DOE facilities and waste sites, STGWG also includes representatives of the National Governors' Association, the National Conference of State Legislatures, and the National Association of Attorneys General. STGWG was instrumental in helping DOE establish its 30-year goal of compliance and cleanup. STGWG not only reviews the Five-Year Plan but also discusses related issues DOE brings before it or which STGWG members bring up for discussion.

Another group, containing some STGWG members as well as representatives from the Environmental Protection Agency, the Natural Resources Defense Council, and the Environmental Defense Fund, has been working with DOE to develop a rigorous, risk-based methodology for prioritizing compliance and cleanup activities.

EM Organization

EM Structure and Responsibilities

The Office of EM consists of three programmatic offices and two support offices. The accompanying chart shows EM's structure and its position within DOE.

The Office of Waste Operations has program responsibility for waste management at all DOE sites. Waste management includes the treatment, storage, and disposal of several types of waste: high-level radioactive waste; transuranic radioactive waste, including the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico; low-level radioactive waste; chemically hazardous waste; mixed (both radioactive and chemically hazardous) waste; and sanitary waste. Waste minimization efforts are directed from this Office, as are Corrective Activities (activities necessary to bring active and standby facilities into compliance with applicable local, State, and Federal regulations) at waste management facilities.

The Office of Environmental Restoration has program responsibility for cleanup of inactive, hazardous, and radioactive waste release sites at DOE sites and some non-DOE sites for which DOE has responsibility. Environmental Restoration includes remedial actions and decontamination and decommissioning (D&D). Remedial actions comprise all aspects of the assessment and cleanup of known and suspected inactive release sites. D&D is concerned with the safe caretaking of surplus nuclear facilities until their decontamination, followed by entombment, dismantling and removal, or conversion to another use.

The Office of Technology Development has program responsibility for providing new and more effective technologies for meeting DOE's 30-year goal for compliance and cleanup. Included are research and development of new technologies; demonstration, testing, and evaluation of technologies developed elsewhere and internally; educational programs to produce the scientists and engineers needed to reach the goal; and transportation.

The Office of Planning and Resource Management supports the program offices in budget preparation and accounting. The Office of Quality Assurance and Quality Control performs independent internal oversight to ensure compliance with environmental and safety laws and regulations, and to assure the technical validity and cost effectiveness of programs and projects.

The new organization structure integrates environmental restoration, waste operations, and technology development activities and supports the 30-year compliance and cleanup goal.

Working to Resolve Infrastructure Limitations

DOE's Office of EM is not yet fully staffed. DOE recognizes that the infrastructure needed to accomplish the work outlined under the Five-Year Plan does not exist and will not exist for some time. Staffing of EM is proceeding as rapidly as practical, but the organization will not be able to manage additional program increases for at least two years. Although DOE's Operations Offices have also embarked on similar expansions, they face a period of too few managers and technical staff. Contractor organizations are also growing and are beginning to experience shortages of qualified applicants.

DOE does not now know the precise resource limits of the cleanup industry, but it is aware of the concern that exists throughout government and the private sector. Preliminary estimates indicate that DOE and its contractors must increase staff to at least two and one-half times present levels.

To help combat the infrastructure problem, DOE is sponsoring research through the Oak Ridge Associated Universities and, separately, through the University of Tennessee, to evaluate the human and industrial resources available to meet the anticipated demand for environmental cleanup. DOE has also begun education, training, and outreach activities to educate and train the human resources necessary to meet its 30-year compliance and cleanup goal.

Management of Waste from Past and Current DOE Nuclear Programs Has Been Consolidated.

DOE's major nuclear programs generate waste. EM is responsible for managing this waste and the sites which generate it.

The Environmental Restoration and Waste Management Five-Year Plan, FY 1992-1996, addresses Environmental Restoration, Waste Operations, Corrective Activities, and Technology Development at nearly 100 sites located in 34 States and Territories.

EM Manages Four Categories of Radioactive Waste.*

High-Level Waste (HLW) is highly radioactive waste material resulting from the reprocessing of spent nuclear fuel. It includes liquid waste produced directly in reprocessing and highly radioactive solid waste derived from the liquid. Some HLW contains elements that decay very slowly and remain radioactive for thousands of years. Most HLW must be handled by remote-control from behind protective shielding. Spent fuel from civilian nuclear power plants, which is also classified as HLW, is the management responsibility of the DOE Office of Civilian Radioactive Waste Management.

Low-Level Waste (LLW) is any radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material. It is generated by uranium enrichment processes, reactor operations, isotope production, medical diagnostic procedures, and research and development projects. It is typically contaminated with small amounts of radioactivity dispersed in large amounts of material. LLW is usually rags, papers, filters, tools, equipment, and discarded protective clothing contaminated with radionuclides. Some LLW material requires shielding during handling and transportation activities.

Transuranic (TRU) Waste is mostly LLW contaminated with alpha-particle-emitting isotopes which have decay rates and concentrations exceeding certain specified levels. It is produced during reactor fuel assembly, weapons fabrication, and reprocessing operations. It contains man-made elements heavier than uranium, thus the name trans (or beyond) uranic. TRU waste decays slowly and requires long term isolation. Protective clothing, equipment, and tools may be contaminated with TRU radionuclides.

Uranium mill tailings are byproducts of uranium mining and milling operations. They are naturally radioactive rock and soil. Tailings contain small amounts of radium that decay and emit radon, a radioactive gas. Released into the atmosphere, radon gas disperses harmlessly, but the gas might be harmful if a person were exposed to high concentrations for long periods of time.

*Technical definitions for the four categories are provided in the glossary.

Radioactive Waste Exists in Many Forms.

Liquid waste from reprocessing plants can be converted to sludge or immobilized in solids to facilitate handling and storage. Contaminated materials, such as empty containers, protective clothing, and used equipment, are compacted and stored in metal drums.

Wall and floor surfaces in certain areas of a nuclear facility can be contaminated by radioactive substances. The decontamination process generates additional radioactive waste materials which must be disposed of.

High-level waste needs heavy shielding to confine penetrating radiation and dissipate heat.

Radiation from most transuranic waste is blocked by a storage container.

Engineered barriers can effectively isolate low-level waste from the environment.

EM Also Manages Hazardous, Mixed, and Sanitary Waste.

Hazardous Waste

Nuclear materials production activities also generate **hazardous waste**. These toxic, corrosive, reactive, or ignitable substances can affect human health and damage the environment. Hazardous waste is chemicals, such as chlorinated and nonchlorinated hydrocarbons, explosives, gasoline, diesel fuel, asbestos, acid, and organic solvents, metals, and pesticides.

Like private industry, DOE must comply with strict Federal, State, and local environmental regulations in treating and disposing of hazardous waste.

Mixed Waste

Some waste which EM manages contains both radioactive and hazardous components. This is called **mixed waste**. Treatment standards are being developed for mixed waste.

EM Also Manages Hazardous, Mixed, and Sanitary Waste (cont).

Sanitary Waste

Sanitary waste is routinely generated by normal housekeeping activities. It is neither radioactive nor hazardous. This waste is garbage and is disposed of in sanitary landfills. Sanitary waste also includes liquid effluents which are treated in sewage treatment plants.

EM Also Manages Contaminated Soil and Groundwater.

Other waste EM manages from past activities includes **soil and groundwater** contaminated with radioactivity, hazardous chemicals, or both. EM's site characterization and cleanup activities themselves will yield additional challenges when materials dug up to satisfy one set of regulations must be reburied according to another set of regulations.

The 881 Hillside area at Rocky Flats Plant in Golden, Colorado, is an important cleanup project. The site contains radioactive and chemical waste dating back to the 1950's and 1960's. The cleanup work focuses on a system to remove chemical contaminants from groundwater. It involves constructing an underground dam and water-collection system at the base of the hillside to intercept groundwater contaminated with organic chemicals.

**DEFENSE
HIGH-LEVEL WASTE**

**DEFENSE
TRANSURANIC WASTE
TOTAL: 65 YARDS**

If all DOE waste produced as of December 31, 1988 were combined to fill football field size areas, high-level waste would fill a hole 100 yards deep and transuranic waste would fill a hole 65 yards deep. There would be about 55 times as much low-level waste as high-level waste and transuranic waste combined since low-level waste would fill a hole about 9,000 yards deep.

**Uranium Mill Tailings
Remedial Action Project**

7,730 YARDS

**Formerly Utilized Sites
Remedial Action Program**

340 YARDS

**Surplus Facilities
Management Program**

630 YARDS

**Decontamination
and Decommissioning**

35 YARDS

Defense

650 YARDS

**LOW-LEVEL WASTE
TOTAL: 9,385**

Corrective Activities

DOE is currently out of compliance with Federal, State, and local environmental requirements at a majority of its sites. Corrective Activities are activities and projects required to bring DOE's active and standby facilities into compliance. Corrective Activities also include those projects and activities in which Operations Offices are able to identify specific cases in which DOE will be in noncompliance with near-term regulatory requirements.

There are three categories of Corrective Activities:

Air Corrective Activities reduce or eliminate releases of contaminants to the atmosphere. These releases occur through regulated sources such as stacks and exhaust vents and must comply with the Clean Air Act, which includes the National Emission Standards for Hazardous Air Pollutants (NESHAPs) Program.

Water Corrective Activities reduce or eliminate releases of contaminants to surface waters regulated under the Clean Water Act which includes the National Pollutant Discharge Elimination System (NPDES) Program.

Solid Waste Corrective Activities bring solid waste management operations that may or may not have contaminated the soil and groundwater into compliance. They are needed to comply with Federal, State, and local solid waste and groundwater requirements. The following Federal Statutes apply to the solid waste corrective activities category: the Resource Conservation and Recovery Act (RCRA), the Atomic Energy Act (AEA), the Safe Drinking Water Act (SDWA), and the Toxic Substances Control Act (TSCA).

Corrective Activities

Corrective Activities cover the full range of environmental releases: (1) air, (2) surface water, and (3) soil and groundwater (solid waste).

At the Kansas City Plant, a berm is being built to protect the site and the surrounding area from contamination in case of flooding. Shown here is an artist's conception of the planned berm. Spill containment devices will be constructed at DOE sites where they are needed to comply with the Resource Conservation and Recovery Act (RCRA) and other applicable laws.

Corrective Activities

The ventilation systems at DOE's gaseous diffusion plants, such as the Paducah, Kentucky one shown above, are over 40 years old. These ventilation systems contain gaskets that were impregnated with PCB-containing materials. Activities will be undertaken to prevent PCB oils from escaping from these systems.

The Central Neutralization Facility was constructed to bring the Oak Ridge Gaseous Diffusion Plant, in Tennessee, into compliance with National Pollutant Discharge Elimination System (NPDES) limits. The facility treats wastewater to remove uranium and chemical contaminants.

The new Nonradiological Waste Water Treatment Project, at Oak Ridge National Laboratory in Tennessee, treats process waste water to remove organics and metals. The operation of this facility will comply with the National Pollutant Discharge Elimination System (NPDES) provision of the Clean Water Act.

A cooling tower is being built at K-Reactor at the Savannah River Site, in Aiken, South Carolina, to comply with the National Pollutant Discharge Elimination System (NPDES) provision of the Clean Water Act.

Corrective Activities

The Coal Pile Run-Off Treatment Facility at the Y-12 Plant in Oak Ridge, Tennessee, collects run off from coal piles and treats it to avoid contamination of the East Fork Poplar Creek and to be in compliance with the Clean Water Act.

Environmental Restoration

Past operations connected with DOE nuclear programs have resulted in contamination of a large number of inactive sites and facilities with quantities of radioactive, hazardous, and mixed waste. Environmental Restoration is concerned with the assessment and cleanup of these sites and facilities to meet Federal, State, and local regulations. The goal is to ensure that risks to human health and safety and to the environment posed by DOE's past, present, and future operations at facilities and sites are either eliminated or reduced to prescribed, safe levels. DOE intends that facilities and sites be returned to a condition suitable for unrestricted use; however, in certain instances, in-place remedies, such as in situ treatment for destruction or detoxification, and stabilization followed by monitoring, may be a preferred alternative. Remediation decisions will be made in accordance with the regulatory and public interaction processes prescribed by law.

Environmental Restoration consists of two sets of activities: Remedial Actions, and Decontamination and Decommissioning (D&D). Remedial Actions encompass (1) site discovery, preliminary assessment, and site inspection; (2) site characterization, analysis of remediation alternatives, and selection of remedy; (3) remediation and site closure; and (4) site compliance monitoring. Although Remedial Actions may deal with surface water contamination or with tanks, buildings, or structures, most Remedial Actions activities are concerned with contaminated soil and groundwater. The number of hazardous substance release sites is approximately 3,700. The Uranium Mill Tailings Remedial Action (UMTRA) Project addresses the cleanup of sites and adjacent properties contaminated with tailings from inactive uranium mills. The UMTRA Project is responsible for 24 former uranium ore processing sites, and an additional 5,000 vicinity properties. The Formerly Utilized Sites Remedial Action Program (FUSRAP) addresses the cleanup of sites and adjacent properties contaminated by activities of the Manhattan Project. The FUSRAP scope is 31 sites, nine of which have been completed.

D&D is concerned with the safe caretaking of surplus nuclear facilities until their decontamination, followed by entombment, dismantling and removal, or conversion to another use. D&D tasks encompass: (1) surveillance and maintenance; (2) assessment and characterization; (3) environmental review; (4) engineering; (5) D&D operations; and (6) closeout. Although D&D activities may deal with soil and groundwater contamination, most are

Environmental Restoration

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concerned with facilities such as reactors, hot cells, processing plants, storage tanks, and other structures from which there have been no known releases to the environment. Approximately 500 contaminated facilities are included under D&D.

The Environmental Restoration and Remediation Process (page 21) shows that information is collected and evaluated to help identify and evaluate potential cleanup remedies that meet requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), and the National Environmental Policy Act (NEPA). CERCLA addresses the uncontrolled releases of hazardous substances to the environment and the cleanup of former or otherwise inactive waste sites. RCRA addresses the management of regulated hazardous waste and requires that permits be obtained for DOE facilities that treat, store, or dispose of hazardous waste or mixed waste; establishes standards for these facilities; and requires corrective actions (e.g., remediation) of past releases of hazardous waste from regulated waste management units. NEPA requires that DOE perform an environmental review, with public participation, of proposed major Federal actions that may have an impact on the human environment. This review usually results in an Environmental Assessment or Environmental Impact Statement. DOE policy is to integrate NEPA requirements with CERCLA and RCRA requirements for all Environmental Restoration projects.

Environmental Restoration and Remediation Process:

DOE Assessment and Cleanup Phase Terminology	RCRA Terminology	CERCLA Terminology	D&D Terminology
Assessment Tasks			
Preliminary Assessment	RCRA Facility Assessment	Preliminary Assessment	Included in Characterization
Inspection	Included as a Part of RCRA Facility Assessment	Site Inspection	Included in Characterization
Characterization	RCRA Facility Investigation	Remedial Investigation	Characterization
Evaluation of Cleanup Alternatives	RCRA Corrective Measures Study	Feasibility Study Record of Decision (ROD)	NEPA Environmental Review Record of Decision (ROD) or Finding of No Significant Impact (FONSI)
Cleanup Tasks			
Cleanup Action	RCRA Corrective Measures	Remedial Design Remedial Action	Engineering & Operation
Compliance	Postclosure Monitoring	Operation and Maintenance	Postdecommissioning

Note: An interim removal remedial action may be undertaken during any phase of the assessment task.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act

D&D: Decontamination and Decommissioning

RCRA: Resource Conservation and Recovery Act

NEPA: National Environmental Policy Act

Remedial actions require completion of a lengthy evaluation and assessment process before actual waste handling, decontamination, treatment, removal, or storage can take place.

Remedial Actions

At a pilot plant in Kansas City, groundwater contaminated with organic compounds is exposed to ozone and ultraviolet light in a reaction chamber. The process breaks down contaminants, leaving only carbon dioxide, nitrogen, hydrogen, and water.

At the Savannah River Site in South Carolina, seepage basins that collected waste water are being emptied and closed.

The four ponds in the photograph above are part of a waste water treatment facility for acid and organic waste containing uranium. In the past, the four ponds were used for disposal of these materials at the Y-12 plant in Oak Ridge, Tennessee. The liquid in these ponds was treated to remove contaminants, and the ponds were drained and capped, as shown below.

Remedial Actions

At the Kerr Hollow Quarry on the Oak Ridge Reservation in Tennessee, several thousand potentially hazardous containers are being removed. The quarry was used for treatment of water-reactive materials and potentially explosive chemicals, and for disposal of empty, compressed gas cylinders. The quarry water contains no traces of hazardous materials.

The SONSUB Remotely Operated Vehicle (shown in the upper right-hand corner), will perform an underwater inspection of the containers. Following the inspection, the empty containers will be removed from the quarry area and placed in a DOE-permitted landfill. Workers monitor the submarine's activities from trailers, as shown above.

The Uranium Mill Tailings Remedial Action (UMTRA) Project evaluates and cleans up sites contaminated with, for example, fill dirt from a uranium mining site. This site in Canonsburg, Pennsylvania required complete removal of all buildings.

Remedial Actions

The Formerly Utilized Sites Remedial Action Program (FUSRAP) ensured that this non-DOE property in Maywood, New Jersey was remediated. Before their hazard was recognized, mill tailings were used as fill in populated areas. FUSRAP activities include their removal and replacement with uncontaminated soil or other uncontaminated materials. Similar cleanups have been conducted under the Uranium Mill Tailings Remedial Action (UMTRA) vicinities cleanup program.

One step in the decommissioning of a plutonium facility in Miamisburg, Ohio involved draining and excavating two large liquid waste tanks containing radioactively contaminated methanol. The tanks were moved inside the building for decontamination and size reduction before disposal.

Decontamination and Decommissioning

The 201-C Strontium Semi-Works at the Hanford Site in Washington State were completely removed and the site restored. The stack and buildings were demolished and radioactive waste was disposed of at the Hanford Site.

Decontamination and Decommissioning

Decommissioning the inactive Shippingport Atomic Power Station involved activities ranging from demolishing all structures to planting grass. The reactor vessel package and all radioactive components were removed and safely transported to a permanent disposal site.

Waste Operations

Waste Operations (WO) embrace ongoing activities throughout DOE's operating complex. The primary purpose of these activities is to manage and to account for and dispose of DOE waste in a safe and environmentally sound manner. Achieving this purpose yields two benefits. It protects people and the environment today and in the future, and it avoids the creation of additional waste sites.

The scope of WO is to accept waste produced by DOE's processing, manufacturing, and research activities and to manage this waste using appropriate treatment, storage, and disposal technologies. Aside from managing waste materials on a daily basis, another fundamental goal of WO is to achieve real reductions in the volume and toxicity of hazardous, mixed, radioactive and sanitary waste generated by DOE's activities. Waste minimization programs are promoted at all DOE sites to assist the generators with detailed planning and implementation. Another major WO goal is to provide treatment, storage, and disposal capacity to accommodate both the waste currently stored and waste expected from future operations.

MINIMIZATION

TREATMENT

STORAGE

DISPOSAL

Waste Minimization

Although historically understood, in part, as reduction in waste volume and concentration, true waste minimization must be seen as avoidance of the generation of radioactive, hazardous, mixed, and solid sanitary waste. DOE will make waste minimization a key objective, not only in process and facility modification, but also in the procurement of goods and services. Waste minimization technology is the most interdisciplinary of the waste management tools, affecting all present and proposed DOE operations. Establishing a waste minimization program requires cultural as well as technical changes in the DOE complex. A "design for minimization" philosophy must be adopted across the DOE system.

The goal of waste minimization is to achieve a 50 to 80 percent reduction in manufacturing waste generation (FY 1985 baseline), within 10 years of program initiation, by material substitution, process alteration, new production hardware, and recycling. A comprehensive waste minimization program will contribute to decreases in waste treatment, storage, and disposal costs and lower health risks to workers and the public. Technical approaches are being sought to (1) optimize the number of production operations required; (2) increase the use of nonhazardous chemicals and chemicals that produce waste compatible with the environment; (3) increase the use of recyclable chemicals and materials; and (4) implement the design of new products, processes, and facilities or redesign existing ones. Some criteria to determine a successful technology include improved processing yield, reduced quantities of scrap, reduced waste and processing of byproducts, reduced use of hazardous chemicals, positive return on investment, and no loss of product quality.

Waste Minimization

Generation prevention is applied to manufacturing activities to reduce the amount of waste produced to begin with. Source reduction, rather than recycle, is the major focus of waste minimization. Adjusting manufacturing processes will help reduce the amount of waste that requires treatment and disposal.

New technology for uranium recycling can reduce waste and lower waste treatment, storage, and disposal costs considerably at the Oak Ridge Y-12 Plant. Scrap from machining operations is processed and compacted into billets which are returned to the manufacturing operation, thereby reducing the amount of new uranium purchased by DOE.

This new process for enriched uranium waste minimization eliminates 100 percent of the fluoride chemical waste and reduces the total process waste 30 to 60 percent. The uranium recovered by this system can be reused with lower overall waste handling cost.

Waste Minimization

Through changes in manufacturing technology, waste can be made environmentally benign.

Treatment

Treatment facilities process waste to reduce the amount and volume of radioactive and hazardous chemical material and make it safer to handle. Selection of treatment methods depends on the quantity and form of the waste material.

Chemical processing plants take liquid waste or sludge and convert it to a waste form suitable for permanent disposal in a geologic repository. Liquid waste can be solidified by spraying droplets onto hot particles and removing moisture (calcining). Sludge can be immobilized by mixing it with molten glass particles (vitrification).

The volume of solid waste can be reduced through processes such as compaction, incineration, smelting, and acid digestion.

DOE's near-term objective is to treat hazardous waste as it is generated to avoid the need for additional storage capacity.

Few mixed waste treatment standards have been established. In May 1990, Congress established four new specific waste treatment standards for mixed waste containing mercury, lead, powdered zirconium, and high-level radioactive waste.

Treatment

The Defense Waste Processing Facility (DWPF), at the Savannah River Site in South Carolina, will process high-level waste into a solid form suitable for permanent disposal. Radioactive sludge is dissolved in molten borosilicate glass and poured into stainless-steel canisters. A plug is fused to the canister opening resulting in a seal that is stronger than the canister itself. DOE plans to construct a similar facility for the Hanford Site in Washington State.

The New Waste Calcining Facility (NWCF) in Idaho converts high-level waste into calcine. Liquid waste droplets contact hot particles in the fluidized bed and solidify onto them. The granular end product is transported through pipes to stainless-steel bins. The bins, which have a life span of hundreds of years, are encased in underground concrete vaults.

Remote maintenance systems in the New Waste Calcining Facility (NWCF) reduce personnel exposure to radiation and shorten plant maintenance downtime.

Treatment

The volume of transuranic-contaminated material can be significantly reduced by various methods before storage or disposal. After reduction, the contents of the drum on the left will fit in the small can on the right.

Compaction of drums makes shipping easier and reduces required storage and disposal space.

35 COMPACT CONTAINERS

This radioactive and mixed waste controlled-air incinerator at Los Alamos National Laboratory, in New Mexico, will be used for volume reduction of transuranic waste and destruction of hazardous components of mixed waste. The incineration process, as it exists today, is the culmination of 15 years of research and development work. The extensive off-gas containment system removes radioactive particles, reduces off-gas temperature, and scrubs and absorbs acid gas from combustion of hazardous waste. The incinerator has been demonstrated to safely process radioactive waste without release of any radioactivity to the environment.

Treatment

Before reduction

After reduction

The Waste Experimental Reduction Facility, at the Idaho National Engineering Laboratory, reduces the volume of low-level waste by a factor of as much as 300 to 1. Volume reduction extends the lifetime of existing low-level waste disposal sites.

Shown above is a liquid low-level waste Storage and Treatment Facility at Oak Ridge National Laboratory in Tennessee. Liquid low-level waste is stored in underground tanks and periodically solidified in the solidification building. This solidification process mixes low-level waste sludge with cement and fly ash resulting in a grout mixture. The solidified grout is stored in above-ground vaults on a gravel pad awaiting final disposal.

This incinerator in Oak Ridge, Tennessee is planned for the processing of hazardous and mixed waste.

Waste Operations

Storage

Waste storage is an interim measure. The goal of the Waste Operations Program is to eliminate the backlog of stored waste and reduce inventories to normal operating levels. Storage of newly generated waste will become only a short-term operational step before disposal.

High-level waste is stored in liquid form in double-wall tanks. Some high-level waste is temporarily stored in single-wall tanks.

Transuranic waste is placed in containers and stacked on asphalt or concrete pads. DOE is proposing that the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, be the final disposal site pending a successful demonstration period.

The majority of DOE low-level waste will continue to be disposed of using proved and improved techniques at selected DOE locations. Some low-level waste must be stored awaiting treatment and/or disposal. Storage requirements for this waste are being assessed.

Hazardous waste is stored in permitted DOE facilities. Hazardous waste storage will rise to a peak, then diminish steadily as advanced minimization and treatment programs are established and implemented. Land disposal restrictions (LDR's) ensure that hazardous waste is stored and disposed of according to specific regulatory provisions in preparation for treatment.

Mixed waste is stored pending treatment. Most storage complies with current regulatory requirements. Regulations restrict the amount of time that untreated mixed waste may be stored.

Waste storage is an interim measure.

DOE's long-term waste management goal is to end storage and begin permanent disposal.

Storage

These storage tanks, at the Hanford Site in Washington State, each hold one million gallons of high-level waste. The double-wall carbon steel tanks are encased in concrete vaults. After construction was completed, the earth was replaced to bury the tanks. Similar storage tanks are in use at the Savannah River Site in South Carolina.

At some sites, metal drums and boxes containing transuranic waste are stored on asphalt pads in trenches. The material is enclosed in a protective vinyl cover and backfilled with soil. When the Waste Isolation Pilot Plant (WIPP) becomes operational, the waste will be easily retrieved for processing and disposal.

Storage

At Idaho, some transuranic waste is stored in an air-supported building. The remainder is stored on asphalt pads in drums, and covered with plastic and earth. The cut-open drums in the photograph below show typical transuranic waste items. Transuranic waste is also stored at the Transuranic Storage Area under berms.

Solidified liquid low-level waste which can't be disposed of is stored in steel drums inside concrete vaults.

Liquid low-level waste is stored in tanks before treatment solidifies it. The liquid in these 350,000 gallon tanks will be grouted (mixed with a cement-like substance) and stored in aboveground concrete vaults.

Storage

Hazardous waste is packaged in drums and stored on concrete pads awaiting treatment and disposal. Some hazardous waste is solidified, packaged in drums, and disposed of in permitted DOE landfills.

Some hazardous waste is stored in buildings on DOE sites and awaits disposal.

Disposal

Waste Operations develops the technologies and processes to prepare DOE waste for permanent disposal. Facilities are being designed, built, and tested so the process of reducing inventories of stored waste can begin.

DOE's goal is to send high-level waste to a planned Federal repository which is proposed to begin operations sometime after the year 2000.

A facility for disposal of transuranic waste has been completed near Carlsbad, New Mexico. If test demonstrations are successful, the Waste Isolation Pilot Plant (WIPP) will become a permanent disposal site. Examination and processing facilities at various DOE sites will certify that transuranic waste shipments meet the criteria for disposal.

Low-level waste is disposed of by shallow land burial in trenches and aboveground in tumulus vaults. New technologies, stabilization techniques, and site monitoring systems ensure protection of the environment.

After treatment, hazardous waste is disposed of in permitted DOE facilities.

Mixed waste is stored pending treatment. Mixed waste disposal facilities are being planned at various DOE sites.

Disposal

DOE plans to send high-level waste to a proposed Federal repository after the year 2000. Yucca Mountain is being characterized to determine its suitability for a deep geologic repository for the permanent disposal of high-level waste.

The Waste Isolation Pilot Plant (WIPP) in New Mexico is designed to demonstrate the safe and permanent disposal of transuranic waste in a salt formation more than 2000 feet underground. If the demonstration is successful, WIPP will become a disposal site for transuranic waste.

This continuous mining machine at WIPP mines salt underground at the rate of 300 tons per hour to form passages and storage rooms.

An Experimental Program for WIPP was developed to thoroughly explore the technological issues of deep geologic disposal in a saltbed. This room is used to test disposal techniques for transuranic waste using simulated waste containers.

At WIPP, simulated transuranic waste containers that can be handled directly are stacked in underground rooms. Storage locations are recorded in a computer so every package is traceable.

Containers that must be handled remotely because of radiation levels are inserted into holes bored in the salt walls at WIPP. A specially designed machine, which emplaces the containers and plugs the hole, can also retrieve this remote-handled waste if required.

Disposal

Transuranic waste, shipped from generating sites to WIPP, must be in a form acceptable for disposal. A Process Experimental Pilot Plant (PREPP) in Idaho will use a number of devices, including a shredder like the one shown below, to process waste. Similar facilities are in operation or are planned at other DOE sites.

Transuranic waste is examined at the Stored Waste Examination Pilot Plant (SWEPP) in Idaho to certify that it meets the acceptance criteria for WIPP disposal. Other DOE sites also have examination and certification facilities.

Disposal

Solid low-level waste is disposed of in tumulus vaults aboveground to protect the environment in humid or wet areas. The concrete-like vaults are sealed on all sides. This photo shows a typical loading operation for tumulus vaults at the Oak Ridge National Laboratory Tumulus I facility in Oak Ridge, Tennessee.

The lower right-hand side of this photo shows the Tumulus I disposal facility loaded. The lower left-hand side shows the newly constructed Tumulus II facility.

Solid low-level waste, such as rags or gloves contaminated with low levels of radioactivity, are safely disposed of by shallow land burial in dry areas. When all available space in the trenches is used, earth and a protective covering for erosion control will be placed on top of the waste containers.

Technology Development

Technology Development (TD) seeks to resolve major technical issues and rapidly advance beyond current technologies for Environmental Restoration and Waste Management activities. TD supports the 30-year compliance and cleanup goal and will reduce overall program costs.

Long-term TD goals are to: (1) become the international leader in technology development for environmental restoration and waste management operations; (2) expand the talent pool for site cleanup and waste management through significant support of education in science and technology; and (3) provide effective support to EM in the identification and resolution of technology needs. Attainment of these goals will reduce waste generation, overall costs, and risks.

Several broad TD program areas have been established. They include Research Development, Demonstration, Testing, and Evaluation (RDDT&E); Technology Integration; Education; and Transportation (which will be discussed in the next section).

The RDDT&E Program develops, demonstrates, and transfers needed technologies to Environmental Restoration, Waste Operations, and Defense Programs. These technologies will minimize the toxicity and volume of waste; manage unavoidable waste more efficiently and safely; accomplish faster, better, cheaper, and safer remediation of waste problems; and produce safe, permanent disposal of waste within regulatory guidelines.

The RDDT&E Program is executed in three phases: Innovative Technology (IT); Research and Development (R&D); and Demonstration, Testing, and Evaluation (DT&E). The IT phase stimulates new and better approaches to all aspects of environmental restoration and waste management. R&D supports research applied to developing waste management technologies. DT&E validates technologies by demonstrating effectiveness, cost savings, improvements, and risk-reduction potential.

RDDT&E is organized into integrated demonstrations and programs that focus activities toward the end objective--a fully workable, faster, and cost-effective technology. The integrated demonstrations and programs are the mechanisms to help move the technology products from the universities, industries, governmental agencies, international agencies, and DOE laboratories and sites into

Technology Development

the hands of the user. The integrated demonstration is the cost-effective mechanism that assembles a group of related and synergistic technologies to evaluate performance individually or as a complete system in correcting environmental restoration and waste management problems. Integrated Demonstrations will be conducted in the areas of (1) Groundwater and Soils Cleanup, (2) Waste Retrieval and Waste Processing, and (3) Waste Minimization and Waste Avoidance.

Groundwater and Soils Cleanup technologies will be developed and advanced through integrated demonstrations that (1) remove or reduce hazardous toxic materials from contaminated groundwater and contaminated soils underground or on the surface; (2) remove or reduce the radioactivity levels; and/or (3) provide interim or temporary measures to retard migration of hazardous materials until a suitable technology can be developed or until agreements can be reached on the applicable compliance requirements.

Waste Retrieval and Waste Processing technologies will be developed and advanced through demonstrations that (1) remotely or otherwise excavate or remove contaminated material from the site or tank; (2) process contaminated material into a suitable form for shipping and/or disposal; (3) treat and dispose of waste arising from operations; and (4) decontaminate and decommission materials, equipment, and facilities.

Waste Minimization and Waste Avoidance technical approaches include substitution of solvents to reduce or eliminate the use of hazardous chemicals; development of alternative metal-forming processes that consume less stock and yield less waste; and recycling of scrap. Minimization goals for reducing waste generation range from 50 to 80 percent.

TD's Technical Integration Program ensures implementation of rapid, efficient technology for environmental restoration and waste management. It does this by encouraging the transfer of technology among Federal agencies, industries, universities, the national laboratories, and the international sector.

Technology Development

Finally, TD's Education Development Program identifies DOE's human resource needs for environmental restoration and waste management and develops innovative programs to ensure the needed human resources are available to meet the 30-year compliance and cleanup goal. It encourages the academic community to focus on environmental restoration and waste management science and technology and stimulates students to pursue environmental management careers. The program also aims to involve minorities, women, Native Americans, and disadvantaged persons in environmental programs. To pursue these goals, pilot DOE-university partnership programs, scholarship and fellowship programs, and an outreach program for grades K-12 have been established.

Site Characterization and Assessment

Advanced technologies for remote sensing will save time, reduce exposure, and save money. Airborne infrared surveys provide rapid characterization data that can be used to delineate waste disposal areas, contamination zones, and site performance characteristics.

The infrared photo shows areas where moisture is retained near the ground surface (shaded). These areas represent disposal trenches which have trapped infiltrating groundwater.

Site Characterization and Assessment

Integration of remote sensing and computer technology is used for non-intrusive characterization of waste sites. Ultrasonic Ranging and Data System (USRADS) was originally developed to survey properties suspected of containing uranium mill tailings. It uses ultrahigh-frequency sound to determine the path of the surveyor and transmit data from the instrument sensor carried. A nearby portable computer processes data from USRADS and creates a real-time display of the results. Non-intrusive surveys can be conducted rapidly and are less expensive than drilling which may spread contamination and create leaks in the waste site. USRADS is being adapted to many types of sensor instruments such as the EM-31 Terrain Conductivity Meter to characterize buried waste that is electrically conductive.

This is an example of survey results taken from the EM-31 Terrain Conductivity Meter shown above. A "bathtubbing" burial trench--partially filled with water--is clearly delineated.

Beneath the large gas exhaust hood, electrodes melt and solidify soil and waste material to isolate contaminants from the environment. Shown is 10 tons of soil vitrified in the pilot scale test.

Remediation

Researchers are working on a system to monitor the effectiveness of environmental barriers designed to prevent migration of contaminants outside the disposal area. The system uses chemically sensitive fiber optic sensors, called optrodes. A bundle of sensors, each treated to react to a different chemical, is buried in the soil. A change in the light reflectivity of a particular sensor indicates the presence of a specific contaminant.

Research to improve disposal methods is carried out at a number of DOE sites. A researcher at Sandia National Laboratories in New Mexico (left), develops instruments to measure the effects of radiation from a nuclear waste container on salt formations. Demonstrations show that improved cover systems (below) ensure isolation of buried low-level waste from the environment.

Remediation

Robots have many applications in environmental restoration and waste management. Field sites can be safely excavated by robots equipped for digging and handling large objects.

Robotics may be the only way to safely disassemble highly radioactive systems. Using robotic equipment, tanks can be emptied without excessive human exposure.

Using robotics, facilities can be efficiently decontaminated, dismantled, and decommissioned.

With the use of robots, laboratory operations can be made more precise and can operate with less human participation.

One of the most promising, cost-effective, and efficient methods of treating contaminated soil uses bacteria. Some microorganisms convert toxic metals into a form that is less toxic or innocuous to the environment. Other biological treatment systems convert organic contaminants into water and carbon dioxide. The systems have been tested in the laboratory and the Environmental Protection Agency (EPA) is now evaluating field studies.

Bioremediation Technologies

Biologically assisted restoration technologies include soil washing and venting. In biologically assisted soil washing, water with added nutrients and air is pumped into the contamination zone, and contaminated water is pumped from beneath the zone through a bioreactor in which contaminants are destroyed or trapped. The effluent is fertilized with nutrients and air and returned to the contamination zone to restart the cycle.

In biologically assisted soil venting a combination of air, nutrients, and methane are injected, with an inoculation of microbes if needed, below the contamination zone. As the contaminants are degraded, the volatile products are collected from above the contamination zone and cycled through a bioreactor for further processing.

Waste Minimization

Waste Type	Reduction goal* (%)
Transuranic	60
Low-level	80
Hazardous	80
Mixed	80
Sanitary	50

The previous photos showed technology development activities in the areas of site characterization and assessment, treatment, and remediation. These activities are integral to achieving EM's environmental goals. Waste minimization technology development efforts, which focus on reducing waste generation, are also necessary to achieve EM's environmental goals. Waste minimization goals for waste reduction range from 50 to 80 percent. This chart shows waste minimization goals for weapons manufacturing and is based on FY 1985 manufacturing waste generation rates using volume or weight as appropriate.

New designs and manufacturing processes will result in efficient material usage and reduced waste.

Transportation

DOE safely and efficiently transports secure shipments of material used in DOE program activities. Although radioactive material makes up a small percentage of the material shipped by DOE, they receive, by far, the most attention. The radioactive material shipped ranges from relatively low levels of radioactivity, such as uranium ore, to more highly radioactive material, such as spent nuclear fuel. Byproducts from processing this material, as well as the production of other useful radioisotopes, are shipped for use in medical treatment, industrial processes, consumer goods, and research programs.

DOE has a system to protect workers, the public, and the environment from the potential hazards of radioactive material. This system is based on a simple principle--if a package contains enough radioactivity to present a significant risk of injury or property loss if released, then the package must be designed to retain its contents during severe transportation accidents. Protection is provided by the packaging, rather than by relying on special handling, routing, or the performance of transportation workers. As a result, there has never been a death or injury due to the radioactive nature of DOE's cargo.

DOE's packaging must be capable of surviving a variety of stringent tests. They must be capable of surviving a 30-foot drop onto an unyielding surface, a drop onto a spike, a hot fire, and eight hours in 50 feet of water. Material containing lower levels of radioactivity does not require as much protection, but still must be packaged in high-quality packaging designed to withstand ordinary handling accidents. These packages must be capable of surviving water spray, drop, compression, and penetration tests.

The stringent packaging requirements, combined with strict regulations and procedures governing the shipment of radioactive material, ensure radioactive transport is a safe activity. DOE follows U.S. Department of Transportation (DOT) regulations, including training, placing and securing the cargo, identifying the material on packages and vehicles through labels and placards, providing detailed information and emergency response contacts on shipping papers, maintaining the vehicles, and selecting the best routes. For shipments containing higher levels of radioactive material, the carrier must use an interstate highway system, including beltways around major cities. State and Tribal authorities may designate an alternate route after consulting with other affected States and municipalities and following DOT guidelines for a safety analysis.

Transportation

EM's Transportation Management Program (TMP) develops policies and management procedures to facilitate and coordinate the many elements of DOE transportation, including the shipment of radioactive material and waste. In addition to developing safe guidelines for DOE's packaging, including packaging maintenance and use, TMP conducts other operational activities such as negotiating rates and services, developing carrier selection standards; training DOE and contractor employees and others on regulations and procedures governing radioactive and other hazardous material shipments; and maintaining data systems to enable DOE and other interested parties to retrieve and analyze information on DOE shipments. TMP also appraises DOE field operations to assure they are in compliance with regulations and procedures.

TMP's Research and Development (R&D) Program improves and develops new transportation systems and packaging designs to meet DOE needs. The R&D Program develops and maintains computer programs to assess the risks and consequences of transporting radioactive material, maintains facilities and equipment for testing and modeling package designs, and works with regulatory bodies to achieve a single technical position on transportation regulatory issues.

In addition, TMP supports an Emergency Preparedness Program to coordinate DOE-wide policies and activities for transportation incidents. This Program supports regional emergency response workshops for DOE and State and local public safety personnel. The Emergency Preparedness Program also sponsors a tracking system called TRANSCOM to monitor the movement of specified radioactive material shipments.

TMP's Institutional Program facilitates interactions between DOE and those interested and affected by DOE's transportation activities, and encourages resolution of transportation issues. Productive exchange is reinforced by the development of transportation-specific resources such as telecourses, videos, exhibits, models, and written materials.

These activities support DOE's commitment to protect the health and safety of the public and the environment during its shipment of radioactive and other hazardous material and waste.

Transportation, especially for radioactive material, is highly regulated by Federal, State, and local laws.

Impact-resistant packagings, called casks, provide safety for radioactive material shipped by rail and truck.

Transportation

Radioactive material is shipped in secure packages. Type A packages contain small amounts of radioactive material and are designed to withstand normal conditions of transport.

Type B packaging is designed to contain more hazardous and larger amounts of radioactive waste. It can withstand severe accident conditions and contain radioactive material under any circumstance.

Packaging for large quantities of radioactive material must survive severe accident conditions. These test conditions exceed those conditions expected during actual shipping. In the photograph below, a cask is raised into position for a free-drop test onto a massive unyielding surface.

Transportation

To evaluate the validity of the design and construction of packaging used to carry highly radioactive material, real-life demonstrations were staged. A truck-mounted cask was struck by a locomotive travelling at 80 miles per hour.

As shown on the previous page, the locomotive was destroyed but the cask was only slightly dented. It suffered no loss of structural integrity or shielding and no release of simulated radioactive material occurred.

DOE provides extensive training courses on hazardous material identification, regulations on shipping radioactive material, and emergency response.

Transportation

A system combining the technologies of land-based navigation, satellite communication, computerized database management, user networks, and ground communication, tracks some shipments of radioactive material enroute.

Glossary

Alpha Particle: A positively charged particle emitted by some radioactive materials undergoing radioactive decay. Alpha particles are the least penetrating of the three common forms of radiation (alpha, beta, gamma); they can be stopped by a sheet of paper. Alpha particles cannot penetrate skin, but are harmful if inhaled or ingested.

Atomic Energy Act (AEA): The Act (1954) which placed production and control of nuclear materials within a civilian agency, originally the Atomic Energy Commission.

Beta Particle: An elementary particle emitted from a nucleus during radioactive decay. Beta particles are easily stopped by a thin sheet of metal. Exposure to beta radiation can cause skin burns.

Burial Grounds: Areas designated for near-surface disposal of containers of low-level radioactive waste and obsolete or worn out radioactively contaminated equipment.

Buried Waste: Low-level radioactive waste that has been disposed of by near-surface burial.

Byproducts: Radioactive materials resulting from the production or processing of nuclear materials. Some byproducts have beneficial commercial uses.

Calcining/Calcination: The process of making unconsolidated powder or granules by thermal evaporation and partial decomposition (release of gases) of high-level waste.

Canister: A container for radioactive solid waste forms, especially high-level liquid waste.

Cask: A thick-walled container that provides shielding during the transportation of canisters of highly radioactive materials.

Characterization: Facility or site sampling, monitoring, and analysis activities to determine the extent and nature of the release. Characterization provides the basis for acquiring the necessary technical information to develop, screen, analyze, and select appropriate cleanup techniques.

Clean Air Act (CAA): The purpose of this Act is to "protect and enhance the quality of the Nation's air resources." Its primary application is through permits to regulate new and existing facilities. Of increasing importance are the National Emissions Standards for Hazardous Air Pollutants (NESHAPs). The CAA was passed in 1970 and was amended in 1977 and 1990.

Cleanup: Actions taken to deal with a release or threat of release of a hazardous substance that could affect humans and/or the environment. The term "cleanup" is sometimes used interchangeably with the terms remedial action, removal action, response action, or corrective action.

Clean Water Act of 1977 (CWA): Amended the Federal Water Pollution Control Act passed in 1956. Its objective is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Act's major enforcement tool is the National Pollutant Discharge Elimination System (NPDES) permit.

Compliance Agreements: Legally binding agreements between regulators and regulated entities that set standards and schedules for compliance with environmental statutes. Includes Consent Order Compliance Agreements, Federal Facilities Agreements, and Federal Facilities Compliance Agreements.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): Federal statute (also known as Superfund) enacted in 1980 and reauthorized in 1986, that provides the statutory authority for cleanup of hazardous substances that could endanger public health, welfare, or the environment. Program activities include establishing the National Priorities List, investigating sites for inclusion on the list, determining their priority level on the list, and conducting, and/or supervising the ultimately determined cleanup and other remedial actions.

Contact-handled: Waste containers that can be handled without shielding. (See Transuranic Waste.)

Contamination: The presence of unwanted radioactive matter, or the "soiling" of objects or materials with "radioactive dirt."

Decay: The spontaneous radioactive transformation of one nuclide into a different nuclide or into a lower energy state of the same nuclide.

Decommissioning: The process of removing a facility from operation, followed by decontamination, and then entombment, dismantlement, or conversion to another use.

Decontamination: The removal of unwanted material (especially radioactive material) from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

Dismantlement: The removal of radioactive and nonradioactive contaminated equipment and materials from a facility to reduce the potential hazard to humans and to meet regulations.

Disposal: Final placement or destruction of toxic, radioactive, or other waste, surplus or banned pesticides or other chemicals, polluted soils, and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface impoundments, land farming, deep well injection, ocean dumping, or incineration.

DOE Orders: Internal requirements which establish DOE policy and procedures for compliance with applicable laws and regulations.

DOE Waste: Radioactive waste from any activity performed in whole or in part in support of DOE atomic energy defense activities; excludes waste under purview of the Nuclear Regulatory Commission (NRC) or generated by the commercial nuclear power industry.

Engineered Barriers: Features of a disposal site constructed of materials designed to isolate radioactive materials from the environment.

Enrichment: A process by which the natural ratios of the isotopes of a given element are altered.

Entombment: The process of sealing or burying radioactively contaminated materials to prevent dispersal or intrusion.

Environmental Assessment: A written environmental analysis which is prepared pursuant to the National Environmental Policy Act (NEPA) to determine whether a federal action would significantly affect the environment and thus require preparation of a more detailed environmental impact statement.

Environmental Impact Statement: A document required of Federal Agencies by the National Environmental Policy Act (NEPA) for major projects or legislative proposals significantly affecting the environment. A tool for decision making, it describes the positive and negative effects of the undertaking and lists alternative actions. The report 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 hazardous substances during past production activities.

Feasibility Study: Analysis of the practicability of a proposal; e.g., a description and analysis of the potential cleanup alternatives for a site on the National Priorities List. The feasibility study usually recommends selection of a cost-effective alternative. It usually starts as soon as the remedial investigation is underway; together, they are commonly referred to as the "RI/FS." The term can apply to a variety of proposed corrective or regulatory actions.

Feed Materials: Refined uranium or thorium metal or their pure components in a form suitable for use in nuclear reactor fuel elements or as feed to uranium enrichment facilities.

Formerly Utilized Sites Remedial Action Program (FUSRAP): A program under the direction of the Office of Environmental Restoration and Waste Management that addresses the cleanup of sites and adjacent properties contaminated by activities of the Manhattan Project.

Fuel: Fissionable material used as a source of power when placed in a critical arrangement in a nuclear reactor.

Fuel Cycle: The series of steps involved in supplying fuel for nuclear power reactors. It includes original fabrication of fuel elements, their use in a reactor, chemical processing to recover the fissionable material remaining in the spent fuel, re-enrichment of the recovered fissionable material, refabrication into new fuel elements, transportation of materials, and disposal of waste products.

Fuel Element: A tube, rod, or other form into which fuel material is fabricated for use in a reactor.

Fuel Fabrication: The process through which fissionable metal is configured into precisely shaped fuel or target elements and clad, ready for use in a production reactor.

Fuel Reprocessing Plant: A chemical plant where irradiated fuel elements are processed to separate fission products from uranium and plutonium.

Gamma Ray: High energy, short wavelength, electromagnetic radiation emitted by a nucleus. Gamma rays are very penetrating and are best blocked by dense materials like lead and depleted uranium.

Gaseous Diffusion: A technology for separating fissionable uranium-235 isotopes from the more abundant nonfissionable uranium isotopes by pumping gaseous uranium hexafluoride through resistant barriers.

Geological Repository: A mined facility for disposal of radioactive waste that uses natural geologic barriers to provide waste containment over geological time scales.

Groundwater: Water that exists or flows in a zone of saturation beneath land surface. Liquid occurring beneath the earth's surface, in the interstices between soil grains, in fractures, or in porous formations.

Groundwater Remediation: Treatment of groundwater to remove pollutants.

Grout: A cement-like substance used to solidify and immobilize liquid radioactive waste for disposal or to stabilize disposal trenches.

Half-Life: Time required for a radioactive substance to lose 50 percent of its activity by decay. After a period equal to 10 half-lives, the radioactivity has decreased to about 0.1 percent of its original value.

Hazardous Waste: As defined in the 1976 Resource Conservation and Recovery Act (RCRA), a solid waste, or combination of solid waste, that because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

High-Level Waste: The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations high enough to require permanent isolation. It also includes other highly radioactive material that the Nuclear Regulatory Commission (NRC), consistent with existing law, determines to require permanent isolation.

Inactive Waste Site: Site formerly used for the treatment, storage, or disposal of waste.

Incineration: A treatment technology using combustion to destroy organic constituents and reduce the volumes of waste, e.g. burning sludge to remove the water and reduce the remaining residues to a safe, non-burnable ash which can be disposed of safely on land, in some waters, or in underground locations.

Irradiation: Exposure to radiation of wavelengths shorter than those of visible light (gamma, x-ray, or ultraviolet). For medical purposes, the destruction of bacteria in milk or other foodstuffs, or for inducing polymerization of monomers or vulcanization of rubber.

Isolation: The placement of radioactive waste so that contact between the waste and humans or the environment will be highly unlikely for a chosen period of time.

Isotope: Atoms with the same atomic number (same chemical element) but different atomic weights. In other words, the nuclei have the same number of protons, but a different number of neutrons.

Land Disposal Restrictions (LDR's): Provisions of the Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) that apply to hazardous waste placed in storage or disposal after November 7, 1986. They prohibit the placement in or on the land of listed or characteristic hazardous waste that does not meet specified standards.

Landfills: Sanitary landfills are land disposal sites for non-hazardous solid waste. The waste is spread in layers, compacted to the smallest practical volume, and cover material applied at the end of each operation day. Secure chemical landfills are disposal sites for hazardous waste. They are selected and designed to minimize the chance of release of hazardous substances into the environment.

Low-Level Waste: Radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproducts material.

Mixed Waste: Contains both radioactive and hazardous components, as defined by the Atomic Energy Act (AEA) and the Resource Conservation and Recovery Act (RCRA).

Monitoring: Periodic or continuous measuring of the quantity and type of discharges or migration of radioactive waste from a management facility to determine the level of compliance with statutory requirements and/or pollutant levels in various media.

National Emission Standards for Hazardous Air Pollutants (NESHAPs): Clean Air Act (CAA) limits for release of hazardous pollutants for which no ambient air quality standard is applicable. Under the March 7, 1989 proposed ruling, NESHAPS will also address radioactive releases to the air.

National Environmental Policy Act (NEPA) of 1969: The Act which established the requirements for conducting environmental reviews of Federal actions that have the potential for significant impact on the human environment.

National Pollutant Discharge Elimination System (NPDES): A provision of the Federal Water Pollutants Control Act (a.k.a. Clean Water Act) which prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the Environmental Protection Agency (EPA), a State, or (where delegated) a Tribal Government on an Indian reservation.

National Priorities List (NPL): The Environmental Protection Agency's (EPA's) list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. A site must be on the NPL to receive money from the Trust Fund for remedial action. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the NPL at least once a year.

Nuclear Fuel Cycle: The complete series of steps involved in supplying fuel for nuclear reactors. It includes mining, refining, enrichment, fabrication of fuel elements, use in a reactor, chemical processing to recover the fissionable material remaining in the spent fuel, re-enrichment of the fuel material, refabrication of fuel elements, and management of radioactive waste.

Nuclear Radiation: Particulate and electromagnetic radiation emitted from nuclei.

Nuclear Reactor: An assembly of nuclear fuel capable of starting and sustaining a controlled chain reaction based on nuclear fission.

Nuclear Waste: A term usually used interchangeably with radioactive waste.

Nuclear Waste Fund: A fund established by the Nuclear Waste Policy Act (NWPA) of 1982 which directed DOE to pursue a program toward disposal of commercial high-level and transuranic waste in a geologic repository. The nuclear waste fund assesses utilities a fee to pay for siting, development, and operation of a commercial repository. The share of the costs commensurate with the portion of the repository committed for disposal of defense waste will be paid by DOE.

Nuclear Waste Policy Act: An Act passed in 1982 and reauthorized in 1987 that directs DOE to design, site, and construct a geologic repository for the disposal of high-level radioactive waste and/or spent fuel from civilian nuclear reactors.

Nucleus: The small positively charged core of an atom, which contains nearly all of the atom's mass.

Nuclide: Any species of atom that exists for a measurable length of time. A radionuclide is a radioactive nuclide.

Off-Site Facility: A hazardous waste treatment, storage, or disposal area that is located at a place away from the generating site.

On-Site Facility: A hazardous waste treatment, storage, or disposal area that is located on the generating site.

Permit: An authorization, license, or equivalent control document issued by the Environmental Protection Agency (EPA) or an approved State agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.

Plutonium: A radioactive element with an atomic number of 94. Its most important isotope is fissionable plutonium-239, produced by neutron irradiation of uranium-238.

Preliminary Assessment: The process of collecting and reviewing available information about a known or suspected waste site or release.

Production Reactor: A reactor designed primarily for large-scale production of tritium or plutonium by neutron irradiation of uranium-238. The term also refers to a reactor used primarily for the production of isotopes.

Quality Assurance/Quality Control: A system of procedures, checks, audits, and corrective actions to ensure that all research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

Radiation: The propagation of energy through matter or space in the form of waves, rays, or streams of energetic particles. The term is frequently used in relation to the emission of rays from the nucleus of an atom. In nuclear physics, the term has been extended to include fast-moving particles e.g., alpha and beta rays, etc.

Radioactive Decay: The spontaneous decay or disintegration of an unstable atomic nucleus, accompanied by the emission of radiation.

Radioactive Waste: A solid, liquid, or gaseous material of negligible economic value that contains radionuclides in excess of threshold quantities. Does not include material contaminated by radionuclides from nuclear weapons testing.

Radioactivity: The rate at which radioactive material is emitting radiation, given in terms of the number of nuclear disintegrations occurring in a suitably small unit of time. The common unit of radioactivity is the curie (Ci), which is 3.7×10^{10} disintegrations per second.

Radioisotope: A radioactive isotope of a chemical element.

Remedial Action Project: A group of activities initiated to access a DOE facility or radioactive waste site that may require restoration to achieve acceptable radiation levels.

Remedial Investigation (RI): The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process of determining the extent of hazardous substance contamination, and as appropriate, conducting treatability investigations. The in-depth study is designed to gather the data necessary to determine the nature and extent of contamination at a CERCLA site; establish criteria for cleaning up the site; identify preliminary alternatives for remedial action; and support the technical and cost analyses of the alternatives. The remedial investigation is usually done with the feasibility study. Together they are usually referred to as the "RI/FS."

Remote-handled: Refers to waste with such a high level of radioactivity that containers holding it cannot be handled directly. See Transuranic Waste.

Removal Action: Short-term immediate actions taken to address releases of hazardous substances that require expedited response. See cleanup.

Repository (Federal): A Federally owned and operated engineered facility for storage or disposal of specific types of waste from DOE sites and/or licenses.

Reprocessing: The chemical/mechanical processing of reactor fuel to recover the fission products and the unused fissionable material.

Resource Conservation and Recovery Act (RCRA): RCRA, an amendment to the Solid Waste Disposal Act (SWDA), was passed in 1976 to address the problem of how to safely dispose of municipal and industrial solid waste generated nationwide. It established a national policy: to reduce or eliminate hazardous waste and conduct treatment, storage, or disposal to minimize its threat. RCRA was amended by the Hazardous and Solid Waste Amendments (HSWA) in 1984 to expand RCRA's scope and add detailed requirements.

Restoration: Measures taken to return a site to pre-violation conditions.

Retrievability: Capability to remove waste from its place in storage.

Risk Assessment: The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific pollutants.

Safe Drinking Water Act: Protects drinking water supplies. The maximum contaminant levels developed under this Act are used in groundwater monitoring programs.

Sanitary Waste: Waste, such as garbage, that is generated by normal housekeeping activities and is not hazardous or radioactive. This waste is disposed of in sanitary landfills. Sanitary waste also includes liquid effluents which are treated in sewage treatment plants.

Shallow Land Burial: Disposal of waste in shallow trenches; commonly used for low-level radioactive waste.

Shielding: A material interposed between a source of radiation and personnel for protection against the danger of radiation.

Shipping Cask: A specially designed container used for transporting nuclear materials.

Site Inspection: The collection of information from a Superfund (CERCLA) site to determine the extent and severity of hazards posed by the site. It follows a preliminary assessment and is more extensive. The purpose is to gather information necessary to score the site, using the Hazard Ranking System, and to determine if the site presents an immediate threat that requires prompt removal action.

Site: For the purposes of this booklet, sites are lands, installations, and/or facilities for which DOE has or shares responsibility for environmental restoration and waste management activities.

Sludge: Slushy matter or sediment such as that precipitated by the treatment of waste.

Solid Waste: Non-liquid, non-soluble material ranging from municipal garbage to industrial waste that contains complex, and sometimes hazardous, substances. Solid waste also includes sewage sludge, agricultural refuse, demolition wastes, and residues. Technically, solid waste also refers to liquids and gases in containers.

Spent Nuclear Fuel: Nuclear reactor fuel that has been irradiated to the extent that it can no longer effectively sustain a chain reaction. Fuel becomes spent when its fissionable isotopes have been partially consumed and fission-product poisons have accumulated in it.

Stabilization: Conversion of the active organic matter in sludge into inert, harmless material.

Standards: Prescriptive norms which govern action and actual limits on the amount of pollutants or emissions produced. The Environmental Protection Agency (EPA), under most of its responsibilities, establishes minimum standards. States are allowed to be stricter.

Storage: Retention and monitoring of waste in a retrievable manner pending final disposal.

Superfund Amendments and Reauthorization Act (SARA): The 1986 Act reauthorizing and amending the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Surplus Facility: Any facility or site (including equipment) that has no identified programmatic use and may or may not be radioactively contaminated to levels that require controlled access.

Toxic Substances Control Act (TCSA): TSCA was enacted in 1976 to protect human health and the environment from unreasonable risk due to exposure to, manufacture, distribution, use, or disposal of substances containing toxic chemicals. Under TSCA, any hazardous waste that contains more than 50 parts per million of polychlorinated biphenyls are subject to regulations under this Act.

Transuranic Elements: Elements with an atomic number greater than 92, including, among others, neptunium, plutonium, americium, and curium.

Transuranic (TRU) Waste: Waste that is contaminated with alpha-emitting transuranium nuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram of waste. Contact-handled (CH) TRU waste does not require shielding and has a surface dose rate of less than 200 millirem (mrem) per hour. Remote-handled (RH) TRU waste has a surface dose rate greater than 200 mrem per hour and requires additional shielding because it presents an exposure hazard. The dose rates at the surface of RH-TRU waste packages fall within the 200 mrem to 1,000 rem per hour range.

Treatment: Any activity that alters the chemical or physical nature of radioactive or hazardous waste to reduce toxicity, volume, mobility, or render it amenable for transport, storage or disposal.

Underground Storage Tank (UST): Any tank or associated piping containing hazardous materials as defined by the Hazardous and Solid Waste Amendments Act (Subtitle C or Subtitle I).

Uranium: A naturally occurring radioactive heavy metal element with the atomic number of 92 and an atomic weight of approximately 238. The two principal isotopes are the fissionable uranium-235 (0.7 percent of natural uranium) and the fertile uranium 238 (99.3 percent of natural uranium).

Uranium Mill Tailings: Naturally radioactive rock and soil that are the byproducts of uranium mining and milling. Tailings may also contain other minerals or metals not extracted in the process of mining uranium from ore.

Uranium Mill Tailings Radiation Control Act of 1978: This Act directed DOE to provide for stabilization and control of the uranium mill tailings from inactive sites in a safe and environmentally sound manner to minimize radiation health hazards to the public. It authorizes DOE to undertake remedial actions at 24 designated inactive uranium processing sites and at an estimated 5,048 vicinity properties. The Uranium Mill Tailings Remedial Action (UMTRA) Project accomplishes this cleanup.

Vitrification: The process of immobilizing waste that produces a glass-like solid that permanently captures the radioactive materials.

Vitrify: To form into a glass-like material by heating and melting and cooling.

Waste Immobilization: The process of converting waste to a stable, solid form that encases the radionuclides to prevent or slow their migration to the biosphere.

Waste Isolation Pilot Plant (WIPP): Research and demonstration facility located at Carlsbad, New Mexico, intended to demonstrate safe disposal of radioactive waste in a deep geologic environment. A decision on whether to convert WIPP to a disposal facility for transuranic waste will be made after successful testing is demonstrated.

Waste Minimization: The reduction, to the extent feasible, of hazardous waste that is generated before treatment, storage, or disposal of the waste. Waste minimization includes any source reduction or recycling activity that results in either: 1) reduction of total volume of hazardous waste; 2) reduction of toxicity of hazardous waste; or 3) both.

Waste Stream: Terminology used to refer to waste leaving a facility or operation.

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