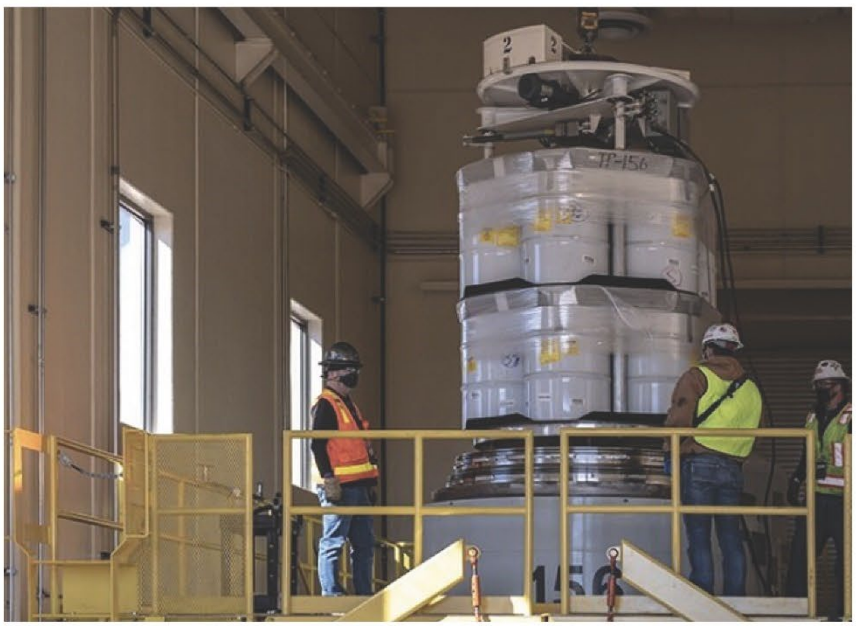
U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

EM Program Plan 2022



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Message from the Senior Advisor for the Office of Environmental Management

EM started 2022 with the release of the EM Strategic Vision: 2022-2032, which provides a concise high-level summary of EM's priorities and the progress we anticipate over the decade ahead. The *EM Program Plan 2022* (EMPP) builds on that Vision, bringing EM's long-term cleanup strategy into greater focus while exploring opportunities to complete the overall mission safely and effectively.

EM is responsible for the largest environmental remediation effort in the world. Over 80 years ago, the Manhattan Project ushered in the development of nuclear weapons and government-sponsored nuclear energy research, resulting in a significant environmental legacy at sites across the country. Established in 1989, EM continues to protect communities as we fulfill our responsibility to safely address contamination and deliver on environmental justice goals. While we are extremely proud of completing 92 of the original 107 cleanup sites, EM must build upon the momentum and experience gained from cleaning up and closing these sites.

Today, the cleanup mission is approaching a crossroads. The EMPP lays out EM's long-term path forward, identifying not only the activities to be completed, but also the process to identify opportunities for acceleration, and make the decisions needed to accomplish our mission in a reasonable period of time and at a cost taxpayers can afford. We will issue future updates to the EMPP to reflect program progress and stakeholder feedback. As you read this document, I hope you will appreciate the tremendous progress we've made and are encouraged by the opportunities that lie ahead.

I am proud of what our team has achieved since we issued our first Vision in 2020. EM has made great strides in working collaboratively and creatively with our stakeholders, in implementing new processes and leveraging new approaches to advance our mission. From a step change in our capability to tackle tank waste through constructing key facilities, to awarding new contracts that enable accelerated progress, we are preparing for the approaching crossroads.

These remarkable accomplishments are due in large part to the dedication and resilience of EM's greatest asset — the individuals who comprise EM's workforce. They are also the result of our strong partnerships with regulators, Tribal Nations, local communities, Congress, and state and local governments.

I encourage our partners across the complex to join us in a discussion on the strategy in the EMPP. I see this plan as another tool that will enable EM to "clear the decks" and focus on the sustained cleanup progress and goals we have defined in the Vision. I look forward to our discussions, and hope you find this plan useful.

William "Ike" White
Senior Advisor for the
Office of Environmental Management

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Executive Summary

Over the last several decades, the Department of Energy (DOE) Office of Environmental Management (EM) has made significant progress in cleaning up the environmental legacy resulting from decades of nuclear weapons development and government sponsored nuclear energy research. This cleanup includes remediation of contaminated soils and groundwater, treatment and disposition of toxic and radioactive wastes, and stabilization and removal of contaminated facilities left over from the Cold War. Contamination areas that once threatened the environment have been contained and remediated through early actions and institutional controls. EM continues to reduce risk through environmental cleanup at the remaining sites - 15 locations in 11 states – California, Idaho, Kentucky, Nevada, New Mexico, New York, Ohio, South Carolina, Tennessee, Utah, and Washington (See Figure ES-1).

EM cleanup has mitigated many of the most urgent hazards and risks through disposition of:

- 5,089 metric tons of plutonium
- 107,828 metric tons of plutonium and uranium residues
- 7.755 million gallons of radioactive liquid tank waste
- 2,132 metric tons of heavy metal of spent nuclear fuel (SNF)
- 108,488 cubic meters of transuranic (TRU) waste
- 758 nuclear and radiological facilities

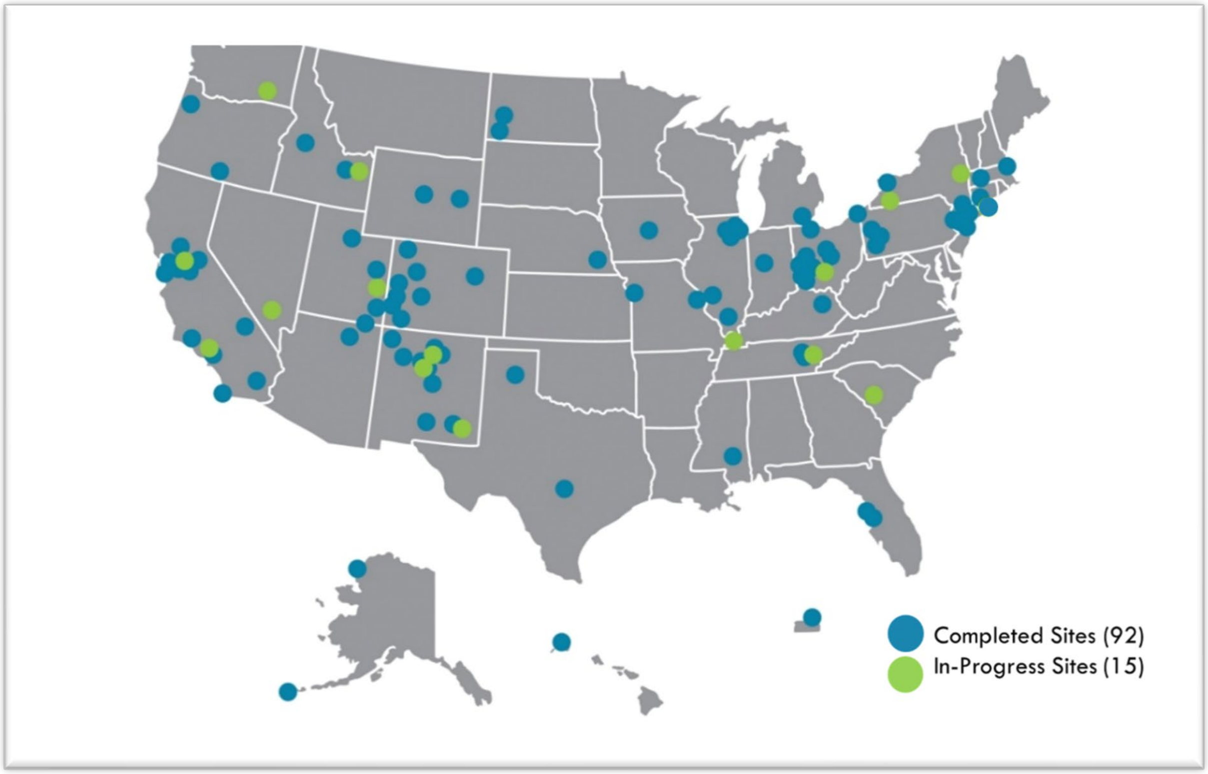
This document builds upon the *EM Strategic Vision: 2022-2032*, which provides a concise high-level summary of the cleanup progress EM anticipates over the coming decade. The purpose of this *EM Program Plan 2022* is to describe the scope of the remaining cleanup work and the strategies for completing the cleanup mission, summarize key opportunities to complete cleanup work earlier to reduce risk, and provide a framework for charting EM's path forward to complete the mission. This document also describes EM's process for identifying and evaluating acceleration opportunities and the corresponding decisions required to implement them.

EM Cleanup
Significant Accomplishments

Completed 92 of 107 sites, including:

- ✓ Rocky Flats, now a wildlife preserve
- ✓ Weldon Spring, now a trailhead
- ✓ Mound, now a business park
- ✓ Fernald, now a nature preserve
- ✓ Brookhaven National Laboratory
- ✓ East Tennessee Technology Park Gaseous Diffusion Plant

Figure ES-1. Map of Original and Remaining EM Cleanup



The strategy for realizing the EM vision and completing the world's largest environmental cleanup project is:

- Ensure the safety and health of the public and EM's workforce while continuing to protect the environment;
- Comply with applicable federal and state environmental laws and regulations to meet commitments as specified in site-specific regulatory compliance documents, including federal facility agreements and consent decrees;
- Continue to explore opportunities to reduce cleanup costs while balancing important considerations, including community and Tribal concerns, the need to sustain a skilled and trained workforce, and best business practices; and
- Support efficient implementation, interdependencies within and between sites, maintenance of infrastructure systems, and the needs of partnering Departmental programs and communities for land and/or facilities.

A core component of EM's strategy is the risk-based cleanup prioritization approach described in the *EM Program Management Protocol*. Employed since EM's inception, this approach assigns the highest priority to mitigating hazards posing an immediate risk to human health or the environment, and then prioritizes cleanup that achieves the highest risk reduction benefit, within the framework of regulatory compliance commitments and best practices.

EM Major Mission Areas

- Tank Waste
- Spent Nuclear Fuel (SNF)
- Nuclear Materials (NM)
- TRU Waste
- Depleted Uranium (DU)
- Low-Level Waste (LLW)/Mixed Low-Level Waste (MLLW)/Other Waste
- Soils & Groundwater (S&GW)
- Excess Facilities D&D

EM manages its work by mission area and site. The most complex and costly mission area is the treatment and disposition of tank waste and the permanent closure of tanks, primarily at the Hanford Site and the Savannah River Site. The deactivation and decommissioning (D&D) of excess facilities, represents the second greatest portion of EM's remaining cost with the other mission areas, and federal support/oversight, making up the remainder. The work at six of the sites is planned to be completed in the next 15 years. Upon completion of EM's scope, sites (or portions of sites) may be transitioned to another DOE program office, the Office of Legacy Management (LM), or the local community.

Managing EM's cleanup mission requires long-term strategic planning of complex, large-scale projects with varying degrees of uncertainty due to the length of time required for cleanup, regulatory decisions still to be made, and unforeseen events. Planning is supported by continuous evaluation of the status quo against viable alternatives to streamline and accelerate cleanup, lower costs, reduce risk to human health and the environment, and benefit from the development of new, innovative cleanup technologies.

The end of the document contains a summary roadmap highlighting the decisions and associated timelines with potential to significantly reduce costs and accelerate schedules. Appendix A provides additional information for each of the remaining sites, including their cleanup strategies, remaining decisions, and milestones.

EM committed to achieving maximum risk reduction and lower cleanup costs by pursuing the strategies and opportunities described in this plan. This will be accomplished by working with local communities, Tribal Nations, regulators, and other stakeholders to evaluate these opportunities to safely complete the EM mission as quickly and as effectively as possible.

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Acronyms

ABD	Accelerated Basin De-inventory
AEA	*Atomic Energy Act of 1954*
AoA	analysis of alternatives
AOC	Area of Concern
BNL	Brookhaven National Laboratory
BPP	bismuth phosphate process
CBFO	Carlsbad Field Office
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CH-TRU	contract-handled TRU
CPP	Chemical Processing Plant
CRESP	Consortium for Risk Evaluation with Stakeholder Participation
Cs	cesium
D&D	deactivation and decommissioning
DD&R	deactivation, decommissioning & removal
DFLAW	Direct Feed Low Activity Waste
DOE	U.S. Department of Energy
DU	depleted uranium
DUF6	depleted uranium hexafluoride
DWPF	Defense Waste Processing Facility
EM	DOE Office of Environmental Management
EM-LA	EM Los Alamos Field Office
EM-NV	DOE Environmental Management Nevada
EMAB	Environmental Management Advisory Board
EMAD	Engine Maintenance Assembly and Disassembly
EMDF	Environmental Management Disposal Facility
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety and Health
ETEC	Energy Technology Engineering Center
ETTP	East Tennessee Technology Park
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	fiscal year
GAO	U.S. Government Accountability Office
GTCC	Greater-than-Class-C
GW	groundwater
HEPA	high-efficiency particulate air
HIP	hot isostatic pressing
HLW	high-level waste
ICP	Idaho Cleanup Project
INL	Idaho National Laboratory
IWTU	Integrated Waste Treatment Unit
IX	ion exchange
LANL	Los Alamos National Laboratory
LAW	low activity waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
LM	DOE Office of Legacy Management
LTS	long-term stewardship
LTSM	long-term surveillance and maintenance
LWA	*Waste Isolation Pilot Plant Land Withdrawal Act of 1992*
MDA	material disposal area
MLLW	mixed low-level waste
MPPB	Main Plant Process Building
MTHM	metric tons heavy metal
NEPA	*National Environmental Policy Act of 1969*
NM	nuclear materials
NMED	New Mexico Environment Department
NNSA	National Nuclear Security Administration
PT	Pretreatment
R&D	research and development
RCRA	*Resource Conservation and Recovery Act of 1976*
RDX	Royal Demolition Explosives
RH-TRU	remote-handled transuranic
RL	Hanford's Richland Operations Office

ROD	record of decision
ROM	rough order of magnitude
S&GW	soils & groundwater
SBW	sodium-bearing waste
SC	DOE Office of Science
SNF	spent nuclear fuel
SNL	Sandia National Laboratories
SPRU	Separations Process Research Unit
NNSS	Nevada National Security Site
NR	DOE Office of Naval Reactors
NRC	Nuclear Regulatory Commission
NTP	National TRU Program
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
ORP	Hanford's Office of River Protection
ORR	Oak Ridge Reservation
OSWDF	On-site Waste Disposal Facility
Sr	strontium
SRS	Savannah River Site
SST	single-shell tank
SWPF	Salt Waste Processing Facility
TBD	to be determined
TCC	Test Cell C
TD	Technology Development
TRU	transuranic
U-233	uranium-233
U-235	uranium-235
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	*Uranium Mill Tailings Radiation Control Act of 1978*
WIPP	Waste Isolation Pilot Plant
WNYNSC	Western New York Nuclear Service Center
WTP	Waste Treatment & Immobilization Plant
WVDP	West Valley Demonstration Project

I. Purpose

The Department of Energy (DOE) Office of Environmental Management (EM) is approaching a crossroads of its cleanup mission. Thirty years of mitigating the most pressing risks resulting from decades of nuclear weapons development and government-sponsored nuclear research now give way to the remaining work that involves some of the greatest challenges. The plan for this remaining work, particularly tank waste cleanup, extends decades into the future. EM must build upon the momentum, lessons learned, and experience gained from cleaning up and closing 92 of 107 sites. EM must also seek innovative approaches to complete the remaining sites more expeditiously than currently planned while continuing to protect the health of workers, communities, and the environment. Continued collaboration with local communities, Tribal Nations, regulators, and other stakeholders is a crucial component of successfully meeting this challenge.

EM's mission is to complete the safe cleanup of the environmental legacy resulting from decades of nuclear weapons development and government-sponsored nuclear energy research.

Construction at the Hanford Waste Treatment and Immobilization Plant lit up at night

This EM Program Plan summarizes accomplishments of the first 30 years and describes the remaining cleanup required to achieve mission completion. Building upon the *EM Strategic Vision: 2022-2032*, this document describes the strategies and plans for completing the remaining cleanup work, identifies opportunities to better meet challenge, and outlines the decision roadmap EM will use as a guide over the next two decades.

EM Strategic Vision

EM's Strategic Vision is to continue making sustained, significant cleanup progress towards achieving its mission. Each year, EM articulates its vision for the next decade in the *EM Strategic Vision*. The most recent *EM Strategic Vision: 2022-2032* provides a high-level summary of the progress EM achieved in 2021 and the progress EM anticipates over the coming decade, based on current assumptions for the remaining sites. The vision includes completing legacy cleanup activities at four of the remaining sites (Moab, Nevada National Security Site, Sandia National Laboratories, and Lawrence Livermore National Laboratory), as well as significant accomplishments in each of EM's mission areas.

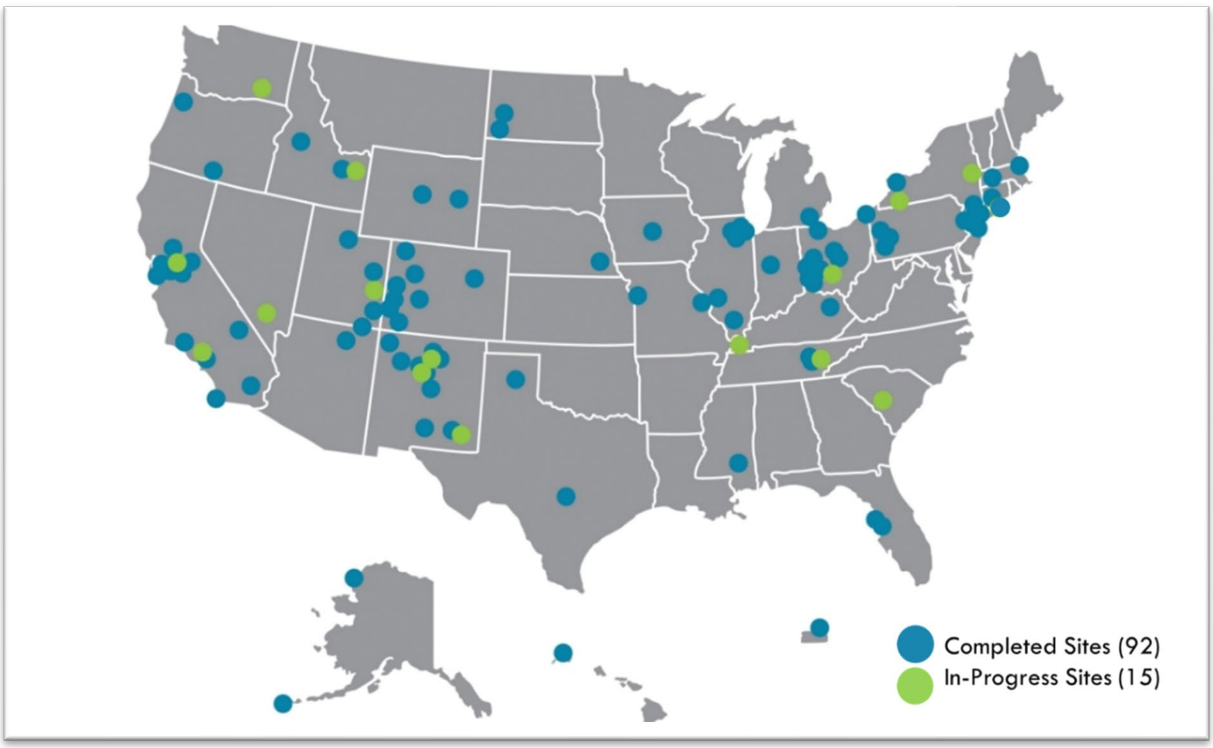
The remainder of this document is presented in the following sections:

- Section II, EM Program History and Accomplishments, provides an overview of completed cleanup activities.
- Section III, EM's Program Strategy, describes EM's overall strategy and enabling functions.
- Section IV, Remaining Cleanup Scope, presents EM's strategy and timelines for completing cleanup for each mission area.
- Section V, EM Program Sites, summarizes cleanup scope and major activities by site.
- Section VI, Remaining Cleanup Cost and End Dates, presents cost and schedule estimates for completing cleanup at each site.
- Section VII, Current Plans and Opportunities, presents current plans and mission elements with the greatest opportunities to reduce overall risks, schedules, and costs.
- Section VIII, Roadmap to Mission Completion, identifies key decisions pending over the next two decades and the collaborative framework EM will use to make them.
- Section IX, Conclusion, summarizes the key next steps to implement the plan described in this document.

II. EM Program History and Accomplishments

The EM cleanup program is the largest environmental remediation effort in the world. More than fifty years of nuclear weapons production and research generated millions of gallons of liquid radioactive waste, millions of cubic meters of solid radioactive wastes, thousands of metric tons of spent nuclear fuel (SNF) and nuclear material (NM), thousands of contaminated facilities, and huge quantities of contaminated soil and water at 107 sites throughout the United States, as shown in Figure 1.

Figure 1. Map of Original and Remaining EM Cleanup Sites



Completed Sites

Commercial Properties/ Laboratories	10	Test Sites	5
DOE Laboratories	14	Uranium Mill Tailings Remedial Action (UMTRA)/Mill Tailings	26
Former Reactor Sites	3	Uranium Processing Sites	2
Former Utilized Sites Remedial Action Program (FUSRAP)	26	Weapons Manufacturing Sites	6

Total Completed Sites: 92

Completed Sites

Since inception, the EM program has focused on mitigating or eliminating risk to the public, workers, and environment at DOE sites, and to achieve compliance with applicable environmental, safety, and health requirements. At the beginning of the EM program, a great deal of effort was placed on containing and understanding the extent and type of contamination at each site. EM quickly identified imminent risks at multiple locations **with the number one priority for the program being to reduce and/or eliminate those risks.**

With basic technologies readily available, efforts to contain or remediate groundwater plumes began early in the program. These efforts were aimed at addressing risks of contamination migrating to drinking water resources on and off site. Additionally, to eliminate hazards or possible spread of contamination, stored wastes were prioritized for processing, packaging, and disposal, as needed. Contaminated soils and other exposed contamination at risk of spreading also were targeted for early action.

The table at the bottom of Figure 1 provides a breakout of the types of sites where cleanup has been completed. These 92 sites have been returned to their owner for future use or transitioned for long-term surveillance and maintenance (LTSM). Among the first sites completed were inactive uranium milling sites, known then as Uranium Mill Tailings Remedial Action (UMTRA) sites; early nuclear test sites and test reactors; and commercial laboratories or commercial fabricators contaminated as a result of weapons material research. Mill tailings from the UMTRA sites were disposed of in either on-site or near-site disposal cells. EM completed targeted cleanup at multi-DOE-program laboratories and weapons production sites. This eliminated process-contaminated facilities and soil and groundwater contamination and these sites were then returned to other DOE organizations for maintenance and/or redevelopment. In 1997, Congress transferred the Former Utilized Sites Remedial Action Program (FUSRAP) locations to the United States Army Corps of Engineers for remediation.

Extensive cleanup was needed at sites such as the Rocky Flats weapons production site, the Weldon Springs and Fernald uranium processing sites, and the Mound nuclear weapons research site. These sites were prioritized because they were near populated areas, had significant maintenance and operating costs, and/or were close to sensitive environments. Once cleaned up, these sites were closed and turned over to DOE Office of Legacy Management (LM) for LTSM. Rocky Flats was a particularly attractive cleanup investment because of the high safeguards and security cost associated with housing much of the nation's excess plutonium. Consolidation of that plutonium at the Savannah River Site (SRS) allowed those unstabilized plutonium materials to be safely stored and the substantial Rocky Flats facility maintenance and security cost to be eliminated.

Completion of Cleanup at Three of EM's Sites

Rocky Flats, Colorado

DOE faced one of the most significant and challenging nuclear weapons plant cleanups. Extensive contamination, including plutonium, beryllium, and other hazardous substances resulted from the production of nuclear weapon trigger mechanisms from 1952 to 1994. Using significant technology development and innovative solutions, EM completed cleanup in 2005, decades ahead of schedule, saving approximately $29 billion. The portion of the site that served as the security buffer zone was transferred to the U.S. Department of the Interior and is now the Rocky Flats National Wildlife Refuge. DOE conducts ongoing LTSM for the central portion of the site (about 1,300 acres).

Fernald, Ohio

One of the largest environmental cleanups in U.S. history at the time, cleanup of this former uranium processing facility was completed in 2006, 12 years ahead of the original estimated completion date, saving more than $8 billion. In awarding Fernald cleanup, the 2007 Project of the Year, the Project Management Institute cited superior project management and project controls. An innovative privatization initiative was used to remediate contaminated waste, soils, and sludges. The community was involved early and often throughout the cleanup. Now known as the Fernald Preserve, DOE conducts LTSM and provides public access to learn the site's history and to hike trails through the wetland, prairie, and forest landscape.

Mound, Ohio

The Mound site operated from 1948 to 2003, working on polonium-beryllium initiators used in early atomic weapons, and eventually expanded into an integrated research, development, and production facility supporting weapons, energy, and space missions. EM used a creative approach for remediation, dividing the site into discrete land parcels, remediating them to an industrial/commercial use end state, and then transferring them for private use. The Mound Development Corporation has accepted approximately 94 percent of the 305-acre former Mound site, DOE retains ownership of the remaining six percent and conducts LTSM on that portion.

Remaining Sites

The sites not yet completed are those that have the most extensive cleanup involving: 1) tank waste and SNF – Hanford, SRS, and Idaho National Laboratory (INL), where first-of-a-kind tank waste processing facilities have taken decades to construct; and 2) sites where very large deactivation and decommissioning (D&D) activities remain – Portsmouth, Paducah, and Oak Ridge Reservation (ORR). In addition, there are several National Nuclear Security Administration (NNSA) sites with remaining D&D and environmental cleanup scopes: Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), Nevada National Security Site (NNSS), and Separations Process Research Unit (SPRU). Another set of sites have been legislatively identified for EM attention: the West Valley Demonstration Project (WVDP), a commercial reprocessing site; the Moab Uranium Mill Tailings Remedial Action Project (Moab); and the Energy Technology Engineering Center (ETEC), owned by Boeing. Lastly, there are two DOE sites with critical waste management disposal assets that support EM cleanup: NNSS (supporting low-level waste [LLW]/mixed low-level waste [MLLW] disposal); and the Waste Isolation Pilot Plant (WIPP). As a national defense repository for transuranic (TRU) waste, WIPP is not itself a cleanup site but is managed by EM.

Because EM sites had waste and/or materials, contaminated excess facilities, and contaminated soil and water, and with many of the sites on the U.S. Environmental Protection Agency's (EPA) National Priority List, EM had an obligation to each of the communities to ensure some level of cleanup progress at each site. Congress supported funding until the cleanup was completed at Rocky Flats, Fernald, and Mound. Prioritizing completion of these sites and gaining lessons learned applicable to the remaining cleanup, while still demonstrating substantial progress, provided an important justification for funding cleanup at the remaining sites. Additionally, Congress has consistently supported funding to permit continued progress. The text box below summarizes the significant cleanup accomplishments at the active EM sites.

Significant Accomplishments at Sites with Remaining EM Cleanup

- **Energy Technology Engineering Center (ETEC), California** – Completed demolition of all 270 DOE-owned structures and continued groundwater interim cleanup actions.
- **Hanford, Washington State** – Stabilized or preserved seven of the nine reactors; completed the majority of cleanup along the Columbia River; shipped all 20 tons of plutonium off-site; moved all 2,300 tons of SNF to on-site safe, dry storage; continued treating billions of gallons of groundwater along the Columbia River and on the Central Plateau to remove radioactive and chemical contaminants; demolished nearly 1,000 buildings, including the Plutonium Finishing Plant; and completed construction of facilities required to support the Direct Feed Low Activity Waste (DFLAW) program, including the Tank-Side Cesium Removal System to begin the first large-scale treatment of radioactive tank waste.
- **Idaho National Laboratory (INL), Idaho** – Exhumed all legacy buried waste and completed disposition or packaging awaiting final disposition; completed construction of the Integrated Waste Treatment Unit (IWTU) in preparation to treat and enable disposition of radioactive sodium-bearing waste; completed remote treatment and repackaging of some of the most challenging waste (fines generated during historic weapons development at the former Rocky Flats Plant) at the Advanced Mixed Waste Treatment Project; and continued treating millions of gallons of groundwater to reduce concentrations of trichloroethylene and other hazardous organic compounds.
- **Los Alamos National Laboratory (LANL), New Mexico** – Completed cleanup and closure of more than half of the 2,100 contaminated areas originally identified for remediation; shipped over 4,000 drums of TRU waste off-site; deactivated and demolished over 90 percent of the 125 buildings at Technical Area 21; and implemented an interim measure to control the migration of the hexavalent chromium groundwater plume.
- **Lawrence Livermore National Laboratory (LLNL), California** – Completed demolition to slab of Building 175, the Mirror Advanced Reactor System E-Beam Facility, and the Livermore Pool Type Reactor in Building 280.
- **Moab Site, Utah** – Successfully relocated 12 million tons of uranium mill tailings away from the Colorado River to an engineered disposal cell, leaving four million tons to be moved and removed a cumulative total of more than 970,000 pounds of ammonia and 5,480 pounds of uranium, from the groundwater to protect the Colorado River.
- **Nevada National Security Site (NNSS), Nevada** – Completed corrective actions at surface soil sites six years ahead of schedule; completed corrective actions at 99 percent of all NNSS infrastructure sites to date; and transitioned three of the four groundwater characterization areas into long-term monitoring.

Significant Accomplishments at Sites with Remaining EM Cleanup (continued)

- **Oak Ridge Reservation (ORR), Tennessee** – Completed demolition of the former gaseous diffusion plant at the East Tennessee Technology Park (ETTP), a first-of-its-kind cleanup, tearing down more than 500 old, contaminated structures, including the 1.6 million square foot K-25 facility – EM's largest demolition project ever – and transferring hundreds of acres back to the community for redevelopment; demolished the Biology Complex at the Y-12 National Security Complex and the Radiological Development Laboratory's West Cell Bank and Tritium Target Preparation Facility at the Oak Ridge National Laboratory (ORNL); and processed the remaining low-dose inventory of uranium-233 stored at ORNL and shipped the material for safe, permanent disposal offsite.
- **Paducah Site, Kentucky** – Completed deactivation of the C-400 Cleaning Facility (over 100,000 square feet); achieved significant progress in deactivation of the C-333 Process Building, one of the four large process buildings at the site; and dispositioned 1.7 million pounds of refrigerant used to cool equipment in the uranium enrichment process.
- **Portsmouth Site, Ohio** – Completed significant progress in demolition of the half-mile long X-326 former gaseous diffusion building; transferred 80 acres of land to the Southern Ohio Diversification Initiative for economic development purposes; and initiated operation of the On-Site Waste Disposal Facility.
- **Sandia National Laboratories (SNL), New Mexico** – Completed all soil corrective actions and continued monitoring activities at three groundwater contamination sites.
- **Separations Process Research Unit (SPRU), New York** – Completed decontamination, demolition, and site restoration activities of the SPRU areas, including removal of the nuclear facilities and remediation of land areas.
- **Savannah River Site (SRS), South Carolina** – Completed in situ decommissioning of the P-Area and R-Area Reactors; shipped all legacy TRU waste off-site; completed construction of the Defense Waste Processing Facility (DWPF) and the Salt Waste Processing Facility (SWPF); produced over 4,200 glass canisters (approximately one-half of the projected total) from the treatment of tank waste; completed construction of two large-scale saltstone disposal units and began construction of two additional large-scale units; disposed of 151,000 cubic meters of saltstone safely in the on-site vaults; and downblended all plutonium and shipped to WIPP or packaged for safe storage.
- **Waste Isolation Pilot Plant (WIPP), New Mexico** – Received over 13,000 shipments of TRU waste, primarily made up of contact-handled TRU waste, with 775 remote-handled waste shipments; completed mining of Panel 8; began mining west access drifts; and completed major advancements on the projects designed to increase air filtration, increase hoisting capacity, and add a utility shaft (the fifth and largest at the site).
- **West Valley Demonstration Project (WVDP), New York** – Demolished the vitrification facility; made significant progress on demolition of the Main Processing Plant; and safely stored the vitrified liquid tank waste (over 600,000 gallons) in 278 canisters pending final disposal in a repository.

Key Activities Supporting Cleanup to Date

The following activities have enabled the significant progress demonstrated by the program thus far and continue to support mission completion:

- **Technology Development (TD).** Recognizing the complexity of the cleanup, EM prioritized TD, spending up to hundreds of millions of dollars each year to solve problems with no known technological solutions. This included successfully developing treatment options for tank waste, improving groundwater modeling and groundwater cleanup technologies (e.g., immiscible liquids), and developing innovative techniques to decontaminate and decommission complex processing facilities – TD was a significant contributor to the success of cleanup at the Rocky Flats site.

- **Construction of Treatment and Disposal Facilities.** EM made significant investments in construction of the facilities and infrastructure required to treat and dispose of waste. These facilities included the NNSA-owned LLW, MLLW, and classified waste disposal facilities at NNSS and other DOE sites for wastes from *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and other cleanups; the Toxic Substances Control Act incinerator at ORR; TRU treatment facilities at ORR and INL; and the first underground TRU disposal facility, WIPP in New Mexico. Once these facilities were built, larger-scale cleanups of buried/stored wastes and contaminated soil, as well as D&D, began in earnest.

INL Advanced Mixed Waste Treatment Project crews prepare a transportation cask containing TRU waste for shipment to WIPP.

- **Facility Stabilization and Deactivation.** EM deactivated contaminated excess operational facilities and placed them in safe, "cold and dark" configurations to minimize surveillance and maintenance costs until they could be prioritized for D&D and/or full demolition. As funding became available, EM completed D&D activities for facilities across the complex, including many large-scale facilities such as the half-mile long, U-shaped K-25 Gaseous Diffusion Process Building at ORR. EM D&D activities are now focusing on sites with ongoing DOE missions.

- **Construction of Tank Waste Treatment Facilities.** As technology solutions became available to treat tank waste, facilities were planned at several sites: the Waste Treatment and Immobilization Plant (WTP) at Hanford; the WVDP; the Integrated Waste Treatment Unit (IWTU) at INL, and the Defense Waste Processing Facility (DWPF) and the Salt Waste Processing Facility (SWPF) at SRS. These facilities required large-scale, first-of-a-kind projects that have taken many years to design, construct, commission, and begin operations.

Tracking Progress

EM has established cleanup performance metrics in each of its major mission areas (the mission areas are described in the text box below) and tracks progress regularly during execution. EM's mission not only includes cleanup of contaminated media (groundwater, soils, and facilities), but also addresses the materials whose production caused the contamination (SNF and NM), and the specialized waste categories that must be managed for cleanup (radioactive tank waste, TRU

Overview of EM's Mission Areas

Tank Waste. Management, treatment, and disposition of the radioactive tank waste generated primarily from SNF reprocessing, and the associated tank closure activities. Tank waste forms include liquid tank waste (both low and high activity), vitrified waste in canisters, calcined waste, and tank sludges. The high-activity fraction of tank waste is high-level radioactive waste that must be disposed of in a geologic repository.

Spent Nuclear Fuel (SNF). Management, storage, treatment/processing, and packaging of SNF, which is nuclear fuel that has been removed from a nuclear reactor. Most SNF is highly radioactive and must be disposed of in a geologic repository.

Nuclear Materials (NM). Management of the remaining inventory of NM used for reactor fuel, nuclear weapons, isotope production, research and development, and other needs. EM's inventory of NM is excess to defense or other DOE mission needs. Primarily, it has some plutonium materials and uranium isotopes. EM has consolidated its excess plutonium to SRS for safe storage awaiting disposition. Uranium materials have been released to the commercial market for energy production or are being processed for disposal.

Transuranic Waste (TRU). Management, packaging, shipping, and final disposal of TRU waste. TRU waste is radioactive waste that contains human-made elements heavier than uranium on the periodic table. It is produced during nuclear fuel assembly, nuclear weapons research and production, and during the reprocessing of SNF. TRU waste largely consists of protective clothing, tools, and equipment used in these processes.

Depleted Uranium (DU). The management and disposition of DU, which is the material left after most of the highly radioactive form of uranium (U-235) is removed from the natural uranium ore.

Low Level Waste (LLW)/Mixed Low-Level Waste (MLLW)/Other Wastes. Management (storage, treatment, and disposal) of waste inventories generated mainly from ongoing soil and groundwater remediation, facility D&D, and cleanup. LLW is any radioactive waste that is not SNF, HLW, or TRU. LLW is considered MLLW if it also contains a hazardous waste component regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA).

Soils and Groundwater (S&GW). Characterization, development, and implementation of selected remedies to address soils and groundwater contamination and expedite cleanup completion and transitioning from active remediation to LTSM.

Excess Facilities Deactivation & Decommissioning (D&D).[a] Deactivation, decommissioning, demolition, and disposition of excess contaminated facilities and supporting infrastructure.

[a] The term "D&D" references deactivation and decommissioning activities. However, for the purposes of this plan, the term "D&D" is expanded to also include disposition activities, which may include facility demolition and the disposal of the resulting waste, or transfer of the facility to another user.

waste, and LLW and MLLW). Figure 2 indicates the status for each of the EM program performance metrics, reflecting the progress made over the last three decades.

Figure 2. Environmental Cleanup Progress

Tank Waste. WVDP site tank waste has been vitrified, the SWPF at SRS is operational, and the IWTU at the Idaho Cleanup Project (ICP) at INL is being readied for operation. Also, Hanford is making significant progress towards the startup of Direct Feed Low Activity Waste (DFLAW) facilities (the required startup was recently extended from 2023 to 2025 due to delays caused by the COVID-19 pandemic; however, DOE plans to begin operations as early as December 2023). The Department's goal, aligned with the recent consent decree, is to begin initial high-level waste (HLW) vitrification operations at Hanford by 2036. Tank waste processing operations at SRS are expected to be completed in the next 20 years, while the remainder of the Hanford tank waste cleanup will take many decades.

NM and SNF. NM from across the complex has been consolidated to SRS for safe storage. Only a limited quantity of uranium (uranium-233 [U-233]) is left at Oak Ridge, where it is being stabilized and processed for disposal.

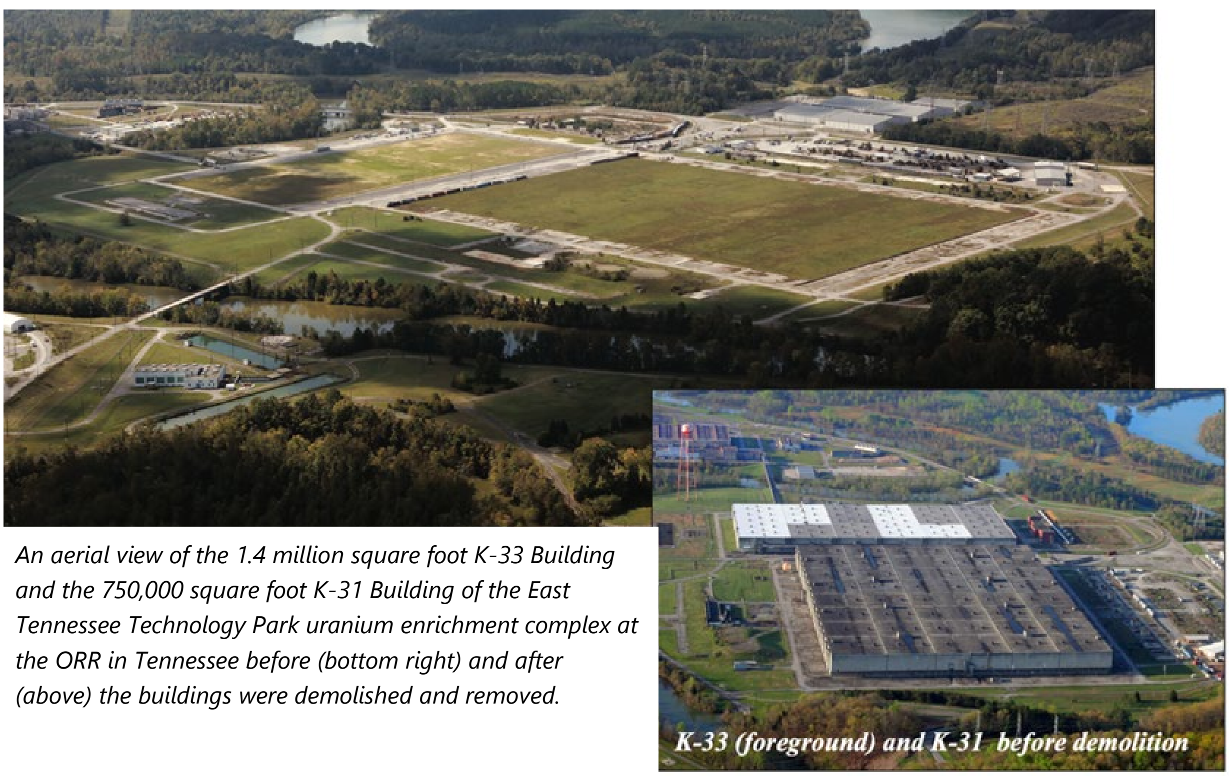
The vast majority of SNF at Hanford has been removed from wet basins along the Columbia River and placed into multi-container overpacks for dry storage; the remaining SNF is stored in concrete overpacks. Apart from continued storage, this completes all SNF and NM operations at

EM's largest site. At ICP, all EM SNF has been removed from wet basin storage and is in dry storage awaiting packaging for disposal. And SNF at SRS is safely stored in L-Basin, awaiting processing in H-Canyon.

TRU Waste. Considerable progress has been made for contact-handled TRU waste (CH-TRU). Disposition of the more hazardous remote-handled TRU waste (RH-TRU) will take years to complete, but many of the technical challenges have been overcome.

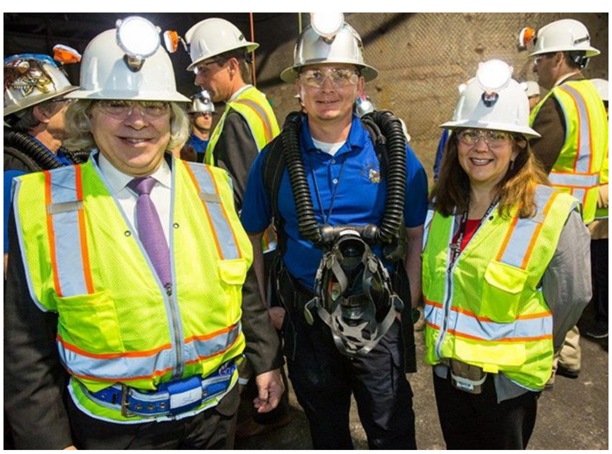
Depleted Uranium (DU). While it will take many years to complete depleted uranium hexafluoride (DUF6) disposition, no major technical challenges remain, and processing facilities are operational at both the Portsmouth and Paducah Gaseous Diffusion Plants.

Excess Facilities D&D. EM has completed disposition of over 3,000 industrial and radioactive facilities, with a more streamlined process now being implemented. A recent example is the successful demolition of the East Tennessee Technology Park (ETTP) uranium enrichment complex at the ORR in Tennessee, which is the first time an entire uranium enrichment complex has been demolished anywhere in the world. Another notable example is the recent removal of the High Flux Beam Reactor exhaust stack which completed the cleanup of Brookhaven National Laboratory (BNL) in 2021, reducing the number of active cleanup sites to 14.



An aerial view of the 1.4 million square foot K-33 Building and the 750,000 square foot K-31 Building of the East Tennessee Technology Park uranium enrichment complex at the ORR in Tennessee before (bottom right) and after (above) the buildings were demolished and removed.

The graphic below was used in 2019 to mark 30 years of the EM cleanup program. Since its inception 33 years ago, EM has completed much of the original cleanup scope and reduced the footprint from 107 sites comprising a total of 3,100 square miles to just 15 sites with an active cleanup footprint of less than 300 square miles. Actions have been taken to contain and control contaminant pathways in soils and groundwater at the remaining sites' boundaries. This risk mitigation has afforded EM the opportunity to rethink strategies formed years ago and consider new approaches and technologies not possible in the past.



III. EM Program Strategy

Program Strategy Overview

EM's program strategy reflects three broad priorities:

- Ensure the safety and health of the public and EM's workforce while continuing to protect the environment. This includes protecting workers and the public from the hazards associated with DOE operations; eliminating, or mitigating, the environment, safety and health (ES&H) risks from the most dangerous legacy wastes and contaminated facilities; controlling contaminant pathways in groundwater and soils to mitigate potential future risks; and maintaining safe conditions of site operations, such as emergency response capability, protection of government property and equipment, and infrastructure operations.

- Comply with applicable federal and state environmental laws and requirements to meet commitments specified in site-specific regulatory compliance documents, including federal facility agreements and consent decrees.

- Seek ways to conduct cleanup efficiently and cost-effectively while balancing important considerations, including:
    - **Community and Tribal input.** Collaboration with local stakeholders is crucial for developing effectively balanced cleanup priorities and approaches, and Tribal consultation ensures meaningful participation in cleanup decisions that affect Tribal communities. EM sites have environmental cleanup needs and DOE has an obligation to each of the communities to make cleanup progress.
    - **Diverse, skilled, and trained workforce.** The investment made in recruiting and training personnel must be maximized, and loss of trained workforce must be minimized.
    - **Funding.** Each year, EM develops its funding request. Congress then evaluates the request while considering the Nation's overall priorities and provides funding to EM through appropriations legislation.[1]
    - **Best business practices.** This includes continuously evaluating existing plans, schedules, and cost estimates to identify areas of potential improvement, identifying opportunities to reduce operations costs, as well as incorporating lessons learned

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[1] For purposes of budgeting, planning, and execution, EM groups similar activities into a standard nomenclature known as "project baseline summaries." Funds are to be expended as appropriated. More information regarding the appropriations process is available at EM's "Budget Documents & The Federal Budget Process" web site, https://www.energy.gov/em/budget-documents-federal-budget-process.

from the completion of similar activities and the application of technological advances.

- **Site Interdependencies**. This includes considerations such as the availability of capacity at a disposal site prior to shipment of waste from another site.
- **Maintenance of Infrastructure Systems.** This includes the need to maintain and upgrade electrical power, water, communications, and other infrastructure systems critical to support EM's cleanup activities.
- **Partnering.** This includes working with Departmental programs co-located on site and the needs of communities for land and/or facilities.

A core component of EM's strategy is the risk-based prioritization approach. The top priority is mitigating immediate risk to human health or the environment. All other cleanup activities are prioritized based on achieving the highest risk reduction benefit per radioactive content as outlined in the text box at right. Specific priorities are established within the framework of regulatory compliance commitments, technical considerations such as the potential for contamination to reach surrounding communities, and the important considerations described above.

Risk-Informed Prioritization Applied to Mission Areas

1. Activities to maintain a safe, secure, and compliant posture
2. Radioactive tank waste stabilization, treatment, and disposal
3. SNF storage, receipt, and disposition
4. Nuclear material consolidation, stabilization, and disposition
5. TRU and MLLW disposition
6. Soils and groundwater remediation
7. Excess facility D&D

Enabling Activities for Mission Success

EM undertakes a variety of enabling activities to support successful completion of site cleanup across all mission areas. These multi-faceted activities include strategic planning; program and project management and acquisition strategies; technology development and innovation; workforce strategy; infrastructure management; and regulatory and legislative initiatives.

Strategic Planning

EM's cleanup mission requires the long-term planning of complex, large-scale activities, with varying degrees of uncertainty due to the timeframe required for cleanup, regulatory decisions still to be made, and unforeseen events. Current cleanup plans reflect many decisions and commitments, some of which were made early in the program before waste characteristics or disposition pathways were better understood. As waste treatment and disposal options are definitized and cleanup strategies are implemented, the activities necessary to complete the cleanup can become more complex and costly than originally anticipated. This also creates opportunities to simplify and reduce costs, such as those presented in Section VII.

Changes in EM's program planning, and corresponding cost estimates, are driven by many factors, including:

- Changes in work scope, such as:
    - Previously undiscovered contamination. Although EM sites have undergone extensive characterization, the need for additional work may be discovered as cleanup progresses (e.g., due to the discovery of additional contamination).
    - Changes to the regulatory and legislative framework. For example, regulatory decisions may differ from previously established planning assumptions.
    - New scope possibly added to EM's portfolio, such as the transfer of contaminated excess facilities from other DOE programs to EM for D&D.
- Changes in schedule, such as:
    - If more work is completed in a year than planned due to efficiencies, receipt of additional funding, or implementation of alternative approaches, the estimated costs are decreased, and the remaining work scope could be accelerated.
    - If less work is completed in a year than planned or if there are cost overruns, the schedule is extended, potentially increasing costs and delaying site completion. If a delay is substantial, there may also be a need for significant infrastructure system upgrades or modifications.
- Efficiency and effectiveness of contractor work performance.
- Other factors, such as national and regional economic factors (e.g., interest rates, inflation, labor costs), also affect program planning estimates.

In addition to EM program planning estimates, the DOE is required to develop an annual environmental liability estimate. The following text box describes the two estimates.

EM Program and Environmental Liability Estimates

The EM program and environmental liability estimates are both affected by the factors described in this section. However, these estimates are developed for different purposes. EM's program estimate is developed to reflect execution plans to complete EM's mission. EM's environmental liability estimate is developed annually for financial reporting purposes as required by the 1994 Government Management Reform Act and is subject to accounting standards and requirements.

While the environmental liability estimate begins with EM's program estimate, it then is adjusted to become a point-in-time estimate as if the cleanup mission could be paid in full in the year of reporting. The accounting adjustments for this estimate include increases, such as contingencies to reflect current levels of uncertainty and risk, and decreases, such as the management of projected future waste from other programs, as well as pension costs reported separately in the Department's financial statement.

Strategic planning is essential in this dynamic environment, to identify strengths, weaknesses, threats, and opportunities relevant to the currently planned work scope, as shown in Figure 3. The status quo is regularly evaluated against potential alternatives to identify opportunities to streamline and accelerate cleanup, improve efficiency, further reduce risk to human health and the environment by completing cleanup sooner and apply innovative cleanup technologies. Ongoing strategic planning and analysis identifies challenges and opportunities which are discussed in more detail in Section VII.

Figure 3. EM Strategic Planning Process

Program and Project Management and Acquisition Strategies

The first step in effective program and project management is to clearly define the work scope and establish cleanup tasks that meet regulatory requirements, worker safety objectives, and schedule and budgetary assumptions. The detailed compilation of work scope, along with its associated cost, schedule, and risks, is baselined and placed under configuration management.

A description of EM's best management practices is provided in two recently issued protocols:

- The *EM Program Management Protocol*, published in 2020, strengthened requirements for planning, budgeting, execution, and evaluation of EM activities, including the application of the U.S. Government Accountability Office's (GAO) cost estimating best practices, life-cycle planning based on funding ranges, and robust risk management plans that consider potential threats and opportunities. In accordance with the protocol, sites are updating their respective program plans and cost estimates, known as Federal Site Life-Cycle Estimates, which will both be incorporated in future updates of this plan.

- The *Cleanup Project Management Protocol and Implementation Standard for Demolition Projects*, also published in 2020, establishes requirements for planning, decision-making, execution, performance measurement, and reporting of demolition projects. The protocol is being implemented in support of demolition projects including the recently demolished X-326 Building, the first of three massive former uranium-enrichment process buildings at Portsmouth.

EM also is seeking to apply best management practices to its acquisition strategies. EM's End State Contracting Model, which is designed to promote effective, significant, and measurable cleanup progress, has been employed at six sites (as of the writing of this plan). It is planned for implementation at additional sites in the coming years. By reinvigorating the cleanup completion mindset, the End State Contracting Model allows EM to partner with industry and stakeholders as it negotiates risk-informed interim and "end states" to complete cleanup at EM sites.

Using the End State Contracting Model, EM negotiates scope, cost, and schedule on discrete, near-term elements of work through task orders in an indefinite delivery/indefinite quantity contract, instead of using cost-based contracts that typically have general scopes of work over a longer period (sometimes up to 10 years or more). This approach yields better clarity and shorter time horizons and provides flexibility to tailor the task order type (e.g., cost reimbursable or firm fixed price) to establish improved performance metrics, cost, and schedule targets, and to achieve more discrete nearer-term completions, or "end states." This model also provides for improved definition and sharing of risk between the contractor and government, and an accountability structure designed to motivate contractors towards improved cost and schedule performance. Although only recently implemented (results are not yet available for evaluation), this model builds on lessons learned from prior successes experienced by EM incentivizing contractor performance.

Technology Development and Innovation

EM is developing an integrated technology development, demonstration, and deployment program by aligning the program with EM mission priorities and leveraging the capabilities of DOE National Laboratories, academia, private industry, and other federal agencies. A wide range of technology development activities are undertaken including scientific studies; technology evaluation, selection, and maturation; scale-up activities; and technical issue resolution efforts. EM considers the following goals when selecting technology development activities:

Featured at the 2018 Waste Management Symposia, the NASA Valkyrie stands 6 feet, 2 inches tall. While EM is years from using a humanoid robot, Valkyrie's highly dexterous arms could make work easier and safer for workers. NASA and EM have been partnering on this and other robotics projects.

- **Advance** technologies in support of completion of the mission.
- **Accelerate** cleanup activities by supporting emerging and viable technologies.
- **Assist** with studies and selection of emerging technologies and approaches that address the difficult challenges facing the mission.

The TD program currently includes four focus areas: tank waste treatment, soil and groundwater remediation, facility D&D, and NM. Recognizing that technological areas support multiple mission areas and cleanup activities, the TD program also focuses on analytical technologies (such as sample collection, laboratory, and in situ analysis), robotics and remote systems, and artificial intelligence. Test bed programs continue to be established through the TD program at various EM sites to allow for evaluation of innovative technologies to address high-priority program needs. The TD program capitalizes on investments and expertise across the DOE complex for application to technical challenges. EM also works with other federal technology centers and commercial industry to transfer non-nuclear technologies into opportunities to innovate and enhance cleanup capabilities. In partnership with the national laboratories, DOE is conducting a holistic EM technology review to evaluate technology development programs throughout the complex to ensure that they have overall unity of effort, they are efficient, and they provide maximum value. This assessment will be used to recommend on the structure and implementation of an integrated research and development (R&D) effort and to prioritize EM and DOE complex-wide issues, challenges, and risks for maximum return on R&D investment.

Workforce Strategy

EM employees across the Nation are the key to the program's extraordinary achievements described in this plan. It is also because of the dedicated workforce that significant cleanup progress was made even as the Nation faced the recent COVID-19 pandemic. EM is committed to maintaining a world-class workforce to meet the challenges of completing the world's largest environmental cleanup program. To meet that goal, EM is:

Students and community members attending the 2019 Teaching Radiation, Energy, and Technology Workshop.

- **Recruiting, hiring, and retaining qualified and creative individuals.** EM has several programs to build and maintain its next generation workforce:

    - Minority Serving Institutions Partnership Program, which promotes the education and development of the next generation workforce in critical science, technology, engineering, and math disciplines.
    - Pathways Internship Program, which allows students to be part of a cooperative-learning environment, providing work opportunities while still completing academic pursuits.
    - Direct engagement with universities and colleges, which provides an opportunity to inform students of the important EM mission and to position a future workforce "pipeline."
    - Partnerships with local learning institutions through contractors aimed at enhancing curriculum programs that prepare students to enter the EM workforce.

  In addition, EM is pursuing direct hire authority and expanded use of excepted service, which streamlines the hiring process and provides additional incentives to fill entry-level, mid-level, and senior-level positions.

- **Providing the necessary training to accomplish work safely and effectively.** This includes occupation-specific training with curriculum aligned to work scope needs as well as single-issue, short-term training. In addition, senior employees mentor newer employees, sharing their lessons learned and institutional knowledge, particularly as many of EM's employees will be eligible to retire in the next several years.

- **Fostering a welcoming and supportive workplace for a qualified professional workforce and encouraging professional development.** To serve the next generation workforce, EM seeks input from its employees on ways in which the program can continue to be a desirable place to work. At every major EM site, there is a union presence with one or more union affiliates representing EM's contractor workforce. Contracts ensure workers have the right to organize, join a union, and bargain collectively with their employers. Focused on a common goal, employees are encouraged to coordinate and collaborate as team members, continually searching for ways to accelerate work safely and efficiently. EM also regularly honors employees who have helped to advance critical mission goals. The challenges of the program serve as incentives for individuals to apply their creative ideas to the complex work to come.

Recognizing the opportunities and challenges that lie ahead, EM has put into place practices and programs that will help to sustain its world-class workforce.

Infrastructure Management

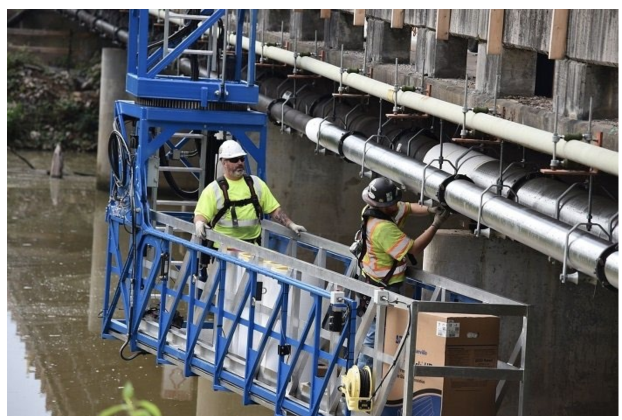
Providing electrical power, water, gas, communications, sanitary sewer systems, roads, emergency services, and other infrastructure to each of the sites is critical to support EM's cleanup activities. With some sites in existence since the early 1940s, infrastructure systems are aging, requiring a robust maintenance and upgrade program. EM is achieving success in upgrading infrastructure across the complex, which will not only help ensure systems are operational but also help enhance its ability to perform cleanup in the future. For sites that will not have an operational mission after cleanup is completed, EM is working diligently to modernize and “right-size” infrastructure to minimize costs and footprint.

EM’s approach for managing infrastructure incorporates lessons learned from decades of site operations, as well as the experiences of NNSA in maintaining infrastructure at multiple sites with similarly aged facilities. EM’s strategic approach includes the following activities:

- Regularly assessing and cataloguing the condition of infrastructure systems using best management practices developed to identify and reduce major risks across the complex using a common set of tools.

- Defining future infrastructure requirements, including not only future EM cleanup needs, but also the potential for reuse of the site upon completion of cleanup (e.g., transition to other DOE programs or the local community).

- Identifying gaps in infrastructure systems between the current condition and future requirements and identifying activities to address the gaps such as adding capacity (e.g., increase electrical power capacity to support new treatment operations), reducing capacity (e.g., reduce sanitary sewer capacity as buildings are torn down), or upgrading the infrastructure systems (e.g., upgrade aging potable water pipelines). EM conducts site infrastructure ‘Deep Dives’ to facilitate understanding and agreement on the future direction of each site’s investments and how it supports their mission, priorities, and goals. For example, recent Deep Dives were completed at ORR and SRS.



To facilitate the transition of Oak Ridge’s East Tennessee Technology Park from EM to the community, utilities and infrastructure have been upgraded and transferred, including most electrical power, gas, and sanitary sewer systems.

- Integrating actions to address the gaps into infrastructure system planning and implementation activities.

EM is committed to identifying and upgrading infrastructure systems to support cleanup operations safely and effectively.

Regulatory and Legislative Initiatives

EM conducts its cleanup in compliance with applicable federal and state environmental requirements (e.g., laws and regulations) and develops its plans to meet commitments specified in binding site-specific regulatory compliance documents. The regulatory and legislative frameworks at each site are unique, with some elements common across the complex. EM sites are subject to environmental laws, including CERCLA, the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Clean Water Act of 1972*, the *Clean Air Act of 1970*, the *National Environmental Policy Act of 1969* (NEPA), and the *Atomic Energy Act of 1954* (AEA). Site-specific regulatory compliance documents, such as federal facility agreements, consent decrees, and other legal arrangements often contain enforceable milestones for specific cleanup actions. These milestones may include the completion of specific activities such as the demolition of a particular building; the completion of documentation (such as a CERCLA record of decision) for an important cleanup decision; or the submission of regular status updates, such as environmental monitoring reports. There are hundreds of enforceable regulatory compliance milestones within more than 40 federal and state cleanup agreements across the complex. Furthermore, sites may also be required to apply for permits to conduct certain activities, such as RCRA permits for the management of hazardous waste.

The regulatory and legislative framework at each site may affect the remedy selection, the order in which cleanup is completed (e.g., which activities to complete by when), and the required outcome (end state) of the cleanup. Thus, any change to the regulatory and legislative framework or related assumptions on future decisions may result in a change to the estimated cost to complete the cleanup.

External and internal reviews of the EM Program have provided recommendations for accelerating work within the complex regulatory and legislative framework including:

- The Environmental Management Advisory Board (EMAB)[2] recommended EM develop, jointly with regulatory stakeholders, a partnering process tailored to each site that encourages discussions early and often with regulators and local community stakeholders. Partnering with stakeholders was identified by EMAB as essential to

[2] The EMAB is an advisory group that provides independent and external advice, information, and recommendations to the Assistant Secretary for EM on corporate issues relating to accelerated site cleanup and risk reduction. More information regarding EMAB, and its reviews is available on the EMAB web site at https://www.energy.gov/em/environmental-management-advisory-board-emab.

achieve faster, more efficient cleanup, and to not only support but also increase the strength of relationships with regulators and stakeholders.

In 2019, EMAB and federal staff and contractors toured WIPP underground during the EMAB Spring 2019 meeting.

- The Consortium for Risk Evaluation with Stakeholder Participation (CRESP)[3] recommended that EM use the most cost-effective best practices among sites to address similar cleanup activities. CRESP provided this recommendation recognizing that decision-making regarding priorities is made within the unique context of the regulatory and legislative framework at each site as well as the unique context of other site-specific factors, including the interests of Tribal Nations and local community stakeholders, available funding, and other considerations.

- The GAO[4] made two key recommendations for improvements at Hanford. The first is to expand future analyses of potential supplemental low-activity waste (LAW) disposal options to include all federal and commercial facilities that could potentially receive grouted LAW from Hanford. The second is to delay construction on the WTP's pretreatment and high-level waste facilities until critical technologies are tested and verified as effective.

To address these and other recommendations, and maintain a continuous improvement posture, potential initiatives are being evaluated, including:

- Collaborating with regulatory partners to support consistency in implementing national regulations and policies when selecting cleanup technologies and approaches addressing similar types of activities across all sites.
- Reviewing and considering lessons learned from other sites addressing similar activities, as well as national risk-based priorities and resource availability when negotiating updates to site cleanup agreements.

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[3] CRESP is an independent multi-disciplinary consortium of universities, led by Vanderbilt University. CRESP organizes and leads independent technical reviews of DOE projects. More information regarding CRESP, and its reviews is available on the CRESP web site at: http://www.cresp.org/.

[4] GAO, often called the "congressional watchdog," is an independent, non-partisan agency that works for Congress. More information regarding GAO and its reviews is available at GAO's web site, https://www.gao.gov/.

- Managing wastes based on their degree of hazard and intrinsic characteristics instead of based on their origins.

EM is committed to working with its regulatory partners to safely protect human health and the environment, and will work closely with Tribal Nations and stakeholders, such as regulators and local communities, regarding initiatives that may be pursued.

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IV. Remaining Cleanup Scope

EM's mission moving forward is now focused on completing cleanup at 14 active sites, supported by the national repository at WIPP.

Sites with EM Cleanup Activities

Energy Technology Engineering Center (ETEC)
Hanford
Idaho Cleanup Project (ICP)
Lawrence Livermore National Laboratory (LLNL)
Los Alamos National Laboratory (LANL)
Moab Uranium Mill Tailings Remedial Action Project (Moab)
Nevada National Security Site (NNSS)
Oak Ridge Reservation (ORR)
Paducah Gaseous Diffusion Plant
Portsmouth Gaseous Diffusion Plant
Sandia National Laboratories (SNL)
Savannah River Site (SRS)
Separations Process Research Unit (SPRU)
Waste Isolation Pilot Plant (WIPP)
West Valley Demonstration Project (WVDP)

The remaining scope, by each of EM's mission areas, is as follows (most sites have more than one cleanup mission area):

- Tank waste to be treated at three sites,
- SNF at three sites,
- NM at two sites,
- DU at two sites,
- LLW, MLLW, and/or TRU waste at 11 sites,
- Soils and groundwater remediation at 13 sites, and
- Facility D&D at 11 sites.

Overview of Remaining Cleanup Scope

Major scope over the next decade is highlighted in the *EM Strategic Vision: 2022-2032* document. This section describes, by mission area, the remaining cleanup scope through the end of EM's mission, including completion timelines reflecting current assumptions regarding future regulatory decisions.

For the remaining active sites, Table 1 and Table 2 provide overall depictions, by mission area, of the scope of work completed compared to the total estimated EM cleanup scope. Progress in some mission areas (Table 1) can convey approximate percent completion of metrics based on total life-cycle inventories and/or estimated projections (e.g., total tank waste volumes, legacy TRU or SNF inventories, total number of facilities that have been officially transferred to EM, legacy or projected waste inventories, etc.). Other activities are less suited to percent-complete calculations, such as for soils and groundwater where the work is not completed until a particular cleanup standard or measurable contaminant level is reached. In such cases, it can be helpful to convey progress from the standpoint of major regulatory process steps completed (Table 2).

Table 1 reflects progress in the following mission areas:

- **Tank Waste.** Because full treatment capabilities have either just been completed (as at SRS) or yet to be completed (ICP and Hanford), much tank waste is left to be addressed.

- **NM.** All NM have been consolidated to SRS, except for U-233 at ORR, which is currently being processed for disposal and scheduled to be completed in the next several years. NM at SRS are being safely stored and a significant blend-down operation is underway to address some of that material.

- **SNF.** All SNF is being safely stored with nearly all of Hanford's SNF awaiting final disposal. INL's SNF is in dry storage awaiting a packaging capability where it will be readied for disposal. SRS's SNF is planned for processing in H-Canyon.

- **DU.** Depleted Uranium processing has been completed at ORR, and processing of the material at Portsmouth and Paducah will continue until completed.

- **TRU.** TRU waste processing is completed or well underway at all sites. Significant work is left at Hanford which will generate TRU in the future from buried waste cleanup and D&D activities that are yet to begin.

- **D&D and LLW.** D&D activities and LLW disposal are generally linked activities with most sites having on-site capabilities to dispose of LLW from D&D. Because D&D can only proceed once related operations are complete, the D&D mission area is among the last to be completed.

Table 1. Remaining EM Cleanup Scope by Site

Site		Tank Waste	Nuclear Materials	Spent Nuclear Fuel	Depleted Uranium	TRU Waste	D&D/Excess Facilities	LLW/MLLW/ Other Wastes
ETEC							⚑	⚑
ICP		○	⚑	○		●	●	●
LANL						●	○	●
LLNL						⚑	○	●
Moab							●	●
NNSS						⚑	●	●
ORR	ETTP				⚑	●	●	●
	ORNL		○			●	○	●
	Y-12					●	○	○
PAD					○		○	●
PORTS					○		○	○
HAN	RL		⚑	●		○	○	●
	ORP	○				○	○	○
SRS		○	○	○	⚑	●	○	●
SNL								
SPRU						●	⚑	
WVDP		⚑		⚑			●	●

KEY	
All EM Work Completed	⚑
Less than ½ Remaining	●
More than ½ Remaining	○
No work scope applies	(blank)

Notes:

- Moab mill tailings are shown under LLW/MLLW Disposition for this table only but are managed as residual radioactive material.
- WVDP completed its tank waste mission in 2017. At that time, all liquid tank waste had been vitrified and the HLW glass canisters were placed into storage casks for long-term, safe interim storage pending availability of a geologic repository. WVDP also has a significant inventory of Greater-than-Class-C (GTCC)/GTCC-like waste to be dispositioned.
- The initial characterization of the volume of LLW/MLLW expected from D&D has not been completed for some sites with significant D&D work scope remaining; percent complete will therefore change periodically as volume estimates are refined.

In Table 2, the progress assessment for soils and groundwater and buried waste is presented[5]. Soils and groundwater (S&GW) remediation reflects an assessment of each site's progress against the following four regulatory steps: (1) conduct initial characterization activities, investigations, and studies; (2) evaluate and select the remedies; (3) install the remedies; and (4) complete remediation activities (i.e., ready for transition to LTSM). Table 2 also shows the progress assessment for buried waste. Until 1970, DOE's predecessors buried these wastes in shallow pits and trenches. Buried waste is defined as radioactive and/or chemically contaminated legacy wastes disposed of in near-surface pits and trenches prior to 1970 (this does not include CERCLA cells or other disposal facilities managed by DOE). For buried waste, Table 2 reflects an assessment of each site's progress against the following four general steps: (1) conduct initial (in situ) characterization; (2) exhume the waste and fully characterize, including assay; (3) package and ready the waste for transport/final disposition; and (4) disposition on-site or off-site (completion of EM scope). The assessment accounts for waste either capped in place or where no further action is required, as agreed to by the regulator.

As Table 2 indicates, significant process has been achieved in each area:

- **Soils.** Most sites have completed (or have almost completed) activities related to soil contamination. A notable outlier is LANL, which has recently begun concentrating on buried wastes and other soil to address priorities of the regulators that have been reflected in the site compliance agreement. EM has also hired its own cleanup contractor, instead of using NNSA's site operating contractor, to better focus on performance on the cleanup mission.

- **Groundwater.** Efforts are also well underway, with almost all sites having completed investigations and studies, and most sites having decisions made for most of their remedies.

- **Buried Waste.** This has been completed or nearly completed at all sites except LANL (as discussed above) and Hanford. Efforts to address some burial areas at Hanford were deferred until greater risks were addressed. Most the contamination of concern in these Hanford burial areas are not mobile and can be safely addressed later in the cleanup.

[5] The specific steps that are conducted at each site for soil and groundwater remediation may vary from these general steps, depending on the site-specific regulatory and legislative framework. Additionally, the specific steps that are conducted at each site for buried waste may vary from these general steps, depending on the site-specific regulatory and legislative framework.

Table 2. Soils and Groundwater EM Progress by Site

Site	Soils and Groundwater Remediation		
	Soils	Groundwater	Buried Waste
ETEC		●○○	
ICP	●●●	●●●	●●●
LANL	●●●	○○○	○○○
LLNL	●●○	●●○	
Moab	●●●	○○○	
NNSS	⚑	●○○	
ORR	●●●	●●○	●●●
PAD	●●●	●●○	●●●
PORTS	●●○	●●○	⚑
Hanford	●●○	●●○	●○○
SRS	●●●	●●●	⚑
SNL	⚑	●●●	
SPRU	⚑		
WVDP[1]	●●○	●●○	

1. Decisions and remedies at WVDP will be finalized as part of the Phase 2 Decommissioning Decision

KEY	
Soils & GW: Investigations/Studies; Remedy Decisions; Remedies In Place; ⚑ All EM Work Completed	**Buried Waste**: Waste Characterized; Waste Exhumed; Waste Packaged; ⚑ All EM Work Completed
Grey: No work scope applies	
Light Green: Work in Progress (<50% complete)	
Dark Green: Mostly/Fully Complete (>50% complete)	

Note: Contaminated soils and groundwater areas/units were weighted equally, regardless of the type or level of contamination. ORR buried waste does not include disposal sites not currently under EM scope. Future regulatory decisions are not represented in the data.

Remaining Cleanup Scope by Mission Area

The remaining scope for each of EM's mission areas is described in the following sections. EM cleanup scope is divided into these mission areas for the purposes of tracking work progress and costs: Tank Waste, SNF, NM, TRU Waste, Depleted Uranium, LLW/MLLW/Other Wastes, Soils and Groundwater, and D&D (see text box in Section II for descriptions of these mission areas). Each subsection below provides a description of the remaining work in the mission area, an inventory of remaining waste (if applicable), the metrics used to measure progress, and a timeline showing the completion of the mission area work at each site.

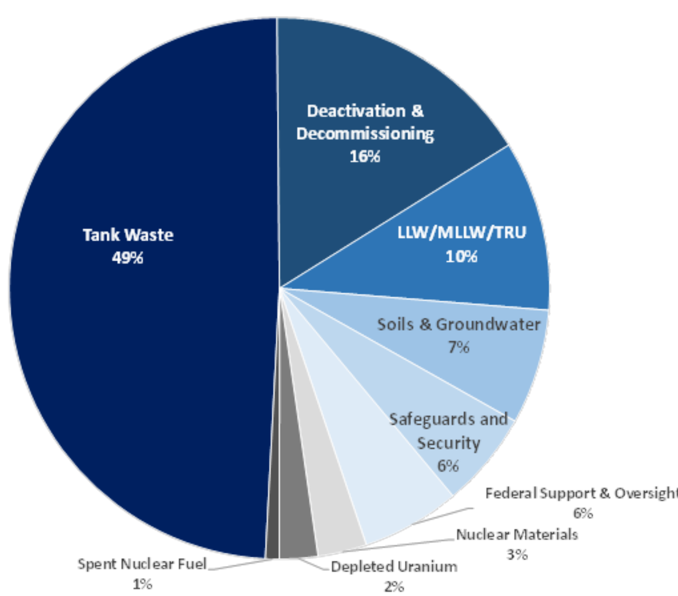
Work among mission areas is often interdependent, as completion of activities in one area can affect the schedule in another (see examples of such interdependencies in the text box to the right). Final waste disposal activities are typically the last of a series of related interdependent mission area activities.

Examples of Interdependencies of Mission Area Activities

- A facility (such as a waste treatment facility) must complete its mission before the D&D can begin.
- D&D activities generate LLW/MLLW debris that must then be disposed.
- A building must be demolished before remediation of soils under the building can be completed.
- Buried waste retrievals can generate TRU waste that then must be disposed of at WIPP.

Figure 4 represents the distribution of remaining estimated cleanup costs by mission area. As shown, the treatment and disposition of tank waste and the permanent closure of tanks where this waste is currently stored is the single greatest liability facing EM. D&D of contaminated facilities and associated waste disposal is the next largest percentage of remaining costs.

Figure 4. Percent of Remaining Estimated Cleanup Cost by Mission Area



Tank Waste

As described earlier, the tank waste mission area is the most technically challenging and greatest liability facing EM. To understand EM's strategy for this mission area, it is helpful to first understand the source of tank waste.

Tank waste was generated primarily from the reprocessing of SNF to recover useful isotopes for weapons production, as well as to demonstrate reuse of commercial SNF. Reprocessing and subsequent waste handling activities (before treatment) include the following steps:

1. The first step is to dissolve the SNF in acid which allows for separation of uranium and plutonium. The waste from this step is called "first cycle raffinate."
2. The next step is to remove unneeded contaminants or refine the concentration of useful material. The waste from this step is referred to as "Final Cycle Raffinate" or "Bismuth Phosphate Process."
3. Following reprocessing, liquid waste is neutralized to reduce risks (such as corrosivity) and then transferred to tanks.

The sources of tank waste at each site, its present storage locations, and current tank waste inventories are shown in Table 3. Table 3 also presents the estimated final inventory of waste after treatment.

All sites must solidify tank waste to make it suitable for eventual permanent disposal. The LAW component can be readily retrieved, treated, and immobilized. The layer of sludge settled at the bottom of the tank is more difficult to retrieve and tends to contain the most long-lived TRU elements. Once all waste in a tank is retrieved to agreed-upon levels, the final risk reduction step involves closing the tanks (or binsets, in the case of ICP), eliminating any pathways for water ingress into the tank or waste egress into the environment, and filling with grout.

The key remaining tank waste cleanup activities at each of the sites are summarized in the text box to the right.

Remaining Tank Waste Cleanup

Hanford

- Complete construction of planned WTP facilities
- Complete disposition of 56 million gallons of liquid tank waste including HLW and LAW
- Close 177 tanks, including 11 bismuth phosphate tanks
- Support direct-feed LAW into the LAW Facility (DFLAW approach)

Idaho Cleanup Project (ICP)

- Treat sodium-bearing waste
- Treat and disposition calcine
- Close remaining 4 waste tanks and 7 binsets

Savannah River Site (SRS)

- Continue solidification of tank waste
- Complete vitrification of HLW (less than half of the projected canisters remain to be poured)
- Treat salt waste through the SWPF
- Close remaining 43 waste tanks

West Valley Demonstration Project (WVDP)

- Continue storage of glass canisters in overpacks and robust concrete casks

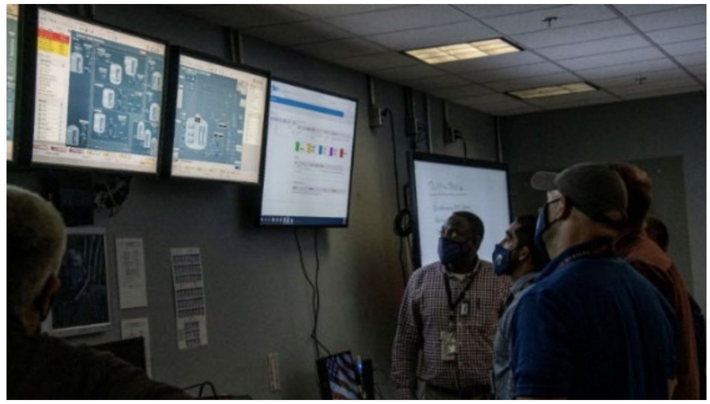
Table 3. Tank Waste Inventory by Site

Site/Source	Storage Facility	Current Inventory	Final Inventory (est.)
Hanford			
SNF Reprocessing	• 138 Single-Shell Tanks • 28 Double-Shell Tanks	• 55 million gallons: liquid tank waste	• 7,300 HLW glass canisters; 89,000 LAW glass containers
Bismuth Phosphate Process (BPP)	• Up to 11 Single Shell Tanks	• 1.3 million gallons: liquid waste (primarily sludge)	• TBD: Dewatered TRU sludge (~8,800 55-gallon drums) or grouted LLW
ICP			
SNF Reprocessing	• 6 Binsets of calcine with plans to transfer Binset #1 contents into Binset #6	• 4,400 cubic meters: granular calcine	• TBD pending amended record of decision on calcine disposition
Final Cycle Raffinate	• 3 Liquid Waste Tanks with sodium-bearing waste (SBW)	• 850,000 gallons: liquid waste	• From 700-1,000 granular SBW canisters
SRS			
SNF Reprocessing	• 51 Liquid Waste Tanks • 6 of 22 tanks in F-Tank Farm are closed • 2 of 29 tanks in H-Tank Farm are closed • Vitrified waste stored in glass waste storage buildings	• 35 million gallons liquid waste currently stored • Over 4,200 glass canisters produced are in storage with 151,000 cubic meters of saltstone disposed in on-site vaults	• Approximately 8,400 glass canisters projected (awaiting off-site disposal) • About 1 million cubic meters of saltstone disposed in on-site vaults
WVDP			
Commercial SNF Reprocessing	• On-Site Concrete Storage Pad	• 275 vitrified HLW glass canisters • 3 additional canisters	• All canisters stored in 56 NRC-licensed storage casks

Note: For more information about tank waste inventory at each site, visit the respective site web sites for Hanford, INL, SRS, and WVDP.

Also of note are the 1,936 cesium (Cs) and strontium (Sr) capsules at Hanford, generated from the removal of Cs-137 and Sr-90 from radioactive liquid tank waste, and planned for dry storage in robust concrete casks pending disposition. Both SRS and Hanford will also store highly shielded columns of spent ion-exchange (IX) media which have captured Cs-137 from tank wastes. Activity levels of fully loaded IX media exceed what is currently authorized for disposal. There currently is no available disposal facility for HLW.

DOE's SRS began immobilizing its sludge tank waste by vitrification at DWPF in 1996. In 2006, DOE issued a final waste determination under section 3116 of the *National Defense Authorization Act for Fiscal Year (FY) 2005* (Public Law 108-375) to authorize separation and pretreatment (PT) of the low-activity fraction of liquid tank waste for disposal as LLW grout in on-site saltstone vaults.



Employees at the Savannah River Site monitor the first transfer of waste to the Salt Waste Processing Facility, Oct. 5, 2020.

In late 2020, in a strategy to dramatically increase the rate of salt waste processing, DOE began SWPF operations. SWPF takes supernatant and dissolved saltcake from SRS's tank farms and removes key radionuclides prior to the production of LLW grout for on-site disposal.

DOE recently amended its Record of Decision (ROD) on H-Canyon operations to expand the facility's mission.[6] The new mission, referred to as Accelerated Basin De-Inventory (ABD), will process all aluminum and non-aluminum SNF stored in L-Basin through 2033. Discards from H-Canyon (the Nation's only large-scale SNF reprocessing capability) would be transferred through 2034 to the H-Area tank farm for eventual immobilization in DWPF (see more information about ABD in Section VII).

Metrics Used to Track Tank Waste Progress

- Number of Canisters Poured
- Volume of Liquid Waste Processed
- Volume of Saltstone Produced (SRS only)
- Number of Tanks Emptied
- Number of Tanks Closed

The ICP has removed reprocessing waste from most waste tanks, converting the liquid into stable solids using a calcination process to reduce the risk of leaks into an underlying aquifer. Eleven of 15 underground waste tanks at INL are operationally closed – one tank is for emergency storage/backup. Currently, 4,400 cubic meters of calcine is stored in stainless steel bins within underground concrete vaults (referred to as binsets) that provide safe, long-term

[6] DOE-EM, *Spent Nuclear Fuel Management, Accelerated Basin De-Inventory Mission for H-Canyon, at the Savannah River Site, Amended Record of Decision*, 87 FR 23504, April 20, 2022.

storage pending future retrieval and treatment. In 2009, DOE issued a ROD selecting hot isostatic pressing (HIP) technology as the preferred approach to immobilize calcine for final disposal in a geologic repository. This approach is being re-visited based on a recent Analysis of Alternatives (AoA), and a final decision will be made within the next few years upon completion of updated NEPA documentation. In addition, ICP is planning to retrieve a portion of its calcine and transfer it to a newer binset. This will demonstrate the ability to retrieve calcine, determine retrieval rates and other parameters, and eventually close the first binset to eliminate risks to public health and safety.

Integrated Waste Treatment Unit (IWTU) operator Samantha Phillips maneuvers a crane at the facility at DOE's Idaho Cleanup Project while Trevor Clark, another IWTU operator, observes.

Hanford has the largest volume of liquid tank waste in the complex. Some tanks at Hanford are at or beyond their design life, and some are known to have leaked. To reduce risk of unintended release of radioactivity, Hanford has moved most of the liquid portion of the waste (the portion most prone to potential leaks) from single-shell tanks into higher-integrity double-shell tanks. At present, the risk to public and worker health and safety is minimal due to the active management of this tank waste and groundwater treatment to reduce risks of prior discharges and leaks.

The WTP is comprised of a group of processing and analytical buildings. While design is continuing for the HLW Facility, construction is complete for all WTP facilities necessary to support DFLAW and commissioning could be completed as early as December 2023.[7] Unlike SRS or any other similar facility, Hanford will produce a LAW glass authorized for on-site disposal. DOE is also considering an alternative to LAW glass through a supplemental LAW treatment approach for the volume of LAW that exceeds the design capacity of the LAW vitrification facility. In addition, DOE is evaluating various approaches to treat HLW. As noted in Table 3, up to 11 tanks in B- and T-Farms may not contain HLW. Within the next few years, DOE will decide

[7] A short video overview of the DFLAW process, *Direct-Feed Low-Activity Waste Animation* [Video], is available on the Hanford Site's YouTube channel at https://www.youtube.com/watch?v=H4FW7yGnmRY. Further DLFAW information is available on the Hanford website at https://www.hanford.gov/page.cfm/DFLAW.

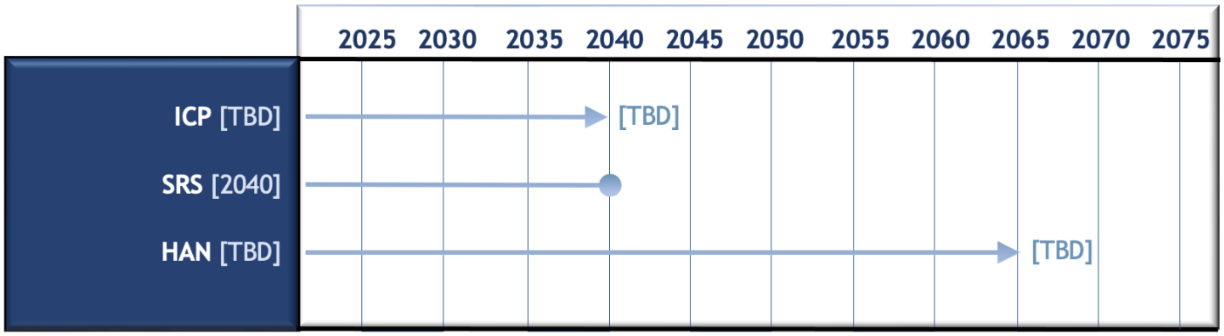
if waste produced from the bismuth phosphate process (BPP) is non-HLW. This may open up alternatives to retrieve and treat this waste and to consider its disposal in an existing facility. Earlier treatment of this non-HLW can reduce the risks of on-site storage in aging tanks and allow the BPP tanks to be closed sooner.

At the WVDP, vitrification of all HLW produced from commercial reprocessing activities at the site has been completed. In 2017, WVDP completed relocation of the HLW glass canisters into robust concrete casks on an on-site concrete storage pad. The casks were designed for long-term storage (at least 40 years), after which the contents are designed to be placed into Nuclear Regulatory Commission (NRC) certified transportation casks for shipment off-site.

Figure 5 is the overall timeline for the tank waste mission by site (WVDP is not included in the timeline as tank waste treatment is complete). The end dates represent the completion of all processing and packaging of waste, defined as immobilizing the high-activity fraction into HLW canisters and vitrifying and/or grouting the low-activity fraction for appropriate disposal. Key scope activities that contribute to this timeline include:

- ICP
  - Complete treatment of SBW (EM’s highest priority at the site) and close remaining liquid waste tanks
  - Initiate and complete treatment of calcine and place in safe storage and close binsets
- SRS
  - Complete immobilization of the high-activity fraction of liquid tank waste in a glass waste form (vitrification)
  - Complete stabilization of low-activity fraction of liquid tank waste in a grout form (immobilization) and on-site disposal
  - Support receipt of waste from H-Canyon operations within the Liquid Waste program
  - Close underground liquid waste tanks
- Hanford
  - Transition DFLAW facilities and systems from construction, commissioning, and readiness activities to begin low-activity tank waste treatment
  - Complete upgrades at the Liquid Effluent Retention Facility and Effluent Treatment Facility to support treatment of the anticipated secondary liquid effluent from DFLAW operations
  - Complete treatment and packaging operations for all tank waste.
  - Close all single-shell and double-shell tanks

Figure 5. Tank Waste Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Also, WVDP is not included in the timeline because vitrification has been completed and the only remaining activity is storage of canisters, pending disposal.

Spent Nuclear Fuel (SNF)

SNF has been generated at several DOE sites. Three DOE sites – INL, SRS, and Hanford – are the primary locations for managing, storing, and packaging up to 2,450 metric tons heavy metal (MTHM) of SNF. Except for SRS, which hosts the only large-scale SNF reprocessing capability in the Nation and a bench-scale facility to process a portion of sodium-bonded SNF at INL, there is presently no intent to chemically process the remaining inventory of SNF.

Idaho Nuclear Technology and Engineering Center workers transfer Experimental Breeder Reactor-II SNF from the Chemical Processing Plant-666 basin to a shipping cask.

All of EM's SNF is safely stored. Hanford SNF has been removed from wet basins near the deactivated reactors along the Columbia River and has been loaded into multi-container overpacks stored at the Canister Storage Building. EM's SNF at ICP has been removed from wet storage. A SNF repackaging facility will be constructed to package all dry fuel into standard canisters to await final disposition. The SNF at SRS is stored in the L-Basin. It is planned to be processed in the H-Canyon to the fullest extent possible, and the resulting waste will be sent to SRS's liquid waste tanks. Any remaining SNF after the H-Canyon mission is completed will be packaged for disposition. Table 4 provides details of the sources and amounts of SNF at the various sites.

Metrics Used to Track SNF Progress

- MTHM SNF Packaged

Table 4. SNF Inventory by Site

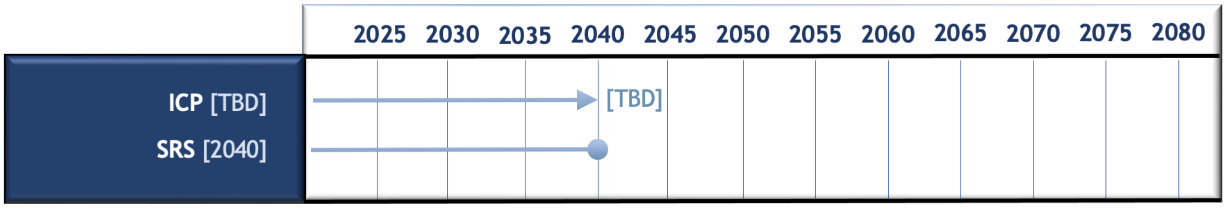
Site	Storage Facility	Primary Sources of Spent Nuclear Fuel (SNF)	Mass, (MTHM)	Volume, m3 Packaged/ Unpackaged
Hanford	Canister Storage Building, Interim Storage Area	Plutonium Production Reactors, Shippingport Pressurized Water Reactor Core Blanket, Fast Flux Test Facility, Commercial Power Reactors, LANL Molten Plutonium Experiment, TRIGA®	2,129.1	476.2 / 231.7
ICP	Chemical Processing Plant (CPP)-603, CPP-666, CPP-749, CPP-1774, CPP-2707, MFC, FSV	Three Mile Island Core Debris, Ft. St. Vrain, Foreign Research Reactors /Domestic Research Reactors, Shippingport Breeder core, Fermi-1 Breeder blanket, Peach Bottom core, commercial reactors, WVDP SNF, Loss of Fluid Test facilities, Advance Test Reactor, miscellaneous fuel types	271.7	987.3 / 558.2
SRS	L-Basin	Aluminum-clad Foreign Research Reactors/Domestic Research Reactors, test, other reactors, and non-aluminum-clad research, test reactors	29.2	304.5 / 58.8

Note: Mass and volume data are from the Department's SNF inventory database. SRS plans to process 29.2 MTHM of SNF, representing all SNF to be stored in L-Basin through 2033 (EIS-0279-SA-07, *Supplement Analysis for the Spent Nuclear Fuel Accelerated Basin De-Inventory Mission for H-Canyon at the Savannah River Site*).

Figure 6 shows completion timelines for the SNF mission by site. Completion end dates represent that spent fuel is stabilized and ready for disposal. Some activities that contribute to the timeline include:

- SRS
  - Complete accelerated de-inventory of SNF in L-Basin and processing in H-Canyon
- ICP
  - Construct and operate SNF packaging facility to support removal of all SNF from Idaho and Colorado

Figure 6. SNF Mission Area: Timeline of Remaining Work



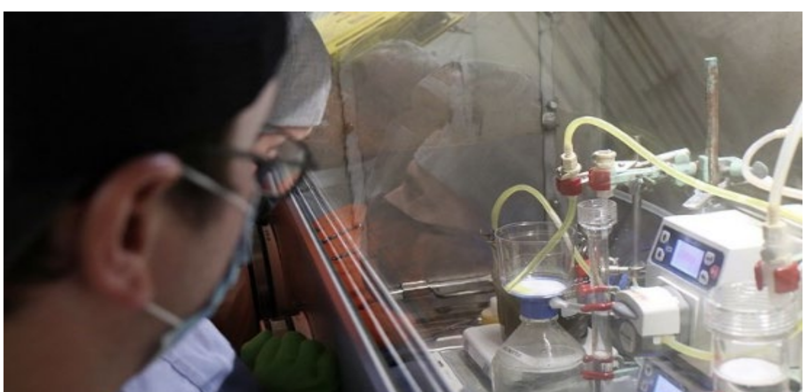
Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Hanford SNF mission milestones are not shown because all SNF at Hanford is safely stored in the Canister Storage Building or the Interim Storage Area. Hanford, SRS, and ICP ultimately will be removing SNF from storage for off-site disposition upon availability of a geologic repository or interim storage facility.

Nuclear Materials (NM)

Metrics Used to Track NM Progress

- Number of Containers of enriched Uranium packaged
- Metric tons of Uranium packaged
- Number of Containers of downblended Plutonium packaged
- Number of Material Access Areas (MAA) eliminated

In addition to SNF, DOE maintains an inventory of NM used for reactor fuel, nuclear weapons, isotope production, research and development, and other needs. The most common NM are uranium (U-233 and U-235) and plutonium (plutonium-238, plutonium-239, and higher isotopes), curium, and tritium. DOE sites continually solicit NM needs from federal, national laboratory, and other entities, and maintain this material for eventual use for commercial, national security, and other purposes. Any NM that does not have a specific purpose in support of national security, commercial, or other use is designated as excess. EM currently manages U-233 at ORR, and approximately 13 metric tons of impure surplus plutonium at SRS that is currently being downblended for disposition.

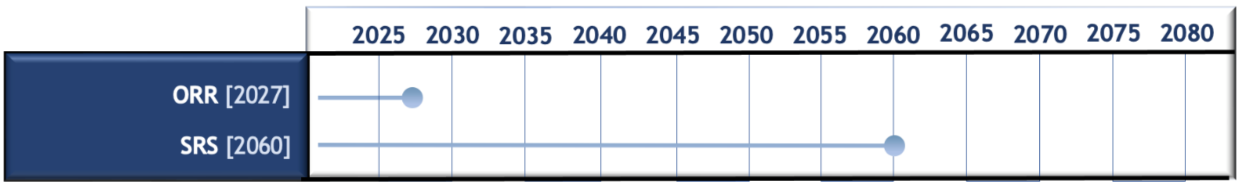


Specially trained fissile material handlers, use shielded gloveboxes to dissolve uranium (U-233) into a low-level form so it can be mixed with grout for safe transportation and disposal.

From a remaining cost standpoint, these programmatic elements combined represent less than six percent of EM's remaining life-cycle cost and six percent of EM's FY 2023 annual budget request. These costs do not include off-site transportation and disposal which will add to the full cost of Figure 7 shows completion timelines for the NM missions at ORR and SRS. Completion is defined as NM stabilized and ready for disposal. Some activities that contribute to the timeline include:

- ORR
    - Complete disposition of remaining inventory of U-233 stored at Oak Ridge National Laboratory (ORNL)
- SRS
    - Complete disposition of legacy NM stored in the L-Area and K-Area

Figure 7. NM Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

Transuranic (TRU) Waste

The WIPP facility, situated 26 miles southeast of Carlsbad, New Mexico, is the Nation's only deep geologic repository to safely and permanently dispose of defense-related TRU waste. TRU waste is radioactive waste containing more than 100 nanocuries (3,700 becquerels) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the EPA, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or (3) waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61. This waste is contaminated with radioactive and/or hazardous substances generated at DOE sites across the country from nuclear research and weapons production. At this DOE-owned site, TRU waste is being permanently emplaced 2,150 feet underground in an ancient salt formation.

Remaining Scope for TRU Disposition

- Continue WIPP operations, including infrastructure improvement projects
- Continue supporting legacy TRU shipments from five sites to WIPP for permanent disposal
- Support shipments and disposition for newly-generated TRU waste (includes waste from other programs/ sites and small-quantity generators)

A truck carrying a TRU waste shipment approaches EM's Waste Isolation Pilot Plant.

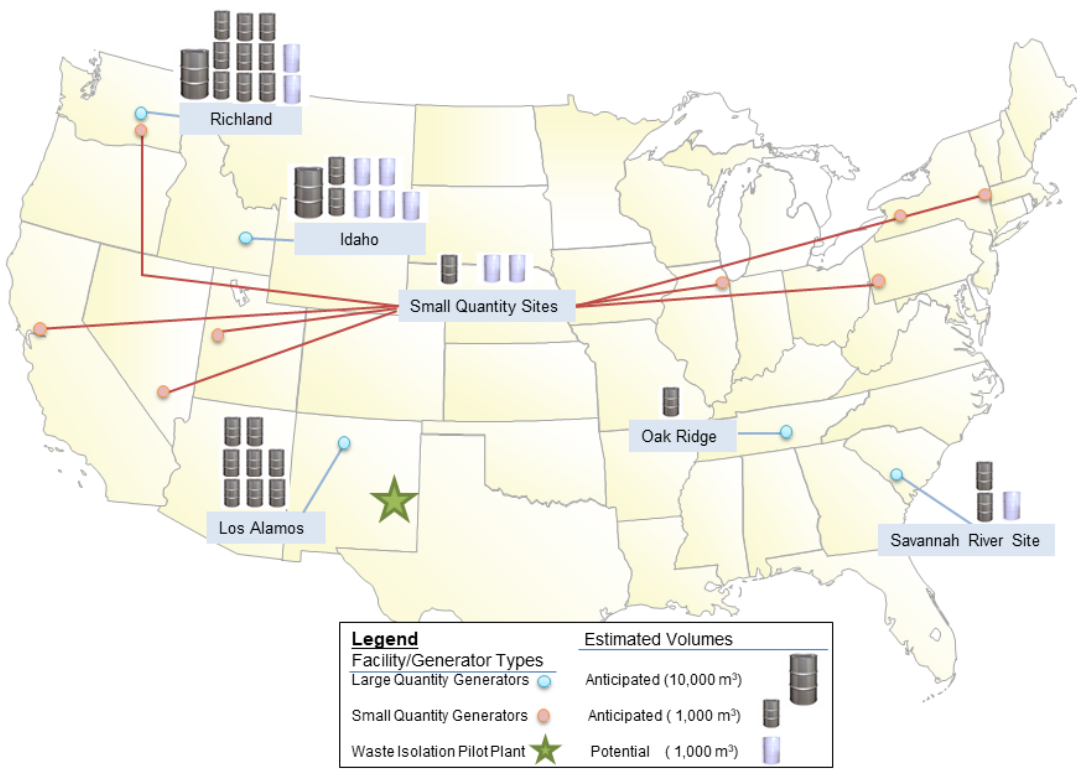
DOE's Carlsbad Field Office oversees the operation of WIPP and the National TRU Program (NTP). The NTP was established by EM to oversee the process of preparing TRU waste from DOE waste generator sites to meet WIPP acceptance criteria, providing guidance and requirements for receiving the waste at the facility. This process involves the characterization and packaging of the waste at the generator sites followed by the transportation of the waste to the WIPP facility for disposal. TRU waste disposed at WIPP includes legacy waste left over from the Cold War, as well as waste generated from ongoing operations from other programs (e.g., "newly generated" waste from the DOE Office of Science [SC] or NNSA facilities). Certified by the EPA and regulated by the State of New Mexico, WIPP enables DOE sites to dispose of their defense TRU waste in support of both EM cleanup and other DOE program missions.

A shipment of TRU waste arrives at WIPP.

As of 2020, EM has removed and/or disposed of TRU waste from 15 DOE sites with 19 TRU waste generator sites still active. Many of these are small quantity generator sites (such as for ongoing "newly generated" waste from operations). Disposition of legacy TRU at SRS was recently completed, leaving only Hanford, ICP, LANL, and ORR with any significant quantities of legacy TRU to disposition. Disposition of legacy TRU from LANL is an EM priority. ICP is currently the largest generator of TRU, coming from buried waste exhumation activities, and is expected to be done by 2028. Disposition of TRU generated from future cleanup or operations will take longer to complete with NNSA operations, to include accelerating pit production operations at LANL and SRS, ultimately becoming the largest generator.

Figure 8 depicts the anticipated and potential volumes of CH-TRU and RH-TRU waste based on estimates provided in *Annual Transuranic Waste Inventory Report – 2021* (DOE/TRU-21-3425, Revision 0). Waste generators including large quantity generators (i.e., Hanford, ICP, LANL, ORR, and SRS) are shown in Figure 8. In addition, small quantity generator sites are located across the U.S., and the total inventory for all these sites are collectively shown. The waste volumes depicted by the black drums represent estimates of anticipated TRU waste. Anticipated volume estimates reflect those defense-related TRU wastes that are either packaged and stored on-site or are projected to be generated through 2033. Potential TRU waste volume estimates, represented as white drums, include those volumes projected to be generated after 2033, and are used as a planning basis for future TRU waste storage and disposal needs. DOE updates TRU waste inventories using a robust tracking and reporting procedure and policy, annually producing an inventory report.

Figure 8. Anticipated and Potential Volumes of TRU Waste



Note: The information shown in the map is based on Annual Transuranic Waste Inventory Report – 2021, DOE/TRU-21-3425. Revision 0.

Metrics Used to Track TRU Waste Progress

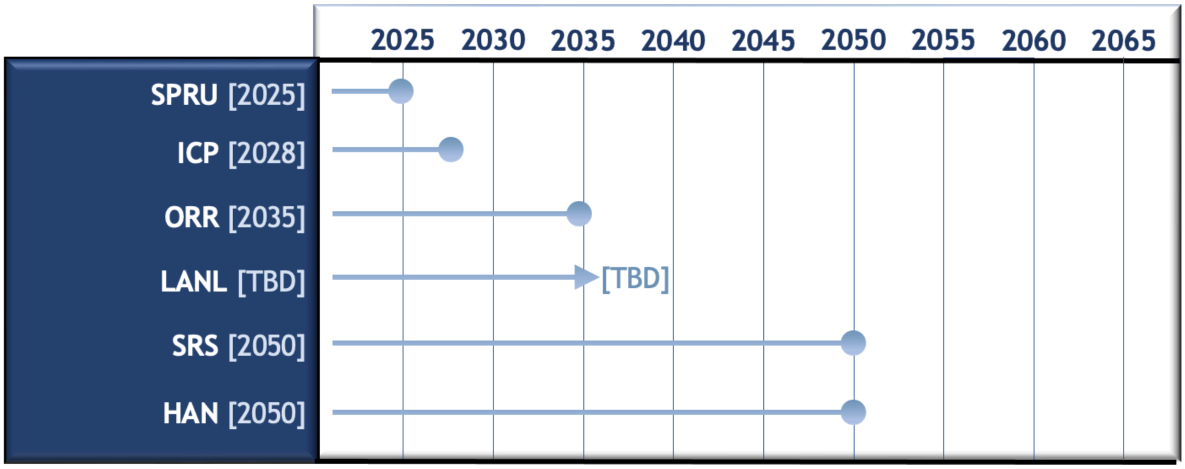
- Number of shipments per week to WIPP
- Volumes of TRU waste fully characterized and certified for disposal (CH and RH)
- Number of packages that are road-ready awaiting shipment

WIPP is in the process of completing multiple infrastructure improvement projects that will lead to increased safety and more efficient waste handling operations, thereby helping to increase the waste emplacement volume over the next decade. DOE is proposing to excavate and use two emplacement panels to replace capacity lost due to operational issues, staying within the current *WIPP Land Withdrawal Act of 1992* (LWA) limits. If approved, these replacement panels would allow WIPP to operate through 2033.

See Figure 9 for timelines by site for the TRU waste mission. Activities that contribute to the timelines include:

- LANL
  - Process and dispose of above ground TRU waste
  - Remove excavatable legacy TRU from material disposal areas (MDAs) and dispose at WIPP
  - Complete disposition of TRU waste currently at the Waste Control Specialists commercial disposal site in Texas
- ICP
  - Annually certify at least 25 percent of the remaining TRU waste until completed
  - Annually ship at least 55 percent of waste receivable by WIPP from ICP until completed
  - RCRA closure of TRU processing and storage facilities
- ORR
  - Complete the final design and construction of the Sludge Processing Facility
  - Process, repackage, and ship all TRU waste for permanent disposal at WIPP
- SRS
  - Continue to down-blend and disposition surplus plutonium in the K-Area, producing TRU waste that will eventually be disposed at WIPP; the first waste shipment expected in 2022
- Hanford
  - Resume TRU retrievals for retrievably stored TRU waste, obtain required processing capabilities to address all TRU waste streams, and complete TRU waste disposition
- SPRU
  - Dispose of the remaining TRU waste at WIPP

Figure 9. TRU Waste Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions (e.g., LANL MDAs). WVDP is responsible for disposition of a significant volume of waste with concentrations of TRU isotopes exceeding 100 nCi/g. However, as this waste was not generated as a result of atomic defense activities, WVDP does not have a TRU waste disposition mission. Instead, this waste is identified as MLLW/LLW and other wastes.

Depleted Uranium (DU)

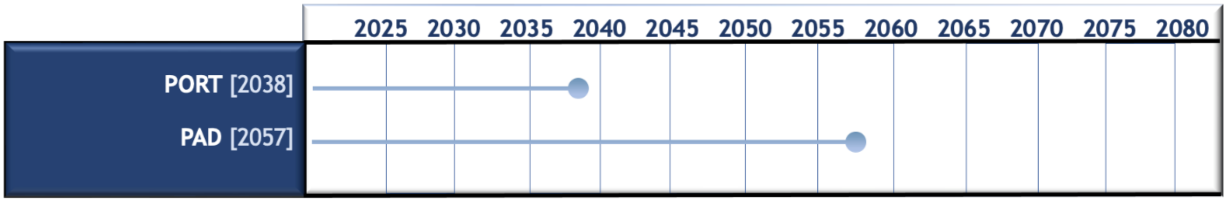
Metrics Used to Track DU Progress

- DUF6 Metric Tons Converted

In Kentucky and Ohio, EM has a significant inventory of DUF6, a coproduct of the uranium enrichment process that operated at the Paducah and Portsmouth sites, as well as the gaseous diffusion plant in Oak Ridge, TN. EM operates processing facilities at both sites to convert the stored DUF6 into depleted uranium oxide, a more stable chemical form that can be disposed of, reused, or stored. A coproduct of the conversion process is hydrogen fluoride, which is reused industrially. There are approximately 800,000 metric tons of DUF6 at the two sites. The Portsmouth DUF6 inventory is expected to be processed in the next two decades, while Paducah's larger inventory will take over 30 years to disposition.

Figure 10 shows completion timelines for DU missions at Portsmouth and Paducah. End dates reflect completion of all DUF6 conversion operations and packaging of stable oxides and hydrogen fluoride for reuse or disposal.

Figure 10. DU Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

Low-Level Waste, Mixed Low-Level, and Other (LLW/MLLW/Other) Wastes

Remaining Scope for LLW/MLLW/Other Waste

- Continue LLW/MLLW legacy waste disposal at 11 active cleanup sites
- Continue supporting remediation and D&D activities until site missions are complete at multiple sites

The waste inventories discussed in this section include waste generated mainly from ongoing soils and groundwater remediation, facility D&D, and other cleanup activities. Excluded in this discussion are waste streams and inventories already covered above, consistent with how DOE defines LLW as any radioactive waste that is not SNF, HLW, or TRU. LLW is considered MLLW if it also contains a hazardous waste component regulated under RCRA. DOE radioactive waste is regulated by DOE. The cleanup of radioactive waste is also regulated by EPA under CERCLA. Hazardous components of mixed radioactive and hazardous wastes are regulated by either the EPA under RCRA or by States having RCRA authority and regulating under their State hazardous waste laws.

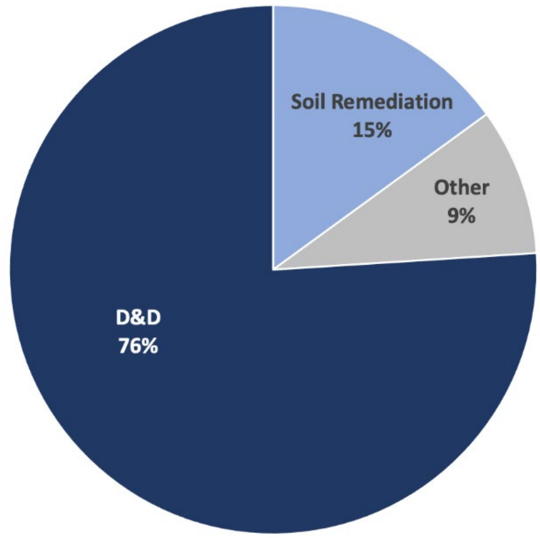
Metrics Used to Track LLW/MLLW Waste Progress

- Number of cubic meters LLW and MLLW disposed

Pre-EM legacy LLW/MLLW have effectively been eliminated over the last 30 years with most future waste volumes to be dispositioned continuing to come from D&D of facilities that managed radioactive materials and ongoing soils remediation (see Figure 11). Much of this waste is solid radioactively contaminated waste which can include equipment and building debris, broken reactor equipment and tools, piles or containers of soils, and contaminated clothing that workers wear during cleanup activities.

Unlike some other waste types, DOE maintains extensive infrastructure to support LLW disposal as well as disposition of MLLW. In addition to on-site DOE disposal facilities, disposition options exist at non-DOE (commercial) facilities that provide DOE with additional disposal options. Cleanup of sites and D&D of facilities cannot proceed efficiently without access to disposal facilities. DOE's current policy is to dispose of LLW and MLLW waste on-site, if practical. When on-site disposal is not available, disposal at another DOE facility is preferred, or waste can be disposed of at a licensed commercial facility if effective and in the best interest of the government.

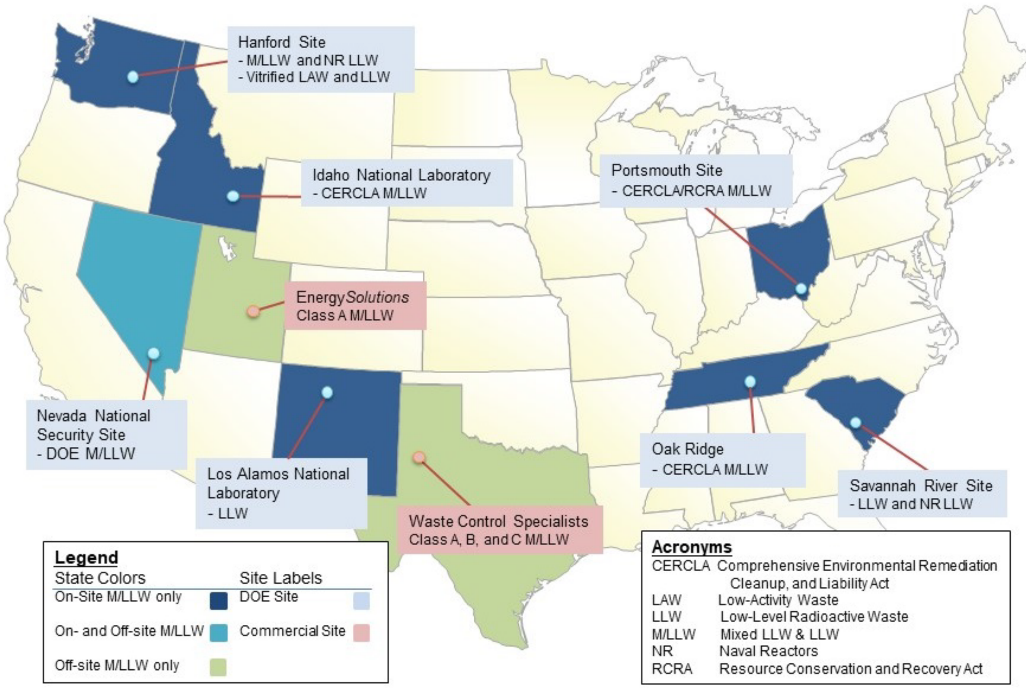
Figure 11. Projected Volume of EM MLLW/LLW



The AEA authorizes DOE to regulate its nuclear safety and radioactive waste management program which it does through DOE internal directives called Orders. In addition to various DOE Orders, DOE has an LLW Disposal Facility Federal Review Group that evaluates the design, operation, and closure suitability of LLW disposal facilities through compliance with DOE Order 435.1, *Radioactive Waste Management*, LLW disposal requirements. The LLW Disposal Facility Federal Review Group supports DOE's regulation of LLW disposal and evaluates the adequacy of documents prepared under CERCLA regulations to meet LLW disposal requirements. Currently, DOE operates such facilities at ORR, SRS, ICP, Hanford, NNSS, LANL, and Portsmouth (see Figure 12). Decisions on potential on-site waste disposal facilities at ORR and Paducah will be needed to support cleanup at those sites.

Crews placing containers of waste into the Radioactive Waste Management Complex at NNSA.

Figure 12. Locations of LLW/MLLW Disposal Facilities



EM strives to maintain disposition options for cleanup sites. Multiple options promote competition and best value pricing to DOE. It is important for EM cleanup operations that commercial disposal sites maintain viability. Operations of DOE disposal facilities and use of commercial disposal facilities require regular coordination with local communities, Tribal Nations, regulators, and other stakeholders. Interactions differ among disposal sites depending upon regulatory roles.

EM manages other waste streams, sometimes referred to as "orphan" waste, that do not currently have a clear disposal pathway. DOE is also responsible for the disposition of an estimated 11,600 cubic meters of commercially generated and DOE waste that either exceeds radioactivity limits for near-surface disposal and/or is ineligible for disposal in WIPP. This waste (much of which is located at WVDP) is collectively known as Greater-Than-Class C (GTCC) and GTCC-like waste. DOE issued NEPA analyses[8] identifying disposition options for this waste and will make a decision subsequent to pending congressional action.

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[8] The NEPA analyses are the *Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (DOE/EIS–0375), and the *Environmental Assessment for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste at Waste Control Specialists, Andrews County, Texas* (DOE/EA-2082).

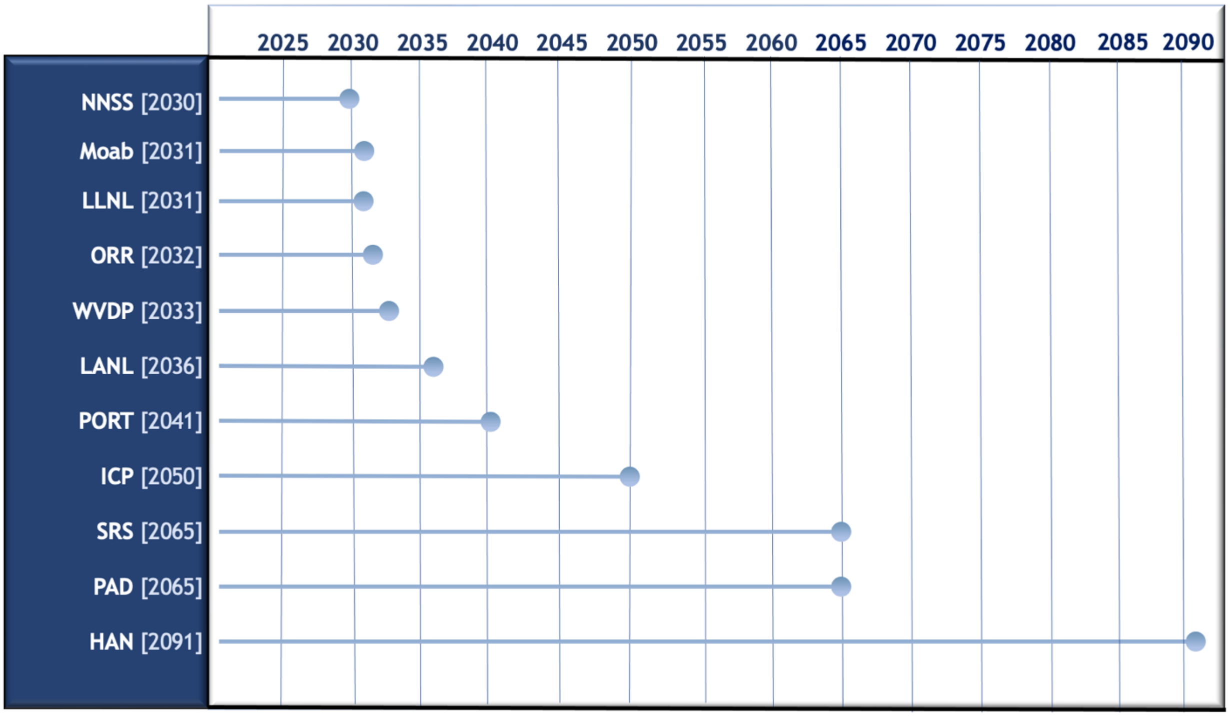
Disposition of LLW/MLLW will typically be one of the last remaining activities pending transition of a site to LTSM as these wastes are generated in significant quantities during final facility D&D and soils remediation.

Figure 13 shows completion timelines for LLW/MLLW/Other Wastes missions by site. End dates reflect completion of disposal activities, including operations of EM on-site disposal facilities. Notable activities that contribute to the timelines include:

- Portsmouth and Paducah
  - Disposition of conversion products and unused cylinders after DUF6 processing
  - Expansion of On-site Waste Disposal Facility (OSWDF) at Portsmouth
  - Complete disposition of LLW and debris from D&D activities
- SRS
  - Complete operations at Saltstone Disposal Facility in the Z Area, including construction of new Saltstone Disposal Units
- ORR
  - Complete final ROD for proposed EM Disposal Facility (EMDF)
  - Dispose of LLW and debris from Y-12 and ORNL cleanup
- Hanford
  - Begin operations at Integrated Disposal Facility
- Moab
  - Complete relocation of all mill tailings to Crescent Junction, CO
- WVDP
  - Complete disposition of GTCC/GTCC-like waste

Hanford's Integrated Disposal Facility, an engineered disposal site designed to receive immobilized low-activity waste from the WTP and MLLW from Hanford Site operations

Figure 13. LLW/MLLW/Other Wastes Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Also, the current estimated end date for the completion of the EM mission at NNSS is 2030; however, it is anticipated there will continue to be a need for disposal at NNSS after 2030.

Soils and Groundwater (S&GW)

Remediation of contaminated soils and groundwater has been ongoing at DOE sites for over three decades. Over the next decade or so, it is expected that additional sites with active soils and groundwater cleanup will be transitioning from active remediation to LTSM. Several other sites are still completing alternatives studies and selecting remedies or are in the process of final design and implementation. While contamination has been contained within site boundaries at these sites, effectively controlling pathways, exposures, and risks to the public, final site closures are more complex and will take longer to accomplish.

Cleanup of residual contamination at the remaining sites is typically challenging, complicated by geologic, hydrologic, and chemical complexities. Additionally, DOE is tracking developments on emerging contaminants, also commonly referred to as "contaminants of emerging concern", which can lead to additional mitigation and remediation requirements at affected sites. It is also important to recognize that one of the keys to successfully completing site closure where final soil and groundwater cleanup is typically the last step, is addressing regulatory, stakeholder, environmental justice, legal, or other related issues.

The first excavation of soil got underway in summer 2021 to remove sources of potential groundwater contamination and provide fill dirt for the On-Site Waste Disposal Facility at the Portsmouth Site.

While addressing these issues may be challenging, EM recently launched a multi-phased initiative to develop a more defined and comprehensive closure strategy. The goals of this effort are to identify applied scienced-based strategies for application at the remaining complex sites; to provide guidance that can be used to expedite cleanup of contaminated soil; to provide more effective metrics to track cleanup progress; and to develop a plan to shrink the remaining cleanup footprint significantly over the next decade. One focus of this activity will be to provide technical and regulatory strategies to transition existing cleanup of DOE's complex groundwater plumes to the next phase of remediation, i.e., active remediation, enhanced attenuation, and/or monitored natural attenuation for eventual transfer to LTSM.

One example of technology development is the Advanced Long-Term Environmental Monitoring Systems project led by Savannah River National Laboratory, which focuses on sites that will likely require an extended period of institutional controls. The project seeks to develop a system that will address issues with plume movement and contaminant sequestration, and to establish a new paradigm of long-term monitoring based on state-of-the-art technologies – in situ groundwater sensors, geophysics, drone and/or satellite-based remote sensing, reactive transport modeling, and artificial intelligence – that will improve effectiveness and robustness, while reducing overall cost. If successful, this system could transform the monitoring paradigm from reactive monitoring (response after plume anomalies are detected) to proactive monitoring (detecting changes in plume mobility before anomalies occur).

As site soils and groundwater cleanup progresses, planning for LTSM is integrated into site program plans. In recognition of the need for smooth transition to LTSM, DOE established in early 2021 a cross-program team, the National Long-Term Stewardship Working Group, which collaborates on high priority topics of interest, aligns strategies, shares lessons learned, leverages contacts, and makes recommendations to resolve LTSM issues. The Long-Term

Stewardship Working Group also fosters communication across DOE offices and with other federal agencies, local communities, Tribal Nations, regulators, and other stakeholders.[9]

A Savannah River Site project team inspects a pump-and-treat groundwater treatment system.

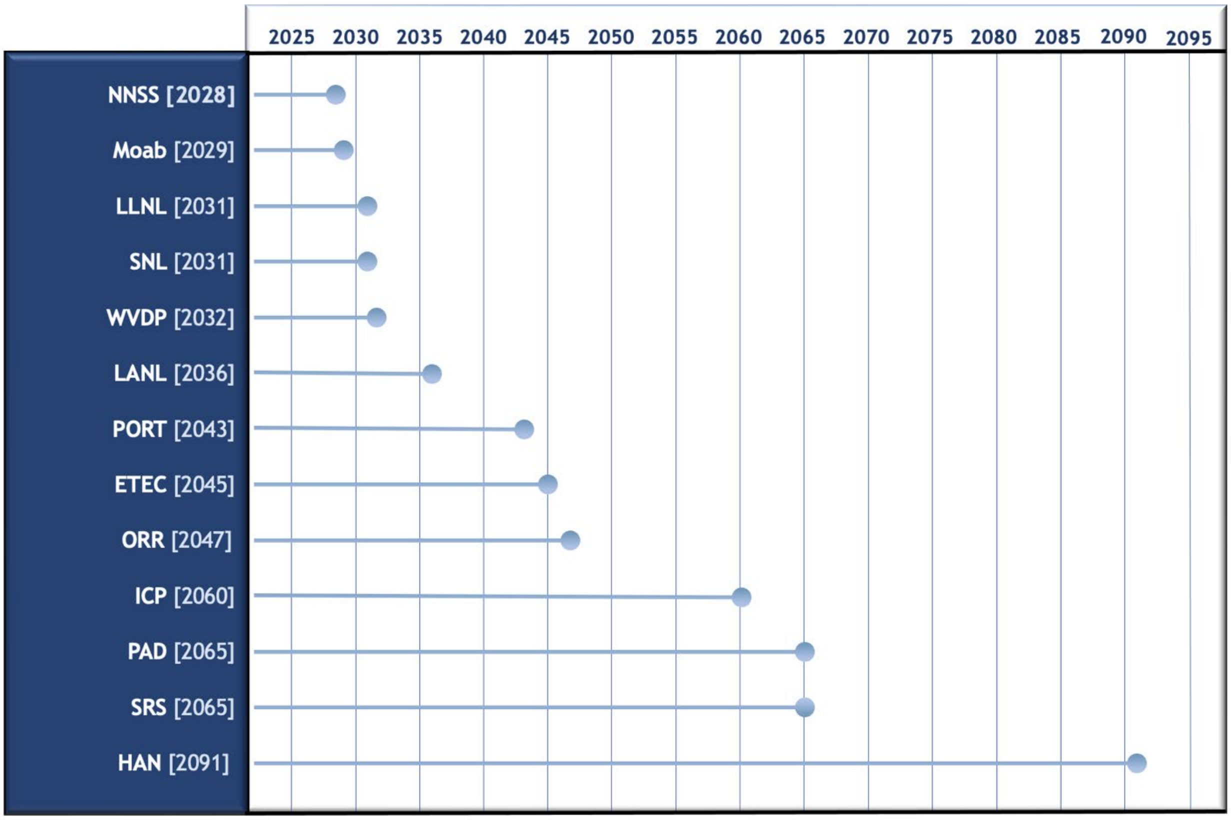
Figure 14 presents the timelines for completion of the S&GW missions at each site. End dates reflect completion of cleanup activities and transition to LTSM. Notable activities that contribute to the timelines include:

- SRS
  - Complete coal ash remediation in A-Area, K-Area, and L-Area
- ETEC
  - Complete groundwater remediation
- Hanford
  - Remediation of waste sites and burial grounds in Central Plateau and River Corridor
  - Remediation surrounding B-Plant, PUREX, REDOX, U-Plant and T-Plant canyons
  - Complete soils and groundwater remediation
- ICP
  - Complete exhumation and off-site disposal of buried wastes from the Subsurface Disposal Area and cap to prevent water infiltration and contaminant migration
  - Cap tank farm after tanks are emptied and grouted
- LANL
  - Remediate Royal Demolition Explosives (RDX) and hexavalent chromium groundwater plumes
  - Complete cleanup of aggregate areas and MDAs per Consent Order
- ORR
  - Address residual mercury at Y-12 by remobilizing and transporting it to the Outfall 200 Mercury Treatment Facility
  - Complete treatment of groundwater at ETTP
- Portsmouth and Paducah
  - Remediate trichloroethylene and other contaminants in soils and groundwater

[9] Additional information regarding LTSM (sometimes referred to as long-term stewardship), is available at the Office of Legacy Management's "Long-Term Stewardship Resource Center" web site, https://www.energy.gov/lm/long-term-stewardship-resource-center.

- WVDP
    - Complete Phase 2 cleanup, including four underground waste tanks, two on-site disposal areas, and the non-source area of the groundwater plume

Figure 14. Soils and Groundwater Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

Excess Facilities Deactivation & Decommissioning (D&D)

Excess facilities are deactivated and decommissioned and then either demolished (with resulting waste being disposed of) or transferred to another DOE Office or a community reuse organization. D&D is typically completed under CERCLA as a "non-time critical" removal action. EM is responsible for D&D of its excess facilities, as well as the D&D of excess facilities transferred to EM from another DOE Program Office.

In January 2015, DOE established the Excess Contaminated Facilities Working Group to analyze and develop options for how DOE may prioritize and address D&D of excess facilities across the complex. The initial analysis was documented in the *Plan for Deactivation and Decommissioning of Nonoperational Defense Nuclear Facilities, Report to Congress* (issued in December 2016). Updates to the analysis were issued in 2018, 2020 and 2022.

Table 5 shows that the Department's 1,077 excess facilities had a rough order of magnitude (ROM) cost estimate for D&D of $14.7B. The risk posed by excess facilities is determined using a qualitative approach that considers potential impacts to public health and the environment, worker safety, and the DOE mission. DOE identified 206 out of the total excess facilities as higher risk with a ROM cost estimate for D&D of $12.1B. This D&D ROM cost estimate for the higher risk facilities represents 82 percent of the total excess facility D&D cost, while only comprising 16 percent of the total number of facilities. A significant portion of the D&D program costs are driven by this small set of higher risk facilities.

Workers are in the final stages of removing the Biology Complex slab at the Y-12 National Security Complex. This makes available the complex's 18-acre footprint for use by the NNSA to support national security missions.

Table 5. Summary of Inventory of Excess Facilities as of November 2021

Program	Total Excess Facilities		Higher Risk Facilities	
	# Facilities	ROM Cost ($B)	# Facilities	ROM Cost ($B)
EM	709	$11.8	149	$9.7
NNSA, SC, NE	368	$2.9	57	$2.4
TOTALS	1,077	$14.7	206	$12.1

Deactivation and decommissioning activities enable facilities to be placed in a low-risk state with minimum surveillance and maintenance requirements. EM maintains excess facilities in a stable condition prior to D&D.[10] Therefore, the sooner D&D is completed, the lower the expenses to maintain the excess facilities

[10] Until EM accepts operational responsibility for an excess contaminated facility, the DOE Program Office responsible for the facility must maintain that facility in a safe condition and prepare it for transition to EM.

To prepare for additional facilities being addressed by EM, a new nationwide Deactivation, Decommissioning & Removal (DD&R) Indefinite Delivery/Indefinite Quantity Contract was awarded to perform DD&R of facilities, waste management, and program support. The contract provides support at various locations across the U.S. in support of EM, NNSA, Office of Naval Reactors (NR), SC, as well as other DOE Offices that may request EM assistance in accomplishing their DD&R requirements.

Metrics Used to Track D&D Progress

- Number of industrial facilities demolished
- Number of radiological facilities demolished
- Number of nuclear facilities demolished
- Footprint reduction (sq ft)

A New Collaborative Approach to D&D

EM and NNSA developed a tailored contracting strategy to facilitate the D&D of three facilities at LLNL (Buildings 280, 251, and 175) allowing LLNL to accelerate completion of Building 280 and its ancillary facilities.

U.S. DOE, *"Plan for Deactivation and Decommissioning of Nonoperational Defense Nuclear Facilities, Report to Congress,"* October 2020.

EM and NNSA are developing a new approach to focus on facility risk reduction, stabilization, and D&D in preparation of EM executing demolition. Under this approach, significant deactivation and stabilization is completed by the Program Office (NNSA) in collaboration with EM, then EM performs the final D&D with funds specifically appropriated by Congress for that purpose.

D&D Scope over the Next Decade

In addition to the facilities designated as excess as of November 2021, DOE anticipates designating approximately 719 additional facilities as excess in the next 10 years.,

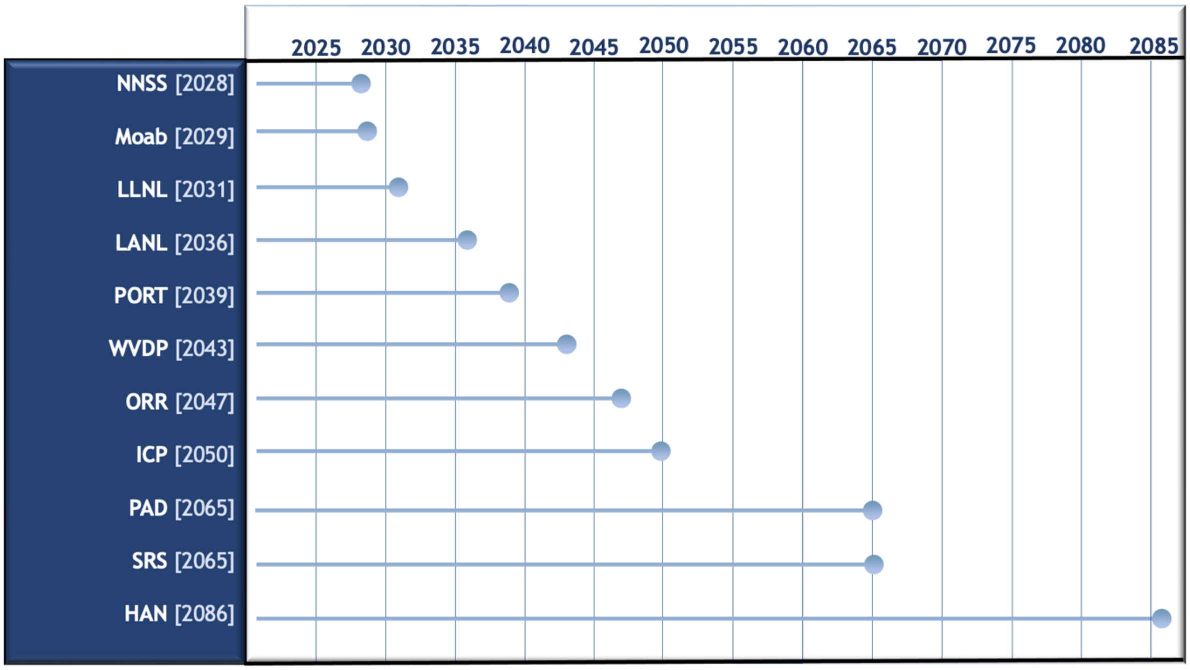
D&D programs will ramp up to provide for remediation of approximately 100 legacy waste units and D&D of over 800 industrial, nuclear, and radioactive facilities. In addition to the increase in remediation and D&D activities, EM will continue to manage the aging infrastructure at its respective sites to ensure minimal impacts to mission critical facilities. EM will continue to perform similar work for other DOE programs (such as NR) which are funded under different (non-EM) appropriations.

Figure 15 presents timelines for completion of D&D missions at each site. Notable activities that contribute to the timelines include:

- LANL
    - D&D of the TA-54 structures and subsequent closure of MDA G and MDA L
    - D&D of excess facilities, including the Ion Beam facility.
- Portsmouth and Paducah
    - Complete D&D of the former uranium enrichment process buildings
- WVDP
    - Pending Phase 2 decisions, complete remaining decommissioning activities
- ORR
    - At ORNL, demolition of East Bank Hot Cell, Bulk Shielding Reactor and Low Intensity Test Reactor, Building 3038 and Isotope Row facilities, Oak Ridge Research Reactor
    - Deactivate Alpha-2, Beta-1, the Old Steam Plant, the Criticality Experiment Lab at Y-12
- ICP
    - D&D of Advanced Mixed Waste Treatment and Subsurface Disposal facilities
- Hanford
    - Complete demolition of facilities in the River Corridor and Central Plateau such as K West Fuel Storage Basin, former plutonium processing facilities, and Fast Flux Test Facility
    - Complete disposition of reactors following interim safe storage
- NNSS
    - Complete demolition of Test Cell C and Engine Maintenance Assembly and Disassembly buildings to grade
- SRS
    - Complete D&D of non-operational nuclear material facilities (e.g., F-Canyon/FB-Line, H-Canyon/HB-Line)

Building upon the lessons learned from recent D&D successes, EM is proactively looking at the number of excess contaminated facilities that will be coming into the program and factoring resource estimates (personnel, contracting, etc.) for priority facilities into planning. EM will continue to explore all opportunities to accelerate cleanup including strategies to minimize D&D costs, increased use of robotics, and alternative waste disposition paths. Integration of facility D&D with soil and groundwater cleanup as a part of "Area Closure" or facility modernization actions will result in a more effective D&D program with opportunities for accelerated site closure.

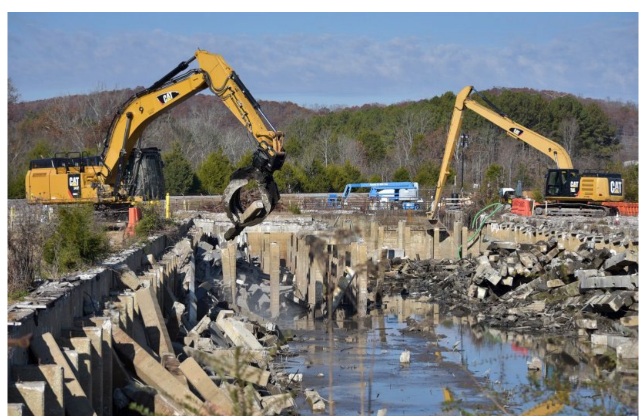
Figure 15. D&D Mission Area: Timeline of Remaining Work



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Also, although D&D activities will be required at WIPP following closure of the repository, WIPP is not included in this figure because it is not a cleanup site.

Summary of Remaining Cleanup Scope

Although several mission areas for cleanup work remain, EM is poised to complete significant work within each of the next several decades. Figure 16 shows the end dates and remaining estimated costs and schedules, by mission area, for the largest sites (i.e., the sites that comprise more than 95 percent of the remaining costs of each of the mission areas). The circles in the figure are positioned in the year in which each site's mission area scope is expected to be completed with the sizes of circles proportional to the remaining cost. Figure 16 highlights completions over the coming decades:

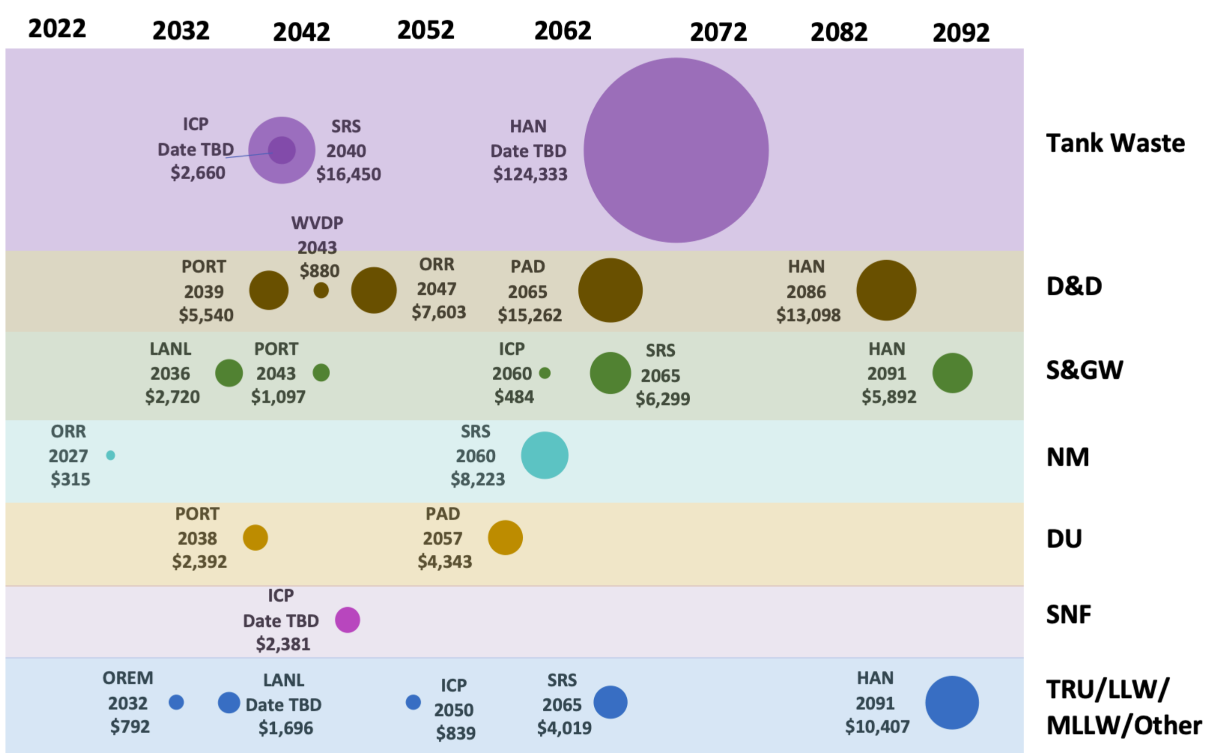


Crews removed concrete subsurface structures of the K-832 basin at Oak Ridge in 2019 and pumped nearly 2 million gallons of water from the basin before beginning demolitions.

- In the next 10 years, cleanup at Moab and NNSS will be complete; ORR will also be completed with NM disposition.

- In the next 10 to 20 years, Portsmouth will complete its D&D and DU activities; and SRS will complete its liquid tank waste program.
- In the next 20 to 30 years, WVDP will complete its D&D activities; ICP will complete its liquid tank waste program, packaging of calcine waste for off-site disposal, and SNF activities; and ORR will complete its D&D activities; and Paducah will convert its DUF6.
- After 2050, the focus will be on three sites:
    - Hanford – liquid tank waste, remediation of soil and groundwater, and facilities D&D.
    - SRS – facilities D&D and soil and groundwater remediation.
    - Paducah – disposition of the DUF6 conversion waste/by-products, soil and groundwater, and facilities D&D.

Figure 16. Timeline and Remaining Cost for the Largest Sites within Each Mission Area ($M Constant 2022 Dollars/Unescalated Dollars)



Note: Dates and estimated remaining costs shown in the figure are based on individual site planning and funding assumptions, as well as site-specific regulatory frameworks. Also, SNF costs are not shown above for SRS or Hanford. At SRS, NM and SNF operations share facilities and are managed as an integrated system, so SNF costs are captured under NM. At Hanford, only safe storage remains for SNF, and such costs are accounted for in other programs (e.g., the safeguards and security program).

V. EM Program Sites

The following section provides brief summaries on the EM Program Sites, outlining remaining scope, costs and schedules, and end state reflecting site conditions upon EM mission completion.[11] End states and completion dates reflect anticipated conditions and timing associated with transfer of responsibility from EM to either the site program, DOE LM, or the community. For more detailed Site information, including milestones and remaining decisions, refer to Appendix A, Site Summaries.

Energy Technology Engineering Center (ETEC)

The ETEC is located on the Santa Susana Field Laboratory in Ventura County, California. EM's remaining scope at ETEC includes groundwater remediation which is expected to be complete by 2045 with a remaining cost of $341 million. The end state for ETEC is an open space. Boeing owns the land on which ETEC sits and has a conservation easement for the property that prohibits development for residential, commercial, industrial, or agricultural purposes which will continue in perpetuity after cleanup is completed. Responsibility for continued groundwater monitoring will transfer to LM.

Hanford

The Hanford site in southeast Washington is managed by two DOE offices – the Richland Operations Office (RL) and the Office of River Protection (ORP). EM's remaining scope at Hanford includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of TRU waste, LLW/MLLW, SNF, and tank waste. EM's mission at Hanford is expected to be complete between 2078 and 2091. Remaining costs for RL are estimated to be between $101 and $110 billion, and remaining costs for ORP are estimated to be between $210 and $395 billion. The end state for Hanford involves conservation and preservation uses in much of the area surrounding the Central Plateau, and industrial use in the Central Plateau and portions of the River Corridor. Additionally, DOE will continue to own and operate the Hanford Unit of the Manhattan Project National

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[11] Costs and schedules reflect current plans and could be affected by regulatory decisions.

Historical Park, with the National Park Service providing interpretation and some visitor services. long-term stewardship (LTS) activities will be managed by LM.

Idaho Cleanup Project (ICP)

The Idaho Cleanup Project (ICP) at the INL Site is in southeast Idaho. EM's remaining scope at ICP includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of TRU waste, LLW/MLLW, SNF, and tank waste (including binsets). EM's mission at ICP is expected to be complete between 2049 and 2060, with remaining costs estimated to be between $7.7 and $11 billion. INL will remain a Nuclear Energy site. After closure of the Radioactive Waste Management Complex and Idaho Nuclear Technology and Engineering Center facilities, the area will continue to be monitored and assessed for any further needed remediation as part of DOE's LTS.

Lawrence Livermore National Laboratory (LLNL)

LLNL is located in Livermore, California. EM's remaining scope at LLNL includes soil and groundwater remediation, and completion of D&D activities. EM's legacy mission at LLNL is expected to be complete in 2031, with remaining costs estimated to be between $142 and $186 million. The site will remain an NNSA Site. Operations and maintenance (O&M) of implemented soil and groundwater remedies will be transferred to NNSA.

Los Alamos National Laboratory (LANL)

LANL is in Los Alamos, New Mexico. EM's remaining scope at LANL includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of TRU waste and LLW/MLLW. EM's mission at LANL is expected to be complete by 2036, with remaining costs estimated to be between $5.7 and $6.8 billion. The end state for LANL involves the completion of legacy waste cleanup to environmental standards or stabilization that is protective of the public and environment. LTS activities will be managed by the site program, NNSA.

Moab

The Moab UMTRA Project is in southeastern Utah. EM's remaining scope at Moab includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of LLW/MLLW. EM's mission at Moab is expected to be complete between 2029 and 2033, with remaining costs estimated to be between $409 and $417 million. The end state for Moab is recreational use. The Moab site, including the former uranium milling site and the Crescent Junction Disposal Site, will be transitioned to LM for LTSM.

Nevada National Security Site (NNSS)

NNSS is in southern Nevada. EM's remaining scope at NNSS includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of LLW/MLLW. EM's mission at NNSS is expected to be complete by 2030, with remaining costs estimated to be between $487 and $610 million. Long-term monitoring of closed corrective action sites will transition to NNSA as part of DOE's LTS. NNSS is anticipated to continue operation receiving DOE waste for storage/disposal with EM's support.

Oak Ridge Reservation (ORR)

ORR is in eastern Tennessee and is made up of three sites — K-25 (present day ETTP), X-10 (present day ORNL), and Y-12. EM's remaining scope at ORR includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of TRU waste, LLW/MLLW, and NM; and disposition of DOE-SC High Flux Isotope Reactor SNF. EM's mission at ORR is expected to be complete by 2047. Remaining costs for ORR are estimated to be around $12 billion. Some cleanup areas at ORR will be retained to perform national security missions. ETTP will be transitioned into a multiuse industrial park; ORNL and Y-12 areas will continue to be managed by their respective programs.

Paducah Gaseous Diffusion Plant (Paducah)

Paducah is located in western Kentucky. EM's remaining scope at Paducah includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of LLW/MLLW and DU. EM's mission at Paducah is expected to be complete between 2065 and 2070. Remaining costs for Paducah are estimated to be between $35 and $42 billion. Light and heavy industrial use is the most likely future scenario for the site after the Kentucky Research Consortium for Energy and Environment developed a community-based end state vision in 2010. Remaining LTS (e.g., groundwater activities) are planned to be conducted by LM.

Portsmouth Gaseous Diffusion Plant (Portsmouth)

Portsmouth is in southern Ohio. EM's remaining scope at Portsmouth includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of LLW/MLLW and DU. EM's mission at Portsmouth is expected to be complete between 2039 and 2043. Remaining costs for Portsmouth are estimated to be between $11 and $13 billion. The desired end state for Portsmouth is reuse for economic development. An 80-acre parcel of land was transferred to the Community Reuse Organization in July 2018. Remaining long-term stewardship activities (e.g., groundwater activities, OSDWF management) are planned to be conducted by LM.

Sandia National Laboratories (SNL)

SNL is located on Kirtland Air Force Base, adjacent to Albuquerque, New Mexico. EM's remaining scope at SNL includes groundwater remediation. EM's mission at SNL is expected to be complete in 2031, with remaining costs estimated at $29 million.

Savannah River Site (SRS)

SRS is located in South Carolina. EM's remaining scope at SRS includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of TRU waste, LLW/MLLW, SNF/NM, and tank waste. EM's mission at SRS is expected to be complete by 2065, with remaining costs estimated to be between $67 and $92 billion. It is anticipated SRS will remain a DOE site supporting NNSA and other DOE program missions. Remaining LTS will be transitioned to the site program upon completion of the EM mission.

Separations Process Research Unit (SPRU)

SPRU is located in New York State. EM's remaining scope at SPRU includes retrieval, management, and disposal of TRU waste. EM's mission at SPRU is expected to be complete in 2025, with remaining costs estimated at $91 million. The site program will remain DOE-NR.

Waste Isolation Pilot Plant (WIPP)

WIPP is located in Carlsbad, New Mexico. DOE's remaining scope at WIPP includes management and disposal of TRU waste, and completion of closure activities. DOE's mission at WIPP is expected to be complete when the WIPP LWA total TRU waste volume capacity limit of 6.2 million cubic feet is met. Remaining costs are estimated to be between $10 and $12 billion. The above ground portion of the site will be returned to as close to pre-construction condition as reasonably possible while protecting human health, the environment, and meeting NEPA and WIPP LWA commitments. DOE will maintain and implement long-term active controls and install the permanent markers.

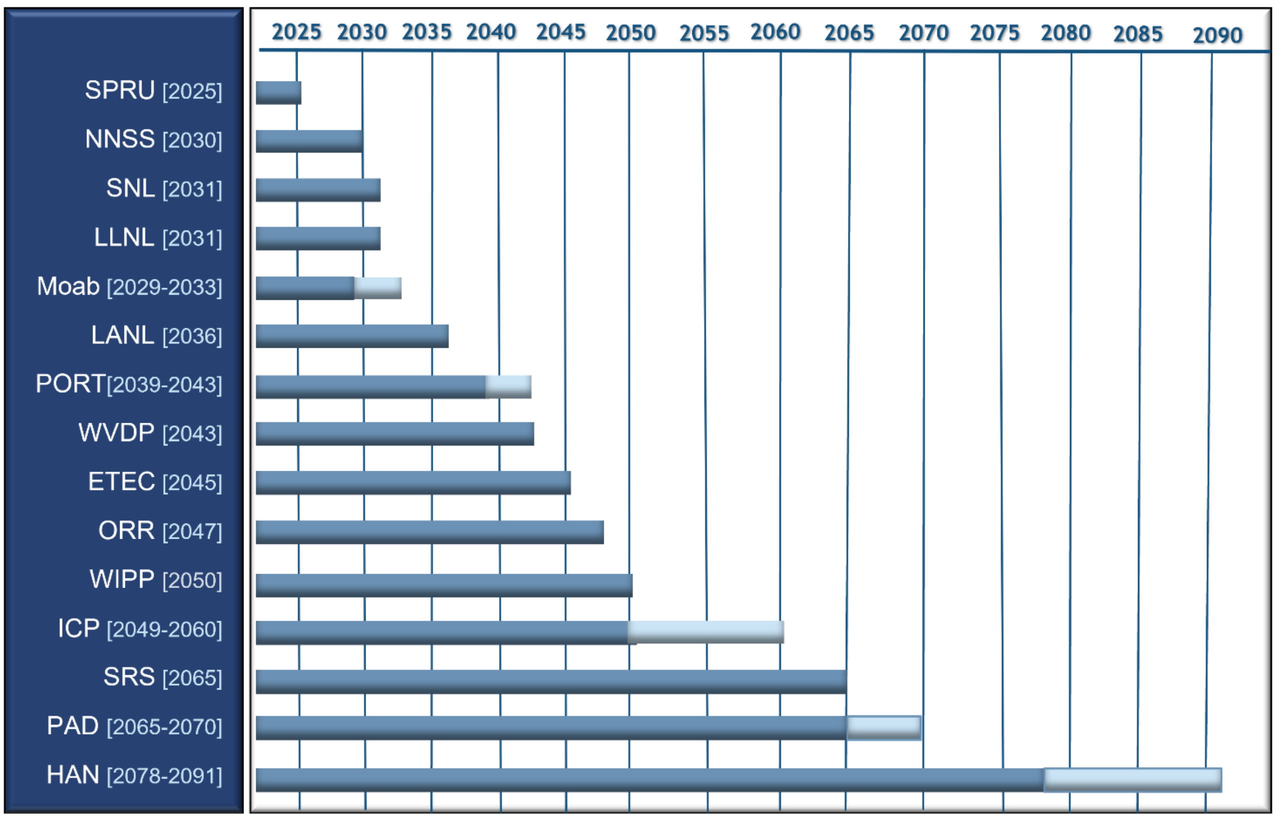
West Valley Demonstration Project (WVDP)

WVDP is located in New York State. EM's remaining scope at WVDP includes soil and groundwater remediation; completion of D&D activities; and retrieval, management, and disposal of LLW/MLLW and tank waste. EM's mission at WVDP is expected to be complete by 2043, with remaining costs estimated to be between $1.3 and $1.6

billion. Final cleanup levels are still to be determined. The owner of the site will continue to be New York State.

Figure 17 shows the timelines for cleanup completion at each site. The work will span over the next several decades at some sites, but others will be completed and turned back over to their respective programs much sooner. Completion ranges reflect current schedule contingency planning and may change as EM updates contingency estimates. Additionally, end dates reflect the fact that after milestones are completed at a site, there may be other closure and transition activities that need to be taken before EM's mission at the site is officially considered complete.

Figure 17. EM Program Site Completion Dates Summary



VI. Remaining Cleanup Cost and End Dates

The estimated costs and projected end dates to address the remaining cleanup scope described in this plan are shown in Table 6. These are informed by historical knowledge of resources required to complete similar cleanup activities, the application of lessons learned from other sites, and assumptions regarding current and anticipated regulatory requirements. The estimates are provided as ranges, reflecting uncertainty in projecting costs and schedules for the future.

Table 6. EM Remaining Costs and End Dates by Site

	Estimated Cost ($M)	Projected End Date
ETEC	341	2045
Hanford	311,676 – 505,391	2078 - 2091
ICP	7,747 – 10,979	2049 - 2060
LLNL	146 - 190	2031
LANL	5,770 – 6,836	2036
Moab	409 - 417	2029 - 2033
NNSS	487 - 610	2030
ORR	12,349 – 12,490	2047
Paducah	35,239 – 42,180	2065 – 2070
Portsmouth	11,498 – 13,486	2039 - 2043
SNL	27 - 29	2031
SRS	67,266 – 92,131	2065
SPRU	91	2025
WVDP	1,432 – 1,591	2043
WIPP	10,386 – 11,985	Supporting mission[a]
Federal Oversight and Program Support	23,638 – 24,580	2078 - 2091
Total[b]	488,504 – 723,332	2078 - 2091

[a] As a facility that supports the completion of EM work at other sites, the WIPP end date will be determined by the completion of cleanup at other sites, as well as the achievement of its capacity, as defined in the *WIPP Land Withdrawal Act of 1992*.

[b] The total estimated cost range shown in this table includes costs estimated for fiscal year 2022 through completion of the EM cleanup mission, including approximately $4M in FY22 to complete the cleanup at BNL.

EM continues to identify and evaluate opportunities to reduce costs and shorten schedules, as described in the next section.

VII. Current Plans and Opportunities

As discussed in Section III, a core element of strategic planning and analysis is identifying opportunities to streamline and accelerate cleanup. Examples include analyzing the "critical path" of activities at a site to identify ways to accelerate cleanup; identifying the costliest cleanup activities and evaluating potentially viable alternatives; and reviewing similar activities at multiple sites for lessons that can be shared, such as application of new or different technologies. EM works with local communities, Tribal Nations, regulators, and other stakeholders to identify and evaluate these opportunities, potential barriers to success, and possible mitigating actions to drive to completion more expeditiously.

Opportunities from Strategic Planning and Technology Development

Strategic planning is an iterative process. Effective planning requires feedback from completed activities to inform the next decision on strategic direction. Regular progress reviews are conducted based on objective measures of cleanup performance conducted under current planning. As the established scope, cost, and schedule assumptions deviate from expectations, rigorous analysis of alternatives may be required.

Multiple approaches are employed for evaluating potential cleanup opportunities, including:

1. **Analysis of Alternatives (AoA):** AoAs are technical evaluations conducted in advance of decisions on significant investments, consistent with GAO best practices. AoAs may be initiated to assess whether changes to current plans are warranted as new and/or better technologies arise, as lessons from current cleanup approaches are learned, as major deviations to performance expectations occur, as key assumptions underlying current plans change, and/or as changes in regulatory framework arise. Independent subject matter experts perform a detailed review of alternatives in terms of overarching assumptions and operational concepts; significant risks and mitigation strategies; readiness of key technology(ies) needed for implementation; quantification of benefits; development of life-cycle cost estimates including confidence levels; and sensitivity analyses.

2. **Technology Development:** As described in Section III, the TD program seeks investment opportunities with potentially significant benefits, such as enhanced protection of human health and environment, reduced costs, accelerated schedules, and resolution of technical challenges. EM is developing an R&D dashboard featuring funding and performance data on R&D efforts. This will enable monitoring and evaluation of R&D results across the EM complex.

3. **Pilot Scale Demonstrations:** These are small-scale demonstration projects undertaken to identify process unknowns, to select a specific technological approach, or to better understand important technical considerations prior to full scale facility engineering and design. Some examples (with Internet links for more information) include the following:

   - Oak Ridge Sludge Processing Mock Test Facility to help advance technologies needed for processing 500,000 gallons of TRU waste sludge. (https://www.energy.gov/em/articles/oak-ridge-constructing-test-facility-sludge-processing)
   - ICP full-scale calcine retrieval simulation to help determine complexity and establish processes for retrieval of 4,400 cubic meters of waste from long-term storage containers. (https://www.energy.gov/em/articles/idaho-calcine-retrieval-crews-use-full-scale-model-test-technologies)
   - SRS waste treatment demonstration project to evaluate ion exchange methodologies for removing cesium from liquid tank waste and accelerating tank closures. (https://www.energy.gov/em/articles/tank-closure-demonstration-project-advances-srs)
   - Hanford test bed initiative using 2,000 gallons of tank waste to demonstrate safe, effective disposal of grouted LAW (https://www.hanford.gov/files.cfm/Fact_Sheet_TBI-WIRCommentPeriod_FINAL.pdf

Potential Opportunities

EM is continually seeking opportunities to better manage and dispose of waste (some of which has been stored for decades with no near-term path forward); to retrieve waste from underground tanks sooner; to accomplish facility deactivation quicker; to enable accelerated disposition; and to better leverage existing capabilities or incorporate new technologies. The objective is to reduce risks to workers, the public, and the environment, and drive down EM's cleanup liability. For example, several years ago, DOE began a public conversation about defining waste based on its radiological constituents instead of how it was generated. In December 2021, DOE affirmed that its HLW interpretation is consistent with the law, best available science and data, and the recommendations of several external technical review groups.[12] Some waste streams at SRS, which were managed as HLW with no existing pathway to disposal, are being evaluated for classification as LLW enabling disposal at an existing commercial facility. Similar opportunities may be available at Hanford.

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[12] U.S. DOE, *Assessment of the Department of Energy's Interpretation of the Definition of High-Level Radioactive Waste*, Federal Register Notice 86 FR 72220, December 21, 2021.

Before any new approach is adopted, multiple technical, regulatory, and programmatic activities are required. Examples include:

- Preparing NEPA analyses leading to a published Record of Decision
- Preparing necessary permit modifications in coordination with regulators
- Coordinating with stakeholders and consulting with Tribal Nations
- Preparing RCRA or CERCLA documentation
- Assessing reasonableness of estimated costs
- Modifying affected contracts
- Initiating project planning and execution activities in accordance with DOE Directives
- Acquiring equipment, facilities, and resources
- Evaluating compliance with disposal facility waste acceptance criteria

DOE will continue to work collaboratively with members of Congress, state and local governments, Tribal Nations, regulators, and other key partners to engage in meaningful discussions to make informed decisions and remove barriers impeding mission completion and the corresponding reduction of long-term risks.

Tank Waste

As discussed in Section IV, cleanup of the waste resulting from SNF reprocessing is the single most complex and costly EM mission area. Alternative disposition approaches for liquid tank wastes can be implemented within existing environmental, health, and public safety requirements. As demonstrated in several recent DOE and expert panel reports, including a recent report to Congress,[13] preliminary estimates of potential benefits are dramatic. These include:

- Reducing health and safety risks by implementing simpler approaches
- Deploying production-scale technologies developed under EM's technology program
- Reducing the length of time to complete tank waste disposition and tank closure thereby reducing overall long-term risks to workers and the public living near DOE sites
- Initiating many cleanup projects earlier and completing them sooner
- Reducing emissions and thermal energy needs to support treatment, thereby reducing the carbon footprint
- Saving life-cycle cost to taxpayers of between $88 and $229 billion

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[13] U.S. DOE, *Evaluation of Potential Opportunities to Classify Certain Defense Nuclear Waste from Reprocessing as Other Than High-Level Radioactive Waste: Report to Congress*, prepared pursuant to Section 3139 of the *National Defense Authorization Act for Fiscal Year 2018*, December 2020.

Table 7 summarizes the current plan to complete the liquid tank waste mission and potential opportunities approved or under consideration. Note that West Valley is not included, as its tank waste has been immobilized by vitrification and the glass canisters are in long-term interim safe storage pending a final disposal option.

Table 7. Tank Waste Potential Opportunities

Site	Current Path	Opportunities
Hanford	• Separate the tank waste into fractions • LAW Pretreatment (PT) to remove cesium • Immobilize a portion of the LAW (direct-feed LAW) using vitrification technology and dispose on-site • Supplemental capability, still to be identified, will be used to immobilize the remaining LAW • Immobilize HLW by vitrification and store it on site until a national repository is available	Use of Grout to Treat Supplemental LAW • Use grout as supplemental LAW immobilization technology (e.g., up to 90% of West Area tank waste) and dispose offsite Streamlined Pretreatment • Process DFLAW and HLW with less complex PT approaches in specially designed facility(ies)
ICP	• Treat the calcine using HIP and dispose at a national repository	Direct Disposal and/or Vitrification of Calcine • Treat the calcine using vitrification technology • Only retrieve and package for disposal (direct disposal)
SRS	• Sludge waste vitrified at DWPF, then stored on site pending a final disposal option • Salt waste processed, primarily through SWPF, then saltstone waste is disposed on site; waste with high radionuclide concentrations will be treated with the sludge waste	• Under the recently approved mission change to H-Canyon, SRS plans to increase the fissile mass loading of HLW glass to reduce the total number of HLW canisters projected and ensuring that no additional glass waste storage capacity is needed

Hanford

The various options achieve benefits by altering how the waste is pretreated/treated. One promising option, consistent with the approach used at SRS, is to transition from vitrification to grouting the LAW portion of tank waste. Studies from organizations, such as the GAO and the National Academies of Science, have recommended DOE consider the use of widely accepted grout technology as a tank waste treatment method for lower activity waste streams. In addition, different tank retrieval strategies are under consideration. It should be noted that Hanford, as required under the Tri-Party Agreement and in coordination with the Washington State Department of Ecology, conducts evaluations of cleanup options as part of periodic River Protection Project System Plan updates, and is also conducting an AoA covering HLW options at Hanford. DOE also recently entered into holistic negotiations with the Washington State Department of Ecology and the EPA regarding certain milestones, which could affect future plans. Decisions are expected to be made over the next several years regarding technologies for LAW and updates to Hanford's tank waste strategy. Options below are representative of those that could be considered.

Hanford Option 1: Use of Grout to Treat Supplemental LAW in 200 West Area

Hanford is the only site planning to vitrify its LAW so that it can be disposed of on site. Several grouting options could be available for alternative treatment of the supplemental LAW, which is the LAW that will not be treated in the LAW vitrification facility. Grout is an internationally recognized, low temperature, low complexity approach to immobilize LLW and has potential to shorten mission duration by a decade or more, decreasing risk to workers and the public. The supplemental LAW could be treated into a grouted waste form for off-site near-surface disposal. Grouted LAW would result in a larger volume than vitrified LAW and must still meet RCRA Land Disposal Restrictions.

> This opportunity could result in life-cycle savings of between $73 and $210 billion and accelerate mission completion by more than a decade.
>
> *Evaluation of Potential Opportunities to Classify Certain Defense Nuclear Waste from Reprocessing as Other than High-Level Radioactive Waste, Report to Congress,* December 2020

Hanford Option 2: Streamlined Pretreatment

The current HLW PT approach is technically complex and likely to be rate limiting to waste treatment. Several options are being analyzed, including options for replacement of the PT facility with a new HLW Feed Preparation facility working in conjunction with other simpler facilities. The *River Protection Project System Plan* (ORP-11242), Revision 9, which includes an analysis of different scenarios for treatment and disposition of tank waste, focuses on treatment functionality (e.g., waste leaching, washing, sampling, and characterization) and modular, tank-farm-based PT to facilitate HLW vitrification.

The most promising approach entails specialized feed preparation and sludge washing capability, followed by direct-feed vitrification of sludge. This approach would use a less complex feed preparation facility, avoiding potential PT facility rate limitations and other issues. It also would allow single- and double-shell tank retrievals to be completed earlier than currently planned but could result in an increase of HLW canisters. Hanford continues to evaluate alternatives to reduce PT risk, accelerate treatment of tank waste, and reduce of life-cycle costs.

> System Plan 9, and other ongoing alternatives analyses, indicate that scenarios focused on treatment could complete SST retrievals and tank waste treatment years earlier, significantly accelerate the overall mission, and reduce life-cycle costs.

Idaho Cleanup Project

In 2009, DOE issued a ROD selecting HIP as the preferred technology to treat calcine for disposal. DOE is re-evaluating this decision with the potential that either direct disposal (no further treatment) or vitrification of some calcine (up to 40 percent) could be selected.

The recently issued Calcine Disposition Project's AoA evaluated all reasonable alternatives for treatment of calcine and concluded that direct disposal or vitrification are the best options to pursue. The analysis notes that a single best option cannot be determined until a disposal facility, and its associated waste acceptance criteria, is authorized to accept some or all calcine waste.

Vitrification is the current standard for immobilizing HLW and offers the lowest regulatory risk in meeting RCRA land disposal restriction requirements. For treatment (vitrification) of calcine, cold crucible induction melting technology is available on a commercial-scale and has advantages over joule-heated ceramic melters used at the other three DOE sites. The life-cycle cost of vitrification is less than that for HIP, but will require physical modifications to IWTU, similar to HIP, due to higher-temperature operations.

Another option for calcine disposition involves no further treatment but rather direct disposal (i.e., retrieval and transfer into canisters for storage pending availability of off-site disposal).

> The direct disposal alternative has the potential to reduce ICP's life-cycle costs for calcine treatment, packaging, and storage by almost $2.3 billion. Vitrification would increase ICP's life-cycle cost slightly but significantly reduce technical and regulatory risks over HIP.
>
> *Independent Analysis of Alternatives for Disposition of the Idaho Calcined High-Level Waste Inventory: Final Report, November 2021*

Direct disposal is the lowest cost option. This option has the lowest technical risk, requiring none of the complex off-gas and other safety systems needed for high-temperature technologies. Direct disposal has the best likelihood of meeting the requirements of the Idaho Settlement Agreement but may not meet expectations for further calcine treatment. Transfer and packaging would be performed in a repurposed IWTU after the SBW treatment mission is complete and the IWTU can be decontaminated and readied for calcine operations. Under the current SBW treatment schedule, IWTU would not be ready for calcine disposition until 2028 or later.

Spent Nuclear Fuel and Nuclear Materials

There are fewer options for the management and disposition of SNF as compared to tank waste, which can be separated into high- and low-activity fractions. Table 8 summarizes the current plan to complete the SNF scope managed by EM and potential opportunities approved or under consideration. Note that some site programs generate SNF as part of their nuclear reactor/ nuclear fuel R&D scope (e.g., ORNL); such sites are not included in Table 8.

Table 8. DOE SNF Potential Opportunities

Site	Current Path	Opportunities
SRS	• Reprocess 22 MTHM of High Flux Isotope Reactor and Advance Test Reactor SNF in H-Canyon as set out in 2013 SNF Management at SRS amended ROD • Construct SRS SNF packaging and storage facility and consolidate all remaining SRS SNF	Reprocess All SRS SNF Inventory • In April 2022, DOE decided to chemically process all L-Basin SNF in H-Canyon with no uranium recovery
ICP	• Construct an ICP SNF packaging and storage facility and consolidate all INL SNF • Treat Experimental Breeder Reactor-II blanket and driver using electrometallurgical treatment	Separate Packaging and Storage of INL SNF • Recent ICP SNF analyses evaluated options for management of INL SNF in a smaller single-purpose facility and for dry storage of canisters on modular concrete pads

Savannah River Site

With the only large-scale chemical processing capability in the DOE complex in H-Canyon, DOE has the opportunity to eliminate all of the SNF stored at SRS. Processing all SNF in H-Canyon would eliminate the need to manage and disposition SNF altogether, while only extending planned H-Canyon operations by an additional five years or less.

In April 2022, EM issued an amended ROD (see 87 FR 23504) to revise the H-Canyon mission. SRS is currently developing detailed implementation plans for processing up to 29.2 MTHM of SNF stored in L-Basin through 2033 (subject to adequate funding). Under the decision, SRS would process almost all its SNF inventory (any small quantities of SNF generated after would not be processed in H-Canyon). H-Canyon operations could be extended to chemically process all, or almost all, of the aluminum and non-aluminum SNF stored in L-Basin. This approach would best balance H-Canyon operating costs, avoid additional SNF conditioning, packaging, and storage facilities, and optimize risk reduction. The ABD mission would add between 435 and 505 additional canisters of vitrified HLW glass and would limit the allowable concentration of fissile isotopes in the glass to 2,500 grams per cubic meter. At the same time, the ABD mission would help accelerate the disposition of SNF. This approach is estimated to save over $4 billion at SRS alone, with additional significant cost savings to taxpayers by eliminating the need to dispose of SNF off site.

The ABD approach eliminates the need for a drying, pretreatment, and packaging facility for non-aluminum SNF and the need for long-term storage of up to 1,500 standard canisters, while resulting in a slight increase in the projected total number of DWPF glass canisters (approximately 5 percent more). Potential future receipts of domestic or foreign SNF (and NM) beyond 2033, which could require processing, were not included.

The ABD approach will allow SRS to process all remaining SNF in the L-Basin storage area through H-Canyon without recovery of highly enriched uranium. It is expected to: save more than 20 years of work and related costs (including securing and managing the stored spent fuel); accelerate work to remove spent nuclear fuel from L-Basin while maintaining safety and security; free up space in L-Basin for other uses; and save taxpayers approximately $4 billion.

DOE EM web site, "Savannah River Site Spent Nuclear Fuel Proposed to be Removed More Quickly,"

Idaho National Laboratory

By 2023, all INL SNF will be safe, dry pad storage awaiting the availability of a geologic repository, reducing the risk of radiological impact to workers and the public. The Idaho Settlement Agreement requires all SNF be removed from the state by January 31, 2035. ICP must plan to package its SNF in storable, transportable, and potentially disposable canisters to achieve safe management and long-term on-site storage.

With the approval of SRS's ABD mission, INL will need to manage both aluminum- and non-aluminum SNF. INL is considering a demonstration project to evaluate key technologies and process approaches and will decide on whether to move forward with a Packaging Demonstration within CPP-603.

A recent ICP SNF analysis[14] evaluated several options for management of INL SNF, including those with the lowest risk and cost. The best ways to condition, package, stage, and store EM-managed DOE SNF were evaluated, with a recommendation to separate packaging from storage at different, smaller facilities. Dry cask storage of SNF on modular concrete pads is preferred over a more traditional integrated packaging and below-grade vault facility. Additionally, DOE will assess the potential to use commercial capabilities and/or repurpose an existing building whose current mission is at or near completion to perform required SNF management functions rather than building a new facility for these capabilities.

Research on Extended Dry Storage of Spent Nuclear Fuel

Several DOE offices are jointly working to evaluate the long-term impacts of dry storage on all types of SNF. With the largest inventory of aluminum clad SNF, DOE must identify and evaluate the technical challenges of storing this type of SNF possibly for decades.

There are five key technical, engineering, and modeling data gaps for which further evaluation is required. These gaps arise from drying SNF at high temperature, the generation of gases from bound water and oxidation layers, potential for gas release from vented storage systems, and performance of some aluminum SNF in existing dry storage systems. Understanding these gaps is important because extended storage could release radiolytic gases, cause internal corrosion of SNF and internal canister degradation, and make it difficult to retrieve the SNF from dry storage. The evaluations are being conducted by INL and the Savannah River National Laboratory and have shown promise in addressing technical gaps in other, novel types of SNF. With the recent decision to process all aluminum SNF at SRS, this technology development work will primarily benefit INL.

Accelerating Remediation at Moab

EM has several sites at which the public health and safety risks are directly related to the amount of waste remaining to be remediated. One site in particular, the Moab Project, demonstrates how small increases in funding coupled with innovative use of incentive-based contracting can accelerate mission completion and corresponding risk reduction.

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[14] DOE Environmental Management, *Management Options for Spent Nuclear Fuel at the Idaho National Laboratory Site, Integrated Project Team Analysis of Alternatives Final Report*, January 2021.

The Moab Project is responsible for remediating 16 million tons of mill tailings and other contaminated material (residual radioactive material) and underlying groundwater contamination resulting from 30 years of commercial uranium ore processing. The mill tailing pile is being relocated to an NRC-approved LLW disposal cell. With additional investment over the next several years, DOE could accelerate the time to relocate the mill tailings pile by almost five years (now estimated to complete by 2029, with other remedial actions to be completed by 2033). This acceleration opportunity will reduce risk to the workers and the public by relocating radioactive contamination from an above-ground soil pile with the potential to disperse uranium, radon, and other radioactive material to a safe, below-ground permanent disposal facility.

Deactivation & Decommissioning Acceleration

Addressing the higher-risk excess facility cleanup scope in the near term would require an estimated $12.1 billion. DOE continues to seek opportunities to accelerate disposition of higher-risk facilities, including working collaboratively with other Program Offices (e.g., NNSA) to perform significant deactivation and stabilization, before EM undertakes final facility disposition.

Accelerating the D&D of excess facilities would reduce the risk posed by these facilities and avoid annual maintenance and other costs associated with delaying D&D. O&M costs required to keep the facilities safe and stable can run into the millions of dollars per year. These costs are avoided when a facility is demolished. In addition to incurring ongoing O&M costs, delaying D&D may:

- Expose individuals, the community, and environment to increasing levels of risk
- Lead to escalating disposition costs
- Affect ongoing missions

The Department's strategy is a distributed approach that involves stabilizing, deactivating, or demolishing certain contaminated, relatively higher-risk, excess facilities currently owned by various programs across DOE laboratories and sites.

Soils and Groundwater Advanced Monitoring Capabilities

Accurately identifying and monitoring the locations and concentrations of soil and groundwater contaminants is critical for effective soil and groundwater remediation. As mentioned in Section IV, EM is pursuing development of advanced, innovative environmental monitoring systems to assess the long-term effectiveness of soil and groundwater remediation efforts. Advanced Long-Term Environmental Monitoring Systems is a multi-laboratory project intended to benefit EM legacy cleanup sites across the complex (see https://altemis.lbl.gov/). Areas of interest include:

- Artificial Intelligence for Soil and Groundwater Contamination
- In Situ Real-Time Monitoring for Early Warning Systems
- Spatially Integrative Monitoring of Surface Cap Systems
- Spatially Integrative Monitoring of Wetlands
- Geochemical Characterization and Modeling
- High Performance Computing-based Reactive Transport Modeling

Technology Development to Implement Wearable Robotics and Exoskeletons

Advances in robotics can enhance the management of hazards beyond personal protective equipment. The use of wearable robotics and exoskeletons can mitigate hazards posed by environmental cleanup work by improving ergonomics, thereby decreasing musculoskeletal injuries. These technologies have been in development for non-radiological applications for some time, but further testing is needed before they can be deployed in repetitive, stressful cleanup work in a radiological environment. EM's TD program has established a testbed at SNL to identify multiple tasks for wearable and attachable robotics and evaluate their implementation for EM cleanup work.

Applied Research to Evaluate HEPA Filter Performance Testing

During many nuclear operations, including D&D, radioactive aerosols are produced during the cutting of contaminated and activated metals. The radioactive aerosols must be collected and removed by a high-performing air filtration system before releasing to the environment by the ventilation system. The use of high-efficiency particulate air (HEPA) filters to capture particles is standard throughout EM and other nuclear sites; however, these filters are least efficient for particles around 300 nanometers in size.

EM's TD program is supporting research to develop state-of-the-art air filtration systems to improve filter performance, reduce the frequency of filter replacement, and reduce worker safety risks. For example, a HEPA filtration system using a new filter design exceeding industry standard recently passed its commissioning tests and is for planned use at Hanford.

Updated Stabilization Plans for Risk Reduction of Non-EM Facilities

In FY 2018, the *National Defense Authorization Act for FY 2018* (Public Law 115-91) provided new congressional authority for NNSA to dispose of process-contaminated facilities for projects less than $50M. Under this new authority, NNSA is looking to accelerate the D&D of certain process-contaminated facilities and is updating its disposition plans accordingly. EM is working closely with other DOE program offices to integrate these accelerated plans into the EM Program.

Participants in a panel session at the 2022 Waste Management Symposia discuss how environmental cleanup is reshaping the Y-12 National Security Complex and Oak Ridge National Laboratory.

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VIII. Roadmap to Mission Completion

The roadmap in this section (see Figure 18) highlights key decisions needed in the coming decades to complete the EM program mission as effectively as possible. For each of the mission areas, the points on the roadmap reflect the targeted timeframes in which opportunities, technical approaches, regulatory decisions, or other waste disposition courses of action should be selected to affect the EM cleanup strategy. Some decisions, such as those for tank waste disposition at Hanford or accelerations of facilities D&D, could happen in the next several years; other decisions, like final remedies or remedial approaches at some larger sites or disposition pathways for some orphan wastes, will take longer. These decisions will be developed in accordance with the EM prioritization approach described in Section III.

It should be recognized that further consideration of some alternatives may require additional analysis under NEPA and that some decisions are outside of EM's control. For example, the tank waste and SNF management mission areas are highly dependent on the availability and timing of a geologic repository to set waste acceptance criteria for packaging, transportation, and disposal. EM is committed to proactively pursuing decision-making and will continue to work with local communities, Tribal Nations, regulators, and other stakeholders to identify and evaluate these opportunities to improve the program.

As discussed earlier, the tank waste program is the largest remaining scope, taking by far the longest time to complete, and therefore represents the greatest opportunity to shorten the timeline of the EM mission. At Hanford, DOE estimates that as much as 90 percent of LAW could be retrieved and solidified as LLW, a potential opportunity to reduce risks and save tens to hundreds of billions of dollars. At INL, a final decision on which technology is optimal for final disposition of calcine will be made after completing NEPA updates, resulting in a major step forward in the tank waste program.

In the area of SNF, INL’s ongoing evaluations related to packaging and storage options are expected to result in significant optimization. And at SRS, the recent decision to accelerate disposal of L-Basin SNF by dissolving it in H-Canyon without recovering the uranium, as part of the ABD project, will save more than a third the cost of operations and avoid the need to build a drying and packaging capability, saving over a billion dollars in life-cycle costs.

Opportunities to accelerate site closures are also being considered and discussed as part of site continuous improvement efforts. Larger sites, where investing in acceleration of current plans for D&D of excess facilities could accelerate mission completion by years and save billions of dollars, provide the biggest opportunities. Accelerations at smaller sites could achieve significant results as well, relative to the size of their remaining scope. The earlier a decision is made to pursue an opportunity, the greater the potential reduction in the associated schedule and infrastructure and maintenance costs. However, the decision to pursue some opportunities may be deferred, particularly if underlying assumptions are expected to change significantly.

The roadmap timeline at the end of this section depicts selected key decisions and the important enabling activities needed to complete the cleanup mission. While there are hundreds of other important decisions not represented, this summary focuses on those that present the greatest opportunity to impact timeframes and reduce risk and costs. There are no major decisions remaining for NM or DU; the key decisions for the other mission areas, are summarized below (see Appendix A for more details on remaining decisions by site).

Spent Nuclear Fuel:
- SRS SNF ABD Decision (Completed)
- ICP SNF Packaging Capability Demonstration and Staging Area Decisions

TRU Waste:
- Hanford RL Retrievably Stored TRU Waste Disposition
- ORR TRU Sludge Disposition Pathway

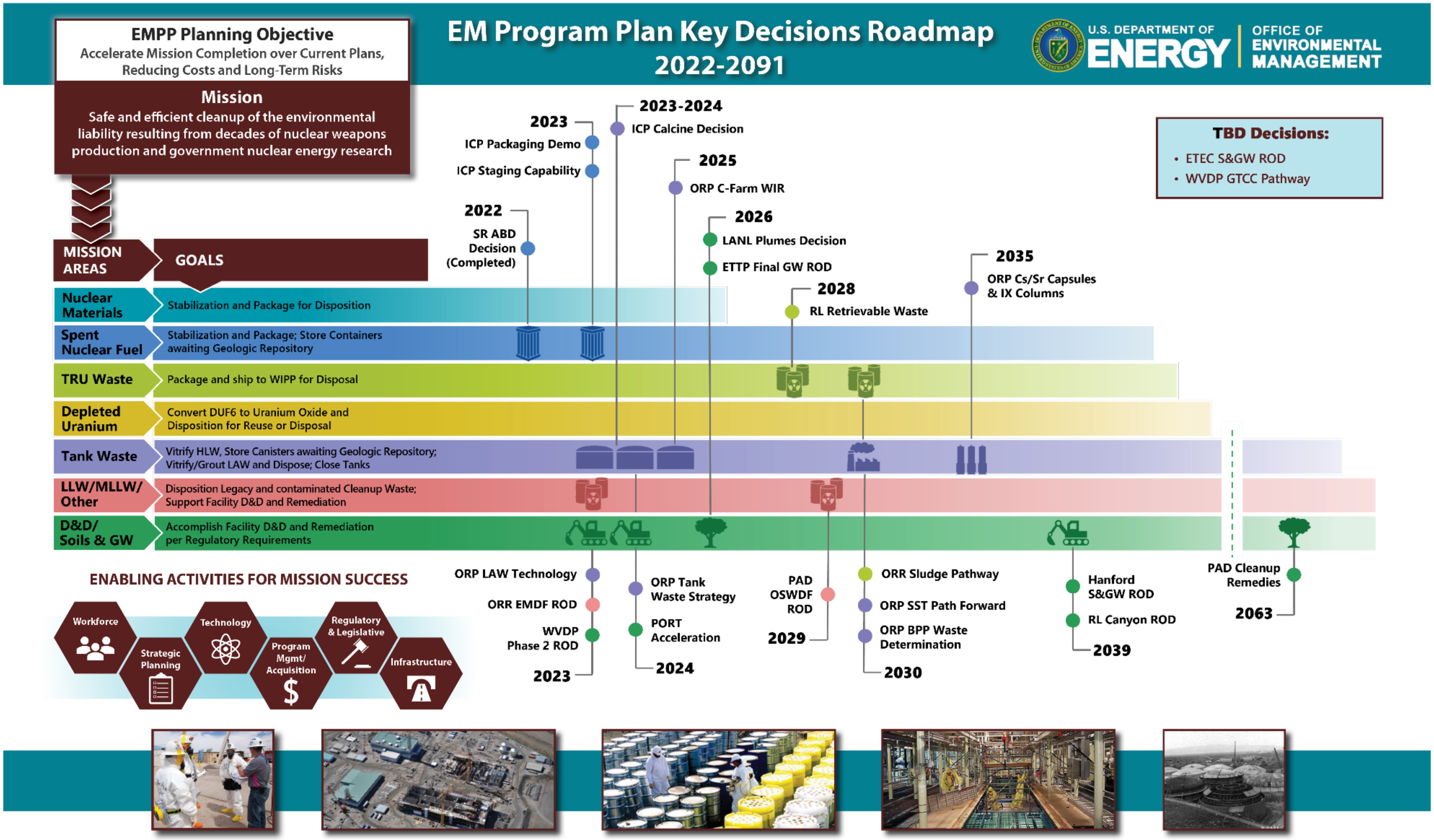
Tank Waste:
- Hanford - ORP
  - LAW Technology and Tank Waste Strategies
  - C-Farm WIR Determination
  - Single-Shell Tank (SST) Closure Path Forward
  - Cs/Sr Capsules and IX Columns Pathway
  - BPP Waste Determination

LLW/MLLW/Other:
- ORR EMDF ROD
- WVDP GTCC/GTCC-Like Waste Pathway
- Paducah OSWDF ROD

D&D/Soils & Groundwater:

- Portsmouth Acceleration
- LANL Chromium and RDX Plumes Final Remedies
- ETTP Final GW ROD
- Hanford RL S&GW ROD
- Hanford RL Canyon ROD
- Paducah Cleanup Remedies
- ETEC S&GW ROD
- WVDP Phase II ROD

Figure 18. EM Program Plan Key Decisions Roadmap



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IX. Conclusion

The most significant challenge facing the EM Program is identifying ways in which the program can continue to accelerate cleanup and reduce risk. EM has successfully eliminated immediate risks and minimized longer-term risks. However, the longer it takes to complete cleanup, the greater the programmatic costs and risks, and the ES&H risks to workers. Timing of decisions is critical as well, to have maximum impact. Discipline, focus, and management commitment will be essential, but the ability for EM to prioritize innovation – and to collaboratively assess opportunities and potential barriers with our stakeholders – will make the biggest difference for the future of the program.

Time Equals Cost and Risk

The longer it takes to complete cleanup, with workers continuing to operate and maintain facilities and actively manage waste and other hazardous materials, the greater the cost and the cumulative ES&H and programmatic risks.

EM has taken a key step with the implementation of the *EM Program Management Protocol*. The protocol will guide the program as it implements the next steps to accelerate site cleanup completions. This will help ensure acquisition plans are realistic and implementable, risk analyses are robust and are integrated into planning, and opportunities for improvement and risk reduction are woven into the EM Program at both the site and headquarters levels.

The vision of accelerating site completions over current plans is achievable, thereby reducing long-term exposures and risks. EM looks forward to continuing to engage local communities, Tribal Nations, regulators, and other stakeholders to plan and successfully implement strategies to achieve this vision safely and effectively.

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EM Program Plan: Appendix A

EM Program Site Summaries

EM Major Mission Areas

- Tank Waste
- Spent Nuclear Fuel (SNF)
- Nuclear Materials (NM)
- Transuranic (TRU) Waste
- Depleted Uranium (DU)
- Low-Level Waste (LLW)/Mixed Low-Level Waste (MLLW)/Other Waste
- Soils & Groundwater (S&GW)
- Excess Facilities Deactivation and Decommissioning (D&D)

This appendix presents site summaries that build upon those found in Section V of the *EM Program Plan 2022* and include additional information on EM cleanup strategies, end states, milestones by mission area, and the remaining decisions impacting cleanup. Brookhaven National Laboratory was not included in this appendix as cleanup there was recently completed.

For sites not planned for transfer to an external entity upon completion, DOE will continue institutional controls and associated operations and maintenance activities to ensure continued protectiveness of completed remedial actions. End states and completion dates in this appendix therefore reflect conditions and timing associated with transfer of responsibility for long-term surveillance and maintenance from EM to either the program site owner or the DOE Office of Legacy Management.

Milestone and decision dates (expressed as calendar years) are estimated based on best available information at time of issuance of this document; where dates are either not yet known or under discussion, they are left blank or listed as to be determined (TBD), respectively. It should also be noted that milestone dates and timelines reflect estimated schedules and could be affected by future regulatory decisions. Site end dates include schedule contingency.

Schedules for milestone completion are based on a logical sequence of interdependent activities and events necessary to complete the project. While many project milestones and activities can advance simultaneously, some involve interdependencies in which advancements or delays will impact projected completion timeframes. In most cases this means that certain activities must occur before a successor activity can begin or be completed (see box on the next page for a few common examples).

Examples of Interdependencies of Project Milestones and Activities

- A treatment facility must first complete its treatment activities before the building may be demolished
- A building must be demolished before remediation of the soil under the building can be completed
- Characterization of contaminated soils must be completed prior to the determination of the remediation approach

At the program level, the Waste Isolation Pilot Plant (WIPP) facility conducts operations to transport and dispose of TRU waste generated by cleanup activities at other sites. WIPP's schedule to transport and emplace waste can impact the pace of cleanup at generating sites, and ultimately the demand for TRU waste disposal will impact the operational life of the WIPP facility itself. Similarly, a decision on, or availability of, a final programmatic repository or interim storage capability for SNF may affect activities associated with construction of on-site storage or re-packaging facilities.

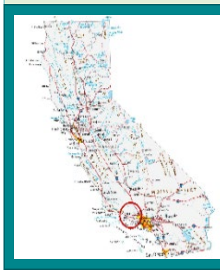
For acronyms, please refer to the Acronym List in the main document.

Energy Technology Engineering Center

Overview

The Energy Technology Engineering Center (ETEC) is located on the Santa Susana Field Laboratory in Ventura County, CA. DOE does not own any land at the laboratory. DOE completed demolition of the remaining DOE-owned buildings in 2021. DOE is also responsible for the cleanup of groundwater in Area IV (290 acres) and the Northern Buffer Zone (182 acres). Cleanup at ETEC is regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA). More information is available in the ETEC Strategic Vision 2022-2032.

Remaining Scope	To Go Costs	Est. End Date
• Groundwater	$341M	2045



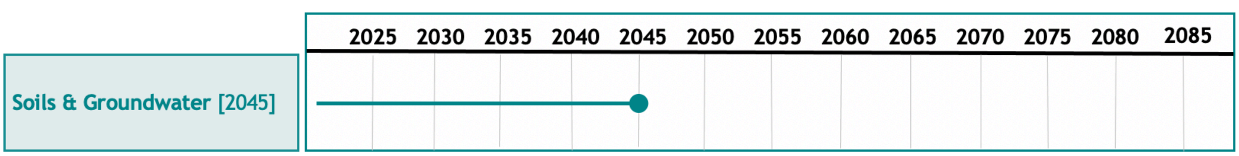
Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Complete groundwater remediation *[TBD]* • Ongoing planning activities, including completion of implementation plans for State approval

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Final remedy decision on soils and groundwater *[TBD]* • Finalize Corrective Measures Study *[TBD]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The end state for ETEC is that the land will become an open space. Boeing owns the land and has a conservation easement for the property that prohibits development for residential, commercial, industrial, or agricultural purposes which will continue in perpetuity after cleanup is completed. Responsibility for continued groundwater monitoring would transfer to LM.

Hanford

Overview

The Hanford Site, a 580-square-mile section of semiarid desert in southeast Washington, was established in 1943 as part of the Manhattan Project to produce plutonium for national defense. During a national security mission that lasted nearly five decades, nine nuclear reactors were built along the banks of the Columbia River to provide materials for five processing facilities that operated throughout the Cold War era. With the signing of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) in 1989 by the DOE, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency (EPA), the primary mission of the Hanford Site shifted from national security to environmental cleanup. Hanford's current mission focuses on treatment of millions of gallons of waste stored in large underground tanks and reducing risks through remediation of contaminated areas, deactivation and decommissioning of facilities, groundwater treatment, and waste management (i.e., waste storage, treatment, and disposal). The tank waste is material left over from nearly 50 years of plutonium production. DOE recently entered into holistic negotiations with the State of Washington's Department of Ecology and the EPA regarding certain milestones, which could affect future plans.

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • TRU • LLW/MLLW/Other • SNF • Tank Waste	RL $101 to $110B ORP $210 to $395B	2078-2091

Cleanup of the Hanford Site is managed by two DOE offices, the Richland Operations Office (RL) and the Office of River Protection (ORP). RL serves as the Hanford Site property owner and oversees cleanup along the Columbia River and in Hanford's Central Plateau, including groundwater and waste site cleanup, facility cleanout and deactivation and decommissioning, management of solid waste and nuclear materials, and all site infrastructure and support services. Congress established ORP in 1998 as a field office to manage the retrieval, treatment, and disposal of approximately 56 million gallons of radioactive tank waste stored in 177 underground tanks in the Central Plateau. In support of this mission, ORP is responsible for the safe operation of the tank farms and its associated facilities along with construction and operation of waste transfer systems and treatment facilities, including the Hanford Tank Waste Treatment and Immobilization Plant (WTP) located in the Central Plateau. The Hanford cleanup mission is regulated by both *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and RCRA, while Tank Farms and WTP are primarily regulated under RCRA. More information is available in the *Hanford Strategic Vision 2022-2032*.

Remaining Scope

Mission Area[1]	Strategy
Soils/Groundwater	• Complete remedial actions for contaminated soil beneath and disposition of the 324 Building *[2030]* • Complete remedial investigation and feasibility study process, including characterization, to support final records of decision (RODs) for soil and groundwater remediation *[2035]* • Complete Pump and Treat activities *[TBD]* • Remediate waste sites and burial grounds in the Central Plateau *[2082]* • Remediate waste sites within the River Corridor *[TBD]*
D&D	• Complete soil remediation and 324 Building demolition *[2025]* • D&D of 105 K West Fuel Storage Basin *[2026]* • Place the K-East and K-West reactors in interim safe storage *[2029]* • Complete demolition of the Fast Flux Test Facility *[2037]* • Complete demolition of facilities in the Central Plateau *[2082]* • D&D of remaining operational facilities *[various]* • Disposition of cocooned reactor cores *[TBD]* • Demolish the five former plutonium processing facilities located on the Central Plateau, including placing the facilities in surveillance and maintenance (S&M) configuration prior to D&D *[TBD]* • Complete demolition of the excess buildings in the River Corridor *[TBD]*
TRU	• Initiate certification activities by processing TRU container *[2028]* • Retrieve, treat (as necessary), and dispose of TRU at WIPP *[2050]*
LLW/MLLW/Other	• Begin operations at Integrated Disposal Facility *[2023]* • Remove all mixed waste containers currently located at the Central Waste Storage Complex from outside Storage Areas A and B *[2026]* • Dispose of contaminated material from remediation activities at the Environmental Restoration Disposal Facility and the mixed LLW trenches (31 & 34) *[2076]*
SNF	• Store SNF at the Canister Storage Building *[2065]* • Package SNF at Interim Storage Area into disposable canisters *[TBD]*
Tank Waste	• Startup Tank-Side Cesium Removal System and associated ion-exchange (IX) storage pad *[Initiated 2022]* • Startup WTP LAW Facility, Balance of Facilities, Effluent Management Facility, and Analytical Laboratory *[2023]* • Transition Direct Feed Low Activity Waste (DFLAW) facilities and systems from construction, commissioning, and readiness activities to begin low-activity tank waste treatment *[2025]*[2] • Complete upgrades to site infrastructure to support DFLAW operations *[2025]* • Complete the transfer of cesium and strontium capsules, currently at the Waste Encapsulation and Storage Facility, to safer and stable dry storage at the nearby Capsule Storage Area that is currently under construction *[2025]*

[1] Significant scope is required throughout Hanford to right-size and reconfigure infrastructure and services to support the Mission Area scope reflected in this table.

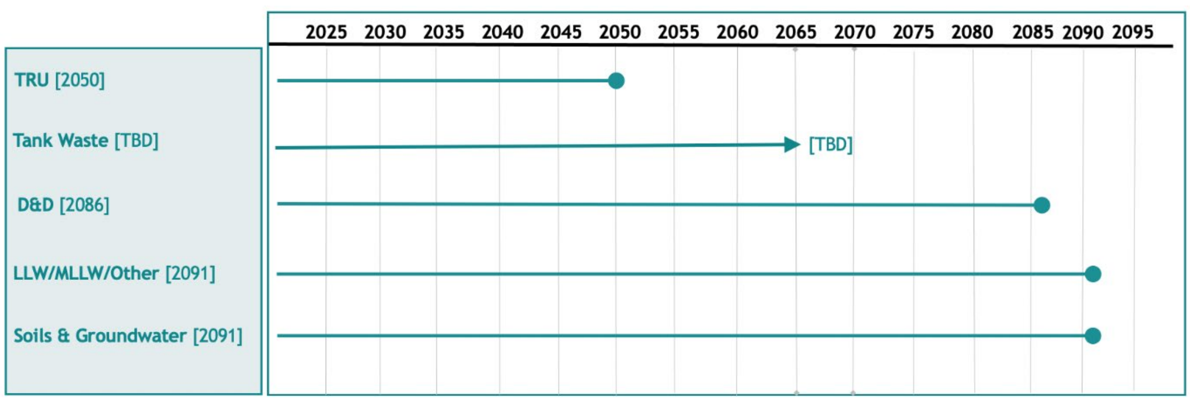
[2] The required startup of DFLAW facilities was extended from 2023 to 2025 due delays caused by the COVID-19 pandemic; however, DOE plans to begin operations as early as 2023.

	• Complete single-shell tank retrievals in A/AX Farms per Consent Decree *[2028]* • Startup high-level waste (HLW) facility operations *[TBD]* • Supplemental LAW facility operations *[TBD]* • Complete remaining single-shell tank retrievals *[TBD]* • Closure of all double-shell tanks *[TBD]* • Complete upgrades at the Liquid Effluent Retention Facility and Effluent Treatment Facility to support the treatment of the anticipated secondary liquid effluent from DFLAW operations *[TBD]*

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater (RL)	• Issue final RODs for soil and groundwater remediation including final decision for the deep vadose zone *[2039]*
D&D (RL)	• Remaining Canyon Facility D&D ROD *[2039]* • Determine final reactor disposition following interim safe storage *[2050]*
TRU	• K Basins sludge treatment technology *[2022]* • Contact-handled TRU (CH-TRU) and remote-handled TRU (RH-TRU) packaging capability *[2024]* • Path forward on Retrievably Stored Waste *[2028]*
LLW/MLLW/Other	• Disposal path for bulk sodium from FFTF *[2024]*
Tank Waste (ORP)	• Supplemental low-activity waste (LAW) treatment technology decision *[2023]* • Finalize the LAW and HLW tank waste mission completion strategies *[2024]* • Regulatory risk definition to support single-shell tank farm closures *[2030]* • Single-shell tank TRU/bismuth phosphate path forward *[2030]* • Disposal path for cesium/strontium capsules as well as spent IX columns from Tank-Side Cesium Removal *[2035]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Also, SNF not included as all SNF is safely stored awaiting the availability of a geologic repository or interim storage facility authorized for receipt of SNF.

END STATE: The end state for Hanford involves conservation and preservation uses in much of the area surrounding the Central Plateau, and industrial use in the Central Plateau and portions of the River Corridor. Long-term stewardship activities will be managed by LM. The National Park Service will continue to provide interpretation and some visitor services for the DOE-managed Hanford Unit of the Manhattan Project National Historical Park.

Idaho Cleanup Project

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • TRU • Tank Waste • SNF • LLW/MLLW/Other	$7.7 to $11B	2049 to 2060

The Idaho National Laboratory (INL) is an 890-square-mile section of desert in southeast Idaho that was established in 1949 as the National Reactor Testing Station. Initially, the missions at the INL Site were the development of civilian and defense nuclear reactor technologies and management of spent nuclear fuel. Fifty-two reactors were built, many of which were first-of-a-kind, including the Navy's first prototype nuclear propulsion plant. Of the 52 reactors, four remain in operation at the site. Cleanup at the INL Site is regulated under both RCRA and CERCLA. More information is available in the *Idaho Strategic Vision 2022-2032*.

Remaining Scope

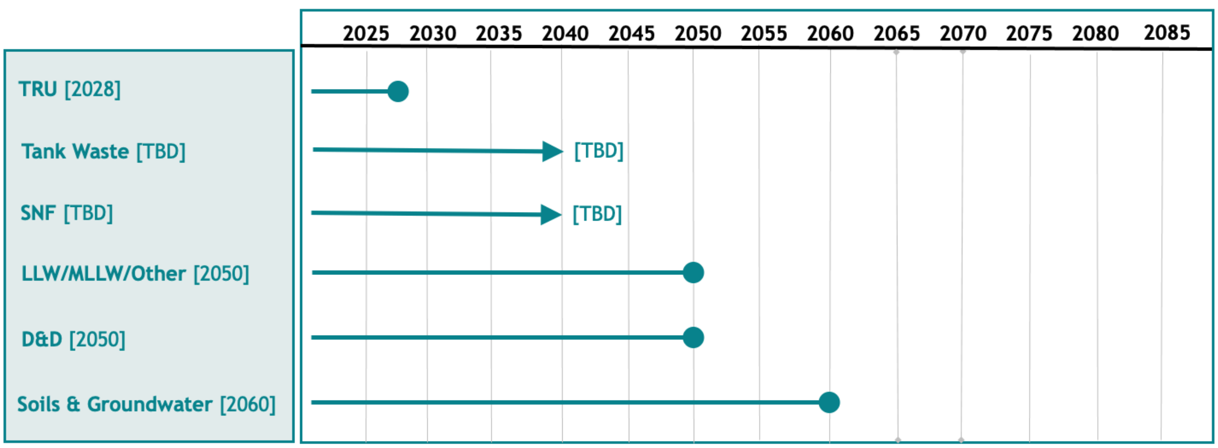
Mission Area	Strategy
Soils/Groundwater	• Complete exhumation of buried wastes from the Subsurface Disposal Area and ship all resulting waste offsite *[2022]* • Cap Subsurface Disposal Area to prevent water infiltration and contaminant migration *[2028]* • Cap tank farm after tanks are emptied and grouted • Expand Idaho CERCLA Disposal Facility to ensure sufficient capacity to support D&D activities • Cap landfills prior to closure • Enhance groundwater bioremediation efforts with environmental injections at the Test Area North trichloroethylene plume
D&D	• D&D all facilities on the Subsurface Disposal Area • D&D all facilities at the Advanced Mixed Waste Treatment Project as their mission ends, and they are no longer needed to support operations and shipping • Support Navy prototype propulsion plant D&D (Navy-funded)
TRU	• Complete sludge waste processing and packaging *[2022]* • Finalize calcine treatment Supplement Analysis *[2022]* • Complete certification of original volume TRU waste *[2024]* • Annually certify at least 25% of the remaining TRU waste until completed • Annually ship at least 55% of waste receivable by WIPP from Idaho until completed • Close TRU processing and storage facilities per RCRA
Tank Waste	• Initiate sodium-bearing waste treatment operations *[2022]* • Complete Integrated Waste Treatment Unit treatment and packaging of remaining liquid sodium-bearing waste to a solid suitable for disposal *[2028]*

	• Construct or modify a facility to package calcine waste for final disposition *[TBD]* • Treated calcine road ready *[TBD]*
SNF	• Complete SNF wet-to-dry storage transfers *[2023]* • Finalize removal of all SNF from Idaho per Idaho Settlement Agreement *[2035]* • Construct SNF packaging demonstration project to guide design and construction of SNF packaging facility • Construct and operate SNF packaging facility to support removal of all SNF from Idaho and Colorado *[TBD]*
LLW/MLLW/Other	• Process and disposition remote handled (RH) LLW/MLLW *[2045]* • Disposition LLW/MLLW wastes generated from D&D effort and waste processing operations

Remaining Decisions

Mission Area	Pending Decisions
Tank Waste	• Finalize treatment alternative for calcine from 2021 analysis of alternatives *[2023-2024]*
SNF	• Confirm requirements for SNF packaging facility *[TBD]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The site will remain a Nuclear Energy site. After closure of the Radioactive Waste Management Complex and Idaho Nuclear Technology and Engineering Center facilities, the area will continue to be monitored and assessed for any further needed remediation as part of DOE's long-term stewardship.

Lawrence Livermore National Laboratory

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other	$142 to $186M	2031

Located in California, Lawrence Livermore National Laboratory (LLNL) was established in 1952 as a multidisciplinary research and development (R&D) center focusing on weapons development and homeland security. The laboratory is operated by Lawrence Livermore National Security, LLC, for the National Nuclear Security Administration (NNSA). The LLNL Site 300 is a remote experimental testing facility where the Department conducts research, development, and testing of high explosives and integrated non-nuclear weapons components. More information is available in the *LLNL Strategic Vision 2022-2032*.

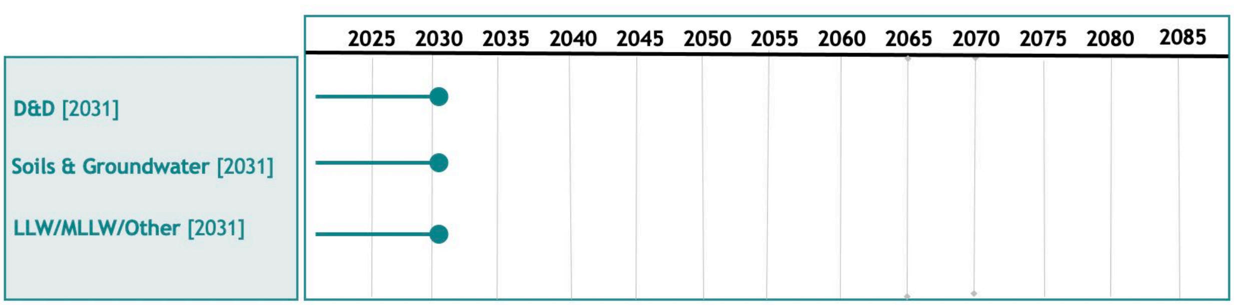
Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Finalize remedial design for Building 812 & 865, and perchlorate in 850 groundwater *[2027]* • Select and implement groundwater remedial actions for Buildings 812, 865, and 850
D&D	• Demolish remaining higher risk excess facilities including Buildings 280, 251, 292, 241, 343, 212, and other process contaminated facilities *[2031]*
LLW/MLLW/Other	• Dispose of waste generate from Building 812 soil remediation activities

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Issue amended ROD for groundwater treatment path at Buildings 812, 865, and 850 *[2026]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The site will remain an NNSA Site. Operations and maintenance of implemented soil and groundwater remedies will be transferred to NNSA.

Los Alamos National Laboratory

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other • TRU	$5.7 to $6.8B	2036


Los Alamos National Laboratory (LANL), located in Los Alamos, New Mexico, was established in 1943 as Site Y of the Manhattan Project. The DOE's mission is carried out jointly by NNSA and EM. The EM Los Alamos Field Office (EM-LA) investigates and remediates sites with hazardous chemical and radioactive contamination resulting from legacy LANL operations. Approximately 500,000 cubic meters of legacy hazardous and radioactive waste is located at LANL. Most of this waste is buried in 26 material disposal areas (MDAs) dispersed throughout the site. Eight MDAs have been cleaned up. Cleanup of legacy hazardous waste at LANL is regulated by the New Mexico Environment Department (NMED), pursuant to the New Mexico Hazardous Waste Act. DOE regulates cleanup of radioactive contamination, pursuant to the Atomic Energy Act. EPA regulates air and storm water. The New Mexico Office of the State Engineer regulates water rights and well drilling. More information is available in the *LANL Strategic Vision 2022-2032*.

Remaining Scope

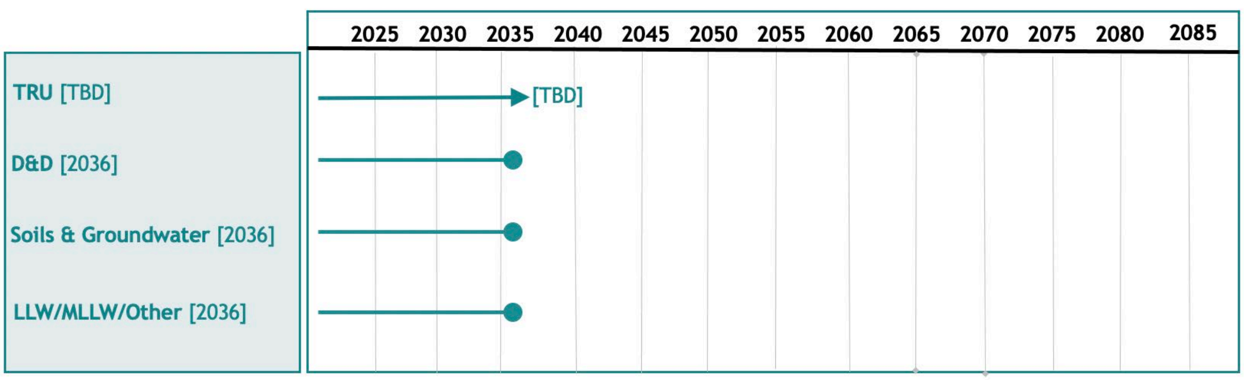
Mission Area	Strategy
Soils/Groundwater	• Characterize and remove buried radiologically contaminated debris from the Middle DP Road Site *[2022]* • Continue managing a hexavalent chromium groundwater plume using a pump, treat, and injection interim measure until final remedy is implemented • Complete aggregate area campaigns, including the Southern External Boundary, Pajarito Watershed, and Upper Watershed *[2026]* • Close remaining Consent Order Campaign MDAs *[TBD]* • Implementation of corrective measures and closure of MDA C • Continue characterizing and monitoring a plume of chemical constituents related to early explosives work, which is referred to as the Royal Demolition Explosives (RDX) plume • Continue site investigations, remediation where required, and closure of about 900 remaining potential areas of contamination under the cleanup campaigns identified in the 2016 Compliance Order on Consent • Maintain compliance with the EPA National Pollutant Discharge Elimination System Individual Permit, which regulates storm water flow on to, and off, 405 potential areas of contamination.
D&D	• Plan for Ion Beam Facility D&D *[2022]* • D&D of the TA-54 structures and subsequent closure of MDA G and MDA L *[TBD]*

	• D&D of Building 257, industrial waste lines, and DP West slabs in Technical Area 21 (TA-21) • Categorize hazard for TA-21 Building 257, industrial waste lines, and the DP west slabs
LLW/MLLW/Other	• Complete disposition of waste from D&D and soil and groundwater remediation *[TBD]*
TRU	• Remove retrievably stored below-grade legacy TRU from MDA-G and dispose at WIPP *[2036]* • Complete disposition of EM-LA TRU waste currently at the Waste Control Specialists commercial disposal site in Texas *[TBD]* • Process and dispose of above ground TRU waste • Complete assessment on 33 shafts, and determine path forward

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Finalize remedy for the hexavalent chromium plume and RDX plume *[2026]* • Approach for site assessment/characterization for Middle DP Rd *[TBD]*
TRU	• Decision on disposal of EM-LA drums in storage at Waste Control Specialists in Texas *[TBD]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions (e.g., LANL MDAs).

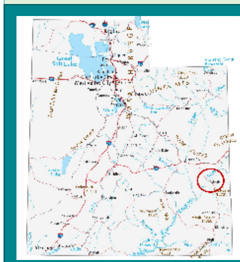
END STATE: The end state for EM-LA involves cleanup of legacy waste to environmental standards or stabilization that is protective of the public and environment. Long-term stewardship activities will be managed by NNSA.

Moab

Overview

The Moab Uranium Mill Tailings Remedial Action (UMTRA) Project is in southeastern Utah. The Moab Site is a former uranium-ore processing facility that operated under private ownership from 1956 to 1984. The property was subsequently designated a *Uranium Mill Tailings Control Act of 1978* (UMTRCA) Title I site through legislation. The site was transferred to DOE ownership in 2001 through Congressional legislation and now encompasses about 480 acres including a 130-acre uranium mill tailings pile. More information is available in the *Moab Strategic Vision 2022-2032*.

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other	$409 to $417M	2029 to 2033



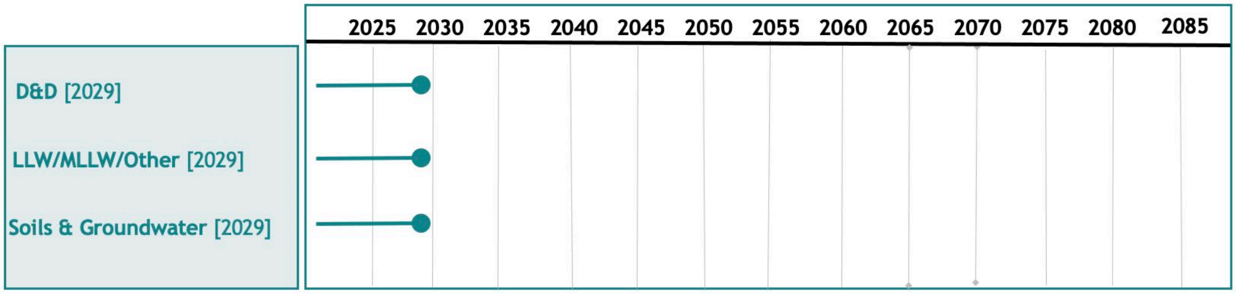
Remaining Scope

Mission Area	Strategy
Soils/ Groundwater	• Remediate the sub-pile (i.e., any contamination beyond 2′ depth) and the off-pile areas at Moab and outside of the disposal cell boundaries at Crescent Junction • Extract contaminants from the groundwater underlying the site, including ammonia and uranium, to protect the Colorado River • Continue groundwater remediation efforts outlined in the Ground Water Compliance Action Plan
D&D	• Remove and disposition site structures, including the Atlas building and other support facilities. Disposition may include placement in the disposal facility or free-release as appropriate and practicable
LLW/MLLW/Other	• Relocate the remainder of the 16 million tons of mill tailings from the former mill site in Moab, Utah, and away from the Colorado River to the Crescent Junction, Utah disposal cell, about 30 miles north *[2026]* • Transport oversized debris from the Moab Site to the Crescent Junction disposal cell, including 14 autoclaves (at least 40 tons each and potentially filled with asbestos) that were decommissioned by the Atlas Minerals Corporation *[2028]* • Dispose of potentially contaminated equipment and intermodal containers and install the cover on the disposal cell • Conduct investigations on the effectiveness of evapotranspiration covers at the Crescent Junction Site, provide recommendations and expertise on cover design, and assist with regulatory approvals

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Decision on final remedy outlined in the Ground Water Compliance Action Plan *[TBD]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The end state for Moab is recreational use. The Moab Site, including the former mill site and the Crescent Junction Site, will be transitioned to the Office of Legacy Management for long-term surveillance and maintenance.

Nevada National Security Site

Overview

The DOE Environmental Management Nevada (EM-NV) Program was established in 1989 to assess and mitigate the impacts of historical nuclear research, development, and testing at the Nevada National Security Site (NNSS), and to operate the LLW, MLLW, and classified waste disposal facilities on the Site. EM-NV is a tenant organization at the NNSS that is administered by NNSA. Hazardous waste cleanup at NNSS is regulated under RCRA. More information is available in the *NNSS Strategic Vision 2022-2032*.

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other	$487-$610M	2030

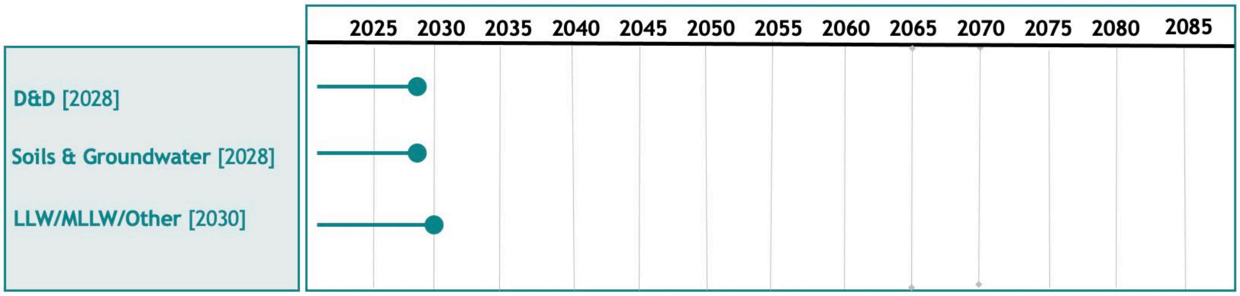
Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Complete corrective action investigation phase 3 at Pahute Mesa groundwater plume *[2023]* • Complete model evaluation phase and regulatory approval at Pahute Mesa groundwater plume *[2027]* • Transition Pahute Mesa groundwater corrective action area to long-term groundwater monitoring program *[2028]* • Transition long-term/post-closure groundwater and soil monitoring to NNSA *[2028]*
D&D	• Submit the Test Cell C (TCC) closure report to the regulator *[2023]* • Submit the Engine Maintenance Assembly and Disassembly (EMAD) closure report to the regulator *[2024]* • Complete demolition of TCC buildings to grade, dispose of the generated waste, and close in place any contamination located below grade, *[2025]* • Complete demolition of EMAD buildings to grade, dispose of the generated waste, and close in place any contamination located below grade *[2026]* • Environmental corrective actions of NNSS industrial sites (TCC and EMAD) *[2028]*
LLW/MLLW/Other	• Continue to support cleanup activities across the DOE complex by providing disposal capacity and services for LLW, MLLW, and classified waste *[2030]*

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Regulatory decisions regarding current groundwater remediation/ monitoring strategies *[various dates]*
D&D	• Regulatory approval for EMAD/TCC sites strategy *[2022]* • Regulatory decisions on discovery of below-grade contaminants during D&D of industrial sites *[various dates]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Also, it is currently anticipated that there will be a need for NNSS waste disposal beyond 2030.

END STATE: Long-term monitoring of closed corrective action sites will transition to NNSA. NNSS is anticipated to continue operation receiving DOE waste for storage/disposal with EM's support.

Oak Ridge Reservation

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • TRU • LLW/MLLW/ Other • NM	$12B	2047


The Oak Ridge Reservation (ORR), located in eastern Tennessee, is one of the three original sites in the Manhattan Project. The U.S. Army Corps of Engineers began acquiring land in the area in October 1942. By March 1943, 56,000 acres were sealed behind fences and major industrial facilities were under construction. The K-25 and Y-12 plants were built to explore different methods to enrich uranium, while the X-10 Site was established as a pilot plant for the Graphite Reactor and to explore methods for the production of plutonium. Throughout the following decades, the three sites – K-25 (present day East Tennessee Technology Park – ETTP), X-10 (present day Oak Ridge National Laboratory – ORNL), and Y-12 – purified isotopes, conducted advanced research, manufactured weapons components, and enriched uranium. These activities created environmental legacies that placed the Oak Ridge Reservation on EPA's National Priorities List in 1989. The ORR Site is regulated under both RCRA and CERCLA, as stated in the Federal Facility Agreement. More information is available in the *Oak Ridge Strategic Vision 2022-2032.*

Remaining Scope

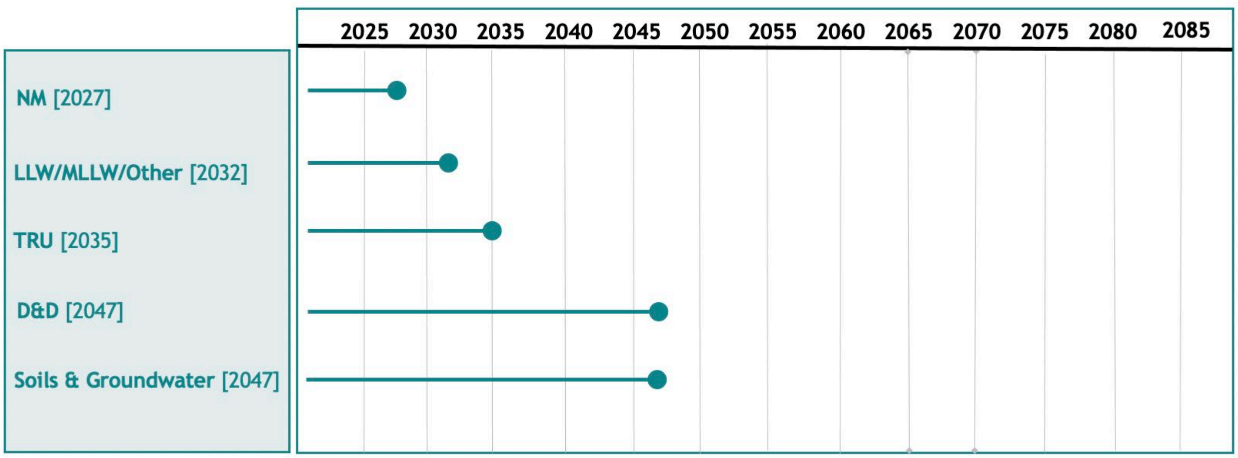
Mission Area	Strategy
Soils/Groundwater	• Complete soil remediation at the Exposure Unit 5 area (former Biology Complex Area) of Y-12 *[2022]* • Remove contaminated soil from ETTP in accordance with the future ROD *[2024]* • Address residual mercury at Y-12 by remobilizing and transporting it to the Outfall 200 Mercury Treatment Facility which is being constructed for operations to begin in *2025* • Remedies in place for ETTP groundwater remediation in accordance with the ROD *[2028]*
D&D	• Demolish the East Bank Hot Cell and remove demolition waste *[2022]* • Demolish the Bulk Shielding Reactor and Low Intensity Test Reactor at ORNL *[2023]* • Demolish Building 3038 and Isotope Row facilities at ORNL *[2025]* • Demolish the Oak Ridge Research Reactor at ORNL *[2026]* • Deactivate Alpha-2, Beta-1, the Old Steam Plant, and the Criticality Experiment Laboratory at Y-12 • Deactivate other contaminated facilities at Y-12 and ORNL to prepare for demolition
TRU	• Process, repackage, and ship the inventory of contact-handled and remote-handled transuranic debris waste for permanent disposal at WIPP *[2028]* • Complete the final design and construction of the Sludge Processing Facility

LLW/MLLW/Other	• Dispose of LLW generated from the cleanup at ORNL and Y-12 in on-site or commercial disposal facilities
NM	• Process, down-blend, and dispose of the remaining inventory of uranium-233 stored at ORNL *[2027]*

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Complete the Record of Decision (ROD) for Final Soils Actions in Zone 1, ETTP *[2022]* • Issue final Site-Wide ROD at ETTP for residual contamination in groundwater and surface water *[2026]* • Issue final soils ROD for cleanup goals for ecological receptors in areas outside main area of ETTP *[TBD]*
TRU	• Decision on ORNL tank sludge disposition pathway *[2030]*
LLW/MLLW/Other	• ROD of on-site EM Disposal Facility *[2023]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: Some cleanup areas at Oak Ridge will be retained to perform national security missions. ETTP will be transitioned into a multiuse industrial park. ORNL and Y-12 areas will be transferred to their respective programs, Office of Science and NNSA.

Paducah Gaseous Diffusion Plant

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other • DU	$35 to $42B	2065 to 2070

The Paducah Gaseous Diffusion Plant (Paducah) began operations in 1952. First used to enrich uranium for the nation's nuclear weapons program, it later supplied enriched uranium for commercial power plants. The DOE and its predecessors managed the plant until it was leased to private industry in 1993 for continued operations. Environmental cleanup ran in parallel until 2013 when operations ceased. DOE accepted the leased facilities back in 2014. Deactivation activities are underway to prepare the Site for D&D, while continuing work on the C-400 Building city block strategy to eliminate the primary source of trichloroethylene at the site. In 1994, the Paducah Site was placed on the National Priorities List. Cleanup at the Paducah Site is regulated under both CERCLA and RCRA. More information is available in the *Paducah Strategic Vision 2022-2032*.

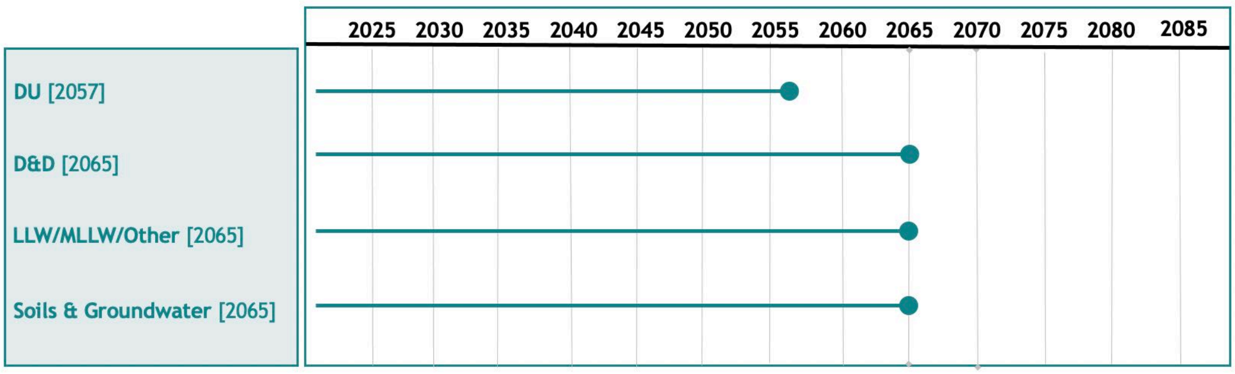
Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Complete the remedial investigation and feasibility study process for the C-400 Complex Operable Unit, the primary source of trichloroethylene groundwater contamination *[2022]* • Pump and treat the trichloroethylene groundwater contamination plume
D&D	• Characterize former uranium enrichment process buildings, remove residual uranium, and reduce other environmental risks inside the buildings • Incorporate lessons learned from Portsmouth and Oak Ridge deactivation and demolition projects • Upgrade and right-size infrastructure systems to support demolition activities • Complete all D&D of the large gaseous diffusion plant buildings *[TBD]*
LLW/MLLW/Other	• Complete disposition of the R-114 refrigerant *[2026]* • Continue and complete disposition of waste from D&D and soil and groundwater remediation • Disposition of conversion products and unused cylinders after depleted uranium hexafluoride (DUF6) processing [TBD]
DU	• Complete DUF6 conversion operations and disposal *[2057]*

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Various CERCLA decisions related to groundwater, burial grounds, soils and surface water to implement final cleanup and D&D *[Various, 2034-2063]*
LLW/MLLW/Other	• On-site Waste Disposal Facility (OSWDF) ROD *[2029]*
D&D	• ROD to identify the final remedial action for the C-400 Complex *[2025]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: Light/heavy industrial use is the most likely future scenario for the site after the Kentucky Research Consortium for Energy and Environment developed a community-based End State vision in 2010. Remaining long-term stewardship activities (e.g., groundwater activities) are planned to be conducted by the Office of Legacy Management.

Portsmouth Gaseous Diffusion Plant

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other • DU	$11 to $13B	2039 to 2043

The Portsmouth Gaseous Diffusion Plant (Portsmouth) was initially constructed to produce enriched uranium to support the nation's nuclear weapons program, and in later years, enriched uranium used by commercial nuclear reactors. The DOE and its predecessors managed the plant until it was leased to private industry in 1993. Environmental cleanup ran in parallel until 2004 when private sector operations ceased. DOE accepted the leased facilities back in 2011 for deactivation and demolition. Portsmouth cleanup is conducted through a Consent Decree and the Director's Final Findings and Orders with the State of Ohio. More information is available in the *Portsmouth Strategic Vision 2022-2032*.

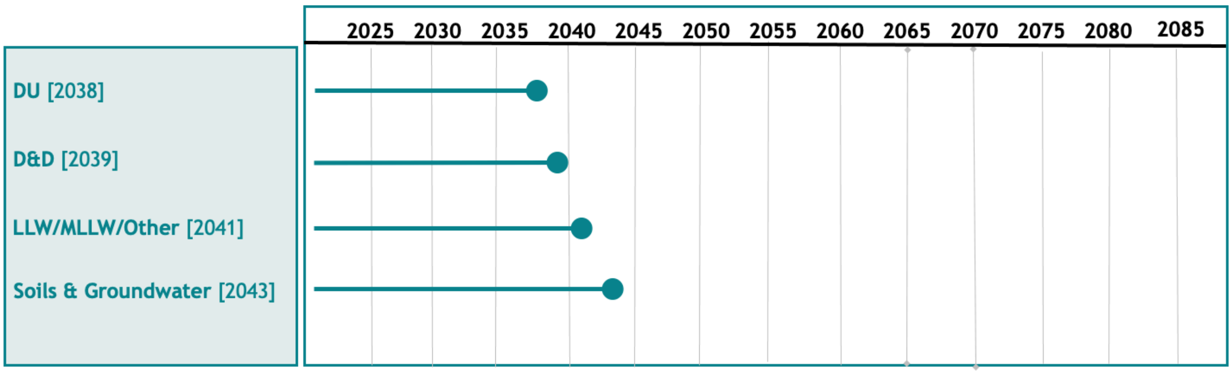
Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Characterize and remediate hazards and contaminants in and around facilities, including trichloroethylene, radionuclides, heavy metals, and polychlorinated biphenyls • Use pump and treat and engineered barriers to cleanup groundwater contaminant plumes • Monitor groundwater regularly to assess the effectiveness of the remedial actions
D&D	• D&D the three gaseous diffusion plant buildings that housed the process equipment (X-326 Process Building, X-333 process Building, and the X-330 Process Building) and other support facilities *[2039]* • Characterize former uranium enrichment process buildings, remove residual uranium and other environmental risks inside the buildings • Right-size site infrastructure to support planned demolition activities: reconfigure the remaining electrical switchyard to accommodate reduced site power needs and modify and reroute site utility infrastructure and high-pressure fire water systems
LLW/MLLW/Other	• Construct individual cells of the OSWDF, phased approach *[2039]* • Establish on-site and off-site waste disposition for waste generated from D&D in accordance with 2015 ROD • Continue and complete disposition of waste from D&D and soil and groundwater remediation • Disposition of conversion products and unused cylinders after DUF6 processing [TBD]
DU	• Complete DUF6 conversion operations and disposal *[2038]*

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Establish final cleanup levels for certain contaminated groundwater and soil areas *[2023]*
D&D	• Decision on potential acceleration of D&D *[2024]*

Timeline of Mission Area Completion



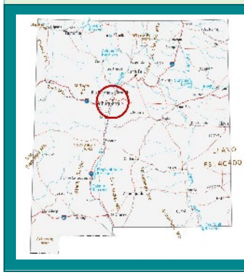
Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The desired end state for the Portsmouth Site is reuse for economic development. An 80-acre parcel of land was transferred to the Community Reuse Organization in July 2018. Remaining long-term stewardship activities (e.g., groundwater activities, OSDWF management) are planned to be conducted by the Office of Legacy Management.

Sandia National Laboratories

Overview

Remaining Scope	To Go Costs	Est. End Date
• Groundwater	$29M	2031



EM's cleanup activities at Sandia National Laboratories (SNL) take place at the section located on Kirtland Air Force Base, adjacent to Albuquerque, New Mexico. The regulatory driver for completing this work is the Compliance Order on Consent signed in 2004 by DOE, the Sandia Corporation, and NMED. DOE's approach is to work closely with NMED to complete RCRA corrective actions at the last three ER sites using cost-effective approaches that meet regulatory requirements. The remaining cleanup scope includes three areas with contaminated groundwater in various stages of characterization and remedy selection — the Tijeras Arroyo Groundwater Investigation Area of Concern (AOC), the Burn Site Groundwater Investigation AOC, and the Technical Area-V Groundwater AOC. All soil sites in SNL's baseline have received Corrective Action Complete status from NMED and have been transferred to the laboratory's program, NNSA. Cleanup at SNL is regulated under RCRA. More information is available in the *SNL Strategic Vision 2022-2032*.

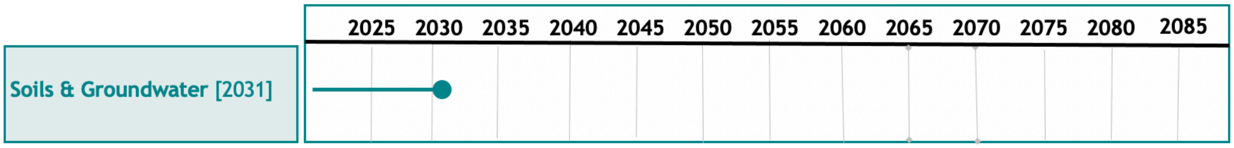
Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Transition the Tijeras Arroyo Groundwater AOC to long-term stewardship *[2023]* • Transition characterization/monitoring wells to long-term stewardship and complete EM mission *[2031]* • Finish installation of injection wells 2 and 3 for Technical Area-V • Complete the second year of planned characterization studies on nitrate contamination at the Burn Site Groundwater AOC section of the laboratory before resuming the corrective action process and proposing alternatives for a remedy

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Decision on a final remedy end states for Tijeras Arroyo Groundwater AOC, Burn Site Groundwater AOC, and Technical Area-V AOC *[TBD]*

Timeline of Mission Area Completion



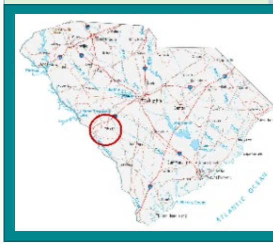
Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The end state of the three remaining groundwater sites will not affect the site's current mission(s). There are active mission activities being conducted on and around these sites.

Savannah River Site

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • TRU • LLW/MLLW/Other • Tank Waste • SNF/NM	$67 to $92B	2065



The Savannah River Site (SRS), an approximately 310-square-mile-site located in South Carolina, focused on the production of plutonium and tritium for use in the manufacture of nuclear weapons from its inception in the early 1950s until the end of the Cold War. In 1992, the focus at SRS turned to environmental cleanup, nuclear materials management, and R&D activities. Today, SRS is a complex site run by DOE-EM and host to NNSA. SRS processes and stores nuclear materials for NNSA in support of national defense and U.S. nuclear nonproliferation efforts. EM is also responsible for the Savannah River National Laboratory, located at the site. Cleanup at SRS is regulated under both RCRA and CERCLA, however the Liquid Waste program at SRS is permitted under Industrial Wastewater Regulations in lieu of RCRA. More information is available in the *SRS Strategic Vision 2022-2032*.

Remaining Scope

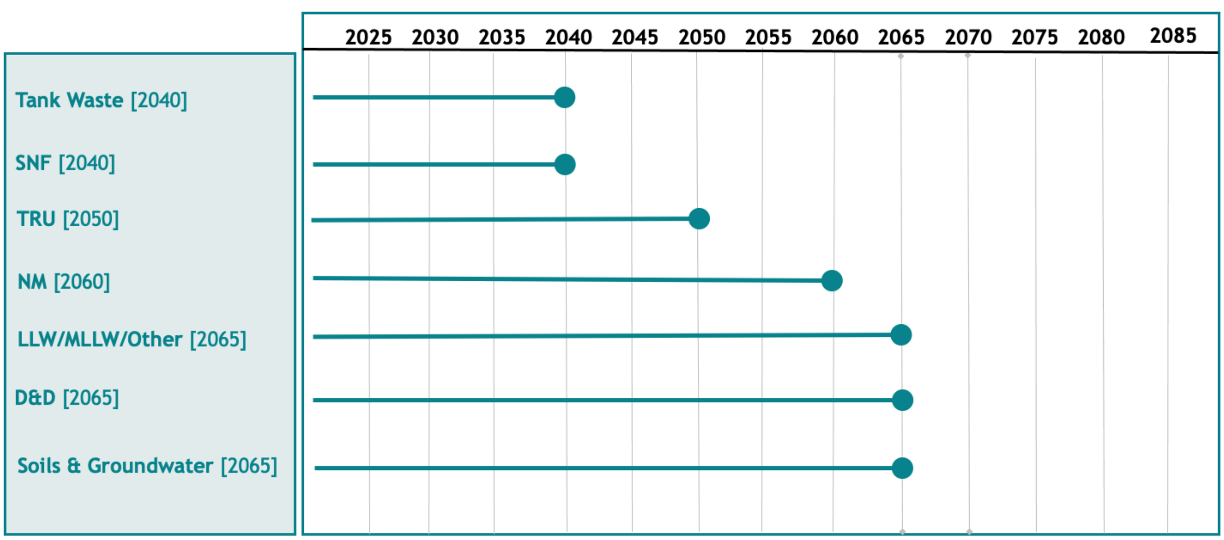
Mission Area	Strategy
Soils/Groundwater	• Start remedial action for Lower Three Runs Stream System *[2023]* • Start coal ash remediation in A-Area *[2026]* • Start remedial action for ancillary facilities in F-Area *[2027]* • Start remedial action for C-Area groundwater *[2028]* • Start coal ash remediation in K-Area *[2028]* • Start remedial action for D-Area groundwater *[2029]* • Start coal ash remediation in L-Area *[2029]* • Remediate waste sites, contaminated soils, surface water, and groundwater; operate regulatory-required remedial systems; and monitor, analyze, and report on over 2,000 groundwater wells *[2065]* • Integrate D&D and soil and groundwater activities in the multiple industrial areas to realize efficiencies of scale in the characterization, assessment, and remediation activities
D&D	• D&D of all industrial, nuclear, and radioactive facilities *[2065]* • Complete deactivation of the remaining non-operational nuclear material facilities (e.g., F-Canyon/FB-Line, H-Canyon/HB-Line) and turn over for decommissioning
TRU	• Continue to down-blend and disposition surplus plutonium in the K-Area, producing TRU waste that will eventually be disposed at WIPP, with the first shipment expected in 2022
LLW/MLLW/Other	• Continue to characterize, store and disposition site-generated wastes in compliance with applicable regulations and requirements

	• Continue operation of LLW disposal facilities in the E Area • Complete operations at Saltstone disposal in the Z Area, including construction of new SDUs
Tank Waste	• Process up to 9 million gallons of tank waste per year at the Salt Waste Processing Facility *[2025]* • Complete waste removal from F-Tank Farm *[2033]* • Complete vitrification at the Defense Waste Processing Facility *[2037]* • Close underground liquid waste tanks • Continue to perform environmental analyses in an effort toward the use of the Department's interpretation of HLW for waste streams • Continue to support the receipt of waste from H-Canyon operations within the Liquid Waste program
SNF/NM	• Complete SNF processing in H-Canyon *[2034]* • Continue disposition of legacy nuclear materials stored in the L-Area and K-Area • Continue to provide wet storage of SNF received as part of the domestic and foreign research reactor fuel receipt programs in the L-Area facilities • Create plan/timeline to transition support for ongoing nuclear materials activities from EM to NNSA

Remaining Decisions

Mission Area	Pending Decisions
SNF/NM	• Decision on Accelerated Basin De-Inventory *[Completed 2022]*

Timeline of Mission Area Completion



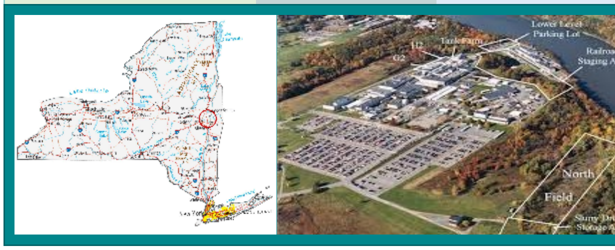
Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: It is anticipated that the Savannah River Site will remain a DOE site supporting NNSA. Remaining long-term stewardship activities will be transitioned to NNSA upon completion of the EM mission.

Separations Process Research Unit

Overview

Remaining Scope	To Go Costs	Est. End Date
• TRU	$91M	2025



The Environmental Management Consolidated Business Center – New York (EMCBC-NY) Project Office, formerly the Separations Process Research Unit (SPRU) Field Office, is located at the Knolls Atomic Power Laboratory in New York State. The former mission of this office was to remove the SPRU, which was constructed and operated by the Atomic Energy Commission as a pilot plant for developing and testing the chemical processes to extract both uranium and plutonium from irradiated fuel. In 2020, the project was completed, the grounds restored, and the site was transitioned to the DOE Office of Naval Reactors. There were 24 containers of suspect TRU waste placed in a temporary storage area pending offsite disposal. More information is available in the *SPRU Strategic Vision 2022-2032*.

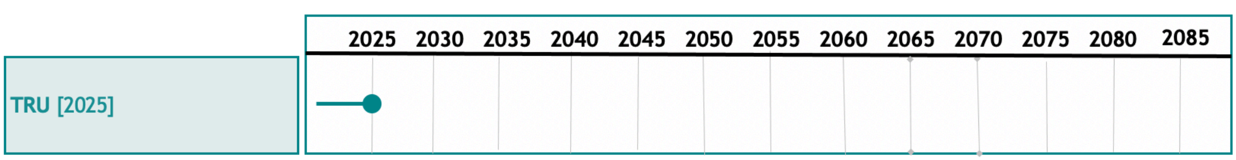
Remaining Scope

Mission Area	Strategy
TRU	• Dispose of the remaining TRU waste at WIPP *[2025]* • Manage the TRU storage facility containing 24 containers of potential TRU waste generated from SPRU demolition operations • Commercially treat a portion of the TRU waste for low level waste disposal

Remaining Decisions

Mission Area	Pending Decisions
TRU	• Finalize the treatment path for TRU *[TBD]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions.

END STATE: The DOE Office of Naval Reactors will remain the owner of the site.

Waste Isolation Pilot Plant

Overview

Remaining Scope	To Go Costs	Est. End Date
• D&D • TRU	$10 to $12B	TBD

The Carlsbad Area Office in Carlsbad, New Mexico, was created in late 1993 to lead the nation's TRU waste disposal efforts through the management of the National TRU Program (NTP) and the Waste Isolation Pilot Plant (WIPP). WIPP received its first shipment of TRU waste from the LANL in 1999. In September 2000, the office was elevated in status to become the Carlsbad Field Office (CBFO). As such, the CBFO has continued its primary mission of managing the NTP to characterize, certify, and ship defense generated TRU and TRU mixed waste to the WIPP, and operating the WIPP to permanently dispose of TRU waste in conformance with the WIPP Land Withdrawal Act (LWA). Waste management at WIPP is regulated under RCRA. More information is available in the *WIPP Strategic Vision 2022-2032*.

Remaining Scope

Mission Area	Strategy
D&D	• Finalize D&D of WIPP, including entombing all waste, closing, and sealing mine shafts/boreholes, and demolition/disposition of surface facilities *[2055]*
TRU	• Construct the Safety Significant Confinement Ventilation System and the Utility Shaft *[2025]* • Dispose of contact handled and remote handed TRU waste from DOE sites • Construct a hoisting system within the new shaft • Mine new replacement panels/disposal rooms • Move to a low-emission or zero-emission underground vehicle fleet

Remaining Decisions

Mission Area	Pending Decisions
TRU	• Obtain permit renewal decisions from the state for the Hazardous Waste Facility Permit *[TBD]*

END STATE: The above ground portion of the site will be returned to as close to the pre-construction condition, as reasonably possible, while protecting human health, the environment, and to meet NEPA and LWA commitments. DOE will maintain and implement the long-term active controls and install the permanent markers.

West Valley Demonstration Project

Overview

Remaining Scope	To Go Costs	Est. End Date
• Soils/Groundwater • D&D • LLW/MLLW/Other • Tank Waste	$1.3 to $1.6B	2043


The West Valley Demonstration Project (WVDP) Act of 1980 directed the DOE to conduct an HLW solidification and decommissioning demonstration project, in cooperation with New York State, at the Western New York Nuclear Service Center (WNYNSC). The WNYNSC was the site of the only commercial nuclear fuel reprocessing plant to have operated in the United States. The WNYNSC, located about 40 miles south of Buffalo, New York, is owned by the New York State Energy Research and Development Authority. WVDP is regulated under RCRA. More information is available in the *WVDP Strategic Vision 2022-2032*.

Remaining Scope

Mission Area	Strategy
Soils/Groundwater	• Issue supplemental EIS for Phase 2 cleanup (four underground waste tanks, two on-site disposal areas, and the non-source area of the groundwater plume), as well as D&D activities and/or long-term stewardship of WNYNSC *[2023]* • Complete soil remediation efforts in Waste Management Area-1 and Waste Management Area-2 *[2030]*

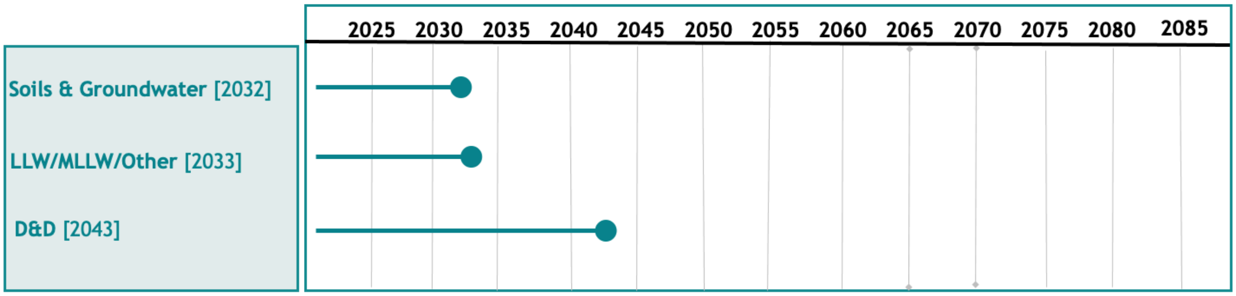
D&D	• Complete facility deactivation and decommissioning activities outlined in 2010 Phase 1 ROD *[2033]*, including:
	  ○ Complete demolition of Main Plant Process Building (MPPB) and ancillary support buildings *[2026]*
	  ○ Complete decommissioning of the below-grade portions of the MPPB and the Vitrification Facility *[2029]*
	  ○ Complete decommissioning of the site's radioactive wastewater treatment system, including four active lagoons and one closed lagoon *[2030]*
	  ○ Remove remaining waste processing facilities (e.g., Remote-Handled Waste Facility) *[2033]*
	• Complete remaining decommissioning activities pending Phase 2 decisions *[2043]*

LLW/MLLW/Other	• Complete the disposition of Greater-than-Class-C (GTCC)/GTCC-like waste, pending Congressional action *[TBD]* • Dispose of LLW and MLLW resulting from MPPB demolition
Tank Waste	• Complete off-site shipment of HLW canisters pending availability of a geologic repository *[TBD]*

Remaining Decisions

Mission Area	Pending Decisions
Soils/Groundwater	• Issue ROD for Phase 2 cleanup (four underground waste tanks, two on-site disposal areas, and the non-source area of the groundwater plume), as well as D&D activities and/or long-term stewardship of WNYNSC *[2023]*
LLW/MLLW/Other	• Determine final disposition path for on GTCC/GTCC-like waste disposal, pending Congressional action *[TBD]*

Timeline of Mission Area Completion



Note: Timeline reflects current planning assumptions and does not reflect future regulatory decisions. Also, tank waste is not included because vitrification has been completed, and the only remaining activity is storage of canisters awaiting a repository. Lastly, WVDP is responsible for disposition of a significant volume of waste with concentrations of TRU isotopes exceeding 100 nCi/g. However, as this waste is not generated as a result of atomic defense activities, WVDP does not have a TRU waste disposition mission. Instead, this waste is discussed as MLLW/LLW and other wastes

END STATE: Final cleanup levels still to be determined. New York State is expected to remain owner of the site.