



May 2020

ENVIRONMENTAL LIABILITIES

DOE Needs to Better Plan for Post-Cleanup Challenges Facing Sites

Accessible Version

GAO Highlights

Highlights of [GAO-20-373](#), a report to the Committee on Armed Services, U.S. Senate

Why GAO Did This Study

After over 70 years of nuclear weapons production and energy research at hundreds of sites across the country, DOE faces over \$500 billion in environmental liabilities associated with cleanup of hazardous contamination and long-term management of these sites. LM is responsible for the portion of these liabilities associated with long-term management of sites after active cleanup has been completed. LM oversees 100 sites across the country. Depending on the sites' clean-up standards and intended reuse, LM will likely be managing some sites for centuries.

Senate Report 116-48 accompanying the National Defense Authorization Act for fiscal year 2020 includes a provision for GAO to review LM's operations, including the nature of its environmental liability. This report examines (1) LM's environmental liability, and (2) any challenges LM faces in managing its sites and how it is addressing those challenges. GAO analyzed data on LM's environmental liability; interviewed officials at LM headquarters and those responsible for the nine sites requiring the most intensive level of management; and reviewed relevant policies, procedures, and guidance.

What GAO Recommends

GAO is making three recommendations, including that DOE develop agreements and procedures for circumstances that require new cleanup work and that it develop plans to assess and to mitigate the effects of climate change on its sites. DOE agreed with all three recommendations.

View [GAO-20-373](#). For more information, contact David C. Trimble at (202) 512-3841 or trimbled@gao.gov.

May 2020

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DOE Needs to Better Plan for Post-Cleanup Challenges Facing Sites

What GAO Found

The environmental liability of the Department of Energy's (DOE) Office of Legacy Management (LM) was estimated at \$7.35 billion in fiscal year 2019 and, according to LM officials, is expected to grow as LM acquires more sites (see figure for LM's current sites). Long-term surveillance and maintenance activities associated with radioactive and hazardous waste, such as treating residual groundwater contamination, account for about 40 percent of the costs. LM's environmental liability has generally remained stable over the past 5 years. As of September 2019, LM is scheduled to receive 52 additional sites by 2050, and officials expect LM's environmental liability to grow as a result. Officials said LM is taking steps to reduce its environmental liability at its current sites, such as exploring alternative approaches for reducing residual contamination.

LM officials identified challenges in providing long-term surveillance and maintenance of sites related to: (1) the performance of remedies that contain or reduce contamination, (2) environmental conditions, and (3) new regulatory requirements. LM is taking some actions to address these challenges. For example, at its Rocky Flats, Colorado, site, LM is repairing an aging landfill that was damaged by extreme rainfall events. However, LM has not yet planned for how to address challenges at some sites that may require new cleanup work that is not in the scope of LM's expertise and resources. By developing agreements and procedures with the entities that would be responsible for conducting this new cleanup work, LM can help mitigate risks to human health and the environment. In addition, LM has not made plans to assess the effects of climate change on its sites or to mitigate those effects, as called for in its strategic plan. By developing plans to assess the effect of climate change on its sites and to mitigate any significant impacts, LM could better ensure that its remedies will protect human health and the environment in the long term.

Figure: Map of 100 Sites Managed by DOE Office of Legacy Management (as of September 2019)



Sources: Department of Energy (DOE) (site locations); Map Resources (map). | GAO-20-373

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Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
EM	Office of Environmental Management
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
LM	Office of Legacy Management
NRC	Nuclear Regulatory Commission
RCRA	Resource Conservation and Recovery Act
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	U.S. Army Corps of Engineers

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May 13, 2020

The Honorable James M. Inhofe
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

Over seventy years of nuclear weapons production and energy research by the federal government has generated large amounts of radioactive and hazardous waste, spent nuclear fuel, uranium mill tailings,¹ and contaminated soil and groundwater at hundreds of sites across the country. Even after active environmental remediation of these sites is completed, few sites will be cleaned up to the point that they can be released for unrestricted human access. Rather, many sites will require surveillance and maintenance to ensure the continued protection of human health and the environment for as long as contamination remains—in many cases, hundreds or thousands of years into the future. The Department of Energy (DOE) is responsible for such surveillance and maintenance, and in 2003, it created the Office of Legacy Management (LM) to manage those responsibilities. Specifically, LM is charged with providing environmental surveillance, facility and site maintenance, records management, and pension and benefit program oversight for sites where active cleanup has been completed, among other things. For fiscal year 2019, DOE budgeted about \$159 million for LM activities.

The estimated future cost of LM's long-term surveillance and maintenance and other activities is known as LM's environmental liability. This cost is part of DOE's overall environmental cleanup and disposal liabilities, which DOE reported as \$505.3 billion in fiscal year 2019. DOE is responsible for the largest share of reported federal environmental liabilities—about 85 percent in fiscal year 2019.² We have previously reported that the federal government's environmental liabilities have been

¹Uranium mill tailings are the residue that remains from extracting uranium from uranium ore. The tailings are radioactive and might contain other metals or hazardous substances.

²See Department of the Treasury, *Financial Report of the United States Government: FY19* (Washington, D.C.: March 2020).

growing for the past 20 years and are likely to continue to increase. In 2017, we designated the federal government's environmental liabilities as a high-risk area because of the large and expanding estimated costs of cleaning up areas where federal activities have contaminated the environment.³ We have also previously reported on challenges created by fiscal exposures, which are responsibilities, programs, and activities that legally may commit the federal government to future spending or create the expectation for future spending (such as in the case of environmental liabilities).⁴

Senate Report 116-48 accompanying the National Defense Authorization Act for FY 2020 includes a provision for us to review LM's operations, including the nature of its environmental liability. This report examines (1) LM's environmental liability and changes in this liability over time, and (2) any challenges LM faces in providing long-term surveillance and maintenance of sites, and the extent to which LM is addressing those challenges.

To examine LM's environmental liability and changes over time, we reviewed environmental liability data provided by LM for fiscal years 2012 through 2019 (the time period for which comparable data were available), including data for each LM site and activity.⁵ To assess the reliability of these data, we reviewed accompanying documentation on LM's sites and its guidance on estimating its environmental liability, interviewed knowledgeable officials from LM and DOE's Office of the Chief Financial Officer about the department's systems for collecting and maintaining the data, and conducted checks for data completeness and other factors. For

³GAO, *High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others*, [GAO-17-317](#) (Washington, D.C.: Feb. 15, 2017). GAO's high-risk program identifies government operations with greater vulnerabilities to fraud, waste, abuse, and mismanagement or the need for transformation to address economy, efficiency, or effectiveness challenges. In our March 2019 update to this high-risk area, we reported that DOE and the Department of Defense, which also shares responsibility for a large portion of the U.S. government's environmental liabilities, have partially met one out of five criteria for removal from the high-risk list; the other four criteria are not met. See GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, [GAO-19-157SP](#) (Washington, D.C.: Mar. 6, 2019).

⁴GAO, *Fiscal Exposures: Federal Insurance and Other Activities That Transfer Risk or Losses to the Government*, [GAO-19-353](#) (Washington, D.C.: Mar. 27, 2019).

⁵LM reports estimated costs associated with its current sites as well as costs associated with sites that it expects to acquire in the future. LM also reports other program-wide costs that are not site-specific, such as costs associated with exploring new technologies and operating a laboratory.

example, we confirmed the completeness of the data by verifying that the number and types of sites represented in LM's data align with documentation listing its current sites as of fiscal year 2019. We found these data to be sufficiently reliable for the purposes of our performance audit, that is, to describe what the environmental liability estimate is and how it has changed over time.

To examine any challenges facing LM in providing long-term surveillance and maintenance of sites and the extent to which LM is addressing those challenges, we reviewed relevant DOE and LM policies, procedures, and guidance documents related to LM's management of its sites. The control activities component of internal control—the policies, procedures, actions, or information systems that management designs or implements—was significant to this objective, along with the related principle that management should design control activities to achieve objectives and respond to risks.⁶ We reviewed DOE documentation on policies and procedures for providing long-term surveillance and maintenance and compared this documentation with internal control criteria to identify any gaps.

For both objectives, we interviewed LM headquarters officials and site-level officials responsible for the nine sites that require the most intensive level of management, which LM refers to as category 3 sites. Appendix I provides information about these sites. We interviewed officials from these sites to obtain their perspectives on any trends in LM's environmental liability in recent years and any projected future changes, as well any challenges facing LM in providing long-term surveillance and maintenance of its sites and any actions or plans to address those challenges. To develop interview questions for site-level officials, we analyzed relevant reports from the National Academies of Science, Engineering, and Medicine on DOE's long-term management of post-cleanup sites.⁷ We categorized major areas of challenges identified in these reports and used these categories to develop questions for site-

⁶GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: September 2014).

⁷National Research Council of the National Academies, Committee on the Remediation of Buried and Tank Waste, *Long-Term Institutional Management of U.S. Department of Energy Legacy Waste Sites* (Washington, D.C.: The National Academies Press, 2000) and National Research Council of the National Academies, Committee on Long-Term Institutional Management of DOE Legacy Waste Sites: Phase 2, *Long-Term Stewardship of DOE Legacy Waste Sites—A Status Report* (Washington, D.C.: The National Academies Press, 2003).

level officials about potential challenges facing LM in providing long-term surveillance and maintenance of sites. In developing these questions, we also drew on challenges identified by LM headquarters officials. We visited and toured one of LM's category 3 sites—the Rocky Flats site in Colorado. We selected this site to visit because, in the portion of LM's fiscal year 2019 environmental liability estimate that is broken down by site, this site accounts for the largest amount.

We conducted this performance audit from August 2019 to May 2020, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

In 1999, DOE issued a report stating that, based on experience from a decade of planning and conducting cleanup work at the sites for which it is responsible, complete restoration to levels acceptable for unrestricted use could not be accomplished at many of its sites.⁸ According to the report, a variety of hazards would remain at many DOE sites after these sites had been cleaned up in accordance with applicable requirements. These hazards include long-lived radionuclides left in place in soils or contained in on-site disposal cells and residual contaminants in surface water and groundwater.⁹ The report cited technical challenges—such as lack of existing technology for completely removing some types of waste—and economic limitations—such as prohibitive costs to employ available technology—as reasons why these hazards would remain.¹⁰ As

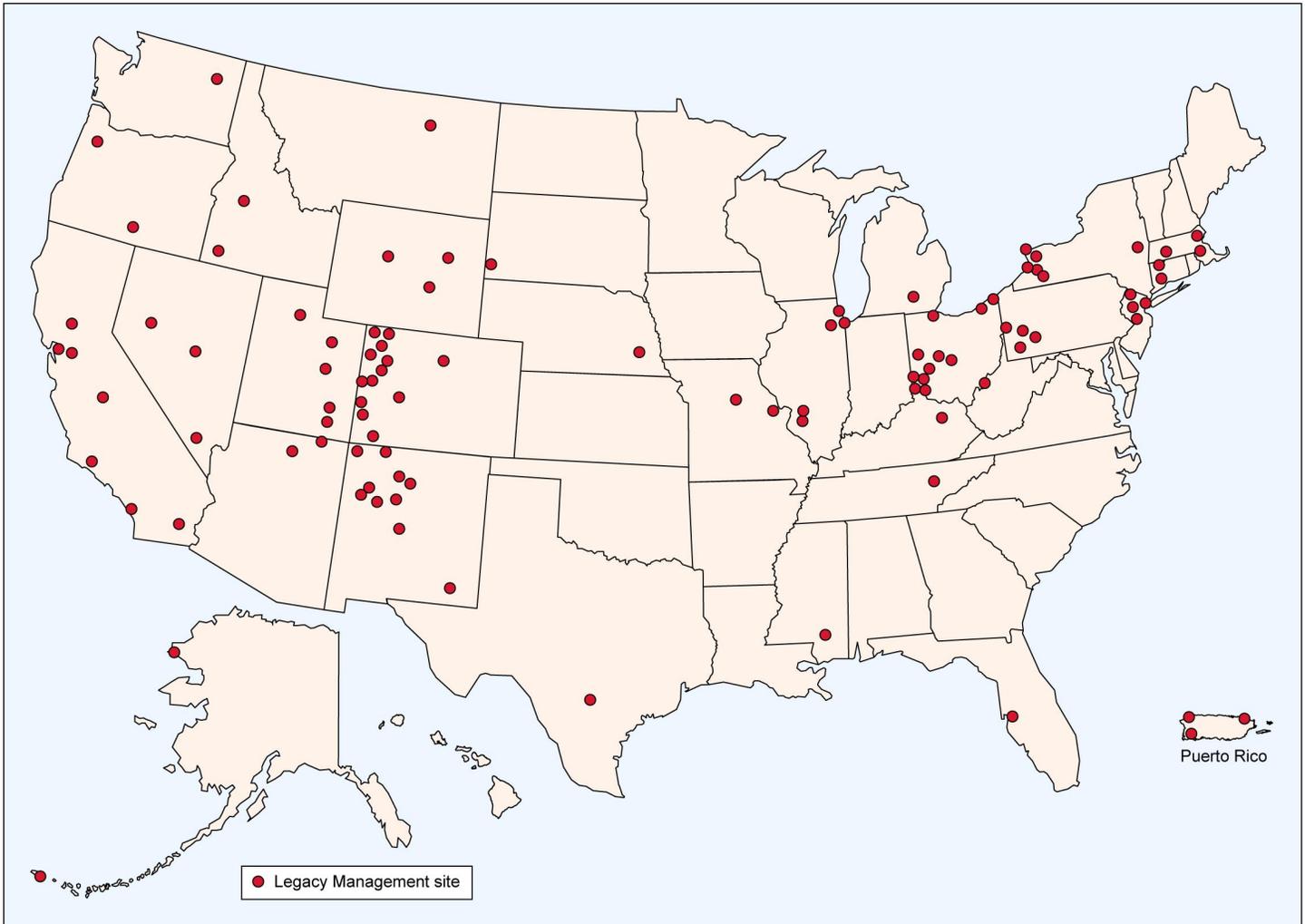
⁸Department of Energy, Office of Environmental Management, *From Cleanup to Stewardship*, DOE/EM-0466 (Washington, D.C.: October 1999).

⁹For example, according to a DOE document, radionuclides (radioactive forms of elements) left onsite after cleanup continue to pose some degree of risk to human health and the environment indefinitely. This is due to radionuclides' long half-lives, or fixed amounts of time required for one half of a given amount of a radionuclide to decay. Depending on the radionuclide, radioactive decay products may persist in the environment for hundreds of thousands of years before decaying into a stable, nonradioactive element.

¹⁰In addition, DOE officials told us that, due to technical and financial impracticability, consistent with current applicable cleanup requirements, some residual contamination remains after cleanup is completed.

a result, DOE reported that long-term management would be needed at these sites to ensure that the cleanup remedies—i.e., the actions, systems, or other measures put in place to clean up a site—would protect human health and the environment from these hazards into the future. Several DOE organizations, including the Office of Environmental Management (EM), were responsible for long-term management of post-cleanup sites until the department established LM in 2003. As of the end of fiscal year 2019, LM had assumed responsibility for 100 sites across the United States, including sites in Alaska and Puerto Rico (see fig. 1).

Figure 1: Map of 100 Sites Managed by DOE Office of Legacy Management (as of September 2019)



Sources: Department of Energy (DOE) (site locations); Map Resources (map). | GAO-20-373

Roles and Responsibilities for Cleanup of Sites

Several different entities conducted cleanup of sites before LM assumed responsibility for the sites. These different entities conducted cleanup under a variety of authorities:

- **EM.** Established in 1989, DOE's EM is responsible for the cleanup of legacy waste that resulted from the development and production of nuclear weapons and government-sponsored nuclear energy research dating back to World War II and the Cold War. Such waste includes radioactive waste, spent nuclear fuel and nuclear material, and contaminated soil and water, among other things. EM cleaned up 83 of the 100 sites that are now within LM's portfolio. Key laws that governed EM's cleanup of these sites include the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended (CERCLA); the Resource Conservation and Recovery Act of 1976 as amended (RCRA); and Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). Title I of UMTRCA authorizes a cleanup program for uranium mill tailings sites—which produced uranium for nuclear weapons and other defense purposes—that were no longer operational as of 1978, the year of the law's enactment.¹¹ DOE is generally responsible for financing the cleanup of these sites. EM also cleaned up sites that are now within LM's portfolio under the Formerly Utilized Sites Remedial Action Program (FUSRAP). This program was established in 1974 to identify, investigate, and clean up sites where radioactive contamination remained from Manhattan Project and early Atomic Energy Commission operations. EM was responsible for cleaning up FUSRAP sites until 1997, when Congress directed the U.S. Army Corps of Engineers (USACE) to assume responsibility for the cleanup work of the remaining designated FUSRAP sites.¹²
- **USACE.** USACE cleaned up 10 FUSRAP sites that are now within LM's portfolio. Under a memorandum of understanding signed by DOE and USACE in 1999, DOE is responsible for the long-term management of FUSRAP sites after USACE completes cleanup. Key

¹¹Specifically, UMTRCA was enacted in part to address the environmental and public health risks associated with residual radioactive material produced at inactive uranium mill sites.

¹²DOE assessed more than 600 candidate sites for eligibility under FUSRAP and determined that 46 would be eligible for cleanup. DOE remediated 25 of the 46 sites from 1974 to 1997, when Congress transferred cleanup responsibility for the remaining sites to USACE.

requirements that govern USACE's cleanup of FUSRAP sites include CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan.

- **Private licensees.** LM's portfolio includes seven sites cleaned up by private licensees, i.e., commercial operators who were permitted to operate uranium mills or other facilities under a license from the Nuclear Regulatory Commission (NRC). In all except one case, private licensees cleaned up these sites under Title II of UMTRCA, which assigned responsibility to the licensee for reclamation of uranium mill sites operating on or after the law's enactment in 1978.¹³ When a private licensee has completed all cleanup requirements, NRC approves transfer of a site to LM for long-term management.

Cleanup activities conducted by these entities included decontaminating, decommissioning, and demolishing buildings; containing and disposing of a variety of hazardous and radioactive wastes; excavating and stabilizing contaminated soil; constructing engineered disposal cells for contaminated materials; containing and treating contaminated surface water and groundwater; and preparing the land for future public, industrial, or commercial use. Depending on the legal and regulatory framework governing cleanup, other agencies or groups may have played a role in setting cleanup standards and helping to select a site's cleanup remedy. For example, sites cleaned up under Title I of UMTRCA must meet regulatory cleanup standards established by the Environmental Protection Agency (EPA). For certain sites cleaned up under CERCLA and RCRA, DOE has entered into agreements with EPA and the relevant state regulator regarding the necessary cleanup actions, and EPA and the state have provided input in selecting the cleanup remedy.

As cleanup of a site nears completion, LM works with the entity responsible for cleanup to prepare the site for transition into LM's portfolio. The transition process for a given site may take up to 5 years, during which time LM and the cleanup entity develop a long-term surveillance and maintenance plan. Depending on the authority under which a site has undergone cleanup, this plan may require approval by regulators such as EPA or NRC. Other transition responsibilities include identifying and preserving records and checking that administrative

¹³The exception is one site (the Parkersburg Disposal Site in West Virginia), cleaned up by a private licensee under Section 151 of the Nuclear Waste Policy Act, which authorizes DOE to take title to certain privately owned low level radioactive waste disposal sites at no cost to the federal government if, among other things, NRC determines that the private owner has successfully cleaned up the site.

institutional controls and other real property instruments are in place.¹⁴ DOE considers site cleanup to be complete when, among other things, short-term cleanup activities have been completed and long-term cleanup measures, such as groundwater treatment, are in place. According to a DOE document, ongoing groundwater remediation continues at many sites after the official completion of cleanup because of the long timeframes required to capture and remediate contaminated groundwater.

Scope of LM's Mission and Activities

Once LM acquires a site, it places each site into one of three categories based on the actual or anticipated long-term surveillance and maintenance activities associated with the site.

- LM has nine “category 3” sites, which require the most intensive surveillance and maintenance due to the extent of residual contamination, according to LM officials. These sites typically have an ongoing remediation system—such as a groundwater treatment system, according to officials—that LM must monitor and maintain.
- LM has 49 “category 2” sites, which require routine inspection, monitoring, and maintenance.
- LM has 42 “category 1” sites, which require management of records or stakeholder requests for information.

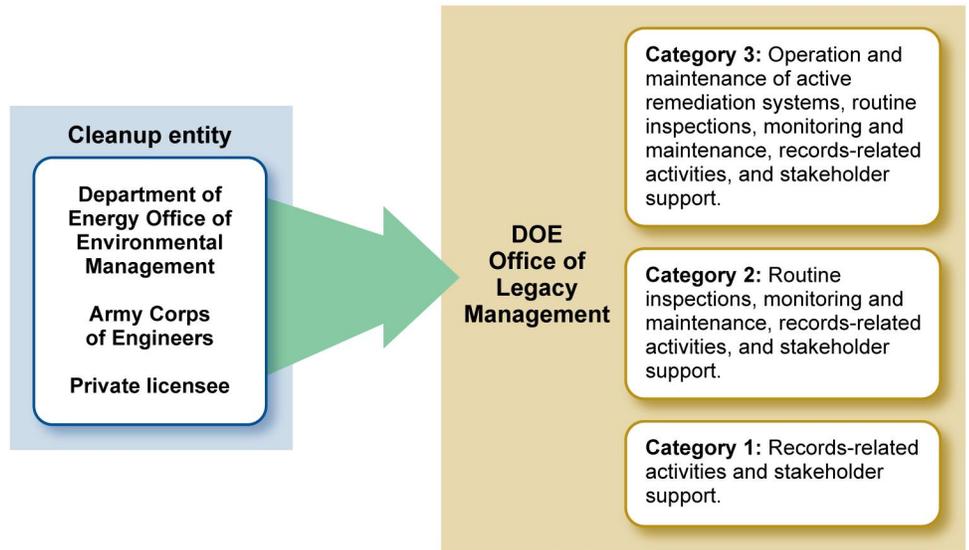
LM also maintains a list of 52 sites that, as of September 2019, are expected to transition into its portfolio over the next three decades. Figure 2 illustrates sites' transition from cleanup entities and their categorization. Appendix II provides additional details about the current sites in LM's portfolio as of fiscal year 2019, and appendix III provides details about sites that, as of September 2019, are scheduled to transition to LM by 2050.¹⁵ According to LM officials, LM does not have a schedule or process for retiring sites from its portfolio. Depending on the sites' clean-

¹⁴Institutional controls include administrative and legal controls that minimize the potential for human exposure, for example, by limiting land use or providing information to guide behavior at the site, such as through zoning restrictions. Institutional controls are a subset of land use control, which can include physical measures such as fencing.

¹⁵In its technical comments on our draft report, DOE revised the planned transition dates for five sites, including revising the transition date for one site (the Paducah site) from 2047 to “beyond 2050.” For consistency with the data we used to examine LM's environmental liability, we continue to report on the sites that, as of the time we drafted our report, LM expected to transition into its portfolio by 2050.

up standards and intended reuse, LM will likely be managing some sites for centuries.

Figure 2: Transition of Contaminated Sites from Cleanup Entity to DOE Office of Legacy Management



Source: GAO summary of Department of Energy (DOE) documents. | GAO-20-373

Note: According to DOE Office of Legacy Management (LM) officials, LM's goal is to move sites into lower categories over time as site conditions allow. LM officials said that LM does not have a schedule for moving sites down in category and told us that many sites will remain in category 2 for the foreseeable future. LM may also move sites to a higher category if new surveillance and maintenance of active remediation systems is needed, according to officials.

LM's budget includes funding for other activities that are not directly associated with its 100 sites. These activities include conducting an inventory of abandoned defense-related uranium mines, overseeing pensions and post-retirement benefits for former contractor workers at closed DOE sites, and leading and coordinating DOE's environmental justice activities. As of fiscal year 2019, LM's overall budget was about \$159 million.

DOE's Environmental Liabilities

Federal accounting standards require agencies that are responsible for cleaning up contamination to estimate future cleanup and waste disposal costs and to report such costs in their annual financial statements as

environmental liabilities.¹⁶ According to these standards, environmental liability estimates are to include probable and reasonably estimable costs of cleanup work. Environmental liability estimates do not include cost estimates for work for which reasonable estimates cannot currently be generated, such as cleanup costs at sites where no feasible remedy exists, according to the standards.

In fiscal year 2019, DOE reported \$505 billion in environmental cleanup and disposal liabilities, of which about \$64 billion are categorized by DOE as “other legacy environment” costs. LM’s environmental liability is part of this category, along with several other types of environmental liability costs.¹⁷

LM’s Environmental Liability Was Estimated at \$7.35 Billion in Fiscal Year 2019 and Will Likely Grow as LM Acquires Additional Sites

LM estimated its environmental liability in fiscal year 2019 at \$7.35 billion, an amount that has been relatively stable over the last 5 years. However, LM expects its environmental liability to increase as it acquires additional sites, according to LM officials.

¹⁶Federal Accounting Standards Advisory Board, *FASAB Handbook of Federal Accounting Standards and Other Pronouncements, as Amended* (Washington, D.C.: June 30, 2017).

¹⁷In fiscal year 2019, DOE reported an estimated \$64 billion in “other legacy environment” environmental cleanup and disposal liabilities. According to data provided by DOE, this estimate includes LM’s long-term management of sites (\$8.1 billion) as well as costs not directly managed by LM, including: costs associated with DOE disposal of surplus plutonium (\$15.1 billion); disposal of high-level waste and spent nuclear fuel currently at EM sites into a geologic repository under the Nuclear Waste Policy Act of 1982 (\$20.3 billion); long-term management of EM sites after cleanup is complete (\$13.4 billion); and liability held by other offices within DOE (\$7.2 billion). According to officials from DOE’s Office of the Chief Financial Officer, the department estimated LM’s fiscal year 2019 environmental liability to be \$8.1 billion rather than \$7.35 billion (as reported to us by LM), because the department added an additional \$700 million in contingency to LM’s estimate to account for uncertainty.

LM's Environmental Liability Largely Reflects the Costs of Long-Term Surveillance and Maintenance of Its Sites

According to LM financial data, LM's environmental liability estimate in fiscal year 2019 was \$7.35 billion. LM's guidance defines its environmental liability as an estimate of life-cycle costs associated with five main activities—determined by DOE—occurring over 75 years (see fig. 3).¹⁸ LM develops guidance on how its site managers should estimate their sites' environmental liability. In accordance with this guidance, site managers are to develop estimates of the direct costs over the upcoming 75-year period. They are also to determine a certain amount of contingency to account for potential changes in LM's project scope because of unknown and unpredictable events over the upcoming 75-year period.¹⁹

¹⁸Although these estimates assume a 75-year timeframe, LM officials told us that some sites will not complete their long-term surveillance and maintenance activities within that period. As a result, the 75-year cost estimates may underestimate LM's full lifecycle costs for managing all of its sites.

¹⁹In particular, in developing its estimates, LM makes assumptions to account for uncertainty about factors that could influence costs in the future, such as those related to site conditions, regulatory requirements, technology, and cleanup standards, according to LM guidance. Further, these estimates are to reflect the most likely, rather than worst-case, scenarios at sites, meaning the actual costs could be either higher or lower than LM's estimates.

Figure 3: Activities that Account for the DOE Office of Legacy Management’s Environmental Liability

Activity	Description
Long-term surveillance and maintenance 	Isolating contaminants, groundwater treatment, environmental monitoring, routine inspections, and site maintenance.
Archives and information management 	Preserving site records, responding to records requests, and enhancing information technology capabilities.
Asset management 	Promoting beneficial reuse of sites, such as through site restoration with grasslands, wetlands, and hiking trails for public use.
Program direction 	Managing project planning, staffing, budget, and acquisition.
Communication, education, and outreach 	Managing outreach to the public, intergovernmental collaboration, and dialogue with tribal nations.

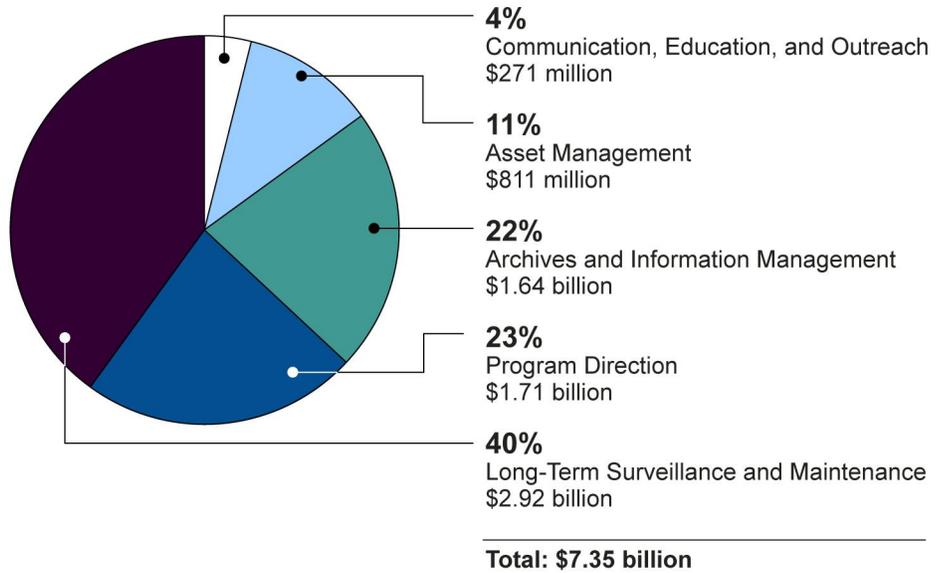
Source: GAO Summary of Department of Energy (DOE) documents. | GAO-20-373

As shown in figure 4, LM activities related to long-term surveillance and maintenance of its sites accounted for about \$3 billion—or 40 percent—of

its fiscal year 2019 environmental liability.²⁰ LM activities related to program direction and to archives and information management each accounted for about 23 percent and 22 percent, respectively, of LM's fiscal year 2019 environmental liability, and activities related to asset management and to communication, education, and outreach combined for about 15 percent.

²⁰This approximately \$3 billion includes the costs of providing long-term surveillance and maintenance for the 100 sites currently in LM's portfolio, as well as costs associated with transitioning an additional 51 sites into its portfolio by 2050. Although, as of September 2019, LM expects to transition a total of 52 sites by 2050, at this point LM has not reported any environmental liability associated with one of these sites (the Elemental Mercury Storage Facility site), because LM is not yet sure about the scope of long-term surveillance and maintenance activities needed at that site, according to LM officials. Regarding these 51 sites, LM's environmental liability estimate includes transition costs associated with each of these sites, such as costs to develop site transition plans. The estimate also includes long-term surveillance and maintenance costs for a portion of these 51 sites—specifically, the portion of sites that is scheduled to transition to LM from USACE and private licensees by 2050. The estimate does not include long-term surveillance and maintenance costs for sites that will transition to LM from EM, according to LM officials. As mentioned previously, part of DOE's other legacy environment liability includes about \$13 billion associated with long-term surveillance and maintenance of sites currently managed by EM. DOE Chief Financial Officer officials told us that although many of these sites will likely transfer to LM in the future, LM cannot fully assess the scope of long-term surveillance and maintenance activities (and thereby determine the associated cost) until the sites' transitioning periods, which are typically five years prior to the transition date. According to LM officials, EM's decisions regarding the final remedies and subsequent long-term surveillance and maintenance requirements for sites are complex and subject to negotiation with regulators. LM officials told us that since LM is not involved in such decisions, it would be difficult for LM to estimate long-term surveillance and maintenance costs for these sites.

Figure 4: DOE Office of Legacy Management Estimated Environmental Liability by Activity (Fiscal Year 2019)

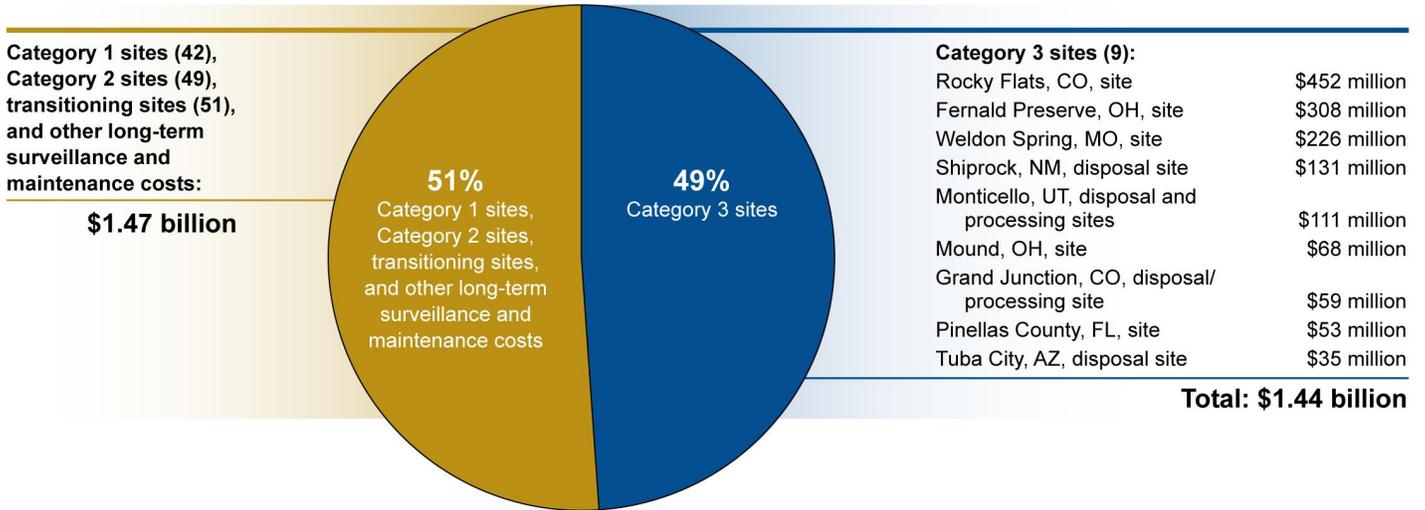


Source: GAO analysis of Department of Energy (DOE) data. | GAO-20-373

Note: According to Office of Legacy Management (LM) officials, aside from long-term surveillance and maintenance, the other four activities that make up LM's environmental liability estimate are not broken down by site because they are primarily programmatic in scope and not site-specific. For example, as part of its archives and information management activities, LM maintains information technology capabilities that are primarily operated and maintained at LM's office locations, rather than at individual sites.

Of LM's approximately \$3 billion in costs for long-term surveillance and maintenance, LM's category 3 sites—the nine sites that require the most intensive level of management—accounted for almost half of these estimated costs (see fig. 5). The Rocky Flats site in Colorado accounted for the largest share of this portion of the liability (about \$452 million), and the Fernald Preserve site in Ohio accounted for the second-largest share (about \$308 million). Long-term surveillance and maintenance responsibilities for category 1 and category 2 sites, transition costs associated with sites that LM will acquire in future years, and other program-wide activities—such as exploring new technologies and operating a laboratory—accounted for the remaining share (about \$1.5 billion) of LM's environmental liability related to long-term surveillance and maintenance.

Figure 5: DOE Office of Legacy Management Estimated Environmental Liability Related to Long-Term Surveillance and Maintenance Activities, by Site Category (Fiscal Year 2019)



Source: GAO analysis of Department of Energy (DOE) data. | GAO-20-373

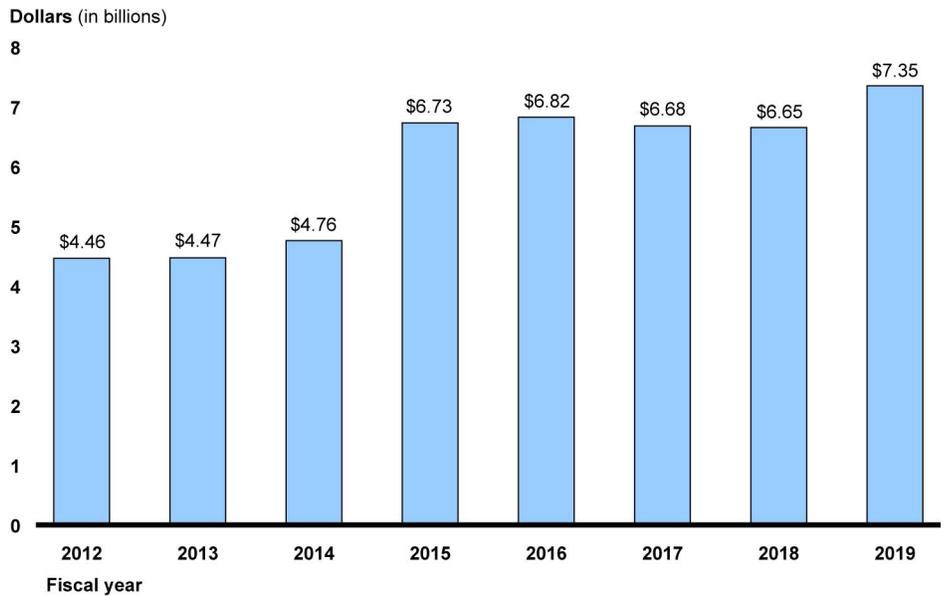
Note: The Office of Legacy Management’s (LM) environmental liability includes the costs associated with providing long-term surveillance and maintenance for the 100 sites currently in LM’s portfolio, as well as estimated costs associated with transitioning 51 sites into its portfolio by 2050. Although, as of September 2019, LM expects to transition a total of 52 sites by 2050, at this point LM has not reported any environmental liability associated with one of these sites (the Elemental Mercury Storage Facility site), because LM is not yet sure about the scope of long-term surveillance and maintenance activities needed at that site, according to LM officials.

LM’s Environmental Liability Has Generally Remained Stable in Recent Years, with Some Notable Fluctuations at Individual Sites

LM’s total environmental liability has generally remained stable in recent years, although there have been some notable fluctuations at individual sites. In fiscal years 2015 through 2018, LM’s total environmental liability remained between \$6 billion and \$7 billion per year, and increased to slightly over \$7 billion in fiscal year 2019 (see fig. 6). Most notably, LM’s total environmental liability increased by about \$2 billion (about 41 percent) between fiscal years 2014 and 2015. LM officials attributed this increase to adopting a more thorough approach for estimating future costs associated with sites scheduled to be transferred from USACE under FUSRAP. LM officials said that, before fiscal year 2015, LM had used a standard cost estimate for all of USACE’s sites, which resulted in

an underestimate of the associated liability.²¹ According to LM officials, in fiscal year 2015 LM began estimating costs based on individual sites' specific conditions, which allowed LM to capture more potential costs.

Figure 6: DOE Office of Legacy Management Estimated Environmental Liability by Fiscal Year



Source: GAO analysis of Department of Energy (DOE) data. | GAO-20-373

Similar to LM's overall environmental liability, the long-term surveillance and maintenance portion of LM's environmental liability has generally remained stable in recent years, though individual sites have seen some notable changes. From fiscal year 2015 through 2018, LM's environmental liability related to long-term surveillance and maintenance remained between about \$3 billion and \$3.5 billion. Similar to LM's overall environmental liability, the long-term surveillance and maintenance portion of LM's liability saw a more significant increase between fiscal years 2014 and 2015, from about \$2.2 billion to about \$3.4 billion. At the site level, of LM's nine category 3 sites, the Fernald Preserve and Mound sites in Ohio are examples of sites that have had mostly steady decreases from fiscal year 2014 to 2019, which LM officials attributed in part to adjustments to groundwater treatment strategies at Fernald Preserve as well as transferring ownership of most of the Mound site to

²¹Although the entity in charge of cleanup may estimate the environmental liability associated with providing long-term management of a site post-cleanup, LM reassesses this estimate upon acquiring a site, according to DOE officials.

another party. In contrast, several other sites (including Rocky Flats and Grand Junction in Colorado and Weldon Spring in Missouri) saw overall decreases from fiscal year 2014 to 2016 followed by steady increases from fiscal year 2016 to 2019, which LM officials generally attributed to costs of site maintenance at Rocky Flats, construction at Weldon Spring, and planning activities for the potential closure of the disposal cell at Grand Junction. LM officials provided additional details on specific factors driving sites' changes in environmental liability. For example:

- At the Fernald Preserve site, the long-term surveillance and maintenance liability has decreased overall from about \$367 million in fiscal year 2014 to about \$308 million in fiscal year 2019 (about a 16 percent decrease). The site manager for Fernald attributed this decrease to improvements in the site's groundwater treatment strategy. In 2014, LM made changes to optimize the site's "pump-and-treat" system (which brings contaminated water above ground so that it can be treated and contaminants removed) by increasing pumping from the wells in the portion of the site with the most contamination, according to the site manager. Further, the site manager said that this change increased the amount of water coming from the more contaminated areas, making the water treatment more efficient and cost-effective in the long-term.
- At the Mound site, the long-term surveillance and maintenance liability has decreased from about \$124 million in fiscal year 2014 to about \$68 million in fiscal year 2019 (about a 45 percent decrease). According to LM officials, this decrease is in part due to a transfer in ownership. Specifically, LM transferred ownership of the majority of the site to the Mound Development Corporation to sell or lease parcels of the land to third parties for commercial use. Transferring ownership meant that LM gave up some of its responsibilities and their associated costs (such as maintenance and repairs at buildings that are now privately owned), although it continues to fulfill ongoing groundwater treatment and records management responsibilities.
- At the Rocky Flats site, the long-term surveillance and maintenance liability has increased substantially since fiscal year 2016, from about \$269 million to about \$452 million in fiscal year 2019 (about a 68 percent increase). According to the site manager for Rocky Flats, this increase can be attributed to additional costs needed to repair aging infrastructure. Specifically, a landfill on the site, which was constructed in the 1950s, has been damaged by erosion in recent years, and LM is currently undertaking a large-scale project to repair and stabilize it after previous repairs failed to provide a long-term fix. This project, which is due to be completed in the summer of 2020,

includes installing about 260 steel anchors of up to 95 feet in length into the soil around the landfill. These anchors are intended to keep the soil intact while drains route groundwater away from the areas of the landfill that are particularly vulnerable to erosion.

LM's Environmental Liability Is Likely to Grow as LM Acquires More Sites in Future Years

LM's environmental liability is likely to grow as it acquires more sites in future years, even as LM takes steps to reduce the environmental liability associated with its current sites, according to LM officials. According to an LM document, as of September 2019, LM is scheduled to acquire 52 additional sites by 2050, including six category 3 sites, 45 category 2 sites, and one category 1 site.²² Since LM does not account for the environmental liability related to long-term surveillance and maintenance for a portion of its sites until it acquires them, LM officials could not tell us by how much its total environmental liability will increase as a result of acquiring these sites.²³ However, officials said that some sites transitioning to LM in the future will be increasingly complex, which will likely mean increased long-term surveillance and maintenance costs. In particular, one official told us that the FUSRAP sites LM is set to acquire from USACE will be larger and have more extensive residual contamination than FUSRAP sites that LM had previously acquired. As a result, these sites will likely require LM to undertake more extensive and costly long-term surveillance and maintenance activities, according to this official.

At the same time, LM officials said they are taking steps to help reduce the environmental liability at LM's current sites, such as exploring ways to improve the cost-effectiveness of managing residual groundwater contamination. For example:

²²The category 3 sites (which require the most intensive level of management) and their projected fiscal year of transfer to LM include: Elemental Mercury Storage Facility site (2022); Hazelwood, MO, site (2023); St. Louis, MO, site (2026); Moab, UT, Disposal/Processing site (2035); Berkeley, MO, site (2038); and Berkeley, MO, Site Vicinity Properties (2038).

²³As mentioned previously, LM estimates long-term surveillance and maintenance costs associated with sites transitioning to LM from USACE and private licensees by 2050, but LM's estimates do not include long-term surveillance and maintenance costs associated with sites transitioning to LM from EM, according to LM officials.

- At the Shiprock site in New Mexico, LM has initiated an environmental assessment to evaluate the impacts of removing an evaporation pond into which contaminated groundwater is being pumped, according to the site manager. The site manager also told us that removing this pond could mean reducing the scope of the site's water pumping activities and ultimately adopting a different groundwater treatment strategy that could prove to be more efficient. Further, the site manager said that this removal would result in reduced long-term surveillance and maintenance costs associated with ongoing repairs to the pond.

At the Tuba City site in Arizona, LM is conducting an environmental assessment to weigh options for a new groundwater treatment strategy. According to the site manager, the current strategy, which involves injecting clean water into the site's contaminated aquifer to flush out contamination, does not cost-effectively address the root cause of the groundwater contamination. Among other options, LM may use its assessment to seek alternate concentration limits accompanied by restrictions to grazing and water use, which LM officials said could be a cost-effective way to manage residual contamination.²⁴

LM Faces Several Challenges and Has Not Planned for Those That Require New Cleanup Work or Address Climate Change Risks

LM officials we interviewed identified a number of challenges that LM faces in providing long-term surveillance and maintenance of sites. In particular, officials identified challenges related to three main areas: (1) the performance of remedies on its sites, (2) environmental conditions, and (3) new requirements and regulations. LM is taking some actions to address the challenges that officials identified. However, it has not planned for how to address challenges with remedies at some sites that may require additional cleanup work outside the scope of its expertise and resources, and it has not developed plans to assess and mitigate

²⁴Alternate concentration limits can be set if groundwater cannot be restored to background levels. NRC will establish a site-specific alternate concentration limit for a hazardous constituent if it finds that the proposed limit is as low as reasonably achievable, after considering practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded. 10 C.F.R. pt. 40 app. A, criterion 5B(6).

challenging environmental conditions that may become more frequent or intense because of climate change.

Challenges with the Performance of Remedies Could Require New Cleanup Work

According to LM officials, LM faces challenges with cleanup remedies not performing as predicted or intended at some sites. For example:

- At the L-Bar site in New Mexico, officials told us that the disposal cell, which was constructed by a private licensee under UMTRCA Title II and holds about 2.1 million tons of radioactive mill tailings, began experiencing erosion problems shortly after NRC transferred the site to LM in 2004. This erosion is threatening to undermine the disposal cell, according to LM officials (see fig. 7).
- At the Monticello site in Utah, monitored natural attenuation²⁵—the groundwater treatment remedy originally agreed to by DOE, EPA, and the Utah state regulator—proved ineffective in meeting cleanup goals within a few years of being implemented and of the site being transferred to LM. As a result, in 2015, LM implemented a pump-and-treat approach that reduced contamination; however, officials told us that the efficacy of this approach has declined over time, and LM is again seeking to change the remedy.

²⁵Natural attenuation relies on natural processes to decrease or “attenuate” concentrations of contaminants in soil and groundwater. Scientists monitor these conditions to make sure natural attenuation is working. The entire process is called monitored natural attenuation. The groundwater remedy at the Monticello site also included implementation and enforcement of institutional controls to prohibit use of contaminated groundwater for domestic purposes.

Figure 7: Damage from Erosion at the DOE Office of Legacy Management's L-Bar Site in New Mexico



Source: Department of Energy (DOE) Office of Legacy Management. | GAO-20-373

To address challenges related to the performance of remedies, LM is currently undertaking a risk analysis effort to rank sites according to several types of risks, including the risk that a site will not attain compliance with cleanup goals or that compliance will not be maintained into the future. According to LM officials, LM plans to use the results of the risk analysis to inform decisions about where to focus resources, to identify systemic technical challenges, and to identify possible opportunities for reducing LM's environmental liability, such as through technology development.

LM is also addressing challenges related to remedy performance by updating some sites' remedies. For example, LM has implemented an erosion monitoring program for the L-Bar site and, at the Monticello site, is collecting data that could allow it to seek regulatory approval for a new groundwater compliance strategy, according to LM officials. LM officials said that, in general, they consider such updates to be routine and to fall within LM's mission to provide long-term surveillance and maintenance of these sites.

Nonetheless, LM officials told us that as LM acquires additional sites and as remedies age, future challenges related to remedy performance could result in the need for more extensive work, including active cleanup work that is outside the scope of LM's mission, capabilities, and resources. We found that LM has developed agreements and procedures for addressing such challenges at sites cleaned up by USACE, but has not developed such agreements and procedures for sites cleaned up by EM or by private licensees under Title II of UMTRCA. Specifically, regarding sites cleaned up by USACE under FUSRAP, under the 1999 memorandum of understanding between DOE and USACE, USACE is responsible for

carrying out additional cleanup actions when it determines such actions are necessary. In addition, LM guidance related to transition and transfer of FUSRAP sites includes examples of situations in which LM would return a site to USACE for additional cleanup, such as situations in which routine monitoring identifies new areas of contamination. Conversely, for sites where EM was responsible for active cleanup, a 2005 memorandum co-signed by the leadership of LM and EM includes a brief statement about the need for LM and EM to coordinate in instances of “significant remedy failures.” LM officials told us that structural or engineering damage could signify evidence of a “significant remedy failure,” but said that such criteria have not been documented. They also said that LM has not defined a process by which such failures would be addressed. Finally, LM officials said that there is no mechanism in place under UMTRCA for LM to return a site to NRC or to seek recovery of costs from a private licensee for any additional cleanup that needs to be done.

According to agency officials, LM has not developed agreements or procedures for addressing challenges that require active cleanup work at sites cleaned up by EM because LM has not yet encountered such instances at any of its sites. They also noted that LM has been more focused on long-term surveillance and maintenance and the process of transitioning sites into its portfolio from EM and private licensees, rather than a process for moving sites back to these entities if a cleanup remedy fails. However, under federal internal control standards, management is to design control activities to achieve objectives and respond to risks, such as by clearly documenting internal control in management directives, administrative policies, or operating manuals.²⁶ By working with EM and NRC to develop agreements and procedures for identifying and addressing circumstances at LM sites that require new cleanup work beyond the scope of LM’s mission, capabilities, and resources, LM can help ensure mitigation by the most appropriate entity of the risks to human health and the environment that such instances would present.

Challenging Environmental Conditions May Become More Frequent or Intense

LM faces challenges with environmental conditions at the sites—some of which may become more frequent or intense—and, according to its

²⁶[GAO-14-704G](#).

mission, LM must react to these challenges to ensure the sites remain protective of human health and the environment. For example:

- At the Rocky Flats site in Colorado, officials told us that extreme rainfall events over the past few years have caused soils covering an on-site landfill to “slump,” or slip downhill. In particular, rainfall during 2015—the site’s wettest year on record, according to LM officials—caused a 20-foot slump in the landfill.
- The Boiling Nuclear Superheater site in Puerto Rico and the Pinellas County site in Florida were both in the path of Hurricane Irma in 2017, though neither site sustained substantial damage.
- At the Weldon Spring site in Missouri, the site manager said that tornadoes pose a risk to the site’s infrastructure, and that a strong tornado in 2013 damaged the site’s interpretive center.²⁷

To address challenges related to environmental conditions, LM has been repairing damages caused by extreme weather events. For example, at the Rocky Flats site, LM is undertaking a major project to repair and stabilize its aging landfill, as discussed earlier. At the Weldon Spring site, LM installed a tornado shelter in 2014 and is currently building a new interpretive center. In addition, according to the 2020 LM Site Sustainability Plan, LM has taken a number of steps to implement emergency and security measures, such as completing emergency drills and tabletop exercises.²⁸

The U.S. Global Change Research Program—which coordinates and integrates the activities of 13 federal agencies that research changes in the global environment and their implications for society—reported in its November 2018 Fourth National Climate Assessment that climate change is playing a role in the increasing frequency of some types of extreme weather, such as extremely heavy rainfall and hurricanes; these are

²⁷Per the long-term surveillance and maintenance plan for the Weldon Spring site, DOE is to maintain and operate an interpretive center at the site to inform the public of the site’s history, cleanup activities, and final conditions. DOE may not discontinue operations of the interpretive center without the approval of EPA in consultation with the Missouri state regulator.

²⁸U.S. Department of Energy Legacy Management, *2020 LM Site Sustainability Plan*, LMS/S07225 (December 2019).

environmental conditions that have presented challenges at LM sites.²⁹ The assessment reported that climate models are consistent with temperature and precipitation extremes becoming more frequent, more intense, or longer in duration, which may make certain natural disasters more frequent or more intense. As a result of the significant risks posed by climate change and the nation's fiscal condition, in February 2013, we added *Limiting the Federal Government's Fiscal Exposure by Better Managing Climate Change Risks* to our list of areas at high risk for fraud, waste, abuse, and mismanagement, or most in need of transformation.³⁰ In our March 2019 update to this high-risk area, we reported that the federal government needs to improve the resilience of facilities it owns and operates, and land it manages, against the effects of climate change.³¹ In addition, in October 2019, we found that EPA needs to improve management of risks from climate change at Superfund sites where remedies may need to be operational indefinitely (see sidebar).

²⁹D.R. Reidmiller, C.W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart (eds.), *2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (Washington, D.C.: U.S. Global Change Research Program, November 2018). Under the Global Change Research Act of 1990 (Pub. L. No. 101-606, § 103 (1990)), the U.S. Global Change Research Program is to periodically prepare a scientific assessment—known as the National Climate Assessment—which is an important resource for understanding and communicating climate change science and impacts in the United States. The Office of Science and Technology Policy within the Executive Office of the President oversees the U.S. Global Change Research Program.

³⁰GAO, *High-Risk Series: An Update*, [GAO-13-283](#) (Washington, D.C.: Feb. 14, 2013).

³¹[GAO-19-157SP](#).

We Found That EPA Should Take Additional Actions to Manage Risks from Climate Change

Superfund is the federal government's principal program to address sites with hazardous substances. It was established by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and is administered by the Environmental Protection Agency (EPA). EPA lists some of the most seriously contaminated sites on the National Priorities List (NPL) and has recorded over 500 contaminants at those sites. Some NPL sites are located at federal facilities, where departments such as the Department of Energy are responsible for cleanup. However, most NPL sites are nonfederal, where EPA generally carries out or oversees the cleanup conducted by one or more potentially responsible parties.

In October 2019, we reported that available federal data on flooding, storm surge, wildfires, and sea level rise suggest that about 60 percent of all nonfederal NPL sites are located in areas that may be impacted by these potential climate change effects. According to EPA officials, remedies at nonfederal NPL sites may have to be operational indefinitely, during which time the potential effects of climate change may become more extreme. We found that EPA has taken some actions to manage risks from the potential impacts of climate change effects at nonfederal NPL sites, but that its actions did not fully align with essential elements of enterprise risk management. For example, we found that EPA officials do not always have direction to ensure that they consistently integrate climate change information into site-level risk assessments and risk response decisions, according to EPA officials. Without providing such direction, EPA cannot ensure that remedies at nonfederal NPL sites will protect human health and the environment in the long-term.

We made four recommendations to EPA, including that it provide direction on how to integrate information on the potential impacts of climate change effects into risk assessments and risk response decisions at nonfederal NPL sites. EPA agreed with one recommendation and disagreed with the other three. We continue to believe that all four are warranted.

Source: GAO, *Superfund: EPA Should Take Additional Actions to Manage Risks from Climate Change* (GAO-20-73). | GAO-20-373

LM's 2016-2025 *Strategic Plan* acknowledges the challenges posed by climate change.³² To support the objective of improving the long-term sustainability of environmental remedies, the plan includes a strategy to "assess the effect of climate change on environmental remedies and develop plans to mitigate significant impacts." However, LM provided minimal information about ongoing or planned efforts to carry out this strategy. Specifically, the *2020 LM Site Sustainability Plan*, which officials said provides information about LM's future plans to adapt to changing climate conditions, includes the term "climate change" one time, in reference to sustainable buildings—not to remedies. The plan describes one pilot project conducted at the Monticello site to evaluate the site's main climate stressors and capacity to adapt to those stressors, but it does not describe whether or how LM intends to use the results of the pilot project, such as any specific plans to roll out the project to other sites.³³ Aside from the *2020 LM Site Sustainability Plan*, LM officials said they have a goal to review sites' conceptual models, which predict how remedies should perform under different conditions, with the aim of updating the assumptions in the models to better account for real-world conditions. However, LM did not provide details about how it intends to meet this goal, such as a schedule for implementing this review across its sites.

According to LM officials, LM has not developed a plan or schedule for reviewing sites' conceptual models because of competing priorities. In addition, LM officials told us they have not assessed the effects of climate change or developed plans to mitigate those effects because of a lack of concern about the risks posed by climate change. Specifically, site managers in charge of several of LM's category 3 sites—including Rocky Flats, which has the highest environmental liability of LM's 100 sites and is currently implementing the large-scale project described above to address erosion caused by extreme precipitation—told us that

³²U.S. Department of Energy Legacy Management, *2016-2025 Strategic Plan*, DOE/LM-1477 (May 2016).

³³LM headquarters officials told us that site managers conduct separate assessments of current climate trends to determine the climate resilience of cleanup remedies at their sites, but said that these assessments are not part of an overall plan to assess the effects of climate change or to mitigate those effects. LM provided documentation of one such assessment for the Monticello site, but officials said that LM has not applied the assessment to other sites.

they have not assessed the potential effects of climate change on their sites because they do not believe climate change is a concern.

Recognizing the federal government's significant role in managing climate-related disaster impacts, GAO's *Disaster Resilience Framework* provides three broad principles that those who oversee or manage federal efforts can consider when analyzing opportunities to enhance their contribution to national disaster resilience.³⁴ For instance, under the information principle, the framework states that accessing authoritative, understandable information can help decision makers to identify current and future risk and the impact of risk-reduction strategies. In addition, the integration principle states that integrated analysis and planning can help decision makers take coherent and coordinated resilience actions. By developing plans to assess the effect of climate change on LM's sites and to mitigate any significant impacts and, as part of these plans, incorporating principles from GAO's *Disaster Resilience Framework*, as appropriate, LM could better ensure that its remedies will protect human health and the environment in the long term.

Regulators Update or Adopt New Requirements, Making Remedies No Longer Compliant With Standards

According to LM officials, LM faces challenges when regulators update or adopt new requirements and regulations for contaminants, meaning that remedies in place when LM received a site may no longer meet standards. For example:

- At several sites, such as the Fernald Preserve and Mound sites in Ohio and the Rocky Flats site in Colorado, LM officials told us they are investigating for per- and polyfluoroalkyl substances (PFAS) or vapor-forming chemicals, which are emerging contaminants that EM

³⁴The principles are (1) information, which is about giving federal and nonfederal decision makers authoritative and understandable information to help identify current and future risks, as well as the impact of risk-reduction strategies; (2) integration, which is about enabling decision makers to take coherent and coordinated actions; and (3) incentives, which is about making long-term, forward-looking, risk-reduction investments more viable and attractive among competing priorities. See GAO, *Disaster Resilience Framework: Principles for Analyzing Federal Efforts to Facilitate and Promote Resilience to Natural Disasters*, [GAO-20-100SP](#) (Washington, D.C.: Oct. 2019).

was not required to address when cleaning up these sites.³⁵ EPA has published information regarding potential impacts to human health and the environment from these and other emerging contaminants. Federal regulatory standards issued by EPA in the future could affect LM sites.

- At the Bluewater site in New Mexico, LM officials said that the state recently adopted an updated, more stringent uranium drinking water standard. Under the new standard, the area of groundwater that is considered contaminated is much larger than the area of groundwater considered contaminated under the standard in place when NRC approved transfer of the site to LM, according to officials.

To address challenges related to new requirements and regulations, LM is monitoring changes to federal and state standards. For example, LM participates in interagency working groups, such as a PFAS working group led by DOE's Office of Environment, Health, Safety, and Security. Participation in the working groups helps LM monitor the evolution of a federal PFAS regulatory standard, according to LM officials. In addition, LM officials told us that they routinely review state and federal regulatory changes, with the aim of providing sites time to prepare for any changes. LM also evaluates its surveillance and maintenance practices against current regulatory and best management requirements to identify any gaps. For instance, in 2018, the contractor that provides support services to LM reviewed site management practices listed in UMTRCA Title I and II sites' site management plans against current regulatory requirements. The review identified a number of discrepancies between practices and requirements. For example, the review found that some site management plans were developed many years ago and had not been updated to reflect changes in remedy requirements. LM indicated it planned to take steps to address the discrepancies identified by this review. For example, LM is planning to update its site management plans to include the most current remedy requirements for each site.

³⁵PFAS are a group of man-made chemicals that have been manufactured and used in a variety of industries around the globe, including in the United States. They can be used in some food packaging and are also used in firefighting foams and in a wide range of manufacturing practices. PFOA and PFOS—two specific PFAS chemicals—have been the most extensively produced and studied of these chemicals. Both are very persistent in the environment and in the human body. Exposure to certain PFAS can lead to adverse human health effects. EPA has issued a non-enforceable drinking water advisory and is evaluating whether to issue drinking water standards for PFAS under the Safe Drinking Water Act. These standards could affect LM sites.

Conclusions

At many sites contaminated from nuclear weapons production and nuclear energy research dating back to World War II and the Cold War, completely eliminating risks to human health and the environment is unlikely. LM is responsible for protecting human health and the environment from the risks that remain after other entities have cleaned up these sites, and its mission is long-term—LM sites will require surveillance and maintenance for hundreds or even thousands of years. Over this period, the likelihood that cleanup remedies will experience performance challenges is high, and these challenges may exceed the scope of LM's mission, capabilities, and resources. LM acquires sites from several cleanup entities, but has not developed agreements or procedures with EM or NRC for addressing challenges that require new, active cleanup work. By working with EM and NRC to develop agreements and procedures for identifying and addressing circumstances at LM sites that require new cleanup work beyond the scope of LM's mission, capabilities, and resources, LM can help ensure mitigation by the most appropriate entity of the risks to human health and the environment that such instances would present.

Environmental conditions also present challenges to LM's sites, and some of these conditions may become more frequent or intense in the future, according to the 13-agency U.S. Global Change Research Program. To ensure the long-term protectiveness of remedies, it is important for LM to understand how climate change may affect its sites. LM's strategic plan includes a strategy to assess the effects of climate change on its sites, but the agency provided minimal information about how it plans to carry out this strategy. GAO's *Disaster Resilience Framework* outlines a set of principles that those who oversee or manage federal efforts can consider when analyzing opportunities to enhance their contribution to national disaster resilience. By developing plans to assess the effect of climate change on LM's sites and to mitigate any significant impacts, and, as part of these plans, incorporating principles from GAO's *Disaster Resilience Framework*, as appropriate, LM could better ensure that its remedies will protect human health and the environment in the long term.

Recommendations for Executive Action

We are making three recommendations to DOE:

The Secretary of Energy should direct the Director of LM and the Assistant Secretary of the Office of Environmental Management to develop agreements and procedures for identifying and addressing circumstances at LM sites that require new cleanup work beyond the scope of LM's mission, capabilities, and resources. (Recommendation 1)

The Secretary of Energy should direct the Director of LM to work with the Nuclear Regulatory Commission to develop agreements and procedures for identifying and addressing circumstances at LM sites that require new cleanup work beyond the scope of LM's mission, capabilities, and resources. (Recommendation 2)

The Secretary of Energy should direct the Director of LM to, as called for in LM's strategic plan, develop plans to assess the effect of climate change on LM's sites and to mitigate any significant impacts. These plans should incorporate principles from GAO's *Disaster Resilience Framework*, as appropriate. (Recommendation 3)

Agency Comments and Our Evaluation

We provided a draft of this report to DOE for comment. In its comments, reproduced in appendix IV, DOE agreed with our three recommendations. In its letter, DOE officials stated that in response to our first two recommendations, it plans to work with DOE's Office of Environmental Management and the Nuclear Regulatory Commission to develop agreements and procedures for identifying and addressing new cleanup work beyond LM's mission scope of long-term stewardship. DOE officials also stated that in response to our third recommendation, LM will develop site assessment and mitigation plans, taking into account any significant effects of climate change and incorporating principles from GAO's *Disaster Resilience Framework*, as appropriate. DOE also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committee, the Secretary of Energy, and other interested parties. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or trimbled@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last

page of this report. GAO staff who made key contributions to this report are listed in appendix V.

A handwritten signature in cursive script that reads "David C. Trimble".

David C. Trimble
Director, Natural Resources and Environment

Appendix I: DOE Office of Legacy Management's Nine Category 3 Sites as of Fiscal Year 2019

Table 1: Category 3 Sites Managed by DOE Office of Legacy Management (LM) as of Fiscal Year 2019

Category 3 sites require the most intensive surveillance and maintenance, typically including an ongoing groundwater remediation system because of the long timeframes required to capture and remediate groundwater.

LM site name (state)	Site history and contamination	Fiscal year of transfer to LM
Fernald Preserve site (Ohio)	<ul style="list-style-type: none"> Former site of a uranium processing facility, which from 1951 to 1989 produced high-purity uranium metal products as the first step in the nuclear weapons production cycle Facility operations contaminated the soil, groundwater, and surface water with uranium 	2008
Grand Junction Disposal/Processing site (Colorado)	<ul style="list-style-type: none"> Former site of a uranium and vanadium mill that operated from 1950 to 1970 A disposal cell at the site holds contaminated materials, and part of it remains open to receive additional low-level radioactive material 	1999
Monticello Disposal and Processing sites (Utah)	<ul style="list-style-type: none"> Former site of a uranium and vanadium mill that operated from the early 1940s to 1960 Properties in the city of Monticello and near the mill were contaminated by windblown uranium mill tailings, tailings carried by surface water, and tailings that were used for construction-related purposes^a 	2002
Mound site (Ohio)	<ul style="list-style-type: none"> Former site of a DOE research, development, and production facility that operated from 1948 to 2003 and supported weapons, energy, and space missions Facility operations resulted in low-level radioactivity in the soil and volatile organic compounds in the groundwater 	2012
Pinellas County site (Florida)	<ul style="list-style-type: none"> Site of a facility that developed and manufactured nuclear weapons components from 1957 to 1994 Waste disposal practices contaminated portions of the underlying aquifer with organic solvents and metals 	2004
Rocky Flats site (Colorado)	<ul style="list-style-type: none"> Site of the Rocky Flats Plant, which from 1952 to 1994 produced nuclear and nonnuclear weapons components, including the plutonium pit, or "trigger," for nuclear weapons Plant operations caused substantial contamination from plutonium, beryllium, and other hazardous substances 	2008

**Appendix I: DOE Office of Legacy
Management's Nine Category 3 Sites as of
Fiscal Year 2019**

LM site name (state)	Site history and contamination	Fiscal year of transfer to LM
Shiprock Disposal site (New Mexico)	<ul style="list-style-type: none"> • Site of a uranium- and vanadium-ore processing facility within the Navajo Nation that operated from 1954 to 1968 • Milling operations created radioactive tailings and contaminated the groundwater with uranium and other contaminants 	1996
Tuba City Disposal site (Arizona)	<ul style="list-style-type: none"> • Site of a uranium mill within the Navajo Nation that operated from 1956 to 1966 • Milling operations created radioactive tailings and contaminated the groundwater with uranium 	1996
Weldon Spring site (Missouri)	<ul style="list-style-type: none"> • Site of a chemical plant and quarry that operated from the early 1940s to the late 1960s and produced explosives and processed uranium • Site operations contaminated soil and ground and surface water 	2003

Source: GAO analysis of Department of Energy (DOE) documents. | GAO-20-373

Note: DOE's Office of Environmental Management was responsible for cleanup of these sites. LM acquired these sites from the Office of Environmental Management once cleanup was completed. DOE considers site cleanup to be complete when, among other things, short-term cleanup activities have been completed and long-term cleanup measures, such as groundwater treatment, are in place.

^aUranium mill tailings are the residue that remains from extracting uranium from uranium ore. The tailings are radioactive and might contain other metals or hazardous substances.

Appendix II: List of DOE Office of Legacy Management's 100 Sites as of Fiscal Year 2019

Table 2: List of Sites Managed by DOE Office of Legacy Management (LM) as of Fiscal Year 2019, by Category

LM site name	State	Cleanup entity	Fiscal year of transfer to LM
Category 3 sites (9)			
Fernald Preserve site	Ohio	DOE Office of Environmental Management (EM)	2008
Grand Junction Disposal/Processing site	Colorado	EM	1999
Monticello Disposal and Processing sites	Utah	EM	2002
Mound site	Ohio	EM	2012
Pinellas County site	Florida	EM	2004
Rocky Flats site	Colorado	EM	2008
Shiprock Disposal site	New Mexico	EM	1996
Tuba City Disposal site	Arizona	EM	1996
Weldon Spring site	Missouri	EM	2003
Category 2 sites (49)			
Ambrosia Lake Disposal site	New Mexico	EM	1998
Amchitka site	Alaska	EM	2008
Attleboro site	Massachusetts	U.S. Army Corps of Engineers (USACE)	2019
Bayo Canyon site	New Mexico	EM	1984/2019 ^a
Bluewater Disposal site	New Mexico	private licensee	1997
Boiling Nuclear Superheater Decommissioned Reactor site	Puerto Rico	EM	2004
Bronco site	Colorado	EM	2019
Burrell Disposal site	Pennsylvania	EM	1994
Burriss Park site	California	EM	2015
Canonsburg Disposal site	Pennsylvania	EM	1996

**Appendix II: List of DOE Office of Legacy
Management's 100 Sites as of Fiscal Year 2019**

LM site name	State	Cleanup entity	Fiscal year of transfer to LM
Central Nevada Test Area	Nevada	EM	2008
Colonie site	New York	USACE	2019
Durango Disposal/Processing site	Colorado	EM	1996
Edgemont Disposal site	South Dakota	private licensee	1996
Falls City Disposal site	Texas	EM	1997
Gasbuggy site	New Mexico	EM	2008
Gnome-Coach site	New Mexico	EM	2008
Grand Junction site	Colorado	EM	2002
Green River Disposal site	Utah	EM	1998
Gunnison Disposal/Processing site	Colorado	EM	1997
Hallam Decommissioned Reactor site	Nebraska	EM	1998
Laboratory for Energy-Related Health Research site	California	EM	2006
Lakeview Disposal/Processing site	Oregon	EM	1995
L-Bar Disposal site	New Mexico	private licensee	2004
Lowman Disposal site	Idaho	EM	1994
Maybell Disposal site	Colorado	EM	1999
Maybell West Disposal site	Colorado	private licensee	2010
Mexican Hat Disposal site	Utah	EM	1997
Monument Valley Processing site	Arizona	EM	1997
Naturita Disposal/Processing site	Colorado	EM	1999
New Brunswick site	New Jersey	EM	2001
Painesville site	Ohio	USACE	2016
Parkersburg Disposal site	West Virginia	private licensee	1994
Piqua Decommissioned Reactor site	Ohio	EM	1998
Pre-Gondola and Trencher site	Montana	EM	2019
Rifle Disposal/Processing site	Colorado	EM	1998
Rio Blanco site	Colorado	EM	2008
Riverton Processing site	Wyoming	EM	1991
Rulison site	Colorado	EM	2008
Salmon site	Mississippi	EM	2008
Salt Lake City Disposal/Processing site	Utah	EM	1997
Sherwood Disposal site	Washington	private licensee	2001
Shirley Basin South Disposal site	Wyoming	private licensee	2005
Shoal site	Nevada	EM	2008
Site A / Plot M Decommissioned Reactor site	Illinois	EM	1998

**Appendix II: List of DOE Office of Legacy
Management's 100 Sites as of Fiscal Year 2019**

LM site name	State	Cleanup entity	Fiscal year of transfer to LM
Slick Rock Disposal/Processing site	Colorado	EM	1998
Spook Disposal site	Wyoming	EM	1993
Tonawanda site	New York	USACE	2017
Utah site	Utah	EM	2019
Category 1 sites (42)			
Acid/Pueblo Canyon site	New Mexico	EM	1985
Adrian site	Michigan	EM	1996
Albany site	Oregon	EM	1993
Aliquippa site	Pennsylvania	EM	1997
Ashtabula site	Ohio	EM	2010
Berkeley site	California	EM	1985
Beverly site	Massachusetts	EM	2004
Buffalo site	New York	USACE	2002
Center for Energy and Environmental Research site	Puerto Rico	EM	2006
Chariot site	Alaska	EM	2005
Chicago North site	Illinois	EM	1989
Chicago South site	Illinois	EM	1989
Chupadera Mesa site	New Mexico	EM	1986
Columbus East site	Ohio	EM	2001
Columbus site	Ohio	EM	2008
El Verde site	Puerto Rico	EM	2006
Fairfield site	Ohio	EM	1996
General Atomics Hot Cell Facility site	California	EM	2005
Geothermal Test Facility site	California	EM	2005
Granite City site	Illinois	EM	1994
Hamilton site	Ohio	EM	1997
Indian Orchard site	Massachusetts	EM	2004
Inhalation Toxicology Laboratory site	New Mexico	EM	2012
Jersey City site	New Jersey	EM	1983
Madison site	Illinois	USACE	2002
Maxey Flats Disposal site	Kentucky	EM	2004
Missouri University Research Reactor site	Missouri	EM	2005
New York site	New York	EM	1996
Niagara Falls Storage Site Vicinity Properties site	New York	EM	1992

**Appendix II: List of DOE Office of Legacy
Management's 100 Sites as of Fiscal Year 2019**

LM site name	State	Cleanup entity	Fiscal year of transfer to LM
Oak Ridge Warehouses site	Tennessee	EM	1994
Oxford site	Ohio	EM	1997
Oxnard site	California	EM	2008
Plowshare/Vela Uniform sites, Records Only	Nevada	EM	2019
Pre-Schooner II site	Idaho	EM	2019
Seymour site	Connecticut	EM	1995
Springdale site	Pennsylvania	EM	1996
Toledo site	Ohio	EM	2001
Tonawanda North site Unit 1	New York	USACE	2009
Tonawanda North site Unit 2	New York	USACE	2009
Vallecitos Nuclear Center site	California	EM	2013
Wayne site	New Jersey	USACE	2007
Windsor site	Connecticut	USACE	2019

Source: GAO analysis of Department of Energy (DOE) documents. | GAO-20-373

Note: LM places each of its sites into one of three categories based on the actual or anticipated long-term surveillance and maintenance activities associated with the site: "category 3" sites require the most intensive surveillance and maintenance, which typically includes maintaining an ongoing remediation system; "category 2" sites require routine inspection, monitoring, and maintenance; and "category 1" sites require management of records or stakeholder requests for information.

^aThe Bayo Canyon Site was formerly two separate sites, both of which were cleaned up by EM. One was transferred to LM in 1984, while the other was transferred to LM in 2019.

Appendix III: List of 52 Sites Transferring to the DOE Office of Legacy Management by Fiscal Year 2050, as of September 2019

Table 3: List of Sites Transferring to DOE Office of Legacy Management (LM) by Fiscal Year (FY)

LM site name	State	Cleanup entity	Anticipated site category
Planned transfer in FY 2020			
Tonopah Test Range site	Nevada	DOE Office of Environmental Management (EM)	2
Planned transfer in FY 2022			
Durita Disposal site	Colorado	private licensee	2
East Tennessee Technology Park site ^a	Tennessee	EM	2
Elemental Mercury Storage Facility	Texas	EM	3
Gas Hills East Disposal site	Wyoming	private licensee	2
Gas Hills North Disposal site	Wyoming	private licensee	2
Panna Maria Disposal site	Texas	private licensee	2
Ray Point Disposal site	Texas	private licensee	2
Split Rock Disposal site	Wyoming	private licensee	2
Planned transfer in FY 2023			
Bear Creek Disposal site	Wyoming	private licensee	2
Hazelwood site	Missouri	U.S. Army Corps of Engineers (USACE)	3
Planned transfer in FY 2024			
Curtis Bay site	Maryland	USACE	2
Deepwater site	New Jersey	USACE	2
Highland Disposal site	Wyoming	private licensee	2
Lisbon Valley Disposal site	Utah	private licensee	2
Middlesex South site	New Jersey	USACE	2
Middletown site	Iowa	USACE	2

**Appendix III: List of 52 Sites Transferring to
the DOE Office of Legacy Management by
Fiscal Year 2050, as of September 2019**

LM site name	State	Cleanup entity	Anticipated site category
Tonawanda Landfill site	New York	USACE	2
Planned transfer in FY 2025			
Ambrosia Lake West Disposal site	New Mexico	private licensee	2
Conquista Disposal site	Texas	private licensee	2
Gas Hills West Disposal site	Wyoming	private licensee	2
Sequoyah County Disposal site	Oklahoma	private licensee	2
Uravan Disposal site	Colorado	private licensee	2
Planned transfer in FY 2026			
Ford Disposal site	Washington	private licensee	2
Maywood site	New Jersey	USACE	2
St. Louis site	Missouri	USACE	3
Planned transfer in FY 2027			
Church Rock Disposal site	New Mexico	private licensee	2
Grants Disposal site	New Mexico	private licensee	2
Planned transfer in FY 2031			
Tonawanda North Site Unit 3	New York	USACE	2
Planned transfer in FY 2032			
Energy Technology Engineering Center site ^b	California	EM	1
Planned transfer in FY 2033			
Lucky site	Ohio	USACE	2
Planned transfer in FY 2035			
Moab Disposal/Processing site	Utah	EM	3
Planned transfer in FY 2038^c			
Berkeley site	Missouri	USACE	3
Berkeley Site Vicinity Properties	Missouri	USACE	3
Carnegie site	Pennsylvania	USACE	2
Cleveland site	Ohio	USACE	2
Ft. Wayne site	Indiana	USACE	2
Hicksville site	New York	USACE	2
Lockport site	New York	USACE	2
Middlesex North site	New Jersey	USACE	2
Niagara Falls Storage site	New York	USACE	2
Parks Township site	Pennsylvania	USACE	2
Planned transfer in FY 2040			
West Valley site ^d	New York	EM	2
Planned transfer in FY 2044			

**Appendix III: List of 52 Sites Transferring to
the DOE Office of Legacy Management by
Fiscal Year 2050, as of September 2019**

LM site name	State	Cleanup entity	Anticipated site category
Portsmouth site ^e	Ohio	EM	2
Planned transfer in FY 2047			
Cañon City Disposal site	Colorado	private licensee	2
Paducah site ^f	Kentucky	EM	2
Salt Lake City 11e.(2) Disposal site	Utah	private licensee	2
Shirley Basin North Disposal site	Wyoming	private licensee	2
Shootaring Canyon Disposal site	Utah	private licensee	2
Sweetwater Disposal site	Wyoming	private licensee	2
White Mesa Disposal site	Utah	private licensee	2
Planned transfer in FY 2050			
Andrews 11e.(2) Disposal site	Texas	private licensee	2

Source: GAO analysis of Department of Energy (DOE) document and LM officials. | GAO-20-373

Note: When sites transfer to LM, LM places each site into one of three categories based on the actual or anticipated long-term surveillance and maintenance activities associated with the site: “category 3” sites require the most intensive surveillance and maintenance, which typically includes maintaining an ongoing remediation system; “category 2” sites require routine inspection, monitoring, and maintenance; and “category 1” sites require management of records or stakeholder requests for information.

^aIn its technical comments on our draft report, DOE revised the planned transfer date for the East Tennessee Technology Park site to 2021, and said that the K-25 slab at the East Tennessee Technology Park Site will transfer in fiscal year 2021. The remainder of the site will transition in fiscal year 2025, according to LM’s site management guide. However, we previously reported that EM officials stated that 2024 is a more accurate completion timeframe for this site. Further, officials at the Environmental Protection Agency (EPA) and Tennessee regulators told us that based on their understanding of remaining work, cleanup of the site may not be completed until the late 2020s. EPA officials also believe this cleanup could be completed as late as the 2040s. See GAO, *Nuclear Cleanup: Actions Needed to Improve Cleanup Efforts at DOE’s Three Former Gaseous Diffusion Plants*, GAO-20-63 (Washington, D.C.: Dec. 17, 2019).

^bIn its technical comments on our draft report, DOE revised the planned transfer date for the Energy Technology Engineering Center site to 2044.

^cFor all sites except the Berkeley, Missouri sites, the transfer date is assumed to be fiscal year 2038 for planning purposes. The actual date of cleanup action completion has not yet been determined by USACE.

^dIn its technical comments on our draft report, DOE revised the planned transfer date for the West Valley site to 2041.

^eIn its technical comments on our draft report, DOE revised the planned transfer date for the Portsmouth site to 2041.

^fIn its technical comments on our draft report, DOE revised the planned transfer date for the Paducah site to “beyond 2050.”

Appendix IV: Comments from the Department of Energy



Department of Energy

Washington, DC 20585

April 27, 2020

Mr. David Trimble
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Trimble:

The Department of Energy (DOE) appreciates the opportunity to provide a Departmental response to the Government Accountability Office's (GAO) draft report titled, *Environmental Liabilities: DOE Needs to Better Plan for Post Cleanup Challenges Facing Sites (GAO-20-373)*. The draft report contained a total of three recommendation and DOE concurs with each of GAO's recommendations. Also, DOE has included technical comments in the enclosure for GAO's consideration.

GAO should direct any questions to Peter O'Konski, Deputy Director, Office of Legacy Management, at 202-586-4873 or via email at Peter.Okonski@hq.doe.gov.

Sincerely,

Peter O'Konski for

Carmelo Melendez
Director
Office of Legacy Management

Enclosure

Appendix IV: Comments from the Department of Energy



Department of Energy

Washington, DC 20585

Management Response

Recommendation 1: The Secretary of Energy should direct the Director of LM and the Assistant Secretary of the Office of Environmental Management to develop agreements and procedures for identifying and addressing circumstances at LM sites that require new cleanup work beyond the scope of LM's mission, capabilities, and resources.

DOE Response: Concur

LM and EM will work together to expand on agreements and procedures for identifying and addressing new cleanup work beyond LM's mission scope of Long-Term Stewardship (LTS).

Estimated Completion Date: September 30, 2021.

Recommendation 2: The Secretary of Energy should direct the Director of LM to work with the Nuclear Regulatory Commission to develop agreements and procedures for identifying and addressing circumstances at LM sites that require new cleanup work beyond the scope of LM's mission, capabilities, and resources.

DOE Response: Concur

LM will work with the Nuclear Regulatory Commission and EM to develop agreements and procedures for identifying and addressing new cleanup work beyond LM's mission scope of Long-Term Stewardship.

Estimated Completion Date: September 30, 2021

Recommendation 3: The Secretary of Energy should direct the Director of LM to, as called for in LM's strategic plan, develop plans to assess the effect of climate change on LM's sites and to mitigate any significant impacts. These plans should incorporate principles from GAO's Disaster Resilience Framework, as appropriate.

DOE Response: Concur

LM currently uses models to project Long-Term Stewardship mission requirements. These model efforts contribute to the evaluation of LM sites' vulnerability and resilience to environmental trends over time. LM will build upon current operations to develop assessment and mitigation plans, taking into account any significant effects of climate change that will incorporate principles from GAO's *Disaster Resilience Framework (GAO-20-100SP)*, as appropriate.

Estimated Completion Date: September 2022.

Agency Comment Letter

Text of Appendix IV: Comments from the Department of Energy

Page 1

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Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

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Carmelo Melendez
Director
Office of Legacy Management

Enclosure

Page 2

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Estimated Completion Date: September 2022.

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

David C. Trimble, (202) 512-3841 or trimbled@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Amanda K. Kolling (Assistant Director), Katherine Killebrew (Analyst in Charge), and Rachel Pittenger made key contributions to this report. Also contributing to this report were Mark Braza, Ellen Fried, Susan J. Irving, Richard Johnson, Keegan Maguigan, Katrina Pekar-Carpenter, Dan Royer, and Doris Yanger.

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