



June 2022

# HANFORD CLEANUP

## DOE Has Opportunities to Better Ensure Effective Startup and Sustained Low- Activity Waste Operations

## Why GAO Did This Study

DOE created the DFLAW program to treat part of the least radioactive portion of the 54 million gallons of radioactive liquid waste held in 177 aging and leak-prone underground storage tanks at the Hanford Site in Washington State. DOE estimates that the DFLAW program will cost \$8.3 billion when complete and begin treating waste in December 2023. DOE is currently in negotiations with the contractor on a possible contract extension for certain DFLAW facilities that may require additional work.

Senate Report 116–236 accompanying S. 4049, the National Defense Authorization Act for Fiscal Year 2021, includes a provision for GAO to review the DFLAW program. Among other things, GAO’s report describes the status of facilities needed to start DFLAW operations and examines the challenges DOE faces in starting and sustaining DFLAW operations. GAO reviewed agency documents and DFLAW program data from December 2020 through May 2021; analyzed DOE documents on DFLAW starting and operating challenges and risks, including DOE plans to manage them; and interviewed DOE officials.

## What GAO Recommends

GAO is making four recommendations, including that DOE ensures that existing challenges and problems in facilities, systems, and components related to DFLAW are resolved by the end of hot commissioning and the start of normal operations. DOE agreed with GAO’s recommendations and stated that it is taking steps to implement them by December 31, 2022.

View [GAO-22-104772](#). For more information, contact Nathan Anderson at (202) 512-3841 or [AndersonN@gao.gov](mailto:AndersonN@gao.gov).

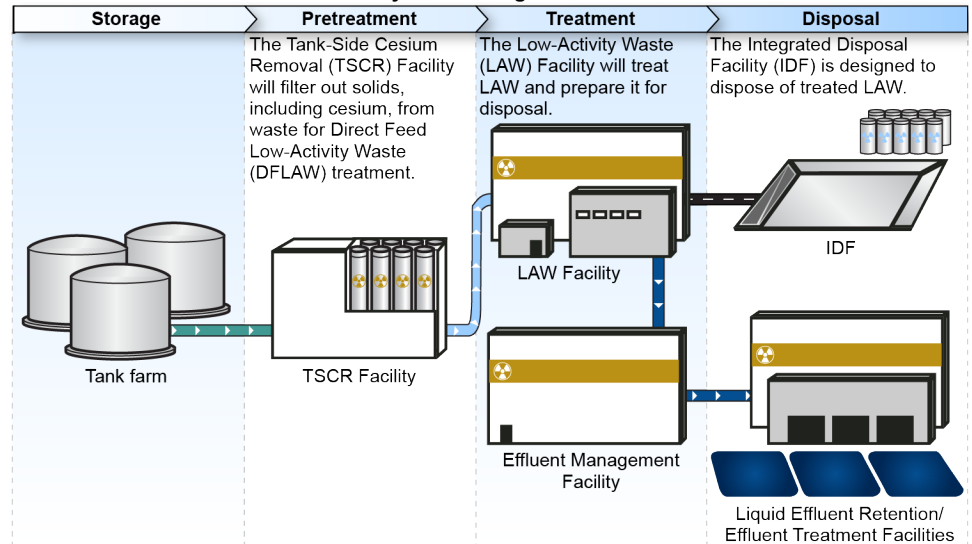
# HANFORD CLEANUP

## DOE Has Opportunities to Better Ensure Effective Startup and Sustained Low-Activity Waste Operations

### What GAO Found

Facilities needed to start Direct-Feed Low-Activity Waste (DFLAW) operations—including pretreatment, treatment, and disposal facilities—are mostly complete, according to Department of Energy (DOE) documents (see fig.). DOE started pretreating tank waste at Hanford in early 2022 to build up a supply of waste feed for DFLAW operations, projected to start in 2023. Furthermore, DOE officials stated that the safety documentation required to start DFLAW operations is complete.

Phases of the Direct-Feed Low-Activity Waste Program at Hanford



Source: GAO analysis of DOE documents. | GAO-22-104772

DOE faces several challenges to starting and sustaining DFLAW operations. For example, according to DOE risk management documents, there is a high risk of inadequate availability of replacement parts and operating supplies for certain facilities, which will likely delay the DFLAW program schedule and increase costs. In addition, some equipment is likely to be obsolete by the time DFLAW facilities are operational, which would potentially delay the DFLAW program schedule and increase cost. According to DOE risk planning documents, several significant challenges may not be resolved by the end of hot commissioning using actual radioactive waste, and the start of normal DFLAW operations.

DOE’s quality assurance program requires that problems with the quality of the work must include a determination of the extent to which adequate operating conditions exist. According to a 2020 DOE review, the contractor may not be aware of all known conditions and potential cost impacts. DOE officials stated that if the contractor has not fully addressed challenges before DFLAW operations are scheduled to begin, the costs may not be covered by the current contract. DOE is in negotiations with the contractor for a contract extension. Resolving challenges and problems by the end of hot commissioning and the start of normal operations will ensure that the costs to resolve challenges and problems do not fall on DOE.

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**Abbreviations**

BNI	Bechtel National, Inc.
DFLAW	Direct-Feed Low-Activity Waste
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
EVM	earned value management
HLW	high-level waste
IDF	Integrated Disposal Facility
ILAW	Immobilized Low-Activity Waste
LAW	low-activity waste
ORP	Office of River Protection
RCRA	Resource Conservation and Recovery Act of 1976
TPA	Tri-Party Agreement
TSCR	Tank-Side Cesium Removal
WBS	work breakdown structure
WTP	Waste Treatment and Immobilization Plant

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June 14, 2022

Congressional Committees

Since 1989, the Department of Energy’s (DOE) mission at the Hanford Site in Washington State has focused on the cleanup of radioactive and chemically hazardous waste stored in underground tanks and on the ultimate closure of the Hanford Site.<sup>1</sup> In 2016, after years of delays in waste treatment stemming from technical and other challenges, DOE created the Direct-Feed Low-Activity Waste (DFLAW) program to treat a portion of the least radioactive liquid waste at its Hanford Site in Washington State. The program involves the construction or modification of several waste treatment facilities, systems, and infrastructure to immobilize a portion of the waste—low-activity waste (LAW), which is DOE’s term for the portion of the tank waste with low levels of radioactivity.<sup>2</sup> As a matter of policy, DOE manages Hanford’s tank waste as “high-level radioactive waste” (HLW) unless and until it is classified as another waste type.

Several of the DFLAW facilities and systems are part of the Hanford Waste Treatment and Immobilization Plant (WTP) project. The WTP project has been under construction since 2000 and was originally designed to treat both HLW and LAW. However, costs increased from approximately \$4.3 billion in 2000 (\$6.3 billion in 2022 dollar values) to more than \$16.8 billion in 2016 (\$18.1 billion in 2022 dollar values). Schedules to start treating some waste were delayed from an original start operations date of 2011 to at least 2023. Additionally, several investigations uncovered lapses in DOE’s project and contract oversight, which found facility designs and equipment that fail to meet nuclear

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<sup>1</sup>Other cleanup projects at Hanford include removal of contaminants from soil and groundwater and deconstruction and demolition of buildings and equipment associated with earlier weapons production activities.

<sup>2</sup>LAW is primarily the liquid portion of the tank waste that remains after as much radioactive material as is technically and economically practical has been removed. In contrast, DOE Manual 435.1-1 defines low-level radioactive waste as radioactive waste that is not HLW, spent nuclear fuel, transuranic waste, byproduct material, or naturally occurring radioactive material. DOE uses the term LAW to mean the waste that, when solidified and properly classified as low-level radioactive waste, may be disposed of as low-level radioactive waste in a near-surface facility. The WTP project is currently designed to treat all of Hanford’s HLW but only a third to half of the LAW. DOE has yet to identify and select another approach for treating the remaining LAW.

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quality and safety standards, among other things.<sup>3</sup> In 2015, because of WTP project management and technical challenges, DOE adopted a phased strategy, beginning with DFLAW. If successfully implemented, DFLAW would allow DOE to start treating a portion of Hanford waste before resolving all WTP technical issues.

Before the DFLAW program starts treating any waste, facilities and systems must meet applicable safety and quality requirements and be permitted to operate by the Washington State Department of Ecology (Ecology). DOE is bound by the terms of a Consent Decree between it and the state of Washington that requires DOE to start treating tank waste by a date after December 2023 yet to be calculated.<sup>4</sup>

Senate Report 116–236, accompanying S. 4049, National Defense Authorization Act for Fiscal Year 2021, includes a provision for us to evaluate the status of environmental cleanup efforts at the Hanford Site, to include DOE’s effort to start and continue DFLAW operations. This report (1) describes the construction status of facilities and systems needed to start DFLAW operations, (2) examines the extent to which the schedule and cost estimates and the project performance system for DFLAW operations follow selected best practices and exhibit key characteristics of reliable estimates, and (3) examines the challenges DOE faces in starting and sustaining DFLAW operations.

To address these objectives, we examined key documents and interviewed DOE and Ecology officials, and contractors responsible for

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<sup>3</sup>For example, see Department of Energy, *Office of Enterprise Assessments, Assessment of Construction Quality at the Hanford Site Waste Treatment and Immobilization Plant* (June 2016); and GAO, *Hanford Waste Treatment Plant: DOE Needs to Take Further Actions to Address Weaknesses in Its Quality Assurance Program*, [GAO-18-241](#) (Washington, D.C.: Apr. 24, 2018).

<sup>4</sup>The Consent Decree, as amended, was established as a result of litigation brought against DOE by the Washington State Department of Ecology. The Consent Decree resolves certain disputes and addresses a subset of cleanup activities at Hanford. The Consent Decree was last amended in 2020 as a result of the COVID-19 pandemic. That amendment establishes a process for extending the December 2023 deadline based on remobilization activities at Hanford. Under the latest version of the Consent Decree, a new deadline for commencing treatment of low-activity waste will be established once DOE commences remobilization at Hanford, as defined in DOE’s COVID-19 Remobilization Plan. See *State of Washington v. Granholm*, Case No. 2:08-cv-05085 (E.D. Wash; Dkt. 59, filed Oct. 25, 2010), as revised in 2016, 2018, and 2020 by docket nos. 222-23, 231-32, 242, and 251.

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constructing and modifying DFLAW facilities. We also took the following specific steps:

- To determine the status of facilities and systems needed to start DFLAW operations, we reviewed DOE and contractor planning documents and reports. These include DOE and contractor planning and status reports, DOE's WTP Project Execution Plan, and the contractor's Monthly WTP Status Reports.
- To assess the extent to which DOE's schedule and cost estimates and the project performance system follow selected best practices and exhibit key characteristics of reliable estimates for the DFLAW program, we compared the DFLAW schedule and cost estimates and the contractor's earned value management (EVM) system to best practices from GAO's Cost Estimating and Schedule Assessment Guides.<sup>5</sup> To conduct these assessments, we obtained the project schedule and cost estimate, which were current at the time of our review, for the WTP that comprised more than 95 percent of the DFLAW program, according to DOE officials. We compared the WTP data and documents that are related to DFLAW against high-quality accepted best practices that, if implemented, would reflect characteristics of reliable schedule and cost estimates. For reporting purposes, we refer to WTP data and documents that are related to DFLAW as data and documents for the DFLAW program. Our analysis assessed data and documentation for the DFLAW program against the best practices that would result in a schedule that exhibits the comprehensive and well-constructed characteristics of a reliable schedule.<sup>6</sup> For our cost assessment, we assessed program data and documents for the DFLAW program against the cost estimating best practices that would result in a cost estimate that exhibits the comprehensive characteristic. In addition, to determine if the project performance system follows GAO's best practices, we examined DOE's EVM system data related to the DFLAW program from December 2020 to May 2021, which were the most recent 6 months of data available for review.

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<sup>5</sup>GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020); and *Schedule Assessment Guide: Best Practices for Project Schedules*, [GAO-16-89G](#) (Washington, D.C.: Dec. 22, 2015). Earned value management is an industry standard and is considered a best practice for conducting cost and schedule performance analysis for projects.

<sup>6</sup>"Comprehensiveness" refers to how complete the schedule is, and "well constructed" refers to how logical the time line or ordering is for various activities.

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- To identify significant challenges that DOE faces in starting and operating DFLAW facilities and systems, we reviewed the 108 risks that DOE identified in the WTP and DFLAW Risk Registers and Databases, which are systems that DOE uses to identify and track project risks. From these 108 risks, we selected a nongeneralizable sample of 11 risks that DOE had identified as risks associated with starting and operating facilities and systems. These risks are critical to DFLAW and represent significant challenges to starting and operating DFLAW. These 11 risks are also those that DOE estimated that the adverse event had a 25 percent or greater chance of occurring and that would cost more than \$25 million to address, if it were to occur.<sup>7</sup> Through document and report reviews, we assessed the extent to which DOE is taking steps to address these significant challenges. Additional details on our objectives, scope, and methodology can be found in appendix I.

We conducted this performance audit from February 2021 to June 2022 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.

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## Background

This section provides an overview of (1) DFLAW program waste processing and treatment, (2) the regulatory framework and policies governing Hanford's tank waste, and (3) DOE oversight and program and project management requirements.

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## DFLAW Program Waste Processing and Treatment

The DFLAW program involves processing and treating tank waste using several interdependent facilities and systems designed to operate together in a number of steps (see fig. 1). About 95 percent of the facilities, systems, and infrastructure that are required for DFLAW operations are part of the WTP. The WTP has been under construction since 2000 and was originally designed to treat both LAW and HLW. DOE started constructing a WTP pretreatment facility to separate tank waste into LAW from HLW, as well as facilities designed to immobilize the pretreated waste.

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<sup>7</sup>We initially selected eight risks and, using information on these and other risks provided by DOE and contractor officials, the team eliminated two risks and added five risks, resulting in 11 risks for our assessment.



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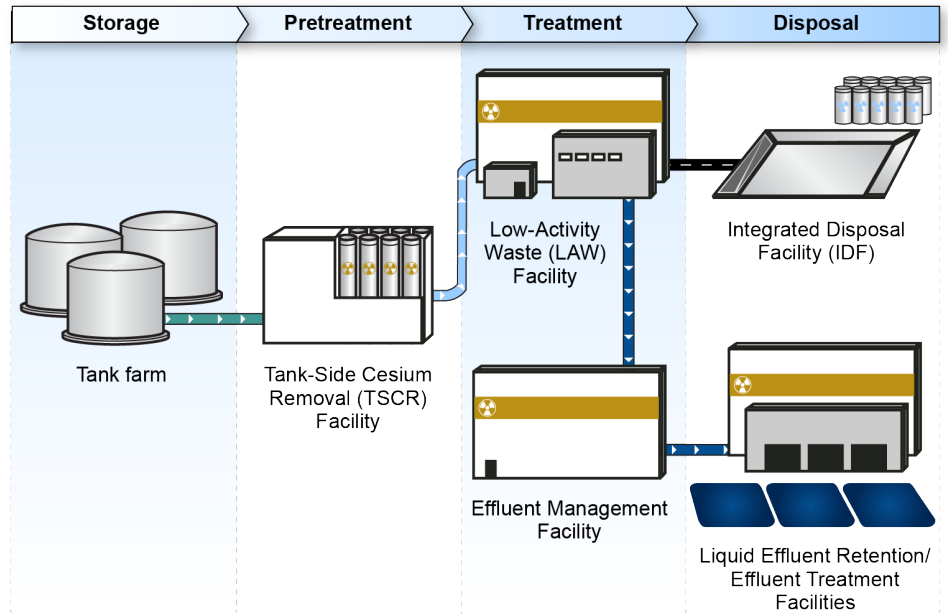
Because of technical challenges associated with treating HLW, in late 2012 DOE stopped work on the pretreatment facility and slowed work on other parts of the WTP that are needed to treat HLW until the technical challenges could be resolved. In 2015, DOE adopted the DFLAW program that, if successfully implemented, will allow DOE to start treating a portion of Hanford LAW before resolving all WTP technical issues.<sup>8</sup> In later phases, DOE plans to complete the WTP pretreatment and HLW facilities and start treating HLW.<sup>9</sup>

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<sup>8</sup>In December 2016, DOE and the contractor modified the WTP contract to account for the new phased strategy, according to DOE officials. The 2016 amended Consent Decree between DOE and Ecology required DOE to complete “hot commissioning” of the LAW Facility, one of the components of the WTP, by December 31, 2023. The Consent Decree defines “LAW Facility hot commissioning complete” to mean “the point at which the LAW Facility has demonstrated its ability to produce immobilized LAW glass of acceptable quality.” *Washington v. Granholm*, Case 2:08-cv-05085 (E.D. Wash; Dkt. 222, filed March 11, 2016). Under the latest amendment to the Consent Decree, the December 2023 deadline will be recalculated based on the DOE’s remobilization activities at Hanford in connection with the COVID-19 pandemic. *See id.* at Dkt. 251.

<sup>9</sup>DOE plans to vitrify this portion of the waste and store it on-site until a final repository is established. In 2010, DOE began taking steps to terminate its proposal for a deep geologic repository for HLW at Yucca Mountain, Nevada, and is now considering other final disposal options.

**Figure 1: Steps in the Direct-Feed Low-Activity Waste Process at the Department of Energy’s Hanford Facility in Washington State**



Source: GAO analysis of DOE documents. | GAO-22-104772

According to DOE DFLAW program documents, the waste processing steps include the following main steps:<sup>10</sup>

1. **Storage:** In the first step, tank waste that is stored in one of Hanford’s tank farms is characterized and qualified for approval for waste

<sup>10</sup>In addition to the primary DFLAW program waste treatment facilities, several additional facilities and systems will support DFLAW. These include the Balance of Facilities, which will provide necessary utilities, facilities, systems, and other services required to support DFLAW waste processing at the LAW Facility. The Analytical Laboratory will analyze the waste produced at the LAW Facility to ensure that it meets all regulatory requirements and standards. DFLAW operations will also require significant upgrades to Hanford Site infrastructure, such as road, electrical, water, and sewer systems, and require the support of Hanford security, information technology, and maintenance services.

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treatment.<sup>11</sup> Once this is complete, waste will be transferred to the Tank-Side Cesium Removal (TSCR) system for pretreatment.<sup>12</sup>

2. Pretreatment: During DFLAW pretreatment, LAW will be separated from the remainder of the waste by the TSCR system, and liquid LAW will be pumped into a different tank for staging for waste treatment at the LAW Facility.<sup>13</sup> TSCR is designed to filter out solids, including cesium, from liquid tank waste.<sup>14</sup>
3. Treatment: Staged LAW will be pumped to the WTP LAW Facility. At the WTP LAW Facility, the waste will be immobilized, using a process called “vitrification.”<sup>15</sup> The resulting waste is referred to as “Immobilized LAW” (ILAW) and is encapsulated in canisters. Liquid effluents resulting from LAW Facility waste treatment are pumped to the Effluent Management Facility. This facility evaporates the liquid effluents to reduce the total amount of effluents requiring disposal.<sup>16</sup>
4. Disposal: Once the ILAW canisters have hardened and cooled, DOE plans to dispose of them at the Integrated Disposal Facility (IDF).<sup>17</sup>

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<sup>11</sup>DOE intends to carry out waste characterization and qualification at the Hanford 222-S Laboratory. Characterization and qualification include sampling tank waste to conduct chemical analysis to determine if waste meets regulatory requirements for pretreatment and treatment for all restoration, tank waste processing, and closure operations on the Hanford Site.

<sup>12</sup>DOE is currently working toward retrieval and closure of the first of Hanford’s 18 “tank farms,” which are groupings of two to 18 tanks. DOE plans to start DFLAW operations with tank waste from the AP-tank farm, according to DOE officials.

<sup>13</sup>According to DOE officials, DOE plans to stage pretreated staged LAW at Waste Tank AP-106, which has been emptied and repurposed to be used during the DFLAW pretreatment stage.

<sup>14</sup>DOE plans to store spent TSCR ion exchange columns containing separated HLW at the TSCR storage pad. According to DOE officials, DOE has not yet conducted an Analysis of Alternatives for the eventual disposal of HLW resulting from TSCR pretreatment waste processing. DOE plans to store this HLW waste on-site until a final repository is established.

<sup>15</sup>Vitrification involves mixing the waste with a glass-forming (vitrifying) material, melting the mixture, and pouring the vitrified waste into stainless-steel canisters to cool and harden.

<sup>16</sup>According to DOE officials, radioactive, dangerous liquid effluents that meet acceptance criteria can be discharged to the Liquid Effluent Retention Facility for temporary storage and to the Effluent Treatment Facility for subsequent treatment.

<sup>17</sup>According to DOE officials, to dispose ILAW at the IDF, DOE must obtain from Ecology modifications to the Hanford Dangerous Waste Permit for various aspects of the IDF operations.

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The canisters will be transported to the IDF using the ILAW Transporter System comprised of four truck-trailer transporters. According to Office of River Protection (ORP) officials, the remaining liquid effluents from the Effluent Management Facility will be transferred in underground transfer lines to the Liquid Effluent Retention and Effluent Treatment Facilities, which provide treatment and storage for secondary liquid wastes.

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## Regulatory Framework and Policies Governing Hanford's Tank Waste

The treatment and disposal of Hanford's tank waste is governed by a number of federal laws—some of which authorize state responsibilities—regulations, DOE orders, and cleanup agreements, including the following:

- The radioactive components of the tank waste are regulated primarily by DOE under the Atomic Energy Act of 1954, as amended, and the Nuclear Waste Policy Act of 1982, as amended. The hazardous components of the tank waste are generally regulated by the Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act of 1976, as amended (RCRA). Where EPA has authorized states to implement hazardous waste programs, those state programs operate in lieu of the federal programs. EPA has authorized Ecology to administer its own hazardous-waste regulatory program in lieu of the federal program.<sup>18</sup> Ecology has issued a dangerous waste permit to DOE under the state's authorized RCRA program that establishes requirements for the treatment, storage, and disposal of mixed waste. This permit includes approval for the

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<sup>18</sup>Under RCRA, EPA may authorize a state to implement its own hazardous waste management program in lieu of the respective federal program, so long as the state program is equivalent to, and at least as stringent as, the federal program. State programs may be more stringent and have provisions that are broader in scope than the federal program.

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construction and operation of the WTP complex, which included key DFLAW facilities and systems.<sup>19</sup>

- DOE Order 435.1 and Manual 435.1-1, issued in July 1999 and subsequently revised, apply to DOE’s management of all HLW and low-level radioactive waste, including the radioactive component of mixed waste, for which DOE is responsible.<sup>20</sup> The order and manual set forth procedures for the management of DOE’s radioactive wastes that are protective of worker and public health and safety, as well as the environment. Under the manual, low-level radioactive waste is radioactive waste that is not HLW, spent nuclear fuel, transuranic waste, byproduct material, or naturally occurring radioactive material.<sup>21</sup> The manual spells out a process by which DOE can determine that certain radioactive waste can be managed as non-HLW, which is less expensive to manage than HLW.<sup>22</sup>

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<sup>19</sup>Hanford’s tanks contain a complex mix of radioactive and hazardous components (such waste is called “mixed waste”) in both liquid and solid forms. Specifically, the term “mixed waste” means waste that contains both (1) hazardous waste subject to the RCRA or authorized state programs that operate in lieu of the federal program; and (2) radioactive source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954. Hanford’s tank waste also includes various metals. Low-level radioactive waste mixed with hazardous chemicals (as is the case with Hanford’s waste) is often referred to as “mixed low-level waste.” In this report, we use the general term “low-level radioactive waste” to refer to both types, except in those instances where we determine that the distinction is important to make.

<sup>20</sup>Department of Energy, *Radioactive Waste Management*, Order 435.1 (Washington, D.C.: Jan. 11, 2021); and *Radioactive Waste Management Manual*, Manual 435.1-1 (Washington, D.C.: Jan. 11, 2021).

<sup>21</sup>Most of the waste managed by DOE cleanup activities is characterized as low-level radioactive waste. Low-level radioactive waste is also generated through commercial activities, such as nuclear power plant operations, and it varies from lightly contaminated soils and building materials to highly irradiated nuclear reactor components. The Low-Level Radioactive Waste Policy Amendments Act of 1985 defines low-level radioactive waste as radioactive material that (1) is not high-level waste, spent nuclear fuel, or byproduct material; and (2) the Nuclear Regulatory Commission classifies as low-level radioactive waste. DOE disposes of low-level radioactive waste at its own sites, as well as at some commercial facilities in accordance with its guidelines.

<sup>22</sup>The order and manual set forth mechanisms by which DOE may determine that certain reprocessing waste is waste incidental to reprocessing, which is non-HLW that can be classified on the basis of its radiological risk. According to DOE and Ecology officials, DOE will use these mechanisms to conduct an evaluation to determine if ILAW is waste that is incidental to reprocessing, is not HLW, and may be managed and disposed of on-site at the IDF as mixed low-level waste. Assuming that DOE determines that it can manage ILAW accordingly, DOE will then have to submit a permit modification request to Ecology to dispose of ILAW at the IDF.

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Cleanup activities at the Hanford Site are also governed by two primary agreements:

- Hanford Federal Facility Agreement and Consent Order of 1989 (or Tri-Party Agreement—TPA), which is an agreement among DOE, EPA, and Ecology that lays out a series of legally enforceable milestones related to the treatment of LAW.<sup>23</sup>
- Consent decree of 2010, as amended, which was established as a result of litigation brought against DOE by Ecology for missing certain TPA milestones. This judicially enforceable Consent Decree establishes specific cleanup milestones for retrieval of waste from certain specified tanks and for the treatment of LAW.

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## DOE Oversight and Program and Project Management Requirements

Three DOE offices oversee the DFLAW program and the contractors that are responsible for constructing and modifying facilities and systems. DOE's ORP and the Richland Operations Office are responsible for the management and execution of the DFLAW program. ORP, the Richland Operations Office, and DOE headquarters offices, including DOE's Office of Environmental Management (EM), are responsible for the oversight of contractor activities associated with DFLAW. Various contractors at the Hanford Site are responsible for constructing or modifying DFLAW facilities and systems based on the scope of each contract. For example, Bechtel National, Inc. (BNI), is contracted to complete the WTP. Other contractors are responsible for completing or modifying other DFLAW facilities and systems.

Certain capital assets required for DFLAW operations are subject to DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets.<sup>24</sup> The stated goal of the order is to deliver fully capable projects that meet safeguards and security, and environmental, safety, and health requirements within the planned cost, schedule, and original

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<sup>23</sup>One purpose of the TPA is to ensure that the environmental effects associated with past and present activities at the Hanford Site are thoroughly investigated and that appropriate response actions are taken, as necessary, to protect the public health, welfare, and the environment. Another purpose is to promote an orderly, effective investigation and cleanup of contamination at the Hanford Site and to avoid litigation between the parties.

<sup>24</sup>Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*, DOE Order 413.3B (Change 6) (Washington, D.C.: Jan. 12, 2021).

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performance baseline.<sup>25</sup> The order specifies requirements, including developing and managing project cost and schedule estimates, to move a project past each critical decision. The order also states that performance baseline cost estimates should be developed, maintained, and documented in a manner consistent with methods and the best practices identified in GAO's Cost Estimating and Assessment Guide.<sup>26</sup>

In 1990, we designated DOE's contract management—including contract administration and project and program management—as a high-risk area. We took this action because DOE's record of inadequate management and oversight of contractors left the department vulnerable to fraud, waste, abuse, and mismanagement. In the 2021 update to our High-Risk Series report, we provided a separate rating specific for EM and assessed it as having partially met all five high-risk criteria.<sup>27</sup>

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## Facilities and Systems That Are Needed for DFLAW Operations Are Mostly Complete

According to DOE reports, planning documents, and officials, all facilities and systems that are needed to begin DFLAW operations are scheduled to be completed and ready to start treating tank waste by December 2023. In 2021, DOE completed construction of all WTP facilities that are needed to start DFLAW operations, according to a December 2021 EM report.<sup>28</sup> In addition, the report stated that DOE had completed construction and testing on TSCR and has started pretreating tank waste in early 2022 in order to build up a supply of waste feed for DFLAW operations to start in 2023. Furthermore, according to DOE officials, the safety documentation required to start DFLAW operations, such as the WTP Documented Safety Analysis and the Plan of Action for the LAW

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<sup>25</sup>The performance measurement baseline includes all budgets for resources associated with completing the program, including direct and indirect labor, material, and other direct costs associated with the authorized work.

<sup>26</sup>[GAO-20-195G](#). DOE Order 413.3B (Change 6) cites GAO, Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs, [GAO-09-3SP](#) (Washington, D.C.: March 2009), which has been updated; the current guidance is in [GAO-20-195G](#).

<sup>27</sup>GAO, *High-Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas*, [GAO-21-119SP](#) (Washington, D.C.: March 2021).

<sup>28</sup>Department of Energy, *2021 Year in Review Highlights EM Cleanup Progress, Priorities*, *Office of Environmental Management News Flash* (Washington, D.C.: December 2021).

Facility Operational Readiness Review, are complete.<sup>29</sup> The primary facilities needed to start DFLAW operations and their completion status are described in table 1.

**Table 1: Completion Status of Facilities and Systems for the Direct-Feed Low-Activity Waste Program, as of March 2022**

Facility or system	Construction or modification status
Low-Activity Waste Facility	Complete
Analytical Laboratory	Complete
Effluent Management Facility	Complete
Balance of Facilities required for Direct-Feed Low-Activity Waste (DFLAW) operations	Complete
Tank waste pretreatment Tank-Side Cesium Removal System	Complete
Liquid Effluent Retention Facility and Effluent Treatment Facility modifications	Scheduled completion in April 2023
Integrated Disposal Facility modifications	Scheduled completion in August 2022
Tank farm modifications for DFLAW	Complete

Source: GAO analysis of Department of Energy data. | GAO-22-104772

According to the WTP Project Execution Plan, DOE plans to start DFLAW operations with cold commissioning WTP facilities in December 2022.<sup>30</sup> Cold commissioning involves the introduction of feed simulants in order to determine individual facility functionality, according to the 2010 Consent Decree, as amended.<sup>31</sup> DOE plans to follow cold commissioning with hot commissioning in December 2023, which includes testing facilities and

<sup>29</sup>A Documented Safety Analysis details potential accident conditions that might lead to the release of radioactive or other hazardous materials. These analyses also identify safety systems and processes to protect workers, the public, and the environment from any adverse consequences of a release of this material. An Operational Readiness Review is a documented, performance-based examination of facilities, equipment, personnel, procedures, and management control systems for ensuring that a facility can be operated safely within its approved safety requirements.

<sup>30</sup>Department of Energy, *Project Execution Plan for the Waste Treatment and Immobilization Plant (WTP)*, MGT-PM-PL-06, Rev. 2 (Richland, WA: September 2016).

<sup>31</sup>See *State of Washington v. Granholm*, Case No. 2:08-cv-05085 (E.D. Wash; Dkt. 222, filed Mar. 11, 2016).



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systems using actual tank waste.<sup>32</sup> According to the 2010 Consent Decree, as amended, completion of the LAW Facility hot commissioning is the point at which the LAW Facility has demonstrated its ability to produce ILAW glass of acceptable quality.

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## DFLAW Program Schedule Estimate, Cost Estimate, and Project Performance System Are Not Fully Following Best Practices

DOE's schedule and cost estimates for WTP are not fully following best practices that, if implemented, would result in improved estimates exhibiting key characteristics of reliable estimates. In addition, the cost estimate for the DFLAW program partially met the characteristic of being comprehensive.<sup>33</sup> Furthermore, DOE has not ensured that the contractor's system for measuring schedule and cost performance of some DFLAW facilities is fully reliable and meets DOE requirements.

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## DFLAW Program Schedule and Cost Estimates Do Not Fully Follow Best Practices

DOE reviews and our assessments indicate that the DFLAW schedule and cost estimates do not reflect characteristics of reliable estimates. DOE estimates that it will complete the work to start DFLAW operations by December 31, 2023, at a cost of approximately \$8.3 billion. However, according to a January 2020 report by DOE's Office of Project Management, many of the estimates that exist to complete facilities and systems and start DFLAW operations are based on immature and unproven designs or are characterized as rough estimates and, as a result, the estimates are of limited reliability. According to DOE's report, this causes a high level of uncertainty associated with budget forecasts

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<sup>32</sup>As a result of the COVID-19 pandemic, December 2023 is no longer the operative deadline for DOE to begin treating LAW because of modifications to the Consent Decree, according to DOE officials. DOE continues to work toward meeting the original dates and to offset the impacts from the COVID-19 pandemic.

<sup>33</sup>GAO's Schedule Assessment Guide identifies 10 best practices associated with effective scheduling, which are summarized into four characteristics of a reliable schedule—(1) comprehensive, (2) well constructed, (3) credible, and (4) controlled. GAO's Cost Guide presents the best practices associated with developing a reliable, high-quality cost estimate—they are (1) well documented, (2) comprehensive, (3) accurate, and (4) credible—and the best practices associated with effective management of program costs using earned value management.

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for the year beyond the current fiscal year.<sup>34</sup> Furthermore, in December 2020, DOE's Office of Project Management concluded that DOE's schedule to start DFLAW operations is optimistic and that the cost estimate to complete DFLAW facilities and systems is understated.<sup>35</sup>

Following DOE direction, in December 2020, BNI developed new schedule and cost estimates to complete facilities and systems that are needed to start DFLAW operations, which were under review by DOE as of November 2021, according to DOE officials. However, BNI's updated schedule and cost estimates do not include additional time and costs that are needed to demonstrate full production capability for DFLAW operations. For example, according to DOE officials, following the initial LAW Facility hot commissioning demonstration test, DOE has requested a proposal for a contract extension from BNI for an additional 16 months to hire additional staff and ramp-up the plant to the full capacity operations to ensure that all facility systems and equipment function as designed. This additional 16 months is not currently within the scope of BNI's WTP contract. Also, according to DOE's December 2021 Monthly DOE Project Portfolio Status Report, COVID-19 impacts severely stress its ability to meet the planned August 2023 start date for WTP cold commissioning operations. DOE and BNI are currently negotiating a contract extension to address the additional scope of work that is needed for extended hot commissioning; according to DOE officials, it is unclear when negotiations will be completed and the contract extension approved.

DOE Order 413.3B governs EM's program and project management activities for the acquisition of capital assets, including certain DFLAW facilities, with the stated goal of delivering fully capable projects within the planned cost, schedule, and performance baseline.<sup>36</sup> In addition, the

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<sup>34</sup>Department of Energy, Office of Project Management, *Project Peer Review of the Waste Treatment and Immobilization Plant, Low Activity Waste, Analytical Laboratory, and Balance of Facilities—Direct Feed Low-activity Waste (WTP LBL DFLAW) Project / Program* (Washington, D.C.: January 2020).

<sup>35</sup>Department of Energy, Office of Project Management, *Project Peer Review of the Waste Treatment and Immobilization Plant, Low Activity Waste, Analytical Laboratory, and Balance of Facilities—Direct Feed Low-activity Waste Project / Program* (Washington, D.C.: December 2020).

<sup>36</sup>Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*, DOE Order 413.3B, (Change 6) (Washington, D.C.: Nov. 29, 2010, as last amended Jan. 12, 2021).

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## Schedule Estimate Assessment

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order states that project performance baseline schedule and cost estimates should be developed, maintained, and documented in a manner consistent with the methods and best practices identified in GAO's Cost Estimating and Assessment Guide.<sup>37</sup>

We compared data and documentation for the DFLAW program schedule and cost estimates for the WTP—which comprises 95 percent of the DFLAW program, according to DOE officials—against the best practices from our Cost Estimating and Schedule Assessment Guides. These best practices, if implemented, would result in estimates exhibiting characteristics of reliable estimates. However, our analyses found that DOE did not fully follow best practices associated with the characteristics we assessed for schedule and cost estimates, which are summarized in the following sections and described in more detail in appendix II.

DOE has substantially followed some, but not all, best practices for developing a schedule that reflects the comprehensive and well-constructed characteristics of a reliable schedule estimate for the DFLAW program.<sup>38</sup> On the basis of our analysis of DOE and BNI data and documentation for the WTP, we made the following observations of the WTP May 2021 schedule estimate to complete work needed to start DFLAW operations:

- **Comprehensive schedule estimate (substantially met):** DOE substantially met best practices for a comprehensive schedule for the WTP work needed to start DFLAW operations. According to our Schedule Assessment Guide, a comprehensive schedule includes all activities for both the government and its contractors to accomplish their objective and establishes how long each activity will take.<sup>39</sup> We found that the schedule has clear start and finish milestones and includes a substantial amount of detail, including risk mitigation efforts. However, we also found that the schedule does not align with

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<sup>37</sup>[GAO-20-195G](#). DOE Order 413.3B (Change 6) cites [GAO-09-3SP](#), which has been updated; the current guidance is in [GAO-20-195G](#).

<sup>38</sup>The ratings we used in these analyses are as follows: "Fully met" means EM provided complete evidence that satisfies the entire best practice criterion. "Substantially met" means EM provided evidence that satisfies a large portion of the best practice criterion. "Partially met" means EM provided evidence that satisfies about half of the best practice criterion. "Minimally met" means EM provided evidence that satisfies a small portion of the best practice criterion. "Not met" means EM provided no evidence that satisfies the best practice criterion.

<sup>39</sup>[GAO-16-89G](#).

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some key milestones. For example, the May 2021 DFLAW Program Monthly Overview briefing shows that cold commissioning starting on April 13, 2022, whereas the WTP schedule shows the cold commissioning start milestone as March 22, 2022. In addition, the WTP Project Execution Plan shows the start of cold commissioning DFLAW facilities in December 2022.

- **Well-constructed schedule estimate (partially met):** DOE partially met best practices associated with the characteristics of being well constructed to start DFLAW operations. According to our Schedule Assessment Guide, a well-constructed schedule sequences all activities; establishes a valid critical path; and identifies a reasonable amount of total schedule float time, meaning an accurate reflection of the schedule’s flexibility.<sup>40</sup>

Our analysis showed that the schedule had some anomalies that, when taken together, indicate that the schedule does not meet best practices. For example, the schedule includes dangling logic—that is, either the start or finish dates for these activities are not properly tied to other activities; date constraints that prevent activities from taking advantage of time savings; and activities with lags that force the passage of time, with no associated effort or resources. Our analysis also showed that the critical path, as calculated by the software, includes activities with constraints and lags. According to best practices, if the critical path is missing dependencies or has date constraints, lags, or level of effort activities or it is not a continuous path from the current status date to the finish milestone, then it is not valid. Incorrect float time estimates may result in an invalid critical path and, thus, will not be reliable indicators of where resources can be shifted to support delayed critical activities, which can lead to inaccurate schedule estimates. Our analysis of the DFLAW schedule found that 25 percent of remaining activities and milestones have an unreasonably high total amount of float time, which could result in an unreliable schedule estimate to complete work needed to start DFLAW operations.

## Cost Estimate Assessment

DOE has partially met best practices for developing a comprehensive cost estimate. We assessed the comprehensive characteristic because if a cost estimate is not comprehensive (that is, not complete), then it may

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<sup>40</sup>[GAO-16-89G](#). Sequencing all activities means that all activities are sequenced in the order that they are to be implemented, with the most straightforward logic possible. A valid critical path is one that represents the chain of dependent activities with the longest total duration. Float time is the amount of time by which a project activity can slip before the delay affects the project’s estimated completion date.

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not fully meet the other characteristics of a reliable cost estimate.<sup>41</sup> The following are observations based on our analysis of the cost estimate for the four best practices that form the basis of a comprehensive cost estimate:

- **Cost estimate includes all life cycle costs (minimally met):** According to our cost guide, a cost estimate should include both government and contractor costs of the program over its full life cycle, from inception of the program through design and development, production, operations and maintenance, and end of the program.<sup>42</sup> However, DOE did not provide a life cycle cost estimate that included all costs of the program. For example, the cost estimate did not include government costs, such as costs of the DOE program office supporting the program. According to BNI officials, the cost accounting model it uses for the WTP cost estimate does not include government costs, and it does not manage the cost estimate from beginning to end. DOE officials noted that DOE includes non-contract costs, contract price, and contingency in the WTP total project cost baseline in the 2022 Hanford Lifecycle Scope, Schedule, and Cost Report.<sup>43</sup> However, this report summarizes the remaining work scope, schedule, and cost estimates. A lifecycle cost estimate should include costs over the full life cycle, from inception through development, production, operations and maintenance, and final disposition. Without fully accounting for life cycle costs, management will have difficulty successfully planning program resource requirements and making wise decisions.
- **Cost estimate based on a technical baseline description that completely defines the program (partially met):** According to our cost guide, a technical baseline description should completely define the program, reflect the current schedule, and be technically reasonable. The technical baseline documents we received met some elements of a technical baseline description as identified in the GAO cost guide. For example, the technical baseline description contains typical technical baseline elements, such as purpose, contract strategy, a work breakdown structure (WBS), and testing description.

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<sup>41</sup>Comprehensive cost estimate best practices assessed include (1) all life cycle costs, (2) a comprehensive baseline description, (3) a comprehensive work breakdown structure, and (4) documents all cost-influencing ground rules and assumptions.

<sup>42</sup>[GAO-20-195G](#).

<sup>43</sup>Department of Energy, Richland Operations Office, 2022 Hanford Lifecycle Scope, Schedule and Cost Report (Washington, D.C.: January 2022).

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Additionally, the technical baseline description is reviewed annually and revised when appropriate. However, we found that it is not clear how the cost estimate will be affected as the technical baseline description is updated. Without explicit documentation of the basis of a program's cost estimate, it will be difficult to update the cost estimate and verify a new cost baseline as key assumptions change during the course of the program's life.

- **Cost estimate based on a standardized WBS (partially met):** According to our cost guide, establishing a product-oriented WBS is a best practice because it allows a program to track cost and schedule by defined deliverables, such as a hardware or software component. However, we found that some common WBS elements are not included, and it is not apparent if the WBS is standardized. Without a standard, product-oriented WBS to facilitate the tracking of resource allocations and expenditures, DOE may not be able to reliably estimate the cost of future similar programs.
- **Cost estimate document defines all cost-influencing ground rules and assumptions (minimally met):** According to the GAO cost guide, each estimate should at a minimum define the following rules and assumptions: program schedule, cost limitations (for example, unstable funding stream or staff constraints), high-level time phasing, base year, labor rates, inflation indexes, participating agency support, and government-furnished equipment. However, our analysis did not identify where these ground rules and assumptions are defined for DFLAW, and we found that the project's historical requirements are not documented. DOE provided several bases for the estimate; however, the risks associated with cost estimating assumptions are not clearly stated. Unless assumptions are documented with their sources and supporting historical data, decision-makers will not understand the level of certainty around the assumption or the cost estimate.

Without fully developing schedule and cost estimates that exhibit the characteristics of reliable estimates for the DFLAW program, DOE cannot reliably commit to when the DFLAW program will be fully implemented, as well as whether estimated costs and dates are realistic to manage the program's performance. Optimistic and aggressive scheduling of the facilities, such as the WTP LAW Facility, could jeopardize project completion schedules and, as a result, the start of DFLAW operations and lead to an increased cost of the program. Furthermore, if DOE is not able to start DFLAW operations on time, DOE could be in violation of the Consent Decree, face an enforcement action from Washington State, or have to negotiate new milestones.

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## DFLAW Contractor's System for Measuring Performance Is Not Fully Reliable

DOE has not ensured that the contractor's EVM system for measuring the schedule and cost performance of DFLAW program facilities meets DOE requirements and, consequently, the system is not fully reliable. DOE relies on the contractor's EVM system to determine the extent to which cost, schedule, and technical performance data are reliable for DFLAW program management purposes.<sup>44</sup> EVM is a management tool used to measure the value of work accomplished in a given period and to compare it to the actual cost of the work accomplished and the planned value of work scheduled for the same period. DOE Order 413.3B states that contractors for certain capital asset projects, such as components of DFLAW, must have a certified and compliant EVM system. Additionally, according to GAO's cost guide, EVM data can alert project managers to potential problems sooner than expenditures alone can, and using EVM as a management tool is considered a best practice for conducting schedule and cost performance analyses for projects.

In November 2019, DOE's Office of Project Management concluded that BNI lacked EVM system management discipline and that BNI is not consistently following or applying their existing EVM system during the execution of the WTP.<sup>45</sup> Furthermore, this office found that DOE's EVM system documents and practices failed to conform to DOE EVM system requirements and that BNI project staff lacked knowledge of, and conformance to, EVM system designated roles, responsibilities, and authorities.

Our findings are consistent with DOE's assessments. We found that the EVM system followed (i.e., substantially or fully met) some best practices but did not fully follow (i.e., partially or minimally met) other best practices.<sup>46</sup> Appendix II provides detailed information on our analysis of

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<sup>44</sup>[GAO-20-195G](#). Earned value management is an industry standard and is considered a best practice for conducting cost and schedule performance analysis for projects.

<sup>45</sup>Department of Energy, Office of Project Management, *Report on the Earned Value Management System (EVMS) Surveillance Review for Bechtel National, Inc. (BNI) Richland Washington, for the Hanford Tank Waste Treatment and Immobilization Plant (WTP) Project* (Washington, D.C.: November 2019).

<sup>46</sup>The ratings we used in these analyses are as follows: "Fully met" means EM provided complete evidence that satisfies the entire best practice. "Substantially met" means EM provided evidence that satisfies a large portion of the best practice. "Partially met" means EM provided evidence that satisfies about half of the best practice. "Minimally met" means EM provided evidence that satisfies a small portion of the best practice. "Not met" means EM provided no evidence that satisfies the best practice.

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WTP's the EVM system, and the following points summarize our observations:

- DOE substantially or fully met some best practices for ensuring that the program management team is using earned value management data for decision-making purposes by ensuring that the EVM system data were (1) reviewed on a regular basis, (2) used to develop corrective action plans, and (3) used to update a performance measurement baseline to reflect changes. For the 6 months of EVM documentation that we assessed, DOE management examined and analyzed EVM data on a monthly basis and used the information to make programmatic decisions. For example, through the use of EVM data, in December 2020, DOE management was able to observe negative trends in the WTP schedule and cost and decided to establish a new cost and schedule performance baseline. We also found that EVM data were reviewed by DOE on a monthly basis for the 6 months that we assessed.
- DOE partially met best practices for ensuring that the EVM system provides reliable data because, for example, the system contained numerous anomalies, leading to the production of unreliable data. According to our cost guide, to ensure that project reported data are reliable, it is important to ensure that EVM data are reasonable and do not contain anomalies that would make them invalid and, if errors are detected and corrected, then the data may be inaccurate. However, we identified several instances of anomalies in DOE's EVM data. For example, according to our analysis of 6 months of WTP EVM project data, there are 58 instances where the cumulative amount of monthly work performed is greater than the project budget at completion. If the contract performance report data contain anomalies, the performance measurement data may be inaccurate and may limit DOE's ability to measure the project's performance, potentially leading to bad decision-making. In addition, we found 743 instances of negative dollar values in the EVM reports. Negative values should occur rarely, if ever, in EVM reporting because they imply that previously scheduled or performed work was not completed.<sup>47</sup>
- DOE minimally met the best practice to ensure that the EVM system is certified. BNI's EVM system was certified as compliant in May 2012, following the initial compliance certification in March 2008. However, from 2013 to 2017, there was no DOE oversight of EVM data for the project. According to DOE Office of Project Management officials,

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<sup>47</sup>While a negative value may occasionally occur as a result of retroactive accounting adjustments, this practice should not be the norm.



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after several years of not assessing BNI's adherence to EVM requirements, their office started assessing BNI's conformance with DOE EVM system requirements in February 2019. This assessment is ongoing and, according to DOE officials, will not be completed until the end of December 2022, or later. During this assessment, however, in November 2019, the Office of Project Management found that BNI's EVM system was not compliant with DOE's system requirements. This office also reported that under BNI stewardship, the utility of the 2008 certified EVM system, as a contractually required project management system and methodology, is no longer serving its intended purpose.

In April 2022, DOE's Office of Project Management concluded that progress had been made in resolving several of the WTP contractor's top priority EVM corrective actions. At the same time, DOE's Office of Project Management recommended the project develop an alternative project control method, as defined in DOE Order 413.3B, for the remainder of DFLAW work scope because construction is complete for DFLAW operations and the facility has been turned over to plant management for commissioning and operating activities.<sup>48</sup> Nevertheless, the Office of Project Management's assessment noted that 40 EVM system deficiencies remain. Because the contractor continues to work on the WTP to complete construction of parts of the project that are separate from DFLAW, it remains critical that all deficiencies in the contractor's EVM system are resolved and verified as fully effective.

An EVM system that produces unreliable data may contribute to DOE's challenges in measuring the cost and schedule performance of WTP facilities needed for DFLAW. Without a compliant EVM system, DOE does not have assurance that it is using accurate and reliable information to reveal when forecasted completion dates differ from baseline dates and whether schedule variances affect future work. Unless the review of the contractor's EVM system for DFLAW facilities is completed to ensure compliance with DOE requirements, there is limited assurance that it complies with DOE's EVM requirements and that it provides reliable data for managing DFLAW and reporting its status to DOE. Such a situation jeopardizes project completion schedules, which could delay the start of DFLAW operations and increase the cost of the DFLAW program.

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<sup>48</sup>Department of Energy, Office of Project Management, *Project Peer Review of the Waste Treatment and Immobilization Plant, Low Activity Waste, Analytical Laboratory, and Balance of Facilities—Direct Feed Low-activity Waste Project* (Washington, D.C.: April 2022).

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## DOE Faces Several Significant Challenges to Start and Sustain DFLAW Operations on Schedule

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### DOE Faces Several Significant Challenges to Starting DFLAW Operations on Schedule

DOE faces several significant challenges to starting and sustaining DFLAW operations, as identified in DOE documents. To manage DFLAW program challenges, in 2015, DOE initiated the DFLAW Program Risk and Opportunity Management Plan. To execute this plan, DOE's risk management program uses WTP and DFLAW Risk Registers and Databases to manage the DFLAW risks.

The DFLAW Program Risk and Opportunity Management Plan identifies and assesses risks. After specific risks are identified, DOE's assessment includes rating the unmitigated chance of the adverse event occurring and its potential impacts on schedule and cost. According to DOE risk management documents, this process involves DOE and contractor subject matter experts initially assigning the approximate chance of the event occurring and potential impacts if the event were to occur, using the most up-to-date information and, thereby, rating its overall risk. The assessed values represent the agency's judgment of the likelihood and consequences of each risk to the DFLAW program. DOE then determines how to reduce the risk and, after steps are taken to reduce or limit the impacts, the chance of the adverse event occurring is recalculated to rate the residual risk on a project.<sup>49</sup> According to ORP officials, the Risk Registers and Databases include all known risks associated with the DFLAW program, as of July 31, 2021. The Risk Registers and Databases listed a total of 108 unresolved risks related to the DFLAW program.<sup>50</sup>

In our examination of the Risk Registers and Databases, we identified 11 risks that represent significant challenges that DOE faces in starting and

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<sup>49</sup>These ratings are subjective judgments that the agency uses for planning and risk mitigation and should not be interpreted as statistical forecasts, according to DOE risk management documents.

<sup>50</sup>The WTP Risk Register and Database includes all risks associated with the project, including several not related to the DFLAW program.

operating DFLAW facilities and systems. According to DOE officials, the challenges we identified include several potential single points of failure within the DFLAW operating system such that, if one facility or system is not functioning or needs modification, then DOE cannot begin or sustain operations. Table 2 lists the 11 significant challenges we identified. It also includes the (1) unmitigated and residual assessments that DOE used to rate the risk level of associated challenges; (2) approximate chances of the challenges occurring based on DOE subject matter professional judgment and evidence available; and (3) approximate potential impacts on schedule and cost. Appendix I includes more detailed information on the process we used to identify these challenges, and appendix III contains additional information on the 11 significant challenges.

**Table 2: Significant Direct-Feed Low-Activity Waste (DFLAW) Challenges**

Significant DFLAW challenges	Assessments <sup>a</sup>	Approximate risk level <sup>b</sup>	Approximate chance of occurrence <sup>c</sup>	Approximate potential impacts <sup>d</sup>
Unknown events that affect schedule or cost	Unmitigated	High	Almost certain	Substantial
	Residual	High	Possible	Substantial
Low-Activity Waste (LAW) Facility is not ready for operations when other facilities are ready to begin	Unmitigated	High	Almost certain	Substantial
	Residual	High	Almost certain	Substantial
LAW Facility does not operate at designed operations capacity	Unmitigated	High	Almost certain	Substantial
	Residual	High	Almost certain	Substantial
Inadequate replacement parts and operating supplies for Waste Treatment and Immobilization Plant Fatality	Unmitigated	High	Almost certain	Substantial
	Residual	High	Likely	Substantial
Aging equipment is inoperable or obsolete—1 <sup>e</sup>	Unmitigated	High	Almost certain	Considerable
	Residual	Moderate	Almost certain	Significant
Aging equipment is inoperable or obsolete—2 <sup>e</sup>	Unmitigated	High	Likely	Substantial
	Residual	Moderate	Likely	Significant
Solid waste processing and management	Unmitigated	High	Likely	Substantial
	Residual	Moderate	Likely	Substantial
Delayed evaluation approval for the disposal of treated waste	Unmitigated	High	Likely	Substantial
	Residual	Moderate	Likely	Substantial
DFLAW control systems do not operate as designed	Unmitigated	High	Likely	Substantial
	Residual	Low	Rare	Significant
DFLAW waste feed system not completed on schedule	Unmitigated	High	Possible	Substantial
	Residual	Moderate	Possible	Considerable
Failure of LAW Facility environmental performance demonstration test	Unmitigated	High	Possible	Considerable
	Residual	Low	Unlikely	Significant

Source: Department of Energy (DOE) Risk Registers and Databases. | GAO-22-104772

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Note: These risk ratings reflect what the agency considers the most likely scenario; however, they are subject to uncertainty. Risk management plans utilize a three-point estimate of best-case, most likely, and worst-case scenarios to distribute uncertainty based on data availability, reliability, and variability; and to show approximate chances and potential cost and schedule impacts. In the best-case scenario, the agency estimates that some of these challenges might not cause either a schedule delay or a cost increase. However, in the worst-case scenario, the agency estimates that scheduling delays or cost increases could be worse than expected. In either of those extreme scenarios, some of the estimated risk ratings could be classified into either a higher or lower level than those that we report in this table.

<sup>a</sup>Unmitigated assessment assigns initial risk ratings where DOE project managers judge the chances that each event would occur and the potential consequences if it were to occur based on available evidence and professional opinion. These ratings are subjective judgments and should not be interpreted as statistical forecasts. Residual assessment reflects the agency's judgment of risk level, chance of occurrence, and potential impacts after the agency has started to address the risk.

<sup>b</sup>Risk level determination is based on a combination of the agency's ratings of chance of occurrence and the potential impacts. For example, high risks are those where the agency judged the potential impact to be substantial, regardless of its chance of occurrence, or where the agency judged the potential impact to be considerable and the chance of occurrence to be either likely or almost certain.

<sup>c</sup>Chance of occurrence ratings reflect the agency's judgment of the chances that a particular event will occur. In ranked order, the classifications are almost certain (approximately 90 percent or greater); likely (approximately 75-90 percent); possible (between 25 and 75 percent); unlikely (between 10 and 25 percent); and rare (approximately 10 percent or less).

<sup>d</sup>Potential Impacts reflect the agency project managers' professional judgment in classifying potential cost overruns and schedule delays if a particular event were to occur. In ranked order, the classifications are substantial (approximately 6 months of a delay, or cost overruns that could exceed \$50 million); considerable (approximately 4-6 months' delay, or cost overruns between \$20 million and \$50 million); significant (approximately 2-4 months' delay, or cost overruns from \$5 million to \$20 million); marginal (approximately 1-2 months' delay, or \$1 million to \$5 million in cost overruns); and negligible (approximately 1 month's delay, or less than \$1 million in additional costs).

<sup>e</sup>The two challenges titled "Aging equipment is inoperable or obsolete" refer to the same challenge but are managed separately by DOE based on whether the contractor or DOE is responsible for addressing the challenge. For "Aging equipment is inoperable or obsolete—1," the contractor is responsible for the remaining potential cost, up to a contractually agreed \$29.1 million after mitigation measures; and for "Aging equipment is inoperable or obsolete—2," DOE is responsible for any additional costs associated with this challenge, which DOE estimates to be \$19 million after mitigation measures.

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## Several Challenges May Persist During DFLAW Operations and Could Result in Delays and Increased Cost

According to DOE officials, DOE has taken some steps to address the 11 significant challenges we identified. However, it is possible that several of the challenges associated with starting DFLAW operations may not be fully mitigated or resolved when DFLAW operations are scheduled to start, which may increase the cost of the program. According to DOE's risk planning documents and DOE officials, the following challenges may persist after DFLAW operations begin:

- Delayed evaluation approval for the disposal of DFLAW program treated waste. According to DOE officials, Ecology must approve modifications to the Hanford Dangerous Waste Permit before the IDF can accept ILAW for disposal. To acquire this permit modification, DOE will need to conduct an evaluation to determine if ILAW can be managed as mixed low-level radioactive waste and disposed on-site at the IDF, according to DOE and Ecology officials. If this evaluation is

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delayed, or DOE determines that ILAW cannot be managed as mixed low-level radioactive waste, the start of DFLAW operations will be delayed or jeopardized, which is a potential single point failure in the DFLAW operating system, according to DOE officials. DOE's management plan for this challenge considers that there is approximately a 75 to 90 percent chance of a delayed evaluation occurring. According to the management plan, if the evaluation is delayed, the DFLAW program could be delayed by approximately 6 months and could incur a cost overrun by as much as \$50 million or more.

- Inadequate replacement parts and operating supplies for WTP Facility. To start and sustain DFLAW operations, an adequate supply of WTP replacement parts and operating supplies is needed. For example, ORP reported in February 2022 that there were problems with service air- and water-cooling systems because of outdated and unused components and equipment that could affect the startup of the melters, which are used in the vitrification process. Similarly, the availability of spare melters is a concern. Once the facilities' two melters are operational, there will be no spare melter available for replacement if one of the melters fails before 2025, at which time a spare melter that is currently being fabricated is scheduled to be completed. This is a potential single point failure in the DFLAW operating system. DOE's management plan for this challenge considers that there is approximately a 90 percent chance or greater of the DFLAW program experiencing inadequate replacement parts and operating supplies. According to the management plan, if this occurs, the DFLAW program could be delayed by as many as 4 to 6 months and could incur a cost overrun by as much as \$50 million or more.
- Aging equipment is inoperable or obsolete — 2. Some WTP equipment and systems, such as LAW Facility waste pumping equipment and mixing vessels, have been stored or installed for at least 12 years. During final commissioning of the LAW Facility, DOE has determined it will likely discover that some facility equipment or systems break down or do not operate as designed because of quality failures that were not discovered during earlier, nonradiological, testing. If this occurs, these equipment or systems will need to be modified or replaced, according to DOE officials. DOE's management plan for this challenge considers that there is approximately a 75 to 90 percent chance that the DFLAW program will encounter aging equipment that is inoperable or obsolete. According to the management plan for this challenge, if this occurs, the DFLAW

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Program could be delayed by approximately 6 months and could incur a cost overrun by as much as \$50 million or more.

According to DOE reports, DOE's aggressive strategy with optimistic scheduling for the WTP project does not provide the necessary schedule flexibility to address these and other challenges that are likely to occur. For example, according to DOE's December 2020 Office of Project Management WTP and DFLAW Project Peer Review, these and other challenges may persist because the contractor did not consider all known conditions and potential cost impacts when managing project challenges.<sup>51</sup> Furthermore, DOE's January 2020 Office of Project Management WTP and DFLAW Project Peer Review, late recognition of challenges and missed opportunities to address challenges could jeopardize project completion schedules and, as result, the start of DFLAW operations, which would increase the cost of the DFLAW program.<sup>52</sup> In response to the project peer review recommendations, DOE performed an integrated baseline review in April 2021 that resulted in incorporating an additional 5 months into the WTP schedule. According to DOE officials and DFLAW contractors, DOE could be in violation of the Consent Decree if waste processing milestones are missed because of delays in starting DFLAW operations and could face fines if DFLAW waste processing capacity is less than expected.

In April 2018, we reported that DOE had not provided adequate oversight of WTP contractual requirements and processes for quality assurance. ORP's quality assurance program requires that corrective actions to mitigate problems with the quality of the work must include a determination of the extent to which the questioned conditions exist, known as an extent-of-condition review, as well as the underlying causes of those conditions. If corrective actions do not address the conditions in question, ORP's quality assurance policy allows the office to call for a suspension of work, if the quality of work is open to question. We recommended that DOE conduct an extent-of-condition review to determine the full extent to which problems exist in all WTP structures, systems, and components to include those needed for DFLAW

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<sup>51</sup>Department of Energy, Office of Project Management, *Project Peer Review of the Waste Treatment and Immobilization, Low Activity Waste, Analytical Laboratory, and Balance of Facilities—Direct Feed Low-activity Waste Project* (Washington, D.C.: December 2020).

<sup>52</sup>Department of Energy, Office of Project Management, *Project Peer Review of the Waste Treatment and Immobilization, Low Activity Waste, Analytical Laboratory, and Balance of Facilities—Direct Feed Low-activity Waste (WTP LBL DFLAW) Project / Program* (Washington, D.C.: January 2020).

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operations.<sup>53</sup> However, DOE has not yet taken action to fully implement this recommendation.

In June 2018, DOE directed BNI to develop an action plan to resolve issues raised in our April 2018 report. In response to this direction, BNI and ORP initiated a quality issues resolution process to identify and resolve all significant legacy quality issues in all WTP structures, systems, and components, to include those needed for DFLAW operations. In March 2019, BNI reported to DOE that (1) it had taken all reasonable steps to determine the full extent to which quality problems existed in the structures, systems, and components for the facilities needed for DFLAW; and (2) all significant legacy quality issues associated with the WTP facilities required for DFLAW operations had been identified, resolved, and closed within their corrective action management program.<sup>54</sup> In response to BNI's March 2019 letter, ORP officials concurred that significant legacy quality issues had been resolved. However, according to ORP officials, BNI's effort did not constitute a full extent of condition review, which would determine the full extent to which problems exist in all WTP structures, systems, and components. DOE officials told us that legacy quality assurance problems may be discovered during the startup of DFLAW operations, such as aging equipment that is inoperable or obsolete.

DOE has stated that a suspension of work—as allowed by ORP's quality assurance policy—is not feasible because the agency must meet the schedule for beginning operations, per the Consent Decree. If DOE has not fully addressed all challenges before DFLAW operations begin, DOE may need to extend the schedule and increase the cost of the DFLAW program. According to DOE officials, BNI's contract to design and construct WTP facilities and systems needed for DFLAW includes funds for both construction and initial operations of functioning facilities. However, according to DOE officials, if challenges are not fully resolved by the time hot commissioning is scheduled to start on December 31, 2023, the costs of resolving these challenges may fall on DOE. If ORP ensures that existing challenges and problems identified in its review of facilities, systems, and components related to DFLAW are resolved by the end of hot commissioning, it would provide DOE with better

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<sup>53</sup>GAO, *Hanford Waste Treatment: DOE Needs to Evaluate Alternatives to Recently Proposed Projects and Address Technical and Management Challenges*, [GAO-15-354](#) (Washington, D.C.: May 7, 2015) and [GAO-18-241](#).

<sup>54</sup>BNI, *BNI Response to GAO Report GAO-18-241* (Richland, Wa: Mar. 28, 2019.)

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assurance that facilities needed for DFLAW will meet nuclear quality and safety requirements. This will also ensure that the costs of resolving these challenges do not fall on DOE.

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## Conclusions

DOE has been working toward treating and disposing of 54 million gallons of radioactive and hazardous liquid waste from 177 large underground storage tanks at Hanford for more than 25 years. With initial DFLAW operations scheduled to begin in December 2023, DOE now appears poised to begin treating waste. However, DFLAW program schedule and cost estimates to start operations are not reliable because DOE has not fully followed best practices. By directing DFLAW contractors to develop comprehensive and well-constructed schedule and cost estimates for the DFLAW program and future Hanford waste treatment phases, DOE will have greater assurance that it can successfully achieve its plans without further delays.

Furthermore, DOE has not ensured that the EVM system complies with DOE's requirements and produces reliable data. By ensuring that the review of the contractor's EVM system for DFLAW facilities is completed to verify compliance with DOE requirements, DOE leadership will have better access to reliable performance data as it manages billions of dollars' worth of cleanup work. This will also position DOE to provide reliable information to Congress and other stakeholders on the cleanup progress.

DOE also faces several significant challenges to starting DFLAW operations and potentially faces additional unplanned expenditures and unbudgeted costs to sustain DFLAW operations in the near future. DOE has taken some steps toward addressing these challenges, such as implementing an active program to mitigate DFLAW program risks. However, several significant challenges associated with starting DFLAW operations may not be fully mitigated or resolved by the time DFLAW operations are scheduled to begin. Some of the challenges DOE faces may persist during DFLAW operations. Ensuring the resolution of all design and construction challenges and problems with facilities, systems, and components needed to start and sustain DFLAW operations would provide DOE with better assurance that the facilities needed for DFLAW meet nuclear quality and safety requirements. Furthermore, resolving challenges and problems by the end of hot commissioning will ensure that the costs to resolve challenges and problems do not fall on DOE.



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## Recommendations for Executive Action

The Assistant Secretary of EM should ensure that schedule estimates for the DFLAW program are developed and updated in accordance with GAO best practices. (Recommendation 1)

The Assistant Secretary of EM should ensure that cost estimates for the DFLAW program are developed and updated in accordance with GAO best practices. (Recommendation 2)

The Assistant Secretary of EM should ensure that the review of the contractor's EVM system for DFLAW facilities is completed to verify compliance with DOE requirements. (Recommendation 3)

The Assistant Secretary of EM should ensure that existing challenges and problems identified in its review of facilities, systems, and components related to DFLAW are resolved by the end of hot commissioning. (Recommendation 4)

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## Agency Comments and Our Evaluation

We provided a draft of this report to DOE for comment. In its written comments, reproduced in appendix IV, DOE agreed with the report's findings and concurred with our recommendations. In its response, DOE described ongoing and planned actions to address our recommendations by December 31, 2022. DOE also provided technical comments, which we incorporated as appropriate.

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

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or [andersonn@gao.gov](mailto:andersonn@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 significant contributions to this report are listed in appendix V.



Nathan J. Anderson  
Director, Natural Resources and Environment

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*List of Committees*

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

The Honorable Dianne Feinstein  
Chair  
The Honorable John Kennedy  
Ranking Member  
Subcommittee on Energy and Water Development  
Committee on Appropriations  
United States Senate

The Honorable Adam Smith  
Chairman  
The Honorable Mike Rogers  
Ranking Member  
Committee on Armed Services  
House of Representatives

The Honorable Marcy Kaptur  
Chairwoman  
The Honorable Michael K. Simpson  
Ranking Member  
Subcommittee on Energy and Water Development, and Related Agencies  
Committee on Appropriations  
House of Representatives

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# Appendix I: Objectives, Scope, and Methodology

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The objectives of our report are to examine (1) the construction status of facilities and systems needed to start the Department of Energy's (DOE) Direct-Feed Low-Activity Waste (DFLAW) operations; (2) the extent to which the schedule and cost estimates and the project performance system for DFLAW operations follow selected best practices and exhibit key characteristics of reliable estimates; and (3) the challenges DOE faces in starting and sustaining DFLAW operations.

To address these objectives, we obtained documentation and interviewed officials from DOE headquarters and Hanford Site offices. These offices included DOE's Office of Environmental Management (EM) and Office of Project Management, and EM's Office of Enterprise Assessments and Office of River Protection (ORP) and the Richland Operations Office at the Hanford Site. In addition, we interviewed representatives with Hanford contractors responsible for constructing or modifying DFLAW facilities and systems, including Bechtel National, Inc. (BNI) and Washington River Protection Solutions and officials with the Washington State Department of Ecology (Ecology) and the Defense Nuclear Facilities Safety Board. For these objectives, we also obtained and reviewed DOE reports and assessments, including those conducted by DOE's Office of Project Management and the Office of Enterprise Assessments on the status and startup of DFLAW facilities and adherence to cost, schedule, and earned value management (EVM) system requirements.

To determine the status of facilities and systems needed to start DFLAW operations, we reviewed DOE and contractor planning and status reports, including DOE's Waste Treatment and Immobilization Plant (WTP) Project Execution Plan, BNI Monthly WTP Status Reports, and were provided DFLAW facilities and systems construction status updates from DOE's ORP. Through review of these documents, we determined specific completion status and planned completion dates for facilities and systems needed to start DFLAW operations. In addition, we reviewed DOE orders, ORP procedures, and documents that describe the requirements that DOE is to follow when constructing facilities and systems needed to start and sustain DFLAW operations.

To assess the extent to which DOE schedule and cost estimates and the project performance system follow selected best practices and exhibit key characteristics of reliable estimates for the DFLAW program, we compared the DFLAW schedule and cost estimates and the contractor's EVM system to best practices from GAO's Cost Estimating and Schedule

Assessment Guides.<sup>1</sup> We did not conduct assessments of every element of the DFLAW program, which are executed by five DOE contractors. Rather, we focused our assessments on the WTP project, which comprises more than 95 percent of the DFLAW program schedule and cost, according to DOE officials, and which is executed by BNI. We conducted assessments of these best practices, as discussed below.

Schedule. To assess the DFLAW program’s schedule, we conducted an abridged analysis of the WTP schedule, assessing comprehensiveness and the degree to which it is well constructed. Typically, in analyzing a schedule estimate against best practices in GAO’s Schedule Assessment Guide (schedule guide),<sup>2</sup> we examine four characteristics, each defined by multiple criteria (see table 3).

**Table 3: Characteristics of High-Quality, Reliable Schedule Estimates**

Characteristic	
Comprehensive	A comprehensive schedule is complete and includes all government and contractor activities necessary to accomplish a project’s objectives.
Well constructed	A well-constructed schedule sequences all activities using the most straightforward logic possible.
Credible	A credible schedule uses data about risks and opportunities to predict a level of confidence in meeting the completion date.
Controlled	A controlled schedule is updated regularly to realistically forecast dates for activities.

Source: GAO. | GAO-22-104772

For this review in general, we assessed the WTP project schedule data and documentation that ORP provided in May and August 2021 against

<sup>1</sup>For our assessment of selected best practices related to DOE’s schedule and cost estimates, and best practices for an EVM system, we applied the following scoring system: “Fully met” means DOE provided complete evidence that satisfies the entire best practice criterion. “Substantially met” means DOE provided evidence that satisfies a large portion of the best practice criterion. “Partially met” means DOE provided evidence that satisfies about half of the best practice criterion. “Minimally met” means DOE provided evidence that satisfies a small portion of the best practice. “Not met” means DOE provided no evidence that satisfies the best practice criterion.

<sup>2</sup>GAO, *Schedule Assessment Guide: Best Practices for Project Schedules*, [GAO-16-89G](#) (Washington, D.C.: December 2015). According to our schedule guide, an integrated master schedule incorporates all activities—those of the contractor and the government—necessary to complete a program.

the comprehensive and well-constructed characteristics, in part because ORP officials told us that they had developed a schedule estimate for the first phase of the WTP project to allow DOE to start treating Low-Activity Waste (LAW) through the DFLAW program. For the schedule assessment, we made observations based on our analysis of DOE and BNI WTP project schedule estimate documents and the May 2021 WTP schedule. If a schedule estimate is not well constructed, it will not be possible to properly calculate dates and predict changes in the future. When activities are missing logic links, the schedule will not be able to automatically transmit these delays to future activities that depend on them. When this happens, the schedule will not allow a sufficient understanding of the program as a whole, and users of the schedule will not have confidence in the dates and the critical path. In addition, we evaluated the comprehensive characteristic because it contributed to our analysis of BNI’s EVM system, as described below. See appendix II for a summary assessment of the WTP schedule estimate compared to selected best practices.

Cost. To assess the DFLAW program’s cost estimate, we conducted an abridged analysis of the WTP’s project cost estimate. For this assessment, we compared DOE’s estimate for the WTP project to the comprehensive characteristic best practices from GAO’s Cost Estimating and Assessment Guide (cost guide).<sup>3</sup> Typically, in analyzing a cost estimate against best practices in GAO’s cost guide, we examine four characteristics, each defined by multiple criteria (see table 4).

**Table 4: Characteristics of High-Quality, Reliable Cost Estimates**

Characteristic	
Comprehensive	A comprehensive cost estimate completely defines the program and reflects the current schedule and technical baseline. It is structured with sufficient detail to ensure that cost elements are neither omitted nor double-counted.
Well documented	A well-documented cost estimate can easily be repeated or updated and can be traced to original sources through auditing. Thorough documentation explicitly identifies the primary methods, calculations, results, rationales or assumptions, and sources of the data used to generate each cost element’s estimate.

<sup>3</sup>GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: March 2020).

<b>Characteristic</b>	
Accurate	An accurate cost estimate is developed by estimating each cost element, using the best methodology from the data collected. Additionally, it is updated regularly to reflect significant changes in the program, and any variances between estimated and actual costs are documented, explained, and reviewed.
Credible	A credible cost estimate discusses and documents any limitations of the analysis, including uncertainty or bias surrounding source data and assumptions. Credible cost estimates include a risk and uncertainty analysis that determines the level of confidence associated with the estimate.

Source: GAO. | GAO-22-104772

For this review, we assessed the cost estimate for the WTP project against the comprehensive characteristic. If a cost estimate is not comprehensive, then it cannot fully meet the well-documented, accurate, or credible best practice characteristics. For instance, if the cost estimate is missing some cost elements, then the documentation will be incomplete, the estimate will be inaccurate, and the result will not be credible because of the potential underestimating of costs and the absence of a full risk and uncertainty analysis. See appendix II for a summary assessment of the WTP cost estimate compared to selected best practices.

EVM system. In addition, we analyzed BNI’s use of EVM as a way to assess its monitoring of the WTP project’s cost and schedule. EVM measures the value of work accomplished in a given period and compares it to the planned value of work scheduled for the period and to the actual cost of the work accomplished. It is an industry standard and is considered a best practice for conducting cost and schedule performance analysis for projects. Our EVM analysis focused on BNI’s EVM data for the WTP project contained in cost performance reports from December 2020 to May 2021 and the project schedule that DOE provided in August 2021. Specifically, we compared this project documentation to EVM best practices as identified in our cost guide. Our research has identified a number of best practices that are the basis of effective EVM and should result in reliable and valid data that can be used for making informed decisions. These best practices are included in the following three high-level characteristics of a reliable EVM system:

- Establish a comprehensive EVM system.
- Ensure that the data resulting from the EVM system are reliable.

- Ensure that the program management team is using EVM data for decision-making purposes.

EVM data are considered reliable if the overall assessment ratings for each of the three characteristics are substantially or fully met. If any of the characteristics are not met, minimally met, or partially met, then the EVM data cannot be considered reliable. See appendix II for our summary assessment of the WTP project's EVM data compared to best practices.

To identify significant challenges that DOE faces in starting and operating DFLAW facilities and systems, we reviewed the 108 risks that DOE identified in the WTP and DFLAW Risk Registers and Databases, which are systems that DOE uses to identify and track project risks. According to ORP officials, these WTP and DFLAW Risk Registers and Databases represented all of the known risks associated with the program as of July 31, 2021. From these 108 risks, we selected a nongeneralizable sample of 11 risks that DOE had identified as risks associated with starting and operating facilities and systems. To identify significant challenges, we used a nongeneralizable sample and the following criteria to select WTP project and DFLAW program risks:

- Risks that are identified as high risks by ORP. These risks are designated as high because of the probability of the threat being realized (the risk actually occurring) and the high cost and schedule impact of the threat occurring as defined in the DFLAW risk guide and management plan;
- Risks that represent single-point-failures in the DFLAW operating system that can have a major impact on DFLAW program cost and schedule;
- Risks that DOE estimated would cost more than \$25,000,000 to address if they were to occur; and
- Risks that DOE estimated that the adverse event had a 25 percent or greater chance of occurring.

Using these criteria, we initially selected eight risks and, using additional information provided by DOE and contractor officials, we eliminated two risks and added five risks, resulting in 11 risks for our assessment. Information provided by DOE and contractor officials served to refine our identification of significant challenges while still applying our selection criteria. To analyze the 11 significant challenges and steps that DOE is taking to address challenges, applying GAO Cost Estimating and Assessment Guide for risk management criteria, we reviewed DOE risk management plans, which include a risk mitigation strategy for each risk,

and interviewed DOE officials and contractors responsible for managing risks. We reviewed DOE's process used to generate these ratings and documentation supporting them. We determined that they were sufficiently reliable for our purpose of broadly characterizing significant challenges to DFLAW operations rather than as statistical predictions. Therefore, we present them as rough, categorical approximations rather than as precise quantitative forecasts.

We conducted this performance audit from February 2021 to June 2022 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.



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# Appendix II: Assessments of DOE's Schedule and Cost Estimates and EVM Practices and Data for the WTP Project

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Our report includes assessments that compared the Department of Energy's (DOE) Waste Treatment and Immobilization Plant (WTP) (1) schedule, (2) cost estimate, and (3) Bechtel National, Inc.'s (BNI) earned value management (EVM) system to best practices from GAO's Cost Estimating and Schedule Assessment Guides.<sup>1</sup> Tables 5 through 7 detail the results of these assessments. For our assessment of selected best practices related to DOE's schedule and cost estimates and best practices for an EVM system, we applied the following scoring system: "fully met" means DOE provided complete evidence that satisfies the entire best practice criterion; "substantially met" means DOE provided evidence that satisfies a large portion of the best practice criterion; "partially met" means DOE provided evidence that satisfies about half of the best practice criterion; "minimally met" means DOE provided evidence that satisfies a small portion of the best practice criterion; and "not met" means DOE provided no evidence that satisfies the best practice criterion.

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## WTP Project Schedule Estimate Compared to Actual Schedule

Table 5 details our assessment of the DOE schedule estimate for the first phase of WTP project construction to allow DOE to start treating Low-Activity Waste (LAW) through the Direct-Feed Low-Activity Waste (DFLAW) program compared to selected best practices for project schedules published in GAO's Schedule Assessment Guide.<sup>2</sup> We assessed the well constructed characteristic because, among other reasons, if a schedule is not well constructed, it will not be able to properly calculate dates and predict changes in the future. In addition, we evaluated the comprehensive characteristic, as it is needed to evaluate an earned value management system. According to our assessment, the WTP schedule substantially met the comprehensive characteristic and partially met the well-constructed characteristic of a reliable schedule.

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<sup>1</sup>GAO, *Schedule Assessment Guide: Best Practices for Project Schedules*, [GAO-16-89G](#) (Washington, D.C.: December 2015); and *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: March 2020).

<sup>2</sup>[GAO-16-89G](#)

**Appendix II: Assessments of DOE's Schedule  
and Cost Estimates and EVM Practices and  
Data for the WTP Project**

**Table 5: Summary Assessment of the Department of Energy's (DOE) Waste Treatment and Immobilization Plant (WTP) Schedule Estimate Compared to GAO Best Practices**

<b>Characteristic</b>	<b>Overall assessment</b>	<b>Best practice</b>	<b>Individual assessment</b>
Comprehensive, reflecting <ul style="list-style-type: none"> <li>all activities as defined in the program's work breakdown structure</li> <li>labor, materials, travel, facilities, equipment, and the like needed to do the work and whether those resources will be available when needed</li> <li>how long each activity will take, allowing for discrete progress measurement with specific start and finish dates</li> </ul>	Substantially met	Capturing all activities	Substantially met
		Assigning resources to all activities	Substantially met
		Establishing the durations of all activities	Substantially met
Well constructed, with <ul style="list-style-type: none"> <li>all activities logically sequenced with predecessor and successor logic</li> <li>limited and justified use of unusual or complicated logic</li> <li>a critical path that determines the activities that drive the program's earliest completion date</li> <li>total float that accurately reflects the schedule's flexibility</li> </ul>	Partially met	Sequencing all activities	Partially met
		Confirming that the critical path is valid	Partially met
		Ensuring reasonable total schedule float time	Partially met

Source: GAO analysis of DOE's schedule data. | GAO-22-104772

Table 6 details our assessment of the DOE cost estimate for the first phase of WTP project construction to allow DOE to start treating LAW through the DFLAW program compared to selected best practices for project cost estimates published in GAO's Cost Estimating and Assessment Guide. For this assessment, we assessed the cost estimate for the WTP project against the comprehensive characteristic, in part because DOE officials told us that they had developed a cost estimate for the project for the first phase of WTP project construction to allow DOE to start treating LAW through the DFLAW program. If a cost estimate is not comprehensive, then it cannot fully meet the well-documented, accurate, or credible best practice characteristics. For instance, if the cost estimate is missing some cost elements, then the documentation will be incomplete, the estimate will be inaccurate, and the result will not be credible because of the potential underestimating of costs and the absence of a full risk and uncertainty analysis. According to our analysis, DOE's cost estimate for the WTP project construction for the DFLAW program partially met best practices for a comprehensive cost estimate.

**Appendix II: Assessments of DOE's Schedule and Cost Estimates and EVM Practices and Data for the WTP Project**

**Table 6: Summary Assessment of the Department of Energy's (DOE) Waste Treatment and Immobilization Plant (WTP) Cost Estimate Compared to GAO Best Practices**

Characteristic	Overall assessment	Best practice	Individual assessment
Comprehensive	Partially met	The cost estimate includes all life cycle costs.	Minimally met
		The cost estimate is based on a technical baseline description that completely defines the program, reflects the current schedule, and is technically reasonable.	Partially met
		The cost estimate is based on a work breakdown structure that is product oriented, traceable to the statement of work, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted.	Partially met
		The cost estimate documents all cost-influencing ground rules and assumptions.	Minimally met

Source: GAO analysis of DOE's cost data. | GAO-22-104772

Table 7 details our assessment of December 2020 to May 2021 data from BNI's WTP project EVM system. EVM measures the value of work accomplished in a given period and compares it to the planned value of work scheduled for that period and to the actual cost of work accomplished. By using the metrics derived from these values to understand performance status and to estimate cost and time to complete, EVM can alert program managers to potential problems sooner than expenditures alone can. Our prior research has identified a number of best practices that are the basis of effective EVM and should result in reliable and valid EVM data that can be used for making informed decisions.<sup>3</sup> According to our analysis, DOE followed (i.e., substantially met) best practices to ensure that its EVM system is comprehensive and followed best practices to ensure that the data resulting from the EVM system are reliable. In addition, according to our analysis, DOE followed (i.e., fully met) met best practices to ensure that the data resulting from the EVM system are used by leadership for decision-making.

<sup>3</sup>GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: March 2020)

**Appendix II: Assessments of DOE's Schedule  
and Cost Estimates and EVM Practices and  
Data for the WTP Project**

**Table 7: Summary Assessment of the Department of Energy's (DOE) Earned Value Management (EVM) Data and Practices Compared to GAO Best Practices**

<b>Characteristic</b>	<b>Overall assessment</b>	<b>Best practice</b>	<b>Assessment</b>
Comprehensive: Establish a comprehensive EVM system.	Substantially met	The program has a certified EVM system.	Minimally met
		An Integrated Baseline Review verified that the baseline budget and schedule captured the entire scope of work, risks were understood, and available and planned resources were adequate.	Substantially met
		The schedule reflects the work breakdown structure, the logical sequencing of activities, and the necessary resources.	Substantially met
		EVM system surveillance is being performed.	Substantially met
Accurate: Ensure that the data resulting from the EVM system are reliable.	Substantially met	EVM system data do not contain any anomalies.	Partially met
		EVM system data are consistent among various reporting formats.	Fully met
		Estimates-at-complete are realistic.	Fully met
Informative: Ensure that the program management team is using earned value data for decision-making purposes.	Fully met	EVM system data are reviewed on a regular basis.	Fully met
		Management uses EVM system data to develop corrective action plans.	Fully met
		The performance measurement baseline is updated to reflect changes.	Substantially met

Source: GAO analysis of DOE's EVM data. | GAO-22-104772

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# Appendix III: GAO Identified Direct-Feed Low-Activity Waste (DFLAW) Significant Challenges: Additional Information

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This appendix contains additional information from the Department of Energy's (DOE) management plans on the 11 significant challenges that we identified that DOE faces to starting and operating the Direct Feed Low-Activity Waste (DFLAW) project.

1. DFLAW waste feed systems not completed on schedule. To start DFLAW operations, tank waste must first be pretreated and transferred to the Waste Treatment and Immobilization Plant (WTP) Low-Activity Waste (LAW) Facility. If the Hanford tank farms contractor is not able to deliver pretreated waste for processing on schedule due to potential problems with the Tank-Side Cesium Removal (TSCR) Facility, then the start of DFLAW operations will be delayed. This could jeopardize all waste treatment schedule completion dates and is a potential single point failure in the DFLAW operating system.
2. Delayed evaluation approval for the disposal of DFLAW program treated waste. To dispose of Immobilized LAW (ILAW) at the Integrated Disposal Facility (IDF), DOE plans to follow mechanisms set forth in DOE Manual 435.1-1 to evaluate whether ILAW is waste incidental to reprocessing, is not high-level radioactive waste, can be managed as low-level radioactive waste, and can be disposed of in a near-surface repository.<sup>1</sup> Assuming that DOE makes these determinations in the affirmative, DOE will then have to submit a request to the state of Washington's Department of Ecology to modify the Hanford Dangerous Waste Permit to allow disposal of ILAW at the IDF, according to DOE officials. If DOE's evaluation or the permit modification is delayed or otherwise disrupted, then the start of DFLAW operations could be delayed or jeopardized. This is a potential single point failure in the DFLAW operating system.
3. Completion schedule risk of WTP facilities. This challenge is associated with resolving the emergence of potential unknown technical problems with WTP facilities systems and equipment, which, if not discovered in a timely manner, may delay the start DFLAW of operations. For example, some LAW Facility computers or computer software may be obsolete by the time DFLAW operations start, requiring upgrades or replacement.

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<sup>1</sup>Department of Energy, *Radioactive Waste Management*, Order 435.1 (Washington, D.C.: Jan. 11, 2021); and *Radioactive Waste Management Manual*, Manual 435.1-1 (Washington, D.C.: Jan. 11, 2021). DOE Order 435.1 and Manual 435.1-1, issued in July 1999 and subsequently revised, apply to DOE's management of all high-level waste (HLW) and low-level waste, including the radioactive component of mixed waste, for which DOE is responsible.

4. Modification or replacement of WTP Facility equipment because of potential aging and obsolescence. Some WTP equipment, such as LAW Facility waste pumping equipment and mixing vessels, has been stored or installed for at least 12 years and, due to potential aging or obsolescence, may need to be modified or replaced. Due to the passage of time between LAW Facility equipment purchase and startup, or if facility commissioning fails, then identical replacements may not be available and additional cost will be incurred to identify equivalent replacements, procure the replacements, and install them in the plant. Bechtel National, Inc. (BNI) is responsible for paying costs associated with addressing this challenge. This is a potential single point failure in the DFLAW operating system.
5. Modification or replacement of WTP Facility equipment because of potential aging and obsolescence, including quality assurance problems. Some WTP equipment and systems, such as LAW Facility waste pumping equipment and mixing vessels, have been stored or installed for at least 12 years. During final commissioning of the LAW Facility, it may be discovered that some of facility equipment or systems break down or do not operate as designed, because of quality failures that were not discovered during earlier, nonradiological testing. If this occurs, some equipment or systems will need to be modified or replaced. DOE is responsible for paying for costs exceeding the money budgeted to the BNI contract to address this challenge. This is a potential single point failure in the DFLAW operating system.
6. Failure of LAW Facility environmental performance demonstration test. Before DOE is able to grant final approval for DFLAW operations to start, the LAW Facility must pass several environmental performance demonstration tests. If the facility fails any of these tests, parts of the LAW Facility may need to be modified so that the facility can operate within performance requirements.
7. Solid waste processing and management. This challenge encompasses several risks associated with the management of DFLAW operations solid waste, such as radioactively contaminated LAW Facility equipment that will need to be replaced. For example, it is possible that a disposal facility for this waste may not be available when needed or that the waste will not meet the requirements for disposal at available facilities. In these instances, DFLAW operation could be delayed, resulting in additional costs.
8. WTP LAW Facility is not approved for operations on schedule. To begin DFLAW operations, DOE must complete and approve several commissioning and operations steps required by DOE Order 413.3B,

Program and Project Management for the Acquisition of Capital Assets.<sup>2</sup> For example, an operational readiness review must be completed and approved to start initial waste treatment and complete cold commissioning. If this review, or several other required reviews, is not completed and approved on schedule, DFLAW operations cannot begin. This could jeopardize all waste treatment schedule completion dates, result in increased program costs, and is a potential single point failure in the DFLAW operating system.

9. DFLAW facilities control systems do not operate as designed. Initial DFLAW operations may be delayed, if control systems for the different DFLAW program facilities are not fully compatible or do not perform as designed. This could result in the need for unanticipated facilities control system modifications, schedule delays, and additional cost.
10. Inadequate replacement parts and operating supplies for WTP Facility. To start and sustain DFLAW operations, an adequate supply of WTP replacement parts and operating supplies is needed. If adequate WTP replacement parts and operating supplies are not available, DFLAW operations may be delayed because of significant facility outages and excessive delays in the ramp up to full capacity operations. Of particular concern is the availability of spare LAW Facility melters, which are used in the waste vitrification process. Once the facilities' two melters are operational, there will be no spare melter available for replacement if one of the melters fails before 2025, at which time a spare melter that is currently being fabricated is scheduled to be completed. This is a potential single point failure in the DFLAW operating system.
11. WTP LAW Facility does not operate at designed operations capacity. WTP LAW Facility operating at full capacity is dependent on the facility functioning as designed, without unanticipated facility shutdowns or slowdowns. Shutdowns could occur because of equipment and system failures and the need for replacement or modification, for example, if there are LAW Facility melter failures. Slowdowns could occur, if waste processing capacity is lower than expected because of a change in DFLAW waste feed and unanticipated waste processing effects impacting the LAW Facility. If the LAW Facility waste treatment operating is stopped, or waste processing capacity is less than anticipated, the Hanford waste treatment schedule could be delayed, resulting in the potential failure

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<sup>2</sup>Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*, DOE Order 413.3B (Change 6) (Washington, D.C.: Jan. 12, 2021).

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**Appendix III: GAO Identified Direct-Feed Low-  
Activity Waste (DFLAW) Significant  
Challenges: Additional Information**

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to meet Consent Decree milestones or the need for DOE to renegotiate milestones.



# Appendix IV: Comments from the Department of Energy



## Department of Energy

Washington, DC 20585

June 2, 2022

Mr. Nathan Anderson  
Director, Natural Resources  
and Environment  
U.S. Government Accountability Office  
Washington, DC 20548

Dear Mr. Anderson:

This letter provides the Department of Energy's (DOE) response to the U.S. Government Accountability Office (GAO) Draft Report, GAO-22-104772, *Hanford Cleanup: DOE has Opportunities to Better Ensure Effective Startup and Sustained Low-Activity Waste Operations*.

This year has been historic for the Department's tank waste cleanup mission at Hanford with large scale treatment of tank waste underway for the first time through the Tank Side Cesium Removal System. Construction and startup testing of all Waste Treatment Plant (WTP) facilities needed to begin immobilizing tank waste in glass are complete. In addition, the pipeline to connect with and feed tank waste to the WTP is finished. This work sets the stage to begin turning this waste into glass via the Direct Feed Low Activity Waste (DFLAW) program. After decades of support from workers, the local community and Congress, this will be a transformational accomplishment for tank waste cleanup in the EM program.

To prepare for waste treatment, DOE is already actively addressing challenges associated with the WTP and DFLAW system. The Department has achieved significant improvements in oversight and execution of the WTP over the last two years with increased management involvement, improved schedule definition, the application of enhanced risk management and schedule risk assessment programs, and the aggressive resolution of commissioning challenges. The Department continues to hold the contractor accountable to strengthen management and execution of WTP DFLAW project elements to begin immobilization of tank waste on schedule, while sustaining a robust safety and quality culture. The Department continues to work diligently to meet project and regulatory compliance commitments, address impacts from the COVID-19 pandemic, and continuously improving discipline to mitigate project risks and challenges.

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**Appendix IV: Comments from the Department  
of Energy**

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Thank you for the opportunity to provide DOE's perspective on the Draft Report GAO-22-104772. If you have any questions, please contact me or Mr. Dae Y. Chung, Associate Principal Deputy Assistant Secretary for Corporate Services, at (202) 586-9636.

Sincerely,



William I. White  
Senior Advisor for Environmental Management

Enclosures

Enclosure 1

**Management Response to Recommendation**  
**GAO-22-104772**  
**GAO Draft Report, Hanford Cleanup: DOE has Opportunities to Better Ensure Effective  
Startup and Sustained Low-Activity Waste Operations**

**Recommendation 1:** The Assistant Secretary of EM should ensure schedule estimates for the DFLAW program are developed and updated in accordance with GAO best practices.

**Management Response: Concur.**

The Office of Environmental Management (EM) has already implemented actions to increase oversight and improve execution of the Direct-Feed Low-Activity Waste (DFLAW) project schedule and will continue these actions in alignment with the U.S. General Accountability Office's (GAO) recommendation. In December 2020, EM completed a Project Peer Review (PPR) and an associated Schedule Risk Assessment, evaluating the significant progress while identifying opportunities for improvement. As recommended by the PPR, EM conducted an Integrated Baseline Review (IBR), which was completed in April 2021, to review the remainder of the project through hot commissioning, resulting in recommendations for corrective actions. All IBR corrective actions have been fully implemented, including the incorporation of additional schedule margin.

In March 2022, EM completed another PPR and Schedule Risk Assessment to further strengthen the schedule estimates. The PPR found significant improvement towards readiness and identified additional recommendations for improvement, which are underway and are expected to be completed by the end of 2022. DOE continues to evaluate opportunities to further improve the integrity and reliability of the schedule to increase confidence in achieving critical project milestone dates and address the impacts from the COVID-19 pandemic. The Department continues to hold the contractor accountable to strengthen both management and execution of the WTP DFLAW project elements to begin immobilization of tank waste on schedule, while sustaining a robust safety and quality culture.

**Estimated Completion Date:** December 31, 2022.

**Recommendation 2:** The Assistant Secretary of EM should ensure cost estimates for the DFLAW program are developed and updated in accordance with GAO best practices.

**Management Response: Concur.**

EM has already implemented actions to increase oversight and improve execution of the DFLAW project cost estimates and will continue these actions in alignment with the GAO's recommendation. As described above, EM completed a PPR and an associated Schedule Risk Assessment in December 2020, and an IBR in April 2021. The IBR included an evaluation of the cost estimates for completing the DFLAW project through hot commissioning, resulting in several proposed corrective actions and subsequent improvement actions. All corrective actions

have been fully implemented. Definitization of the extended hot commissioning and transition contract modifications are estimated to be completed by the end of 2022.

The Department will continue to evaluate opportunities to further improve cost estimating and reporting mechanisms to ensure project cost estimates are as accurate and reliable as possible. Ongoing and future cost estimates to support contract changes, including the contract modifications for extended hot commissioning and transition to the future operating contractor, will apply best practices, informed by feedback from external teams such as the PPR.

**Estimated Completion Date:** December 31, 2022.

**Recommendation 3:** The Assistant Secretary of EM should ensure the review of the contractor's EVM system for DFLAW facilities is completed to ensure compliance with DOE requirements.

**Management Response: Concur.**

DOE's Office of Project Management (PM) conducted an Earned Value Management System (EVMS) Surveillance Review on the WTP project in November 2019, which identified corrective actions. The WTP project developed a corrective action management plan with a priority approach to address performance measurement baseline (PMB) development (priority 1), PMB maintenance (priority 2), and other system elements (priority 3). All priority 1 corrective actions were addressed by early 2022 and are being reviewed for completion by PM. In addition, the priority 2 and 3 corrective actions are being implemented and will be reviewed for completion by PM. The PPR conducted in March 2022 evaluated the progress of the corrective actions from the EVMS Surveillance Review. The PPR, recognizing that construction is complete, and the facility has been turned over to plant management for commissioning and operating activities with a high percentage (~70 percent) of remaining work scope as level of effort (LOE), recommended the project utilize alternative project control methods (consistent with those defined in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets) since EVMS is best used to manage discrete work versus LOE. Corrective actions are anticipated to be completed by the end of December 2022. The WTP EVMS will continue to receive routine review by the Hanford senior management, as well as reviews from PM and future PPRs.

**Estimated Completion Date:** December 31, 2022.

**Recommendation 4:** The Assistant Secretary of EM should ensure existing challenges and problems identified in its review of facilities, systems, and components related to DFLAW are resolved by the end of hot commissioning.

**Management Response: Concur.**

The Department is committed to a culture of continuous improvement, achieving improvements in oversight and execution of the WTP over the last two years with increased management involvement, improved schedule definition, the application of enhanced risk management and schedule risk assessment programs, and the aggressive resolution of commissioning challenges.

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**Appendix IV: Comments from the Department  
of Energy**

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The Department continues to hold the contractor accountable to strengthen both management and execution of the WTP DFLAW project elements to begin immobilization of tank waste on schedule, while sustaining a robust safety and quality culture. The DFLAW program began pretreatment of tank waste with the Tank Side Cesium Removal system in January 2022, representing a major milestone, and mitigating significant risk toward beginning immobilization of tank waste. Furthermore, the head of EM reviews the DFLAW program progress and any associated challenges monthly with the DFLAW leadership project team.

The Department continues to work diligently to meet project and regulatory compliance commitments, addressing impacts from the COVID-19 pandemic, and improving discipline in mitigating project risks and challenges.

**Estimated Completion Date:** December 31, 2022.

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# Appendix V: GAO Contact and Staff Acknowledgments

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## GAO Contact

Nathan Anderson, (202) 512-3841 or [andersonn@gao.gov](mailto:andersonn@gao.gov)

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## Staff Acknowledgments

In addition to the contact named above, Wyatt R. Hundrup (Assistant Director), Peter Ruedel (Analyst-in-Charge), Mark Braza, Jennifer Echard, William Gerard, Yvette Gutierrez, Claudia Hadjigeorgiou, Jason Lee, Corinna Nicolaou, Kevin Tarmann, Mary Weiland, and Mark Young-McMurchie made key contributions to this report.

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