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May 2015

HANFORD WASTE TREATMENT

DOE Needs to Evaluate Alternatives to Recently Proposed Projects and Address Technical and Management Challenges

GAO-15-354

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GAO Highlights

Highlights of GAO-15-354, a report to the Committee on Armed Services, U.S. Senate

Why GAO Did This Study

The WTP is a key part of DOE's strategy for treating 56 million gallons of radioactive waste held in underground tanks at the Hanford site in Washington State. The WTP is being constructed under a design-build contract and has a history of technical and management challenges. DOE stopped construction in 2012 on parts of the WTP, including the Pretreatment facility, pending resolution of these challenges and has stated that several milestones will likely be missed.

In September 2013, DOE proposed a waste treatment strategy that may allow some waste to be treated before resolving WTP's technical issues, including construction of two new facilities. Senate Report 113-44 accompanying the National Defense Authorization Act for Fiscal Year 2014 included a provision for GAO to examine the status of construction and operations at the WTP. This report examines (1) how DOE's two new proposed facilities help achieve Hanford's waste treatment mission and how they were selected, (2) the extent to which DOE's estimated costs and schedules for constructing the facilities meet best practices for reliable estimates, and (3) the extent to which technical and management challenges continue to affect the WTP. GAO reviewed DOE and contractor data and documents.

What GAO Recommends

GAO recommendations include that DOE (1) broaden the facilities' statements of mission need to allow for a full analysis of alternatives, (2) revise the facilities' cost and schedule estimates in accordance with industry best practices, and (3) enlist the services of an external entity to assist with oversight of the WTP contractor. DOE generally agreed with GAO's recommendations but not some of the conclusions. GAO continues to believe its conclusions are fair and well supported.

View GAO-15-354. For more information, contact David C. Trimble at (202) 512-3841 or trimbled@gao.gov.

What GAO Found

The Department of Energy's (DOE) two proposed facilities may help achieve Hanford's waste treatment mission by expediting treatment of some waste and addressing some technical challenges within the Waste Treatment and Immobilization Plant's (WTP) Pretreatment facility. However, DOE selected the facilities based on past proposals and excluded other potential alternatives from consideration. One facility is a low-activity waste pretreatment system to treat some of the low-activity waste in the tanks, and the other is a tank waste characterization and staging facility to stage, mix, sample, and characterize high-level waste from the tanks prior to delivery to the Pretreatment facility. The proposed facilities are at the initiation phase of DOE's project management process. During this phase, under its project management order, DOE is to develop statements of mission need that do not identify a particular facility or technology solution in order to preserve the flexibility to explore alternatives. DOE, however, developed narrow statements of mission need based on facilities it had proposed in prior years but never constructed. Without revising these statements to allow DOE flexibility, the scope of alternatives DOE analyzes will exclude consideration of other potentially viable alternatives.

DOE's preliminary cost and schedule estimates for constructing the two proposed facilities are not reliable because they do not meet industry best practices for reliable cost and schedule estimates. DOE estimates that constructing the two proposed facilities could, together, cost at least $1 billion and take 6 to 8 years to construct. These cost and schedule estimates, however, cannot be considered reliable, in part because the department excluded from its estimates some costs of major activities that will be needed to construct the facilities, such as costs to support feeding low-activity waste directly, and did not sequence activities to complete them in accordance with best practices. Without reliable estimates that reflect best practices, DOE may be committing to courses of action that will require undisclosed future resources and will commit DOE to project time frames it may be unable to meet.

Significant technical and management challenges continue to affect the WTP and hinder its completion. According to DOE commissioned reviews, technical challenges continue to affect the Pretreatment facility and the facilities intended to treat low-activity and high-level waste. DOE has increased its technical oversight, but it has not fully developed aggressive risk mitigation strategies that address all technical uncertainties, as required by its project management order. Furthermore, design management challenges continue. The contractor's design management program is to ensure that WTP's design meets nuclear safety requirements. However, contractor data indicate that significant, unresolved design issues remain, and recent internal and external reviews show that some facilities may require extensive and expensive rework. Under the WTP construction contract, and as recommended by a DOE advisory group, DOE can employ an owner's agent to assist the department in reviewing the contractor's approach to design management and mitigating design challenges. Enlisting the services of an external entity to assist in this way may help DOE mitigate some long-standing challenges.

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Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
EPA	Environmental Protection Agency
Framework	Hanford Tank Waste Retrieval and Disposition Framework
NRC	Nuclear Regulatory Commission
RCRA	Resource Conservation and Recovery Act
TPA	Tri-Party Agreement
TRU	transuranic
WTP	Waste Treatment and Immobilization Plant

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The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
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United States Senate

Since 1989, the Department of Energy (DOE) has spent more than $19 billion on treatment and disposition of 56 million gallons of radioactive and hazardous waste at the Hanford site in southeastern Washington. Over the last 25 years, DOE has considered and abandoned several different approaches to treating and disposing of this waste but, to date, no waste has been treated. In 2000, DOE awarded a contract to Bechtel National, Inc., to design, construct, and commission a Waste Treatment and Immobilization Plant (WTP) to treat and immobilize large quantities of this waste and prepare it for disposal. The WTP is a complex, first-of-a-kind project made up of several facilities and is being constructed under a design-build contract. In the design-build approach to construction, technology development activities, plant design, and construction occur simultaneously rather than sequentially. DOE's use of the design-build approach has led to cost and schedule overruns, and DOE no longer encourages its use for complex, first-of-a-kind facilities but has continued to use it for the WTP.[1] In 2000, the project was expected to cost $4.3 billion and to be completed in 2011. In 2006, DOE increased the project cost baseline to $12.3 billion and extended completion to 2019. In 2011, the department notified the state of Washington that several milestones associated with retrieving waste from the tanks and completing the WTP would likely be missed. As of March 2015, DOE and the state had not

[1]As of 2010, DOE's project management order states that the department no longer supports the use of design-build contracts for its first-of-a-kind complex facilities. DOE, *Program and Project Management for the Acquisition of Capital Assets,* DOE Order 413.3B (Washington, D.C.: Nov. 29, 2010). The order also states that "aggressive risk mitigation strategies are required" for fast-tracked, design-build projects.

yet agreed to new deadlines and the matter had returned to court.[2] New deadlines could result in pushing back the dates for starting WTP operations. In light of current obstacles to completion of certain facilities due to technical issues, DOE has proposed, as part of the ongoing litigation with the state, two new capital projects intended, among other things, to expedite treatment of some waste.

In addition to cost and schedule overruns, the project has long faced technical and management challenges. For example, over the past 10 years, we have found that DOE's Office of River Protection, which is responsible for managing the construction of the WTP, has been unable to successfully demonstrate the technology selected to prevent a nuclear accident by keeping waste uniformly mixed in WTP's Pretreatment facility—a large waste processing facility that is intended to process all waste before separating it into high-level and low-activity waste streams.[3] Because of technical challenges, in late 2012 DOE stopped work on this facility and slowed work on another WTP facility needed for treating high-level waste. In addition, internal and external assessments of the project conducted since 2001 have identified a number of management challenges. In particular, the Nuclear Regulatory Commission (NRC), the Defense Nuclear Facilities Safety Board (DNFSB), and internal DOE offices have identified problems with DOE's oversight of the contractor. For example, in 2008, NRC found that DOE's oversight of the contractor's design management program had not ensured that the contractor's design documentation met nuclear safety requirements and that DOE's oversight of the contractor's quality assurance and corrective action program did not ensure that significant quality assurance and corrective action functions had been effective over several years.

In September 2013, to make progress on treating waste while working to resolve technical challenges within the Pretreatment and other WTP facilities, DOE identified options to advance the WTP project. These options included a phased waste treatment strategy that includes constructing two new capital asset projects: a low-activity waste

[2]DOE negotiated with the state of Washington from March through September, 2014, but could not reach agreement. Both sides filed motions to amend an existing consent decree with the court on October 3, 2014. Both sides filed reply briefs on January 16, 2015, and the court heard oral arguments on February 19, 2015.

[3]GAO, *Hanford Waste Treatment Plant: DOE Needs to Take Action to Resolve Technical and Management Challenges,* GAO-13-38 (Washington, D.C.: Dec. 19, 2012).

pretreatment system to treat some of the low-activity waste in the tanks, and a tank waste characterization and staging facility to effectively stage, mix, sample, and characterize high-level waste from the tanks prior to delivery to the WTP's Pretreatment facility. Senate Report 113-44 accompanying the National Defense Authorization Act for Fiscal Year 2014 noted the change in the WTP's scope and included a provision for GAO to examine the status of construction and operations at the WTP. In response to this mandate, this report examines (1) how DOE's proposed capital asset projects will help achieve Hanford's tank waste treatment mission and how they were selected, (2) the extent to which DOE's estimated costs and schedules for constructing the proposed capital asset projects meet best practices for reliable cost and schedule estimates, and (3) the extent to which technical and management challenges continue to affect completion of the WTP.

To address all objectives, we interviewed current and former DOE officials from headquarters organizations and from the Office of River Protection at Hanford; Office of River Protection contractors and subcontractors; and officials from the Washington State Department of Ecology, the DNFSB, and other institutions. We visited the WTP project construction site to observe operations and to gain an understanding of the WTP project and the incorporation of the proposed capital asset projects. We reviewed and analyzed a wide range of documents. Specifically,

- To examine how DOE's proposed capital asset projects will help achieve Hanford's tank waste treatment mission and how they were selected, we reviewed federal and state regulations and legal agreements that describe DOE's responsibilities for completing the tank waste treatment mission at Hanford; DOE's requirements for initiation and oversight of capital asset projects and for nuclear safety; and DOE regulations, policy documents and project documents that describe DOE's strategy for completing the new projects and the tank waste treatment mission.

- To examine the extent to which DOE's estimated costs and schedules for constructing the proposed capital asset projects meet best practices for developing cost and project schedule estimates, we reviewed DOE orders and documents that describe the process DOE must follow to implement capital asset projects and that describe the projects' estimated costs and schedules. We also reviewed our guides identifying best practices for reliably estimating project costs and project schedules and compared DOE's cost and schedule estimates

with these best practices.[4] We took steps to assess the reliability of the cost and schedule data, including interviewing DOE officials responsible for developing them, and determined that they were not reliable. (See apps. I, II, and III for further information about our review of DOE's cost and schedule estimates.)

- To examine the extent to which technical and management challenges continue to affect completion of the WTP, we identified and reviewed reports on the WTP project's engineering, procurement, quality assurance, and nuclear safety practices prepared by DOE Headquarters, the DOE Office of the Inspector General, and the Office of River Protection; DOE contractors and technical experts; and the Consortium for Risk Evaluation with Stakeholder Participation, DNFSB, and NRC.[5] We filtered more than 8,000 technical and management issues reported in the PIERS database—the contractor's corrective action management system— since 2009, to identify unresolved items and their level of significance. We identified more than 1,200 issues that were unresolved as of June 2014, and we focused on the 164 that the contractor deemed significant. We also interviewed former DOE officials in charge of nuclear safety and engineering for the WTP project and officials from NRC who are familiar with nuclear safety and engineering requirements.

We conducted this performance audit from December 2013 to May 2015 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.

[4]GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: March 2009) and *Schedule Assessment Guide: Best Practices for Project Schedules,* GAO-12-120G (Washington, D.C.: May 2012).

[5]The Consortium for Risk Evaluation with Stakeholder Participation is a multiuniversity consortium that supports DOE through a cooperative agreement with Vanderbilt University. Its objective is to advance cost-effective, risk-based cleanup of the nation's nuclear weapons production facility waste sites and cost-effective, risk-based management of potential future nuclear sites and wastes. It does this by seeking to improve the scientific and technical basis for environmental management decisions by DOE and by fostering public participation in that search.

Background

This section describes DOE's evolving strategies for achieving the tank waste treatment mission at Hanford, the technical and management challenges that have affected the WTP, and DOE's phased waste treatment strategy proposed in the litigation with the state for overcoming certain challenges that have stalled the WTP's progress.

Evolution of DOE's Strategies for Achieving the Tank Waste Treatment Mission

Beginning in 1943, nine nuclear reactors—including the world's first operating nuclear reactor, developed as part of the Manhattan Project during World War II—were built at Hanford and operated until the late 1980s. The primary mission at Hanford was to produce plutonium and other special nuclear material for DOE's nuclear weapons program.[6] At the time, little attention was given to the resulting by-products—large amounts of radioactive and chemically hazardous waste—or how to safely dispose of these by-products. Since 1989, Hanford's mission has been focused on the cleanup of such waste, which is stored in underground tanks, and on the ultimate closure of the Hanford site.[7] To this end, several types of radioactive waste are being managed at the site, including (1) high-level radioactive waste, which consists primarily of sludge and saltcake and contains most of the radioactivity of the tank waste, but constitutes less than 10 percent by volume;[8] (2) potential contact-handled transuranic waste, which includes approximately 1.4 million gallons of waste in single-shell tanks that could potentially be transferred to another location for permanent storage;[9] and (3) low-activity radioactive waste, which consists primarily of the liquid portion of the tank

[6]Special nuclear material includes uranium enriched in the isotope of uranium-235, uranium-233, and plutonium.

[7]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.

[8]Sludge consists of denser water-insoluble or solid components that generally settle to the bottom of a tank to form a thick layer having the consistency similar to peanut butter. Saltcake consists of water-soluble compounds, such as sodium salts, that can crystallize or solidify out of wastes to form a salt-like or crusty material.

[9]The term transuranic means those elements with an atomic number greater than that of uranium. This waste includes transuranic (TRU) solid waste, which typically consists of discarded rags, tools, equipment, soil, or other solid materials that have been contaminated by certain man-made radioactive elements, particularly plutonium. The term TRU waste generally includes radioactive waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years.

waste and contains about 10 percent of the radioactivity of the tank waste but about 90 percent of the tank waste by volume.

Cleanup of the Hanford site is governed by two main compliance agreements: (1) the 1989 Hanford Federal Facility Agreement and Consent Order, or Tri-Party Agreement (TPA), an agreement between DOE, the Washington State Department of Ecology, and the Environmental Protection Agency (EPA);[10] and (2) a 2010 consent decree.[11] The consent decree currently requires DOE to begin treating waste by the end of 2019, and the TPA requires DOE to complete waste treatment by 2047.[12] Under this legal framework, DOE has attempted and abandoned several different strategies to treat and dispose of Hanford's tank waste, including the following:

- In 1989, DOE's initial strategy called for treating only the waste in the double-shell tanks. This effort included renovating a World War II-era facility in which DOE planned to start waste treatment. As part of this effort, DOE planned to vitrify only the high-level waste in the tanks at a Hanford Waste Vitrification Plant and treat the liquids by combining the waste with grout for disposal in a Hanford Grout Disposal Facility. DOE spent about $23 million on this project. The Hanford Waste Vitrification Plant and the Hanford Grout Disposal Facility were cancelled because of technical and environmental issues. Once DOE agreed pursuant to the TPA to retrieve and treat nearly all of the single-shell tank wastes, DOE determined that the original, planned vitrification facility would have been too small to handle these wastes.

[10]Hanford Federal Facility Agreement and Consent Order, EPA Docket No. 1089-03-04-120, Ecology Docket No. 89-54, as amended through April 15, 2015. The agreement as available at http://www.hanford.gov/page.cfm/TriParty/TheAgreement.

[11]Washington v. Chu, Civ. No. 08-05085 (E.D. Wash), entered October 25, 2010.

[12]The TPA lays out a series of legally enforceable milestones for completing major activities in Hanford's waste treatment and cleanup process. The purpose of the TPA is to ensure that Hanford cleanup activities comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), and Washington's Hazardous Waste Management Act. DOE entered into the TPA pursuant to CERCLA, Executive Order 12580, and the Atomic Energy Act of 1954. The consent decree addresses a subset of these cleanup activities: completing the construction and achieving initial operations of the WTP, and the retrieval of waste from 19 single-shell tanks.

- In 1993, DOE was developing a new strategy aimed at treating waste from all 177 tanks. Under this strategy, DOE was to complete the treatment facility before other aspects of the waste treatment program were fully developed. However, after spending about $418 million on this strategy, DOE found that the planned treatment facility would not have had sufficient capacity to treat all the waste in a time frame acceptable to EPA and the Washington State Department of Ecology.

- In 1994, the TPA was amended to reflect a new goal of vitrifying both low-level and high-level waste, instead of treating low-level waste with grout. In 1995, DOE planned, under a fixed price contract, to have a contractor design, finance, build, commission, and operate waste treatment facilities on the Hanford Site. The department was to pay the contractor for successfully processed waste it placed in canisters. The first phase of this project was to involve treating about 10 percent of the waste in a pilot-scale facility at a contract price of $3.2 billion. From 1996 to 2000, however, the proposed contract price increased to more than $14 billion. In June 2000, DOE canceled the contract, after spending about $300 million, mostly on plant design.

In December 2000, DOE awarded a new cost-reimbursable contract with incentive fee to the current contractor, Bechtel National, Inc., to complete the waste treatment plant that the previous contractor had begun to design.[13] When the contract was awarded to Bechtel National, Inc. in 2000, it specified that the project would cost $4.3 billion and would be completed in 2011. In October 2002, DOE authorized design changes recommended by the contractor, eliminating the pilot-scale facility and converting the WTP to a full-scale facility, to accelerate waste treatment and save an estimated $20 billion on the total costs of the waste treatment mission. DOE renegotiated the contract in April 2003 to reflect this revision and to address cost increases and construction problems, such as engineering and technical issues. These changes led to DOE's current strategy for dealing with tank waste—construction of the WTP in its current configuration—to pretreat the waste for permanent disposal within the design life of the WTP.

[13]Cost-reimbursement type contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract. A cost-plus-award-fee contract is a cost-reimbursement contract that provides for a fee consisting of (a) a base amount (which may be zero) fixed at inception of the contract and (b) an award amount, based upon a judgmental evaluation by the agency, sufficient to provide motivation for excellence in contract performance.

The WTP project is made up of the following separate facilities in various stages of construction:

- **Pretreatment facility.** This facility is to receive the waste from the tanks and separate it into high-level and low-activity waste streams. Under the WTP design, all waste must first pass through this facility before it can be treated. Tank waste to be sent to the Pretreatment facility for processing must meet specific physical and chemical characteristics, known as waste acceptance criteria, and the waste must be certified as having met these criteria before transfer from the tank farms to the Pretreatment facility. For example, WTP waste acceptance criteria may stipulate that waste meet certain requirements for chemical composition, particle size, and density in order to be handled by the Pretreatment facility. As of February 2015, construction of the facility is currently on hold.

- **High Level Waste facility.** This facility is to receive the high-level waste from the Pretreatment facility and immobilize it by vitrification. Vitrification involves mixing the waste with a glass-forming (vitrifying) material, melting the mixture into glass, and pouring the vitrified waste into stainless-steel canisters to cool and harden. The current plan is to provide interim storage for these canisters on-site until a final repository is established.

- **Low Activity Waste facility.** This facility is to receive the low-activity waste from the Pretreatment facility and immobilize it by vitrification. The containers of vitrified waste will be permanently disposed of at another facility at Hanford.

- **Analytical Laboratory.** This facility will conduct analyses as needed for the processing facilities, such as testing samples of the waste/glass mixture from both vitrification facilities to ensure that the mixture conforms to acceptable waste acceptance criteria and regulatory requirements.

- **Balance of Facilities.** These facilities consist of the 22 support facilities that make up the plant infrastructure, such as the steam plant and silos that hold vitrifying materials.

Technical and Management Challenges That Have Affected the WTP

The WTP project has encountered significant technical and management challenges for much of its history. As we reported in 2012, significant technical challenges included the following:[14]

- **Pulse-jet mixer performance.** Up to 16 of the 177 tanks at Hanford contain large-size plutonium particles that could settle onto internal surfaces of the pulse-jet mixer vessels, which use compressed air to mix the waste.[15] If the pulse-jet mixers could not then resuspend settled particles, an uncontrolled nuclear chain reaction known as a criticality accident could occur.[16] In addition, accumulating solids in pulse-jet mixing vessels could cause excessive air to be discharged in the vessels. This discharge could cause premature erosion of vessel surface bottoms, all of which are located in nonmaintanable areas called black cells.

- **Hydrogen in piping and ancillary vessels.** In the Pretreatment facility and High Level Waste facility, the accumulation of hydrogen gas in piping and small vessels can occur after the loss of off-site power or after an interruption of a transfer of waste due to operator error and during normal operation in isolated pipe sections, potentially causing an explosion. DOE Office of River Protection officials told us such an explosion could only happen in the presence of an ignition source, which they believe is unlikely.

- **Erosion and corrosion.** Because of uncertainties in waste feed characteristics, the vessel and piping design in the Pretreatment facility and High Level Waste facility may require revisions to account

[14]GAO-13-38.

[15]Such devices have previously been used successfully in other materials mixing applications but required testing and analysis to ensure satisfactory performance for waste conditions like that to be treated at the WTP, according to Office of River Protection officials.

[16]Criticality accidents result from the unintentional assembly of a critical mass of fissile material, such as plutonium or enriched uranium, in a protected or unprotected environment. To shield plant workers from intense radiation that will occur during WTP operations, some processing tanks will be located in sealed compartments called “black cells.” These black cells are shielded rooms where inspection, maintenance, repair, or replacement of equipment or components is extremely difficult because high radiation levels prevent access into them. As a result, plant equipment in black cells must last for WTP’s 40-year expected design life without maintenance. According to DOE, black cells are intended to provide for a protected/shielded environment in the event that a criticality did occur.

for the amount of wear the equipment will need to withstand.[17] Excessive wear could damage plant equipment and result in interruption of operations or leakage of material from vessels and piping.

In addition, as WTP facilities' designs have progressed, DOE has identified through its studies other significant, long-standing technical challenges to completing the WTP:

- **Design redundancy in black cells and in-service inspection.** Once WTP operations begin, equipment in black cells within the Pretreatment facility and High Level Waste facility must last for the WTP's 40-year expected design life without maintenance because significant failures of components installed in the black cells could impact the throughput and mission duration of the WTP. Potential weaknesses in equipment and piping located within black cells must be identified before WTP operations begin to ensure that timely repairs can be conducted, should failure of these components occur.

- **Pulse-jet mixing vessel structural integrity.** Pulse-jet mixing vessels may need structural modifications to account for abnormal environmental conditions, such as seismic events.

- **Facility ventilation.** Ventilation systems in the Pretreatment facility, High Level Waste facility, and Low Activity Waste facility must be able to contain radioactive material that could be released from primary confinement. The structural integrity of some internal vessel components in these facilities could be compromised if seismic or other events beyond the design basis occur. The ventilation system must survive a release of radioactive material without shutdown, plugging, or blowing out filters to continue to provide confinement.

- **Waste feed preconditioning requirements**. Plutonium particles within the tank waste may be too large to be processed by the Pretreatment facility. A method for preconditioning the waste before delivery to the Pretreatment facility needs to be identified to ensure

[17]DOE does not have comprehensive data on the specific physical, radiological, and chemical properties of the waste in each tank. DOE Office of River Protection officials told us they have established waste acceptance criteria to minimize wear and that they are also evaluating remote repair and in-service capabilities to monitor for excessive wear.

that waste particles are within the size limit that the facility can process.

The technical challenges have primarily affected the Pretreatment facility, and, to a lesser degree, the High Level Waste facility and the Low Activity Waste facility. As a result of these challenges, in late 2012, DOE stopped construction of the Pretreatment facility and slowed construction of the High Level Waste facility. Table 1 summarizes the WTP technical issues by facility.

Table 1: DOE Waste Treatment Plant Technical Issues by Facility

Technical issue	Pretreatment facility	High Level Waste facility	Low Activity Waste facility
Pulse-jet mixer performance	X	X	
Hydrogen in piping and ancillary vessels	X	X	
Erosion and corrosion	X	X	
Design redundancy in black cells/in-service inspection	X	X	
Pulse-jet mixing vessel structural integrity	X	X	
Facility ventilation	X	X	X
Waste feed preconditioning requirements	X		X

Source: DOE Environmental Management Capital Asset Project Reports. | GAO-15-354

In addition to the technical challenges, the WTP faces management challenges. Since 2001, several external and internal reviews have found that DOE's oversight of its contractors' design management and quality assurance programs has been ineffective. The management challenges identified in these reviews include the following:

- **Oversight of design management programs.** DOE's nuclear safety management regulations govern activities that affect or may affect the safety of DOE's nuclear facilities, including those in design.[18] Pursuant to DOE's regulatory requirements, the contractor must ensure that documented safety analyses and hazard controls provide reasonable assurance that a DOE nuclear facility can be operated safely, in a manner that adequately protects workers and the

[18]10 C.F.R., Part 830, Nuclear Safety Management.

environment.[19] Several external reviews found that DOE's oversight of the WTP has not always ensured that the design of the facility conforms to nuclear safety requirements. For example, in 2001, NRC issued a report in which it found that the contractor's design and authorization basis documents—which show the department's process for ensuring the safe operations of a nuclear facility once construction is completed—were not current.[20,21] In 2008, NRC issued another report, which found that DOE did not ensure that the WTP contractor's nuclear criticality safety staff reviewed new or changed designs and that staff were not sufficiently documenting the reviews they were conducting, meaning that the facility design may not meet nuclear safety requirements—a management challenge we also identified in our 2012 report.[22] NRC's report also stated that a new or changed design could potentially introduce a new nuclear criticality hazard that could become an unreviewed safety issue.[23] In addition, from 2006 to 2012, DOE's Office of Health, Safety, and Security conducted six investigations into the WTP design's compliance with

[19]To support implementation of DOE's nuclear safety regulatory requirements, DOE Order 420.1C establishes facility and programmatic safety requirements for, among other things, nuclear safety design criteria. According to this order, safety must be integrated into the design of nuclear facilities throughout the design process.

[20]The 2001 NRC report summarized findings it had identified from 1997 to 2000, when NRC provided assistance to DOE on the tank waste treatment program at Hanford, including assistance in performing reviews in a manner consistent with NRC's regulatory approach for commercial nuclear facilities. NRC, *Overview and Summary of NRC Involvement with DOE in the Tank Waste Remediation System-Privatization (TWRS-P) Program* (Washington, D.C.: August 2001).

[21]The authorization basis is DOE's process for ensuring the safe operations of the facility once construction is completed. It is the aggregate of all safety-related elements of the project, including hazard analysis and controls to mitigate identified safety hazards.

[22]NRC, *Review of the U.S. Department of Energy's Regulatory Processes for the Hanford Waste Treatment Plant* (Washington, D.C.: Aug. 4, 2008).

[23]According to 10 C.F.R., Part 830, an unreviewed safety question (or issue) means a situation where (1) there could be an increase in the probability of the occurrence or the consequences of an accident or the malfunction of equipment important to safety previously evaluated in the documented safety analysis, (2) the possibility of an accident or malfunction of a different type than any evaluated previously in the documented safety analysis could be created, (3) a margin of safety could be reduced; or (4) the documented safety analysis may be inadequate.

nuclear safety requirements.[24] Each completed enforcement case revealed violations of nuclear safety requirements, such as inconsistencies between design documents and the authorization basis for the facility, and resulted in DOE imposing civil penalties against the contractor.

- **Oversight of contractor's quality assurance program.** DOE's nuclear safety regulatory requirements establish quality assurance requirements for contractors conducting activities that affect, or may affect, safety of DOE nuclear facilities.[25] Specifically, the contractor responsible for a DOE nuclear facility must develop a quality assurance program, according to regulatory requirements, which must be approved by DOE, and the contractor must conduct work in accordance with the program.[26] DOE's Office of River Protection's quality assurance policy calls for work suspension when safety or quality of the work is indeterminate.[27] Furthermore, according to the policy, corrective actions to address problems with the quality of the work must include a determination of the extent to which the quality problems exist, known as an extent-of-condition review, as well as the underlying causes of those conditions. Since 2001, external assessments have identified challenges with DOE's oversight of the contractors' quality assurance program. For example, in its 2001 report, NRC found that DOE had not ensured that the WTP contractor had adequately applied and implemented quality assurance requirements for the design of WTP facilities. In addition, in its 2008 report, NRC found that the contractor's quality assurance functions

[24]Office of River Protection officials told us that two of the six investigations have not been completed. DOE has recently reorganized the Office of Health, Safety, and Security into two offices, the Office of Enterprise Assessments and the Office of Environment, Health, Safety, and Security.

[25]Specifically, ORP's Quality Assurance Program implements DOE's nuclear safety quality assurance requirements at 10 C.F.R. Part 830, Subpart A.

[26]DOE required the WTP contractor to develop and follow a quality assurance program based on the American Society of Mechanical Engineer's Quality Assurance Requirements for Nuclear Facility Applications Standard. The DOE Office of River Protection's Quality Assurance Program serves as the quality assurance policy and is part of the management system that DOE uses to ensure work is performed safely and in accordance with nuclear safety requirements.

[27]According to the DOE Office of River Protection Quality Assurance policy, work suspension is appropriate when continued work would be unsafe, would be likely to create rework, and when safety or quality is indeterminate.

were not effective, and had not been for years, and that DOE did not provide adequate oversight of WTP contractual requirements and processes for quality assurance.

DOE's New Strategy for Addressing Certain Technical and Management Challenges

In 2013, to address certain technical and management challenges that led to the suspension of work at the Pretreatment facility and High Level Waste facility, DOE proposed a new, phased strategy for achieving the tank waste treatment mission, which includes the construction of two new capital asset projects.[28] In September 2013, DOE issued its Hanford Tank Waste Retrieval and Disposition Framework (also known as the "Framework"), which describes this strategy. According to the Framework, DOE's strategy includes three phases, although DOE does not estimate when each phase will begin or how long each phase will last. The three phases are as follows:

- **Phase 1.** During this phase, DOE intends to conduct the following activities:
  - Continue work to complete WTP's Analytical Laboratory and Balance of Facilities.
  - Begin working on a plan to bypass the WTP Pretreatment facility and to feed the liquid portion of some low-activity waste directly from underground tanks to the WTP Low Activity Waste facility for vitrification.
  - Construct a new facility, the Low Activity Waste Pretreatment System, to receive and treat liquid waste from the tanks in preparation for direct-feed to the WTP's Low Activity Waste facility, as well as infrastructure to transport the waste, such as piping.

[28]DOE headquarters officials told us that, in 2012, significant emphasis was placed on resolving technical issues associated with the High Level Waste facility and Pretreatment facility. According to the officials, based on the complexity and expected time to resolve the technical issues, the decision was made to complete the WTP project in phases; and the initial phase provides for the direct feed of low-activity tank waste to the Low Activity Waste facility instead of routing it through the Pretreatment facility. This would require the completion of the Low Activity Waste facility and portions of the Analytical Laboratory and Balance of Facilities associated with the direct feed of waste to the Low Activity Waste facility.

- Complete, commission, and start up the Low Activity Waste facility.[29]

- Construct another new facility, the Tank Waste Characterization and Staging facility, to support eventual delivery of high-level waste to the WTP's Pretreatment facility or High Level Waste facility.[30]

- Continue to work on resolving technical challenges related to the Pretreatment facility.

- **Phase 2.** During this phase, DOE intends to complete WTP's High Level Waste facility, the Tank Waste Characterization and Staging facility, and infrastructure such as piping and holding tanks to support delivery of high-level waste directly from the characterization facility to the High Level Waste facility. DOE also would continue construction of the Pretreatment facility during this phase.

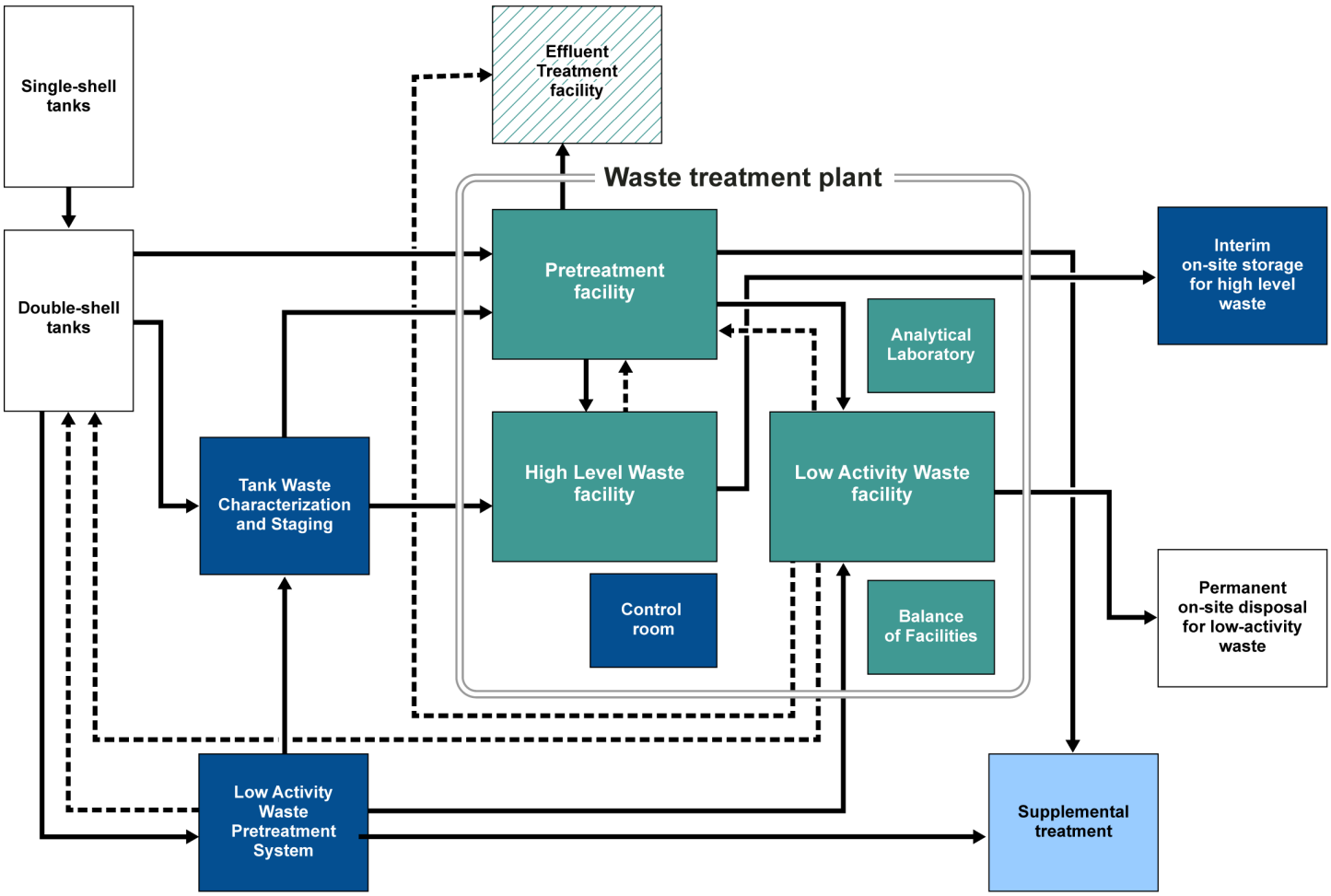
- **Phase 3**. During this phase, DOE intends to complete the full WTP, including commissioning the Pretreatment facility, beginning integrated WTP operations, and possibly adding preconditioning capability for harder-to-process waste, such as waste with higher concentrations of solids and radioactivity.

Figure 1 illustrates the integration of the proposed new capital asset projects into the WTP project.

[29]The commissioning process includes testing the facility, first by making production runs using agreed-upon simulant waste, then by "hot commissioning" using actual tank waste, and continues until the facility is turned over to the future WTP operations contractor.

[30]According to DOE's Framework, this facility may transport high-level waste directly to the High Level Waste facility if technical challenges prevent timely completion of the Pretreatment facility.

Figure 1: Hanford's Constructed and Proposed Waste Treatment Facilities as Presented in the Framework



Source: GAO analysis of DOE information. | GAO-15-354

Note: Primary waste includes high-level radioactive waste, potential contact-handled transuranic waste, and low-activity radioactive waste. Secondary waste is waste generated from various treatment and operational processes during Waste Treatment Plant operations.

According to documents DOE filed in court as part of the pending litigation related to the consent decree, DOE provided the Framework to the state of Washington as a starting point for discussions between the

parties. On March 31, 2014, DOE and the state of Washington exchanged proposals to amend the consent decree. According to DOE, the March 2014 proposal refined the options developed in the Framework and presented a general strategic view of the WTP project. After rejecting each other's proposals, the parties continued negotiations, which were ultimately unsuccessful. On October 3, 2014, DOE submitted to the court its proposed modification to the consent decree which, according to DOE, further refined the March 2014 proposal and included provisions addressing: Direct Feed Low Activity Waste, a process by which waste would be fed directly from underground tanks to the WTP Low Activity Waste facility for vitrification; technical issue resolution; and a Tank Waste Characterization and Staging facility, which would allow DOE to sample, mix, and pre-condition waste before it was fed to the WTP. The state submitted its own proposed amendment on the same day, which included provisions addressing: a detailed schedule for all portions of the WTP, including new facilities and processes necessary to carry out the phased approach to completing construction and start-up of the WTP; requirements and deadlines for DOE to continue retrieving tank waste; and additional accountability measures including required quarterly status reports to the state and the court. As of April 2015, the parties were waiting for the court to rule on evidentiary matters related to the consent decree litigation.

DOE Order 413.3B establishes program and project management requirements for the acquisition of capital assets. DOE's Office of Environmental Management is required to manage its projects in accordance with the order.[31] The order defines five major milestones—or critical decision points–that span the life of a project. The order's first two critical decision points establish requirements the department is to follow for selecting projects. Specifically,

- The first critical decision point, critical decision 0 (CD-0) initiates a project and preconceptual planning and design used to develop alternative concepts and functional requirements. To achieve CD-0 approval, programs must, among other things, identify a credible performance gap between DOE's current capabilities and those required to achieve the mission goals, prepare a statement of mission need, which translates the identified gap into functional requirements,

[31]DOE, Program and Project Management for the Acquisition of Capital Assets, DOE Order 413.3B (Washington, D.C.: Nov. 29, 2010).

and develop rough order-of-magnitude cost ranges and schedule estimates for the project alternatives under consideration. According to the order, to allow DOE the flexibility to explore a variety of alternatives without limiting potential solutions, the statement of mission need should not identify a particular solution such as equipment, facility, or technology.

- The next critical decision point, critical decision 1 (CD-1), defines, analyzes, and refines project concepts and alternatives and ultimately identifies a cost-effective and preferred alternative to meet the mission need. During this critical decision point, DOE guidance suggests that DOE should develop a life-cycle cost estimate for each alternative.[32] According to the order, DOE is also to complete a conceptual design for the project, develop an independent cost estimate for the selected alternative, and establish a quality assurance program.

The Proposed New Capital Asset Projects May Expedite Treatment of Some Waste, but DOE Selected Them Based on Past Proposals, Thereby Excluding Consideration of Potential Alternatives

DOE's two proposed new capital asset projects are intended to help achieve Hanford's tank waste treatment mission by expediting treatment of some waste and addressing some technical challenges within the Pretreatment facility, but DOE selected the projects based on past proposals that effectively exclude consideration of potential alternatives at CD-1, in contrast to requirements in DOE's project management order. The Low Activity Waste Pretreatment System is intended to bypass the Pretreatment facility and feed low-activity waste directly to the Low Activity Waste facility, thereby enabling the treatment of some waste sooner than if DOE waited for the Pretreatment facility's technical challenges to be resolved. Similarly, the Tank Waste Characterization and Staging facility is intended to help reduce some of the technical challenges faced by the Pretreatment facility by ensuring that radioactive waste particles are small enough to be processed and treated; it may also allow DOE to bypass the Pretreatment facility, if necessary, and feed high-level waste directly to the High Level Waste facility. DOE selected these projects on the basis of similar past proposals to begin waste treatment before completing the Pretreatment facility.

[32]GAO, *DOE and NNSA Project Management: Analysis of Alternatives Could Be Improved by Incorporating Best Practices*, GAO-15-37 (Washington, D.C.: Dec. 11, 2014).

The Low Activity Waste Pretreatment System May Allow DOE to Bypass the Pretreatment Facility and Expedite Treatment of Low-Activity Waste

According to DOE's proposal in the consent decree litigation, the first proposed capital project—the Low Activity Waste Pretreatment System—is intended to enable pretreating some liquid waste from the double-shell tanks, sending low-activity waste to be vitrified in the WTP Low Activity Waste facility, while the department works to resolve the technical challenges affecting the larger and more complex Pretreatment facility. The Low Activity Waste Pretreatment System—which, as of February 2015, was at CD-0 (i.e., preconceptual design)—is intended to receive liquid low-activity waste from the tanks, pretreat the waste by removing cesium and solids,[33] and then feed the pretreated waste directly to the WTP Low Activity Waste facility for vitrification when that facility is completed. Doing so would allow DOE to bypass the currently stalled Pretreatment facility. If DOE completes the Low Activity Waste Pretreatment System on schedule, it could allow low-activity waste treatment to begin earlier than if DOE waits until the WTP, including the Pretreatment facility, is fully operational, according to Office of River Protection officials. In addition, the Low Activity Waste Pretreatment System could provide a second pathway for low-activity waste treatment if the Pretreatment facility, once completed, becomes temporarily inoperable during the waste treatment mission.[34]

DOE's 2014 proposal to amend the consent decree that it submitted to the state of Washington states that, by treating some low-activity waste before completing the WTP project, the Low Activity Waste Pretreatment System could shorten the time required to achieve the overall waste treatment mission and could allow DOE to free up space in existing double-shell tanks which, as we reported in November 2014, is limited.[35]

[33]According to Office of River Protection officials, cesium (CS)-137 is a radioactive isotope that results from nuclear fission. Cesium makes up the majority of the radioactive material in the tank waste and is transported with the supernate, or liquid portion of the waste, normally as a dissolved salt. To meet the waste form requirements for the Low Activity Waste facility, cesium must be removed to lower the radioactivity levels in the waste before the waste is sent to the facility.

[34]DOE, *Proposal by the U.S. Department of Energy to the State of Washington to Amend the Consent Decree* (Washington, D.C.: Mar. 31, 2014). In this proposal, DOE also stated that the Low Activity Waste Pretreatment System would allow DOE to operate the Low Activity Waste facility before completing construction of the more complex Pretreatment facility and High Level Waste facility, thereby providing DOE with experience in the vitrification process and lessons learned that could enable a more efficient start-up of the WTP when it is completed.

[35]GAO, *Hanford Cleanup: Condition of Tanks May Further Limit DOE's Ability to Respond to Leaks and Intrusions,* GAO-15-40 (Washington D.C.: Nov. 25, 2014).

Officials from DOE's Office of River Protection estimate that the Low Activity Waste Pretreatment System will receive about 1 million gallons of low-activity waste from the double-shell tanks for treatment each year of operation. However, this would not necessarily reduce the volume of the waste in the double-shell tanks by 1 million gallons. According to these officials, a significant amount of "secondary" radioactive waste will be created during the low-activity waste vitrification process, but they are uncertain as to how much secondary waste would need to be returned to the double-shell tanks. DOE Office of River Protection officials told us that for every 1 million gallons of low-activity waste taken from the tank farms and fed through the Low Activity Waste Pretreatment System to the Low Activity Waste facility, they estimate that about 700,000 gallons of secondary waste would be created and may need to be returned to the tanks for future processing. Thus, a net of 300,000 gallons of additional tank space would be created for every 1 million gallons of low-activity waste processed.[36] However, Office of River Protection officials subsequently provided us with a written update in February 2015 estimating that, for every 1 million gallons of low-activity waste delivered through the Low Activity Waste Pretreatment System, no more than 250,000 gallons would be returned to the tanks for future processing. They explained that under this scenario, less secondary waste will be returned to the tanks because the contractor is designing an effluent management facility that may be used to evaporate much of the secondary waste and reduce the amount returned to the tank farms.

[36]300,000 gallons is slightly less than one-third of the capacity of one double-shell tank.

The Tank Waste Characterization and Staging Facility May Help Solve Some Technical Challenges with the Pretreatment Facility and Expedite Treatment of High-Level Waste

According to DOE's proposal in the consent decree litigation, the second proposed capital asset project, the Tank Waste Characterization and Staging facility, is intended to help DOE resolve some technical challenges within the Pretreatment facility. Specifically, DOE states that the Tank Waste Characterization and Staging facility is intended to serve as an intermediary between the tank farms and the Pretreatment facility by receiving waste from the tanks; sampling, characterizing, and blending waste so that it meets the WTP waste acceptance criteria; and then feeding the waste to WTP's Pretreatment facility.[37] According to DOE, the department needs the capability to sample and characterize waste before delivering it to the Pretreatment facility because DOE does not have comprehensive data on the size of waste particles, among other things, which increases the risks of erosion or corrosion in the Pretreatment facility and High Level Waste facility piping and vessels.[38] If the Tank Waste Characterization and Staging facility operates as intended, it may mitigate these risks by providing DOE with the capability to precondition waste by, for example, reducing the size of large waste particles before feeding the waste to the Pretreatment facility.

In addition, although DOE has not proposed in the consent decree litigation to pursue direct feed high-level waste, DOE has stated that the Tank Waste Characterization and Staging facility could enable high-level waste to be fed from the tanks directly to the High Level Waste facility.

DOE Proposed These Two Projects on the Basis of Similar Past Proposals without Consideration of Other Alternatives

DOE proposed these two projects on the basis of similar past proposals without consideration of other potentially viable alternatives, in contrast to requirements in DOE's project management order. An official from DOE's Office of Environmental Management told us that, in the spring of 2013, after work on the Pretreatment facility and High Level Waste facility stalled, the Office of River Protection and the tank farms' contractor

[37]Waste acceptance criteria describe the physical and chemical characteristics that waste must have in order to be certified as acceptable prior to transfer from the tank farms to the WTP. For example, WTP waste acceptance criteria may stipulate that waste meet certain requirements for chemical composition, particle size and density in order to be handled by a WTP facility.

[38]DOE and others, such as the DNFSB, have raised concerns about the absence of such data, with DOE acknowledging that inaccurately characterized waste that does not meet the facility's waste acceptance criteria could damage the WTP facilities or interrupt operations.

proposed the two projects to DOE headquarters officials. According to a DOE Office of River Protection official and documentation, DOE had previously considered projects with similar capabilities in 1995, 2009, and 2012. The tank farms contractor and DOE's Office of River Protection had prepared plans for the design of such facilities—leading the department to formally identify the Low Activity Waste Pretreatment System and Tank Waste Characterization and Staging facilities' projects in the Framework, according to the official.[39]

DOE's decision to consider the projects on the basis of past proposals does not comply with its project management order. The two proposed projects are at the first critical decision point, or CD-0, in DOE's project management process.[40] According to Order 413.3B, at CD-0 DOE must develop statements of mission need that do not identify a particular solution such as equipment, facility, or technology, to allow DOE the flexibility to explore a variety of alternatives without limiting potential solutions.[41] Nevertheless, DOE effectively chose these two projects as technical solutions to expedite waste treatment more than 1 year before the proposed projects reached CD-0. For example, a DOE Office of Environmental Management official told us that in early 2013, officials from the Office of River Protection and the tank farms contractor recommended to DOE headquarters the direct-feed of low-activity waste and a capability for characterizing and staging tank waste as strategies to begin treating some waste as soon as possible. The Office of River Protection began planning projects to implement these strategies at that

[39]Specifically, the tank farms contract, signed in 2008, includes options to design, construct, and operate a low-activity waste pretreatment capability like that provided by the Low Activity Waste Pretreatment System. According to DOE Office of River Protection officials, this project had been considered on multiple occasions in the past because the department has long recognized a potential need to begin phased start-up of the WTP. Similarly, DOE had conducted preliminary design work in 1995, 2009, and 2012 on several projects intended to provide capabilities similar to the Tank Waste Characterization and Staging facility. According to the officials, this project has been considered in the past because the department has long recognized the need to address the problem of effectively sampling, characterizing, blending, and feeding waste from the tank farms to the WTP.

[40]The Low Activity Waste Pretreatment System project received CD-0 approval in March 2014, and the Tank Waste Characterization and Staging facility CD-0 package is under review. DOE told us in October 2014 that an approval date has not been estimated.

[41]GAO best practices for DOE's analysis of alternatives process also state that DOE should define a mission need and functional requirements without a predetermined solution in mind. See GAO-15-37.

time—about 1 year before the Low Activity Waste Pretreatment System reached the CD-0 critical decision point and at least 2 years before the Tank Waste Characterization and Staging facility is scheduled to do so.

Beginning in early 2013, when DOE's Office of River Protection first recommended the projects to DOE headquarters officials, the office developed narrow statements of mission need that effectively excluded other potential alternatives from being considered. In March 2014, the Office of River Protection approved a statement of mission need for the Low Activity Waste Pretreatment System, stating that it was necessary for DOE to address the following two mission needs:

- Accelerate the disposition of liquid low-activity waste stored in underground tanks because the tanks are known or assumed to have leaked, and

- Pretreat the waste by constructing a Low Activity Waste Pretreatment System and then delivering the waste to the Low Activity Waste facility for vitrification.

As of December 2014, DOE's Office of River Protection had not approved the Tank Waste Characterization and Staging facility for CD-0, but the office has developed a draft statement of mission need that specifies a need to expedite the disposition and treatment of the high-level waste in the tanks, in light of the October 2012 announcement of a leak in one of the double-shell tanks. The draft statement of mission need further specifies that the Hanford site needs a tank waste characterization and staging capability to safely and reliably mix and sample tank contents, meet the Pretreatment facility waste acceptance criteria, supply the WTP with waste feed, and potentially deliver high-level waste directly from the tank farms to the WTP High Level Waste facility. By narrowly defining the mission needs this way, DOE effectively narrowed the range of acceptable options and excluded from consideration other alternatives to expediting waste treatment and addressing the potential danger posed by the leakage of waste from the tanks.[42]

[42]A 2013 construction project review of the WTP conducted by the DOE Chief of Nuclear Safety recommended that by June 1, 2014, DOE consider a complete and rigorous study of alternatives for completing the Office of River Protection mission that is not limited to the option of direct-feed of low-activity waste but, as of January 2015, DOE had not conducted this study.

By developing narrow statements of mission need, potentially less costly or more effective alternatives will not be considered. For example, in 2012, DOE issued a Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford site that analyzed 11 alternatives for retrieval, treatment, and disposal of waste from the 177 underground tanks (see table 2), elements of which could be alternatives to the two proposed capital projects. For example, some of the alternatives that DOE analyzed involve building new double-shell tanks, each of which cost about $80 million, according to DOE documents. Considering such an alternative, for example, as established by the TPA in milestones related to contingency planning, may also give DOE and the contractor time to resolve WTP's technical challenges and mitigate the risks posed by the leaking tanks. The environmental impact statement represented what DOE considered as the range of reasonable treatment alternatives, using available technologies and processes.[43] DOE has not analyzed, as part of the CD-0 process, whether elements of these alternatives could be suitable alternatives for the two proposed capital projects.[44]

[43]Under the National Environmental Policy Act of 1969, agencies evaluate the potential environmental effects of projects they are proposing using an environmental assessment or, if the projects likely would significantly affect the environment, a more detailed environmental impact statement.

[44]In commenting on a draft of this report, DOE stated that it would not be expected to perform the robust alternatives analysis that it performed in the environmental impact statement here. We are not suggesting that DOE should redo the analysis in its 2012 EIS, but rather that it should, to the extent practicable, avail itself of the results of that analysis in deciding how to proceed with the WTP project.

Table 2: Tank Waste Treatment Alternatives Identified by DOE in the 2012 Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site

Alternative	Description of tank waste treatment component of alternative
1	Stop construction of the Waste Treatment and Immobilization Plant (WTP) and isolate the WTP site pending some future use, if any; fill tanks that show signs of deterioration with grout/gravel.
2A	Complete construction of, and operate, the WTP in its existing configuration; replace double-shell tanks in a phased manner, as each exceeds its design life.
2B	Supplement the existing WTP configuration with expanded low-activity waste vitrification capacity.
3A	Operate the WTP in its existing configuration; supplement WTP capacity with bulk vitrification treatment for a portion of the low-activity waste.[a]
3B	Operate the WTP in its existing configuration; supplement WTP capacity with cast stone treatment for a portion of the low-activity waste.[b]
3C	Operate the WTP in its existing configuration; supplement WTP capacity with steam reforming treatment for a portion of the low-activity waste.[c]
4	Operate the WTP in its existing configuration; supplement WTP capacity with a combination of cast stone and bulk vitrification treatment for a portion of the low-activity waste.
5	Supplement the existing WTP configuration with one additional low-activity waste melter at the WTP and a combination of cast stone and bulk vitrification treatment for a portion of the low-activity waste.
6A	Modify the WTP configuration through expanded high-level waste vitrification capacity to allow for processing of all waste as high-level waste; do not pretreat waste; build new double-shell tanks as the existing tanks reach the end of their design life.
6B and 6C	Supplement the existing WTP configuration with an expanded low-activity waste vitrification capacity including four additional low-activity waste melters at the WTP.

Source: DOE, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site*, Richland, Washington, DOE/EIS-0391 (Benton County, Washington: November 2012). | GAO-15-354

[a]The bulk vitrification process would convert low-activity waste (i.e., lower radioactivity waste) into solid glass by drying the waste, mixing it with Hanford soils, and applying an electric current within a large steel container (electrodes would be inserted into the waste and sand/soil mixture). Waste would be processed in vitrification boxes, which would cool for 3 days before being transferred to a disposal site.

[b]The cast-stone process would include treating a portion of the tank waste by mixing low-activity waste with grout-formers (e.g., Portland cement), pumping the mix into disposal containers, then allowing it to solidify into a cement matrix.

[c]In a steam-reforming process, pretreated waste or low-activity waste retrieved from the tanks would be diluted with water so it could be pumped into a vessel. Within the vessel, the water would be heated into steam, and the low-activity waste would be converted to granular minerals. Off-gases would be treated and discharged. The solid portion of the waste would be placed in steel packages for storage or disposal.

DOE Office of River Protection officials told us they plan to analyze other alternatives for meeting the mission—as defined by the narrow statements of mission need—before the two proposed projects receive CD-1 approval. However, without revising the statements of mission need for the two proposed projects to allow DOE the flexibility to explore a variety of alternatives without limiting potential solutions, as required by

DOE's project management order, the scope of alternatives analyzed will exclude consideration of other potential viable alternatives.

DOE's Preliminary Cost and Schedule Estimates for Constructing the Proposed Projects Cannot Be Considered Reliable

DOE's preliminary cost and schedule estimates for constructing the two new capital projects cannot be considered reliable because they do not meet best practices for reliable cost and schedule estimates. DOE estimates that constructing the Low Activity Waste Pretreatment System and the Tank Waste Characterization and Staging facility could, together, cost more than $1 billion and take from 6 to 8 years to construct. At the early phase of these projects, cost and schedule estimates are preliminary and considered rough-order-of magnitude; nevertheless, the cost and schedule estimates for these proposed projects cannot be considered reliable because DOE did not conform to best practices for reliable cost and schedule estimates.

DOE Estimates That the Proposed Projects Could Cost Over $1 Billion and Take 6 to 8 Years to Construct

DOE's Office of River Protection estimates that construction costs could range from $243 to $375 million for the Low Activity Waste Pretreatment System and from $390 to $690 million for the Tank Waste Characterization and Staging facility—for a potential combined total of $633 million to more than $1 billion—and that the facilities will take 6 to 8 years to complete. The costs of these proposed projects are not included in the approved cost of the WTP and instead are additions to it.[45] Because both projects are in the early stages of DOE's project management process,[46] their rough-order-of-magnitude cost and schedule estimates are based on preliminary information, consistent with DOE's project management order requirements for CD-0, and the estimates may change significantly going forward, according to the projects' CD-0 documents.[47]

[45]The WTP's approved total project cost is $12.3 billion, but DOE Office of Environmental Management capital project performance reports acknowledge that it will exceed this cost.

[46]As noted previously, the Low Activity Waste Pretreatment System received CD-0 approval in March 2014, and the Tank Waste Characterization and Staging facility's CD-0 approval is under review.

[47]According to DOE's project management order, a rough-order-of-magnitude cost estimate may underestimate a project's actual cost by as much as 75 percent or overestimate the cost by as much as 25 percent.

For the Low Activity Waste Pretreatment System, DOE estimated a cost range of $243 million to $375 million and a schedule estimate of 6 years from when CD-0 was approved in March 2014, with a completion date in 2020. According to DOE Office of River Protection officials, the cost estimate is a rough-order-of-magnitude estimate—as called for in DOE's project management order for projects at the CD-0 stage—and is based on an estimate from a 2010 CD-0 package for a project that would have provided similar capabilities. Tank farm contractor officials who developed the schedule estimate told us it was based on direction from the Office of River Protection to assume that the Low Activity Waste Pretreatment System would begin operations by 2020. In January 2015, DOE Office of River Protection officials told us that the current schedule estimate for the Low Activity Waste Pretreatment System shows that operations would begin in 2021.

For the Tank Waste Characterization and Staging facility, DOE estimated a cost range of $390 million to $690 million and estimated that it will take 6 to 8 years to construct, once CD-0 is approved, and if full funding is available. According to DOE Office of River Protection documents, the cost and schedule estimates are rough-order-of-magnitude ranges, as called for in DOE's project management order for projects at the CD-0 stage. In May 2014, DOE Office of River Protection officials told us that completing the project will likely take more than 10 years because criteria for the design of the facility depends on results from tests of the pulse-jet mixing vessels, and that testing is expected to take 3 years. According to documentation from the draft CD-0 package for the project, the cost estimate is based on prior estimates for projects with similar capabilities.[48] Specifically, the cost estimate is based on a CD-2 package from 2009 for the High Level Waste Feed Certification-Characterization Facility and on a CD-1 cost estimate for a similar capability, the Solids Segregation

[48]DOE adjusted the estimates from these previous projects to develop its current cost estimate in several ways. For example, it added a 2.5 percent annual adjustment factor to the earlier estimates and increased estimated costs of start-up operations and permitting based on historical experience with similar projects, according to Office of River Protection documents.

Facility, which was developed by the Office of River Protection in 2012.[49] Office of River Protection officials told us the schedule estimate was based on two different projects, which they said were also similar to the proposed facility—specifically, the Highly Enriched Uranium Materials Facility at the Y-12 National Security Complex in Tennessee and the Advanced Mixed Waste Treatment Project at the Idaho National Laboratory.

DOE's Cost and Schedule Estimates for the Proposed Projects Cannot Be Considered Reliable Because DOE Did Not Conform to Best Practices

We assessed DOE's cost and schedule estimates for the proposed projects and found that they do not conform to industry best practices and, consequently, cannot be considered reliable. DOE's estimates are rough-order-of-magnitude estimates, which are allowable under DOE's project management order requirements for projects at this critical decision point. However, DOE is using the estimates as the basis for budget requests and contract proposals, and industry best practices state that the estimates must meet the characteristics of reliability when used in this way.[50] We found that the rough-order-of-magnitude cost estimates do not comply with industry best practices, in large part because they excluded costs for key activities that the department knows it will incur if the projects are approved, and the rough-order-of-magnitude schedule estimates do not comply with industry best practices because key activities were not logically sequenced with other activities.

The characteristics of high-quality, reliable estimates as established by industry best practices are documented in our *Cost Estimating and Assessment Guide* and *Project Schedule Assessment Guide*.[51] These guides apply to cost and schedule estimates throughout a project's life cycle, including rough-order-of-magnitude estimates developed at project initiation. According to cost estimating best practices, four characteristics

[49]These facilities share some of the functions and requirements of a tank waste characterization and staging capability, but do not encompass all that would be expected of this capability, and they were never constructed. The High Level Waste Feed Certification-Characterization Facility was designed to include six tanks capable of holding 500,000 gallons each, located in a single vault facility. The Solids Segregation Facility was intended to reduce the size of waste particles, but the proposed project was never fully designed.

[50]Industry best practices state that rough-order-of-magnitude estimates should not be used as the basis for budget requests. See GAO-09-3SP.

[51]GAO-09-3SP and GAO-12-120G.

make up reliable cost estimates—they are comprehensive, well-documented, accurate, and credible. Similarly, according to project schedule best practices, four characteristics make up reliable schedule estimates—they are comprehensive, well-constructed, credible, and controlled (see table 3). Cost and schedule estimates are considered reliable if each of the four characteristics is substantially or fully met. If any of the characteristics is not met, minimally met, or partially met, then the estimates cannot be considered reliable.[52]

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

Characteristics of reliable cost estimates	
Comprehensive	A comprehensive cost estimate has enough detail to ensure that cost elements are neither omitted nor double counted.
Well-documented	A well-documented cost estimate allows for data it contains to be traced to source documents.
Accurate	An accurate cost estimate is based on an assessment of most likely costs and has been adjusted properly for inflation.
Credible	A credible cost estimate discusses any limitations because of uncertainty or bias surrounding data or assumptions.
Characteristics of reliable project schedule estimates	
Comprehensive	A comprehensive schedule 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 periodically to realistically forecast dates for activities.

Source: GAO. | GAO-15-354

Cost Estimates

For the cost estimates of both projects, DOE, in general, minimally met best practices. A detailed analysis of the extent to which DOE's cost estimates for the two proposed projects met the characteristics of reliable

[52]In our analysis, "not met" means an estimate provided no evidence that satisfied the best practice. "Minimally met" means an estimate provided evidence that satisfied a small portion of the best practice. "Partially met" means the estimate provided evidence that satisfied about half of the best practice. "Substantially met" means the estimate provided evidence that satisfied a large portion of the best practice. "Fully met" means the estimate provided complete evidence that satisfied the entire best practice.

and high-quality cost estimates is presented in appendixes I and II. See table 4 for a summary of the results of our assessment of DOE's cost estimates.

Table 4: GAO Assessment of DOE Cost Estimates

Characteristics of reliable cost estimates	Low Activity Waste Pretreatment System assessment	Tank Waste Characterization and Staging facility assessment
Comprehensive	Partially met	Minimally met
Well-documented	Minimally met	Partially met
Accurate	Minimally met	Minimally met
Credible	Minimally met	Minimally met

Source: GAO. | GAO15-354

DOE's estimate for the Low Activity Waste Pretreatment System did not meet all characteristics of a reliable cost estimate. For example, for the "comprehensive" characteristic, DOE Office of River Protection's cost estimate partially met the characteristic of a reliable estimate because the Office included descriptions of the work breakdown structure and certain assumptions used to develop the cost estimate. To fully meet the "comprehensive" characteristic, however, industry best practices state that an estimate—even a rough-order-of-magnitude estimate of a project at initiation—should fully account for all costs (i.e., all resources and associated cost elements required to develop, produce, deploy, and sustain a project) over the full life cycle of a project.[53] The Low Activity Waste Pretreatment System cost estimate does not include the following costs:

- costs for handling secondary waste that results from direct-feed of low-activity waste,
- costs to modify tank farm infrastructure to support direct-feed of low-activity waste,
- costs to modify tank farm documentation and permits to allow direct-feed of low-activity waste, and

[53]GAO-09-3SP.

- costs of additional infrastructure needed to implement the Low Activity Waste Pretreatment System project.

DOE Office of River Protection officials told us that estimates for the costs of handling secondary waste and for the additional infrastructure needed to implement the Low Activity Waste Pretreatment System are currently under development. According to DOE documents, modifications to tank farm infrastructure, documentation, and permits are estimated to cost at least $54 million. In addition to these costs, WTP contractor documents show that the engineering and permitting needed to modify the WTP's Low Activity Waste facility to accept direct-feed of low-activity waste are estimated to cost nearly $96 million. Furthermore, a January 2015 report to DOE Office of Environmental Management senior officials stated that DOE's Office of Acquisition and Project Management conducted an independent cost estimate for the Low Activity Waste Pretreatment System and identified a number of additional risks that would likely increase the cost range.

DOE's estimate for the Tank Waste Characterization and Staging facility also did not meet all characteristics of a reliable cost estimate. For example, for the "comprehensive" characteristic, DOE Office of River Protection's cost estimate minimally met the characteristic of a reliable estimate because it does not include all costs. Specifically, the estimate does not include the costs of installing and modifying waste transfer lines to connect the tank farms to the proposed facility and to connect the proposed facility to the WTP.[54] DOE Office of River Protection officials told us they do not have estimates for the costs of these additional activities. Notably, in April 2014 DOE's Office of Acquisition and Project Management determined that the Tank Waste Characterization and Staging facility cost estimate was not credible. Acquisition and Project Management officials recommended that the project be classified as a major system project—a type of capital project with an estimated total cost of at least $750 million and subject to oversight requirements, such as independent cost reviews, that are stricter than those for projects with

[54]In reviewing Office of River Protection documents, we also found that the estimate is based on the costs of other projects with some similar capabilities, but in updating the estimates Office of River Protection officials either did not correctly adjust for inflation or did not adjust for it at all.

lower costs.[55] Further, officials from DOE's Office of Environmental Management estimated that the Tank Waste Characterization and Staging facility would cost from $1 billion to $1.5 billion. Officials from the Office of River Protection, however, told us they decided not to classify the Tank Waste Characterization and Staging facility as a major system project because their cost estimate adhered to requirements in DOE's project management order for the CD-0 stage.

As we have found in the past, reliable cost estimates provide a basis for accurate budgeting and effective resource allocation, which increases the probability of a project's success in meeting its goals.[56] Office of River Protection officials told us that some characteristics that are not met in the current rough-order-of-magnitude estimates will be included as the projects move forward. They added that rough-order-of-magnitude estimates are appropriate for projects at CD-0, per DOE's project management order. However, because DOE is using these cost estimates as the basis for budget requests and contract proposals, industry best practices state that all characteristics must be fully met, regardless of whether they are rough-order-of-magnitude estimates. Notably, in 2014, we found that DOE's cost estimating requirements and guidance for projects generally do not reflect industry best practices for developing cost estimates.[57] Specifically, none of the cost estimating requirements in DOE's project management order, such as the need for a cost estimate at each CD stage, ensures that project cost estimates will be prepared in accordance with cost estimating best practices. Without reliable estimates that include all costs to implement the projects, the Office of River Protection is potentially committing DOE to a course of action that will require significant yet undisclosed future resources.

Schedule Estimates

DOE, in general, partially met industry best practices in estimating the schedule for the Low Activity Waste Pretreatment System. We were

[55]Office of Acquisition and Project Management officials told us they reached this conclusion after they compared documentation of the Office of River Protection's cost estimate with best practices in GAO's *Cost Estimating and Assessment Guide*, GAO-09-3SP.

[56]GAO, *Modernizing the Nuclear Security Enterprise: NNSA's Reviews of Budget Estimates and Decisions on Resource Trade-Offs Need Strengthening,* GAO-12-806 (Washington, D.C.: July 31, 2012).

[57]GAO-15-29.

unable to assess the reliability of DOE's schedule estimate for the Tank Waste Characterization and Staging facility because the Office of River Protection has not yet prepared detailed schedule documents for the project. See appendix III for our detailed analysis of DOE's Low Activity Waste Pretreatment System schedule estimate against industry best practices.

DOE's Office of River Protection schedule estimate for the Low Activity Waste Pretreatment System partially met one characteristic for a high-quality, reliable schedule estimate. For our assessment of the schedule estimate for the Low Activity Waste Pretreatment System, we considered only the "well constructed" characteristic of DOE's estimate because the technical points addressed through the "well constructed" characteristic were sufficient to establish a sound basis for the purposes of reliably calculating date forecasts for the project and were appropriate for what can be expected at this stage in project development. A schedule is considered well-constructed if, for example, all its activities are sequenced with the most straightforward logic possible—that is, activities should be listed in the order in which they are to be carried out. The schedule estimate partially met the well-constructed characteristic because the critical path appeared to be a straightforward, continuous path of activities through 2022. Our analysis found, however, that the Low Activity Waste Pretreatment System's schedule did not fully meet the characteristic of a well-constructed estimate because, among other things, the schedule had numerous missing or incorrect logic links, and it did not link to schedule activities in the time frame from 2027 to 2030. We found that over 70 percent of the activities in the schedule are not logically sequenced with other activities—34 detailed activities did not include a relationship to their predecessor activities, 33 detailed activities did not include relationships to successor activities, and 14 detailed activities did not include relationships to predecessor or successor activities.[58] As one example, before commissioning a nuclear facility, DOE must ensure that a documented safety analysis has been prepared that analyzes the extent to which a nuclear facility can be operated safely with

[58]According to GAO's Schedule Assessment Guide, logical relationships between activities identify whether activities are to be accomplished in sequence or parallel. Activities that are logically related within a schedule are referred to as predecessors and successors. A predecessor activity must start or finish before its successor. As a general rule, every activity within the schedule should have at least one predecessor and at least one successor. Incomplete logic inhibits the schedule from correctly forecasting start and end dates of activities within the plan. See GAO-12-120G.

respect to workers, the public, and the environment, including a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety. The contractor must generally prepare a preliminary documented safety analysis before construction begins—in essence, verifying that a facility's design complies with nuclear safety requirements.[59] Predecessor activities to a safety analysis, including the safety evaluation report, are often multimonth or multiyear efforts that must be carried out in sequence and across various phases of a project's life cycle, but DOE's schedule documents do not logically link these activities in sequence. Without the logical sequencing of activities within the schedule estimate, activities that slip do not transmit delays to activities that depend on them.[60]

We were unable to assess the schedule estimate for the Tank Waste Characterization and Staging facility because DOE did not provide us with documentation to support the estimate. Office of River Protection officials told us they developed the schedule estimate based on officials' experience with similar projects. For example, Office of River Protection officials told us the department has built comparable capital projects within 8 years—specifically, the Highly Enriched Uranium Materials Facility at the Y-12 National Security Complex in Tennessee and the Advanced Mixed Waste Treatment Project at the Idaho National Laboratory. However, the Highly Enriched Uranium Materials facility does not include waste treatment capabilities that are comparable to DOE's proposed project because it is a receiving, shipping, and storage building for nuclear material. The second facility is not meeting its expected cost and schedule targets because it cannot function as intended. More specifically, as we found in 2008, the waste processing rate for the second facility fell short of projected rates. DOE subsequently revised its

[59]According to DOE's nuclear safety regulation, the contractor must also prepare a preliminary documented safety analysis before the contractor can procure materials or components or begin construction; provided that DOE may authorize the contractor to perform limited procurement and construction activities without approval of a preliminary documented safety analysis if DOE determines that the activities are not detrimental to public health and safety and are in the best interests of DOE.

[60]In January 2015, officials from DOE's Office of River Protection told us that, now that the project is approaching CD-1 approval, the schedules are more developed.

design to reflect a more realistic rate, adding 4 years to the project schedule and increasing costs by about $450 million.[61]

According to officials from DOE's Office of River Protection, the schedule estimates for the two projects are not required to have robust estimates at this stage, per the department's project management order. They said that some characteristics of high-quality schedule estimates will be reflected as the projects move forward. However, without reliable schedule estimates that contain logically sequenced activities, the Office of River Protection is potentially committing DOE to project time frames it may be unable to meet.

The WTP Project Continues to Face Significant Technical and Management Challenges

DOE continues to face significant technical and management challenges with the WTP project, which hinder its completion. Technical challenges have significantly affected, and continue to affect, the Pretreatment facility and the High Level Waste and Low Activity Waste facilities. In addition, recent internal and external assessments show that management challenges, such as those with the contractor's design management and quality assurance programs, continue to affect the WTP.

Technical Challenges Continue

Technical challenges with the WTP's Pretreatment facility, High Level Waste and Low Activity Waste facilities persist. In 2012, when we last reported on the WTP's technical challenges, we found that DOE had not resolved technical challenges with pulse-jet mixing and with erosion and corrosion of piping, among others, particularly at the Pretreatment facility and High Level Waste facility.[62] Since our last report, internal and external assessments show that these and other technical challenges persist. DOE's project management order directs its Office of River Protection to employ two risk mitigation strategies for design-build projects encountering technical challenges, but the office has not always employed both strategies for each facility.

Recent internal and external assessments show that technical challenges continue at the Pretreatment facility and the High Level Waste and Low Activity Waste facilities.

[61]GAO, *Nuclear Waste: Action Needed to Improve Accountability and Management of DOE's Major Cleanup Projects,* GAO-08-1081 (Washington, D.C.: Sept. 26, 2008).

[62]GAO-13-38.

- **Pretreatment Facility.** Since we last reported on the Pretreatment facility's technical challenges, an external assessment found that some of these same challenges persist. As we last reported in 2012, the Pretreatment facility's technical challenges included pulse-jet mixing, erosion and corrosion of piping, and buildup of explosive gases (e.g., hydrogen), which prompted DOE to suspend engineering, procurement, and construction. To address the technical challenges with the facility, in November 2012 the Office of River Protection formed a design completion team composed of subgroups responsible for resolving each major technical challenge. For example, to address the technical challenges associated with the pulse-jet mixing vessels, the design completion team developed a plan to standardize and test a new design to address pulse-jet mixing challenges, but Office of River Protection officials told us they do not know how long it will take to implement this plan, and they could not yet estimate the potential effects on the cost and schedule for completing the facility. According to these officials, resolving the technical challenges will likely result in changed designs for the Pretreatment facility and significant rework, leading to cost increases and schedule delays. In December 2013, the Consortium for Risk Evaluation with Stakeholder Participation reviewed the design completion team's pulse-jet mixing vessel test plan and found that the design, design verification, and operations of the Pretreatment facility were unresolved and were impeding progress in resolving issues with the pulse-jet mixing vessel design.[63] Specifically, the review found that DOE did not have a clear strategy for ensuring that the pulse-jet mixing vessel design would meet nuclear safety requirements.

- **High Level Waste facility.** Since we last reported on the High Level Waste facility's technical challenges, an internal assessment found that some of these challenges remain and new ones have emerged. As we last reported in 2012, the High Level Waste facility's technical challenges included pulse-jet mixing performance and hydrogen buildup in piping and vessels, among others, which prompted DOE in 2012 to largely suspend engineering, procurement, and construction of the facility. In 2013, DOE's Office of River Protection commissioned a design review of 12 out of 24 technical systems in the High Level Waste facility to inform DOE's decision on whether to resume

[63]Consortium for Risk Evaluation with Stakeholder Participation, *CRESP WTP PTF Technical Issues Review Team, Letter Report 1* (Nashville, TN: Dec. 2, 2013).

engineering, procurement, and construction activities. The review was to provide DOE with information on the design and operability of key High Level Waste facility mechanical and process systems. In May 2014, the review team—composed of engineering experts from 11 companies with extensive experience in nuclear facility design and radiochemical engineering and process operations—reported that all 12 systems reviewed were at risk of failure and required either further design or additional engineering studies.[64] According to the review report, all 12 reviewed systems had vulnerabilities that, if unmitigated, have a potential to impact timely start-up of facility operations and production efficiency. For example, the review report identified problems with the facility off-gas containment ventilation system—such as the likely failure of filters, design requirements that would not meet the fire code, and the inaccessibility of components such as gaskets that require routine replacement—that could undermine the system's ability to confine radioactive and hazardous gases.[65, 66]

- **Low Activity Waste facility**. Since we last reported on the Low Activity Waste facility's technical challenges, an internal assessment found that some of these challenges remain and new ones have emerged. Preliminary information from a review of the Low Activity Waste facility that DOE conducted in 2014 shows that technical challenges affect this facility as well, which may require hundreds of millions to solve. In February 2014, DOE initiated a design review of 13 of 26 of the systems in the Low Activity Waste facility.[67] According to DOE documents, preliminary results show that the review team—composed of 34 experts from 14 companies in the commercial nuclear energy industry—identified 536 vulnerabilities within the 13

[64]Radiochemistry is the chemistry of radioactive materials.

[65]An off-gas system is a ventilation system used to confine radioactive and hazardous gases so that personnel are protected, and to treat the gases to remove radioactive and hazardous components to protect personnel, the public, and the environment.

[66]In a February 2, 2015 letter to DOE, the DNFSB also expressed concerns that the design of the High Level Waste facility ventilation system may not protect workers and the public from exposure to contamination in the event of a seismic accident.

[67]According to a preliminary briefing from the review, the final report was to be completed in December 2014. In January 2015, the Office of River Protection told us that the report issuance could be delayed until the second quarter of fiscal year 2015. The officials told us that the 13 systems not selected for review were determined to be low risk and will be reviewed by the contractor as the design and safety basis for the Low Activity Waste facility is completed.

systems reviewed, 110 of which could result in “severe consequences” to system operability. For example, the review found that radioactive contamination may spread because the contractor eliminated secondary contamination confinement zones, which were to serve as buffer in the event of a leak.

DOE’s project management order directs its Office of River Protection to employ, among other things, two risk mitigation strategies for design-build projects encountering technical challenges, and while the office appears to have employed one of them, it has not employed the other at each facility. First, the order requires DOE to increase technical oversight. Second, the order requires DOE to employ aggressive risk mitigation strategies to address all technical uncertainties. The Office of River Protection appears to have fulfilled the first requirement for each facility—and has also employed an aggressive risk mitigation strategy for the Pretreatment facility—but the office has not developed aggressive risk mitigation strategies that address all technical uncertainties at the High Level Waste and Low Activity Waste facilities, as required by the department’s project management order.

For the Pretreatment facility, the Office of River Protection increased technical oversight and employed an aggressive risk mitigation strategy by instituting a design completion team charged with resolving each major technical challenge and suspending construction on the facility until technical challenges are resolved. Office of River Protection documents state that the design completion team has developed a plan to standardize and test a new design to address pulse-jet mixing challenges. In addition, DOE employed an aggressive risk mitigation strategy by halting engineering, procurement, and construction on the facility until the design completion team resolves the technical challenges.

For the High Level Waste facility, the Office of River Protection increased technical oversight in part by commissioning the 2013 design review of half of the facility’s systems, but the office has not directed the contractor to employ aggressive risk mitigation strategies, including those recommended by the review. For example, the review recommended, among other things, that DOE review the remaining technical systems in the High Level Waste facility. As of January 2015, DOE had not reviewed the remaining systems, and Office of River Protection officials told us they

have no plans to do so.[68] Furthermore, in August of 2014, DOE authorized the contractor to resume all engineering work to finalize the design of the High Level Waste facility and to resume limited procurement and construction activities, even though the technical challenges identified in the 2013 design review have not been resolved. Office of River Protection officials told us that they directed the contractor to resume these activities because the office has completed engineering studies that will allow the office to develop a specific plan for resolving the technical issues with the High Level Waste facility within 2 years.[69]

For the Low Activity Waste facility, the Office of River Protection increased technical oversight by commissioning the February 2014 design review of half the facility's systems. As of January 2015, the department has not released the final report or communicated the risk mitigation strategies it plans to employ to address the technical challenges identified in the review. As stated earlier, the draft review report identified weaknesses in the design of the facility's ventilation system, which could result in inadequate confinement of radioactive gases. DOE does not know the potential level of radiation exposure to operations and maintenance personnel should such a leak occur, according to the February 2014 review. Office of River Protection documents show that problems with the Low Activity Waste facility's confinement ventilation system may significantly affect the cost and schedule of the Low Activity Waste facility. While DOE has not established a cost estimate for resolving the technical challenges identified in the review, the department acknowledged that the contractor estimated the cost may range from $10 million to $928 million to address the issues identified in the review, with $525 million being the most likely scenario, according to contractor documents.[70] DOE headquarters officials told us that the numbers in the upper range of the estimate reflect

[68]Office of River Protection officials told us that the contractor informed them that it will review the remaining systems.

[69]See U.S. Department of Energy response to Washington's Petition to Modify Consent Decree, filed December 5, 2014.

[70]In addition to the February 2014 review of half the facility's systems, in October 2014, the contractor submitted a contract modification proposal to address all risks to completing the Low Activity Waste facility. This contract modification proposal estimated the contractor needed between $151 million and $2 billion. This range estimate included the cost to address the issues identified in the February 2014 Low Activity Waste facility design review.

the costs of mitigating all risks. They added that, in all likelihood, not all risks will be realized, so mitigating some of the risks may not be necessary. In February 2015, Office of River Protection officials told us that they would not review the facility's remaining systems because they determined them to be low-risk. They told us that these systems will instead be reviewed by the contractor as the contractor continues designing the facility.[71]

Notably, DOE's project management order states that construction of nuclear facilities should not begin until engineering and design work is essentially complete, and technologies have been tested and proven to work.[72] By continuing construction activities without employing aggressive risk mitigation strategies, DOE has limited assurance that technical challenges will be solved or mitigated without significant rework.

[71]On September 30, 2014, the WTP contractor submitted a contract modification proposal to DOE's Office of River Protection that includes revised cost estimates to complete the Low Activity Waste facility (including the modifications needed to accept direct feed of low-activity waste), the Analytical Laboratory, and the Balance of Facilities. According to the proposal, the cost for this work is about $3.7 billion, including the contractor's fee, which is in addition to the $151 to $2 billion the contractor estimated it may need to address risks facing the Low Activity Waste facility. According to DOE headquarters officials, these costs are estimates developed by the contractor that have not been validated or accepted by DOE. The department has not agreed to these estimated costs. Additionally, the department has not concurred with or agreed to the inputs that form the basis of these estimates. It is possible that the cost estimate reflects the contractor's negotiation strategy and may not accurately reflect estimates for the scope of work and the terms ultimately agreed to in the final modification. DOE headquarters officials told us that, once the proposed contract modification to implement this initial phase is negotiated, a proposed baseline change will be presented to the Secretarial Acquisition Executive for approval. The deliberations for the proposed baseline change will include the preparation of an External Independent Review. Once the proposed baseline change is approved, the contract modification will be executed by the contracting officer. The proposed baseline change is expected to be prepared in the second quarter of fiscal year 2016. The preparation of a contract modification and subsequent proposed baseline change for the High Level Waste facility and the Pretreatment facility will be performed in the future.

[72]DOE measures technology readiness using Technology Readiness Levels, which range from 1 to 9; where 9 represents a fully tested and proven technology. DOE guidance indicates that critical technologies should be at Technology Readiness Level 6 or higher before construction begins. However, in 2007, the last time DOE assessed Technical Readiness Levels for the entire WTP project, DOE found that 14 out of 21 critical technologies assessed were at a Technology Readiness Level lower than 6.

Design and Quality Assurance Challenges Continue

DOE continues to face management challenges at the WTP. In 2012, when we last reported on the WTP's management challenges, we found, among other things, that DOE had encountered challenges ensuring that the design of WTP facilities complied with nuclear safety requirements. Since that time, internal and external assessments show that management challenges persist, particularly with the WTP contractor's design management and quality assurance programs—two programs that are intended to ensure that nuclear safety requirements are met.

Contractor's Design Management Program

Challenges with the WTP contractor's design management program continue. The contractor's design management program is intended to ensure that the design of WTP facilities meets nuclear safety requirements. In December 2012, when we last reported on management challenges at the WTP, we found that the contractor's preliminary documented safety analyses had not always kept pace with the frequently changing designs and specifications for the WTP facilities.[73] At that time, officials from DOE's Office of Environmental Management told us that the contractor had identified the reasons for the continuing misalignment between the preliminary documented safety analysis and the facility design and had taken actions to address the challenges. In addition, the officials said that they had established a safety basis review team to review the documented safety analysis for each WTP facility to ensure that the facilities' designs meet DOE's nuclear safety requirements. However, our review of internal and external assessments of the WTP conducted by DOE, the contractor, and others since our last report, along with our review of data in the contractor's corrective action management system, shows that the contractor's design management program has not always been effective in ensuring that WTP facilities' designs meet nuclear safety requirements.

Internal and external reviews conducted since our last report, as well as our review of contractor data, found that challenges continue with the contractor's design management program, particularly in ensuring that the designs of WTP facilities meet nuclear safety requirements. For example,

- In 2013, DOE's Office of Inspector General reported significant shortcomings in the Office of River Protection's oversight of the WTP

[73]GAO-13-38.

design process.[74] The Inspector General found that the Office of River Protection had not ensured that design changes for the WTP were appropriately approved and adequately documented. Specifically, the contractor approved design changes to waste processing equipment without obtaining the required safety review to determine the impact of the changes on the safety of the facility. The Inspector General concluded that there were significant shortcomings in the Office of River Protection's process for managing the procurement of waste processing equipment for the WTP.

- We reviewed data from the contractor's corrective action management system—which is intended to document and manage resolution of adverse conditions and issues that warrant management attention—and found that, as of June 2014, there were 164 project issues deemed significant, according to DOE, for which corrective actions had not been completed. Office of River Protection officials told us that, in their view, this number of issues is generally consistent with what would be expected for a nuclear facility construction project of this scope and duration. According to DOE's classification of these issues, 15 project issues, if uncorrected, could have serious effects on safety or operability.[75] Notably, three significant issues regarding the design of the Pretreatment facility and High Level Waste facility first reported October 2011—which ultimately led to DOE suspending work

[74]DOE, Office of Inspector General, *DOE/IG-0894 Department of Energy Quality Assurance: Design Control for the Waste Treatment and Immobilization Plant at the Hanford Site* (Washington, D.C.: Sept. 30, 2013).

[75]In the contractor's corrective action management system, project issues are identified through Project Issue Evaluation Reports. Within this system, project issues are rated as Level A, B, C, or D. Level A issues are the most serious and are defined as performance issues that, if uncorrected, could have serious effects on safety or operability. In other words, it is (1) a performance issue that directly or indirectly resulted in, or could result in, a major event or systemic breakdown in safety or quality; or (2) an issue that identifies or could have a serious effect or impact on quality, worker health or safety, operability, the public, the environment, facility operations, or regulatory compliance. A Level B project issue is also a serious issue that indicates an adverse condition such as a noncompliance or breakdown of a management system. Of the 1,238 issues reported in the WTP contractor's corrective action management system, 15 were classified as Level A issues, 149 were Level B issues, 796 were Level C issues, and 278 were Level D issues.

at the facilities—are still unresolved, and 12 additional, significant findings of shortcomings have since been reported.[76] For example,

- According to one project issue report, an engineering review found that the contractor had designed the ventilation system for the Low Activity Waste facility's vitrification melters in such a way that any pinhole leak in the system would cause fatal concentrations of gases to be released, in a matter of seconds, into an area occupied by people.[77]

- Another project issue reported by WTP engineers noted that, contrary to industry best practices, the contractor had not established a design and safety margin management program, and engineers identified multiple examples where the design and safety margins were inadequate.[78] According to the report, the absence of a design and safety margin management program has resulted in technical problems and in acceptance of poorly or undocumented evaluations of design margin and, consequently, has resulted in a design for the facility that does not adequately address potential hazards to workers, the public, or the environment.[79]

[76]According to the Office of River Protection Quality Assurance Program Manual, issues may be classified as significant based on the significance, severity, and potential impact of the problem on the safety, security, operability, and mission of the Office of River Protection. A significant condition adverse to quality includes such things as deficiencies in design, manufacturing, construction, testing, or process requiring substantial rework, repair, or replacement; or repeated failure to implement a portion of an approved procedure, among others.

[77]Melters are containers within the Low Activity Waste and High Level Waste facilities that heat mixtures of waste and glass-forming material with electrical current for several days to form molten glass, which is then poured into stainless steel containers to cool and harden.

[78]Proper design and safety margin management means to account for all possible safety hazards in the design of the facility to ensure that the facility can be operated safely in a manner that adequately protects workers, the public, and the environment.

[79]The WTP contractor did not view all of the examples cited by DOE as margin management issues and submitted a corrective action plan including their analysis of the issues cited by DOE (Attachment 4 to CCN 251466). DOE did not fully agree with the contractor's analysis (corrective action plan was not accepted, letter 13-WTP-0015) and the contractor acknowledged that fact in their analysis. DOE and the WTP contractor continued to work on an adequate path forward to address the issues through multiple revisions to the WTP contractor proposed corrective action plan.

- In other project issue reports, WTP engineers identified significant problems with the design of remotely operated mechanical arm systems used in the Low Activity Waste facility. One report stated that modifications were needed to the design of equipment and that some equipment that had already been procured and installed required modification or replacement. In October 2014, the contractor submitted a contract modification proposal for the Low Activity Waste facility to address this and other risks facing the facility, estimating it needed $427 million to mitigate these risks.[80] This contract modification proposal is being reviewed by the Office of River Protection.

- The contractor's preliminary documented safety analyses may continue to be based on outdated facility designs.[81] In December 2012, we reported that these required analyses had not kept pace with facility design for some project facilities and, as a result, we recommended that DOE avoid resuming construction on two facilities—the Pretreatment facility and High Level Waste facility—until, among other things, the department addressed the misalignment between preliminary documented safety analyses and facility

[80]This amount is in addition to the $525 million the contractor estimates it needs to address issues identified in the 2014 Low Activity Waste facility review. The contractor's October 2014 contract modification proposal stated that it would cost from $151 million to $2 billion to mitigate the risks to the Low Activity Waste facility, with $952 million the most likely scenario.

[81]According to DOE's nuclear safety regulation, preliminary documented safety analysis means documentation prepared in connection with the design and construction of a new DOE nuclear facility or major modification to a DOE nuclear facility that provides a reasonable basis for the preliminary conclusion that the nuclear facility can be operated safely through the consideration of factors such as (1) the nuclear safety design criteria to be satisfied; (2) a safety analysis that derives aspects of design that are necessary to satisfy the nuclear safety design criteria; and (3) an initial listing of the safety management programs that must be developed to address operational safety considerations.

designs.[82] In December 2014, the DNFSB reported that the contractor's approach for updating the preliminary documented safety analysis for the High Level Waste facility may not ensure that certain aspects of the design ultimately meet nuclear safety regulatory requirements.[83] In a still ongoing investigation initiated in 2012 by DOE's Office of Health, Safety, and Security, officials reviewed project issues reported by the contractor and by the Office of River Protection and identified a significant number of deviations from DOE nuclear safety requirements by the contractor.[84] Specifically, in a November 2012 draft report prepared as the investigation progressed, DOE's Office of Health, Safety, and Security identified differences between the WTP facilities' preliminary documented safety analyses and facility designs. The draft report stated that these resulted in part from contractor procedures that were either inadequate or not followed. In a March 2014 letter to the Office of River Protection, the contractor disputed the draft report's conclusions. As of February 2015, the Office of Health, Safety, and Security had not issued the final report because it, along with the contractor's response, is still under review by agency officials.

DOE's nuclear safety management regulation requires that, in connection with the design of a new DOE nuclear facility, the contractor prepares a preliminary documented safety analysis to provide a reasonable basis

[82]Under DOE's nuclear safety regulations, the contractor was required to obtain DOE approval of a preliminary documented safety analysis for each WTP facility before procuring materials or components or beginning construction. A preliminary documented safety analysis documents the reasonable basis for a preliminary conclusion that the facility can be operated safely. The purpose of the preliminary documented safety analysis and associated documentation is to ensure that the directions and decisions made regarding project safety are explicitly identified and dealt with in early stages of design, and to reduce the likelihood of costly late reversals of design decisions involving safety. The preliminary documented safety analysis serves as a basis for the design safety analysis which, in turn, serves as a license to operate the facility in a safe and effective manner. DOE's project management order requires the contractor to submit preliminary documented safety analyses as part of the CD-3 approval package. DOE approved the CD-3 package for the WTP in April 2003.

[83]Letter from the DNFSB to Mark Whitney, December 5, 2014. In April 2012, the contract was modified to require the contractor develop, and DOE approve, a procedure to implement a program to keep the preliminary documented safety analyses current. DOE did not provide information on whether it has approved this procedure.

[84]DOE's Office of Health, Safety, and Security is now known as the Office of Enterprise Assessments. The requirements are contained in 10 C.F.R., Part 830, Subpart A, Quality Assurance Requirements and 10 C.F.R., Part 830, Subpart B, Safety Basis Requirements.

that the facility can be operated safely. This analysis should include, among other things, the nuclear safety design criteria to be satisfied. In addition, under the WTP construction contract, the contractor is responsible for ensuring that the design of each WTP facility meets nuclear safety requirements, and DOE is responsible for managing and overseeing the contractor's design of the facility.[85] Office of River Protection officials told us that in 2012 they directed the contractor to resolve design management challenges, specifically requiring the contractor to align WTP design with nuclear safety requirements. According to Office of River Protection officials, the contractor's efforts in this regard are in progress, but the contractor has not yet resolved the design management challenges, and Office of River Protection officials could not provide us with an estimated time frame for their resolution. Also, under the WTP construction contract, DOE can employ aggressive strategies to ensure that the contractor meets DOE and contract requirements. Specifically, DOE may employ an owner's agent to assist with managing the project, including design management. An owner's agent would not necessarily take design authority and responsibility away from the contractor but could assist DOE with reviewing and evaluating contractor design documents and have authority to challenge the contractor's approach to mitigating design challenges within the WTP, according to DOE documents.[86]

Noting DOE's long-standing challenges overseeing the design of the WTP, in 2011 DOE's Office of Environmental Management Tank Waste

[85]Specifically, the WTP construction contract states, "DOE is responsible as the '*Owner*' and '*Regulator*' of the WTP. As the Owner, DOE will establish requirements, administer the Contract, and confirm that the Contractor meets Contract requirements." WTP Contract No. DE-AC27-01RV14136, Section C. 3(b). Conformed Through Modification No. 344.

[86]According to DOE documents, an owner's agent or equivalent can participate in formal multidiscipline reviews at appropriate levels of engineering, procurement, construction and commissioning maturity, thereby increasing confidence in the design and operability of the WTP and reducing life-cycle risk to DOE by ensuring design adequacy. The long-term operator or owner function typically creates a healthy tension within the project and ensures appropriate decisions are made regarding the impact to capital cost and schedule versus lifetime cost. If not adequately addressed, some decisions—made in the interests of short-term goals and milestones rather than long-term operability—can result in major and lasting impact to the viability of the facility mission. DOE places importance on safety being incorporated into the design, but it is just as critical that operations be factored into the design process to achieve life-cycle cost savings. It is imperative that safety and operability are integrated into the design to achieve mission goals.

Subcommittee recommended to the Environmental Management Advisory Board that DOE employ an owner's agent to assist DOE with overseeing the contractor. According to the subcommittee report, an owner's agent is needed at the WTP to strengthen project management and contract administration because DOE has insufficient numbers of skilled manpower and subject matter experts to manage the risks posed in design and construction.[87] Office of River Protection senior officials, however, told us they do not believe an owner's agent with such authority and expertise is needed because they use external reviews when they believe such assistance is needed, as evidenced by their High Level Waste and Low Activity Waste facility design and operability reviews. They added that it would be difficult to find an external owner's agent that could be effective in the design authority role in a relatively short time frame. Nevertheless, Office of River Protection documents show that substantial work remains throughout the WTP facilities, and the office's schedule estimates show that partial WTP start-up is at least 7 years away. Without an owner's agent or similar independent entity responsible for verifying that the design for the WTP meets operability requirements for nuclear facilities before design progresses, challenges with the contractor's design management program may continue and result in portions of facilities' design either being unchecked or progressing significantly before problems are identified and require rework.

Contractor's Quality Assurance Program

Challenges with the contractor's quality assurance program also continue. The contractor's quality assurance program is intended to ensure that the contractor's work activities are performed in accordance with nuclear safety requirements. When NRC last reported in 2008 on the WTP contractor's quality assurance program, it found that the contractor did not always demonstrate that it met contractual quality assurance requirements and processes. Recent internal reviews and reports show that, since that time, the WTP contractor's quality assurance program has not always ensured that the contractor has met the department's quality assurance requirements.

[87]The Environmental Management Advisory Board is to provide advice and recommendations to the Assistant Secretary for Environmental Management concerning issues affecting the Environmental Management program, such as site cleanup and risk reduction of the Environmental Management program including, but not limited to, project management and oversight, cost/benefit analyses, program performance, human capital development, and contracts and acquisition strategies. It consists of representatives from industry, academia, government, and nongovernmental organizations.

DOE's quality assurance regulations for DOE nuclear facilities state that the contractor must conduct work in accordance with quality assurance criteria, including, among other things, identifying, controlling, and correcting items, services, and processes that do not meet established requirements, as well as identify the causes of problems to prevent recurrence.[88] DOE Office of River Protection's quality assurance policy requires that corrective actions to address 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, the Office of River Protection's quality assurance policy allows the office to call for a suspension of work if the quality of work is open to question.[89] Noting DOE's challenges with the contractor's quality assurance program, in December 2012, WTP's then Engineering Division Director recommended that DOE conduct an extent-of-condition review for all facilities to understand the extent to which the breakdown in quality had affected the project. At that time, the office had stopped or slowed construction on portions of the WTP. Instead of conducting an extent-of-condition review, the Office of River Protection directed the contractor to implement measures to minimize the potential for rework and develop corrective actions.

Recent DOE reviews and reports, however, continue to show that the WTP contractor's quality assurance program has not always met the department's quality assurance requirements, even with the contractor's corrective actions. For example,

- In 2013, an audit by DOE's Office of Inspector General found that the department's oversight of the contractor's quality assurance program lacked focus and noted that the depth and breadth of the department's oversight was not sufficient to identify weaknesses in the implementation or adequacy of the contractor's quality assurance procedures. The Inspector General reported that the WTP contractor approved design changes requested by suppliers without conducting required safety reviews to determine the impact of the changes on the

[88]10 C.F.R., Part 830.

[89]DOE, Office of River Protection, *Quality Assurance Program Description* MGT-PM-PL-04, Revision 3. The policy does not specify criteria for when such a suspension should occur or how long it should last.

safety of the WTP project. For example, the contractor had approved action to repair a Low Activity Waste facility melter lid that did not meet design specifications. Early in the audit, the Inspector General brought this issue to the attention of the Office of River Protection and the contractor. In response, the contractor reviewed a sample of 235 of 4,028 supplier design documents spanning a 3-year period. In doing so, the contractor discovered that more than a third of the changes made to supplier documents had not received the required nuclear safety review and approval. As a result of this audit, the Office of Inspector General concluded that the contractor's process for verifying and accepting items from suppliers was not fully effective in ensuring that products met quality assurance requirements for nuclear safety.[90]

- In response to the 2013 Office of Inspector General report, in October 2013 the Office of River Protection's Quality Assurance Division undertook a broad review of the WTP contractor's quality assurance and corrective action programs and found that they were not fully effective. Specifically, DOE Office of River Protection quality assurance engineers found that the contractor's overall quality assurance program and corrective action programs were not implemented in accordance with nuclear safety requirements.[91] For example, the engineers found that the contractor's procedures to ensure that suppliers performed adequate inspections, examinations, and tests on components were insufficient. In a subsequent analysis conducted by the contractor to identify the root causes of the ineffective quality assurance and corrective action programs, the contractor concluded that the project's engineering, procurement, and

[90]DOE headquarters officials told us that they concurred with the DOE Inspector General's recommendations and indicated, in some cases, that they had already taken actions to address specific weaknesses identified in the audit report. In other instances, DOE detailed steps it planned to take to address the remaining concerns. The DOE Inspector General stated DOE management's comments and planned corrective actions were fully responsive to its findings and recommendations. DOE continues to conduct corrective actions to address the issues identified in the report.

[91]Office of River Protection, *Bechtel National, Inc. Quality Assurance Program Requirements 3, 4, 7, 8, 15, and 16; Report U-13-QAT-RPP-WTP-001* (Richland, WA: Oct. 7, 2013).

construction processes were not designed or intended to support nuclear construction quality requirements.[92]

In October 2013, DOE's Office of River Protection directed the contractor to develop a Managed Improvement Plan to address all systemic quality assurance program and implementation issues and required that the contractor implement the plan within 2 years. Officials from the Office of River Protection's Quality Assurance Division told us that the contractor is still developing the plan. They added that they expect to conduct reviews of the plan and associated corrective actions as the contractor develops and implements it. In January 2015, DOE Office of River Protection officials told us that the Managed Improvement Plan is to be a compilation of corrective actions and that many of the actions to be identified in the plan have already been completed or are in the process of being completed by the contractor.

Notwithstanding the contractor's ongoing efforts to develop a plan to identify all corrective actions it needs to take to address systemic quality assurance problems, engineering, procurement, and construction continue at most WTP facilities. Office of River Protection officials told us they did not address the former WTP Engineering Division Director's recommendation to conduct a 100 percent extent-of-condition review to identify all existing quality problems because, in 2013, DOE's Assistant Secretary for Environmental Management decided to pursue the development of a phased approach to the WTP start-up aimed at treating low-activity waste first. Under the phased approach, the Office of River Protection intends to resolve technical challenges for the Pretreatment facility and High Level Waste facility while developing a path to feed low-activity waste from the tank farms to the Low Activity Waste facility. Nevertheless, DOE has continued to experience challenges overseeing the contractor's quality assurance program, including challenges that affect the High Level Waste and Low Activity Waste facilities, even though engineering, procurement, and construction continues on these facilities without DOE or another entity independent of the contractor

[92]Bechtel National, Inc., *Common Cause Analysis of Quality Assurance Program Implementation and Effectiveness Issues* (Richland, WA: Mar. 27, 2014).

having reviewed all facility systems.[93] Without conducting an extent-of-condition review to determine the breadth and depth of problems, particularly for those facilities' systems that have not been reviewed, DOE does not know the extent to which such problems may affect other facilities and systems.

Conclusions

Decades of nuclear weapons production at Hanford have created challenging conditions for DOE, which is responsible for cleaning up 56 million gallons of radioactive waste—generally viewed as one of the most complex environmental cleanup projects in the world. Since beginning this mission more than 25 years ago, the department has spent more than $19 billion on tank farm projects and on several different waste treatment strategies, none of which have succeeded in treating any waste. DOE's latest strategy to achieve the waste treatment mission includes two new projects intended to begin treating some waste while the department works to resolve technical challenges that have stalled progress on key portions of the WTP. Although DOE's project management order requires it to explore a variety of options in devising strategies or projects to meet its mission needs, DOE has defined narrow statements of mission need to effectively preselect projects that are similar to past proposals and chosen largely on the basis of expedience. By narrowly defining the mission need, DOE effectively excluded from consideration other alternatives to addressing the tank waste treatment mission and the danger posed by the potential leakage of waste from the tanks. These two projects might represent the best path forward, but without unbiased statements of mission need, DOE is unable to explore other alternatives, including some that might be less costly solutions. Furthermore, DOE does not have reliable estimates for the cost or schedule for constructing the projects it selected because it did not follow industry best practices when devising the estimates, excluding the costs and time associated with significant activities that will be needed to complete these projects. Without estimating all costs and the schedules of all activities, DOE is potentially committing to (1) a course of action that

[93]DOE's May 2014 design review of the High Level Waste facility also recommended an extent of condition review for systems for which design is complete and procurement and construction is under way, but Office of River Protection officials told us they have not conducted the review and instead will rely on the contractor to review the completed systems.

will require significant yet undisclosed future resources to successfully implement and (2) project time frames that it may be unable to meet.

Whatever projects DOE ultimately chooses to carry out its new strategy will likely involve delivering waste to the WTP and will, therefore, rely on WTP facilities to operate effectively. This cannot be assured, however, given that the WTP continues to be hindered by technical and management challenges, many of which it has faced for years. Even with DOE's actions to direct the contractor to address problems with its design management and quality assurance programs, neither the department nor the contractor can verify that WTP facilities' current designs meet nuclear safety requirements. This problem is made more acute by DOE's recent discoveries that (1) some WTP components already purchased and installed do not meet quality assurance requirements, (2) key systems within the High Level Waste and Low Activity Waste facilities may require extensive and expensive rework, and (3) construction continues at these facilities even though the contractor has not yet developed corrective actions for some questioned conditions. Without conducting an extent-of-condition review—as called for by the DOE Office of River Protection quality assurance policy—DOE does not know the extent to which similar conditions may exist at the WTP facilities' other systems. Further, even as unresolved technical challenges persist, DOE has continued the design-build approach to constructing the WTP without fully implementing aggressive risk mitigation strategies, as currently required by the department's project management order. One such risk mitigation strategy has been recommended by external DOE advisors—namely, that DOE enlist the services of another agency or external entity, such as an owner's agent, to assist with reviewing and evaluating the WTP contractor's management of design and approach to mitigating design challenges. In the absence of employing aggressive risk mitigation strategies, DOE will have little assurance that technical challenges will be solved or that emerging ones will be mitigated in design, which may result in portions of facilities' designs either being unchecked or progressing significantly before problems are identified.

Recommendations for Executive Action

To improve DOE's management and oversight of the WTP project, we recommend that the Secretary of Energy take the following five actions:

- Revise the statements of mission need for the two proposed projects to allow DOE to consider a variety of alternatives without limiting potential solutions, consistent with the DOE requirement that mission

need statements should not identify particular solution such as equipment, facility, or technology.

- In assessing the alternatives, revise cost and schedule estimates for the Low Activity Waste Pretreatment System and the Tank Waste Characterization and Staging facility in accordance with industry best practices.

- In accordance with DOE's Office of River Protection quality assurance policy, conduct an extent-of-condition review for WTP's High Level Waste and Low Activity Waste facilities' systems that have not been reviewed by DOE.

- Consider whether or to what extent construction activities for the High Level Waste and Low Activity Waste facilities should be further limited until aggressive risk mitigation strategies are developed and employed to address technical challenges that DOE, the contractor, and others have identified but not yet resolved.

- Enlist the services of another agency or external entity to serve as an owner's agent to assist the Office of River Protection in reviewing and evaluating the WTP contractor's design and approach to mitigating design challenges.

Agency Comments and Our Evaluation

We provided a draft of this report to DOE for review and comment. DOE provided written comments, which are printed in full in appendix IV along with our responses to their comments; and provided technical comments, which we incorporated in our final report as appropriate. In its comments, DOE stated that the department generally agrees with the report's recommendations but that it is concerned with some of the conclusions contained in the draft report. However, DOE's responses to the recommendations generally state that it has implemented them; we believe that for each recommendation additional actions are needed.

DOE stated that of most concern to the department is the suggestion that the department should re-evaluate alternatives and depart from the path it has determined is most appropriate—consistent with existing legal obligations—for completing the tank waste treatment mission. DOE noted that its considerable analysis demonstrates that a phased approach, beginning with low-activity waste as soon as practicable is the best approach to moving forward with the WTP while working to meet the legal obligations that govern tank waste cleanup. Later in their comments, DOE specified that it had developed an alternatives analysis that considered

the full range of reasonable options to meet schedule milestones, including at-tank, in-tank, and near-tank capabilities to facilitate the direct-feed low-activity waste process. Further, DOE stated that our draft report does not recognize that DOE cannot unilaterally abandon or reject the legal obligations governing the waste cleanup mission at Hanford and that without court approval, the department cannot stop construction on all WTP facilities to focus solely on technical issue resolution at the Pretreatment facility. We disagree with DOE's statements.

First, we did not recommend that the department should re-evaluate alternatives. Our recommendation was that DOE revise the statements of mission need for both proposed projects, which was based on our findings that DOE developed narrow statements of mission need that precluded consideration of other possible alternatives, as required by DOE's project management order. By doing so, DOE effectively pre-selected the solutions that its preferred course of action was to achieve. As we note in our report, DOE turned to expedient strategies that had previously been developed rather than, for example, considering options the department identified in its 2012 Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site. Furthermore, DOE's statement that the scope of alternatives it assessed—including at-tank, in-tank, and near-tank capabilities to facilitate the direct-feed low-activity waste process—reflected the "full range of reasonable options" indicates that DOE had already chosen its preferred technology, and the nature and placement of equipment in proximity to the tanks to facilitate the project were the only variables for subsequent analysis. DOE's project management order states that "the mission need is independent of a particular solution, and should not be defined by equipment, facility, technological solution, or physical end-item." In this case, the mission need was so narrowly drawn that construction of a direct-feed low-activity waste system was the only possible solution. Concerning DOE's statement that the report does not recognize that it cannot unilaterally abandon or reject the legal obligations governing the waste cleanup mission at Hanford, we note that DOE points to nothing in its existing legal obligations that would prohibit it from defining mission need in accordance with its own project management order.

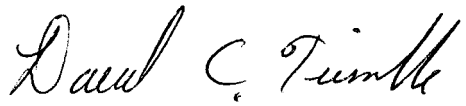
DOE acknowledges that it has proposed changes in the current consent decree requirements, in large part because it believes certain existing consent decree milestones are unachievable. In our report, we found that the scope of the strategies DOE considered was driven primarily by schedule—that is, options that could potentially allow DOE to get

reasonably close to meeting the schedule milestones set in the 2010 consent decree. We disagree with DOE's rationale for limiting consideration of technical solutions to only those that can meet scheduled milestones when the department is in the process of renegotiating consent decree milestones now. In its current proposal to modify the consent decree, DOE relies in part on a flexible approach to project implementation that ties milestone-setting to the availability of key project information, because DOE states that there is too much uncertainty at this time to establish construction milestones for the Pretreatment and High Level Waste facilities with any meaningful level of confidence. Moreover, DOE has argued in the consent decree litigation that the state of Washington's proposed amendment to the consent decree, which contains numerous fixed dates, "compounds the problem by pegging dozens of additional construction and operation milestones to the flawed hard milestones for technical issue resolution, and by making no provision for the reality that technical issue resolution may require changes that affect the project cost and schedule."

We note that DOE's approach to its recently proposed projects recalls DOE's original justification for pursuing a "fast-track design-build" approach to WTP, notwithstanding the complexity and technical challenges in the WTP that made this strategy inappropriate. The technical problems encountered on the WTP using this approach have not been resolved, and the start of waste treatment operations are still years away. In addition, treating some low-activity waste sooner is of course better than later. However, given that the waste treatment mission at Hanford is expected to last for decades, it seems prudent to carefully consider all options to meet the requirements so that there is confidence that the preferred solution is both cost effective and meets mission requirements in the short- and long-term.

We are sending copies of this 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 trimbled@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.



David C. Trimble
Director, Natural Resources and Environment

Appendix I: Assessment of the Department of Energy's Low Activity Waste Pretreatment System Cost Estimate

This appendix provides the results of our analysis of the extent to which the Department of Energy's (DOE) cost estimate for the Low Activity Waste Pretreatment System met the characteristics of a reliable and high-quality cost estimate. Our research has identified a number of best practices from federal cost-estimating organizations and industry that are the basis of effective program cost estimating and should result in reliable cost estimates that management can use for making informed decisions. These best practices are published in the *GAO Cost Estimating and Assessment Guide.*[1] For our reporting needs, we collapsed these best practices into four general characteristics for high-quality and reliable cost estimates: comprehensive, well-documented, accurate, and credible. Table 5 provides the detailed results of our analysis.

Our methodology for assessing cost estimating includes five levels of conformity with the best practices we have identified. "Not met" means DOE provided no evidence that satisfies any of the criteria associated with a given characteristic. "Minimally met" means DOE provided evidence that satisfies a small portion of the criteria. "Partially met" means DOE provided evidence that satisfies about half of the criteria. "Substantially met" means DOE provided evidence that satisfies a large portion of the criteria. "Fully met" means DOE provided evidence that completely satisfies the criteria.

[1]GAO-09-3SP.

Table 5: Assessment of DOE's Low Activity Waste Pretreatment System Cost Estimate Compared with Best Practices

Characteristic and overall assessment	Best practice	GAO assessment
Comprehensive: **Partially met**	The cost estimate includes all life-cycle costs, completely defines the program/project, reflects the current schedule, and is technically reasonable. The work breakdown structure is product-oriented, traceable to the statement of work/objective, and at an appropriate level of detail to ensure cost elements are neither omitted nor double counted. The estimate documents all cost-influencing ground rules and assumptions.	The cost estimate did not appear to contain the costs of the project over the entire life-cycle because there were no operations and support stage costs included. A limited amount of technical and programmatic information was provided. There was a work breakdown structure and work breakdown structure dictionary provided, but it was not product-oriented. The cost estimate did not include costs of the additional infrastructure that will be needed to implement the project. In addition, the documentation provided by DOE showed some general program assumptions, but there were no assumptions provided in the basis of estimate document.
Well-documented: **Minimally met**	The documentation should capture the source data used, the reliability of the data, and how the data were normalized. The documentation describes in sufficient detail the calculations performed and the estimating methodology used to derive each work breakdown structure element's cost. The documentation describes step by step how the estimate was developed so that a cost analyst unfamiliar with the project could understand what was done and replicate it. The documentation discusses the technical baseline description, and the data in the baseline are consistent with the estimate. The documentation provides evidence that the cost estimate was reviewed and accepted by management.	The basis of estimate document did not contain any documentation of the data sources or of the methodology for calculating the cost estimate. Evidence of management approval of the estimate was provided.
Accurate: **Minimally met**	The cost estimate results are unbiased, not overly conservative or optimistic, and based on an assessment of most likely costs. The estimate has been adjusted properly for inflation. The estimate contains few, if any, minor mistakes. The estimate is based on a historical record of cost estimating and actual experiences from other comparable programs/projects.	No confidence level based on a risk assessment was presented so it is difficult to determine if the costs are most likely. Inflation was not documented. No cost model or detailed documentation was provided so calculations and methodologies could not be verified.
Credible: **Minimally met**	The cost estimate includes a sensitivity analysis that identifies a range of possible costs based on varying major assumptions, parameters, and data inputs. A risk and uncertainty analysis was conducted that quantified the imperfectly understood risks and identified the effects of changing key cost driver assumptions and factors. Major cost elements were cross-checked to see whether results were similar. An independent cost estimate was conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results.	No sensitivity analysis was done. Although a risk and uncertainty analysis was not done, contingency was added, and a risk register was provided. No evidence of cross-checks was provided, and no independent cost estimate was done.

Source: GAO analysis of DOE data. | GAO-15-354

Appendix II: Assessment of the Department of Energy's Tank Waste Characterization and Staging Facility Cost Estimate

This appendix provides the results of our analysis of the extent to which the Department of Energy's (DOE) cost estimate for the Tank Waste Characterization and Staging facility met the characteristics of a reliable and high-quality cost estimate. Our research has identified a number of best practices from federal cost-estimating organizations and industry that are the basis of effective program cost estimating and should result in reliable cost estimates that management can use for making informed decisions. These best practices are published in the *GAO Cost Estimating and Assessment Guide.*[1] For our reporting needs, we collapsed these best practices into four general characteristics for high-quality and reliable cost estimates: comprehensive, well-documented, accurate, and credible. Table 6 provides the detailed results of our analysis.

Our methodology for assessing cost estimating includes five levels of conformity with the best practices we have identified. "Not met" means DOE provided no evidence that satisfies any of the criteria associated with a given characteristic. "Minimally met" means DOE provided evidence that satisfies a small portion of the criteria. "Partially met" means DOE provided evidence that satisfies about half of the criteria "Substantially met" means DOE provided evidence that satisfies a large portion of the criteria. "Fully met" means DOE provided evidence that completely satisfies the criteria.

[1] GAO-09-3SP.

Table 6: Assessment of DOE's Tank Waste Characterization and Staging Facility Cost Estimate Compared with Best Practices

Characteristic and overall assessment	Best practice	GAO assessment
Comprehensive: **Minimally met**	The cost estimate includes all life-cycle costs, completely defines the program/project, reflects the current schedule, and is technically reasonable. The work breakdown structure is product-oriented, traceable to the statement of work/objective, and at an appropriate level of detail to ensure cost elements are neither omitted nor double counted. The estimate documents all cost-influencing ground rules and assumptions.	The cost estimate does not appear to contain the entire life cycle; there is no operations and support stage included. There is a high-level work breakdown structure; however, the work breakdown structure is not product-oriented or traceable to a statement of work and does not contain a work breakdown structure dictionary. There is no evidence of a technical baseline description. The costs to connect the facility to the WTP were not included in the estimate. A few general assumptions are documented; however, the basis of estimate does not provide all the cost-influencing ground rules and assumptions.
Well-documented: **Partially met** .	The documentation should capture the source data used, the reliability of the data, and how the data were normalized. The documentation describes in sufficient detail the calculations performed and the estimating methodology used to derive each work breakdown structure element's cost. The documentation describes step by step how the estimate was developed so that a cost analyst unfamiliar with the project could understand what was done and replicate it. The documentation discusses the technical baseline description, and the data in the baseline are consistent with the estimate. The documentation provides evidence that the cost estimate was reviewed and accepted by management.	The estimate documents at a top level how the costs were derived and captures the normalization process, but it does not provide a technical baseline description, documentation of data reliability, or sufficient detail that an analyst unfamiliar with the program could recreate the estimate. There is evidence of management review and approval of the estimate.
Accurate: **Minimally met**	The cost estimate results are unbiased, not overly conservative or optimistic and based on an assessment of most likely costs. The estimate has been adjusted properly for inflation. The estimate contains few, if any, minor mistakes. The estimate is based on a historical record of cost estimating and actual experiences from other comparable programs/projects.	The cost estimate is based on analogy to previous programs' estimates rather than historical data. Inflation was not applied correctly to the cost estimate for the version of the project without a capability for particle-size reduction and was left out entirely from the estimate of the project version that included this capability. No cost model or detailed documentation was provided, so calculations and methodologies could not be verified. No confidence level based on a risk assessment was presented, so it is not possible to determine the project's most likely cost.

Credible: **Minimally met**	The cost estimate includes a sensitivity analysis that identifies a range of possible costs based on varying major assumptions, parameters, and data inputs. A risk and uncertainty analysis was conducted that quantified the imperfectly understood risks and identified the effects of changing key cost-driver assumptions and factors. Major cost elements were cross-checked to see whether results were similar. An independent cost estimate was conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results.	No sensitivity analysis was done. Although a risk assessment was not done, contingency was added, and a risk register was provided. No evidence of cross-checks was provided. No independent cost estimate was done.

Source: GAO analysis of DOE data. | GAO-15-354

Appendix III: Assessment of the Department of Energy's Low Activity Waste Pretreatment System Schedule Estimate

This appendix provides the results of our analysis of the extent to which the Department of Energy's (DOE) schedule estimate for the Low Activity Waste Pretreatment System met the characteristics of a high-quality, reliable schedule estimate. Developing the scheduling concepts introduced in the *GAO Cost Estimating and Assessment Guide*, *GAO's Schedule Assessment Guide* presents them as 10 best practices associated with developing and maintaining a reliable, high-quality schedule.[1] For our reporting needs, we collapsed these 10 best practices into four general characteristics for sound schedule estimating: comprehensive, well-constructed, credible, and controlled. For this assessment, we considered only the "well constructed" characteristic. The technical points addressed through the "well constructed" characteristic are sufficient to establish a functional and technically sound basis for the purposes of reliably calculating date forecasts. Table 7 provides the detailed results of our analysis.

GAO's methodology includes five levels of compliance with its best practices. "Not met" means DOE provided no evidence that satisfies any of the criteria associated with a given characteristic. "Minimally met" means DOE provided evidence that satisfies a small portion of the criteria. "Partially met" means DOE provided evidence that satisfies about half of the criteria. "Substantially met" means DOE provided evidence that satisfies a large portion of the criteria. "Fully met" means DOE provided evidence that completely satisfies the criteria.

[1]GAO-12-120G.

Table 7: Assessment of DOE's Low Activity Waste Pretreatment System Schedule Estimate Compared with Best Practices

Characteristic and overall assessment	Best practice	GAO assessment
Well-constructed **Partially met**	All activities are logically sequenced with predecessor and successor logic, with limited amounts of unusual or complicated logic techniques that are justified in the schedule documentation.	The schedule has several missing or incorrect logic links and contains a significant number of date constraints that can lead to a lack of confidence in activity dates and the critical path.
	A critical path that determines which activities drive the project's earliest completion date.	Critical path activities in 2022 are not linked to succeeding activities that occur from 2027 to 2030. Additionally, lags for critical activities in 2014 range from 20 to 52 days. Lags are useful in summary schedules because portions of long-term effort are likely to be unknown; however, lags for activities later in the project are as long as 188 days. The critical path should be free of lags to avoid complications with the identification and management of critical activities.
	Total float that accurately determines the schedule's flexibility.	The schedule should identify reasonable total float (or slack)—the amount of time by which a predecessor activity can slip before the delay affects the program's estimated finish. Our analysis shows a high level of total float in the schedule, and some activities appear to have questionable values of float. Incorrect float estimates may result in an inaccurate assessment of project completion dates.

Source: GAO analysis of DOE data. | GAO-15-354

Appendix IV: Comments from the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

See comment 1

See comment 2

See comment 3

See comment 4

See comment 5

Department of Energy
Washington, DC 20585
April 10, 2015

Mr. David Trimble
Director
National Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

This letter responds to the draft U.S. Government Accountability Office (GAO) Report GAO-15-354. We appreciate the opportunity to review the draft report.

While we generally agree with the recommendations of the draft report, we are concerned with some of the conclusions contained in the draft report. Of most concern is the suggestion that the Department of Energy (DOE) should re-evaluate alternatives and depart from the path it has determined is most appropriate - and consistent with existing legal obligations - for completing the tank waste treatment mission. After significant evaluation, DOE has determined that beginning to treat waste as soon as practicable through a phased approach to Waste Treatment and Immobilization Plant (WTP) project construction is the only practical and permanent way to address the concerns associated with tank waste. In addition, DOE has also determined that proceeding with a direct feed process for the Low Activity Waste Facility so that facilities not affected by technical issues can begin treating tank waste by the end of 2022 will have the benefit of creating double-shell tank space and facilitate the retrieval of single-shell tank waste. DOE's considerable analysis demonstrates that a phased approach, beginning with vitrification of low-activity waste as soon as practicable is the best approach to moving forward with WTP while working to meet the legal obligations that govern tank waste cleanup. In addition, the draft report does not recognize that, because of the legal framework which governs tank waste cleanup at Hanford, DOE cannot unilaterally abandon or reject the legal obligations that framework imposes on it. Thus, without court approval, DOE could not stop construction on all WTP facilities to focus solely on technical issue resolution at the Pretreatment Facility.

Because the draft report appears to emphasize documents that are now almost 18 months old, instead of more recent materials made available to GAO, it does not accurately portray the Department's current and ongoing efforts and path forward for the WTP, compromising the draft report's analysis and its conclusions. For example, the draft report relies heavily on a Framework document published in September 2013 that identified potential options for a path forward at WTP instead of the Department's more recent October 2014 motion to modify the 2010 Consent Decree and related declarations

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and briefs.[1] These filings provide the proposed approach and rationale for completing WTP and the tank retrievals covered by the 2010 Consent Decree.

Since the 2010 Consent Decree addressing the construction and initial operation of the WTP was entered, significant technical obstacles have unfortunately led to delays making certain Consent Decree milestones unachievable. This prompted DOE to reconsider the approach embodied in the Consent Decree of having all of the WTP facilities start up and achieve radioactive operations simultaneously. More specifically, ongoing engineering work and scientific analysis by DOE's own experts and outside experts, including recommendations from the Defense Nuclear Facilities Safety Board, identified technical concerns that, if not resolved, could potentially lead to nuclear-safety problems, including the release of radioactive material within the WTP and the inability to confidently assure operational efficiency. Those concerns led to DOE's determination that it was necessary to suspend construction work on two key WTP facilities until these technical issues are resolved.

In light of these technical concerns, in October 2014, both DOE and the State of Washington submitted competing proposals to the court to modify the Consent Decree. DOE's proposal retains all the core objectives of the Consent Decree: the construction and initial operations at the WTP; and completion of the retrieval of waste from the 19 single-shell tanks. In addition, DOE's proposal includes installation of new capabilities to allow WTP to begin treating waste by 2022.

Specifically, DOE proposes to send liquid waste directly to the Low-Activity Waste (LAW) Facility for vitrification, bypassing the Pretreatment Facility. This Direct Feed LAW approach requires a new capability - a Low Activity Waste Pretreatment System (LAWPS) - to remove highly radioactive cesium and solids from the liquid waste stream before it is sent to the LAW Facility. It will also require DOE to make certain modifications to the LAW Facility, the Analytical Laboratory, and support facilities to accommodate the new approach. This approach will allow DOE, despite delays in construction of the Pretreatment Facility, to begin the vitrification of liquid wastes, which make up the majority by volume of the waste to be treated. DOE believes that implementing Direct Feed LAW will reduce the time needed to complete the overall tank-waste treatment mission, compared to waiting to begin vitrification until after the Pretreatment and High-Level Waste Facilities are completed. Implementing Direct Feed LAW will also give DOE valuable experience with the vitrification process (including some of the pretreatment processes that are planned to be used in the Pretreatment Facility), and provide a secondary path for routing liquid waste to the WTP at times when the Pretreatment Facility is undergoing planned maintenance.

[1]The Department's legal obligations regarding the tank waste mission were created by the October 2010 Consent Decree entered by the court in the case of *State of Washington v. Chu*, Case No. 08-5085 and the Hanford Federal Facility Agreement and Consent Order (HFFACO, also known as the Tri-Party Agreement).

See comment 6

In compliance with DOE directives (DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, which establishes a serious of "critical decisions" governing construction processes), the LAWPS mission need (Critical Decision-0) was carefully considered and approved by the Department.

See comment 7

Prior to the Critical Decision-1 stage, *Approve Alternative Selection and Cost Range*, the Department developed an alternatives analysis that considered the full range of reasonable options including at-tank, in-tank, and near-tank capabilities to facilitate the direct feed LAW process. Two independent reviews of these alternatives were performed. The first review (summer 2014) was conducted by an external expert review team, and determined that LAWPS was the appropriate approach to meet the mission need. A second review was performed by an independent project review team as required by DOE Order 413.3B. This review similarly confirmed the LAWPS approach to meeting the mission need and recommended the approval of Critical Decision-1.

The *Alternatives Selections* process (Critical Decision-1) also required the LAWPS Project to develop its own cost and schedule estimate. In addition to this cost and schedule estimate, the *Alternatives Selections* process also requires the Department's Office of Acquisition and Project Management to prepare its own cost and schedule estimate to compare with that prepared by the LAWPS Project. These two cost and schedule estimates superseded the material referenced by GAO's draft report. Just recently, the Department's newly established Project Management Risk Committee reviewed the alternatives analysis and the cost and schedule estimate and agreed that LAWPS is ready to proceed to Critical Decision-1.

See comment 8

In the proposal to amend the Consent Decree, DOE proposed a process for acquiring a tank waste characterization and staging (TWCS) capability to allow DOE to sample, mix, and precondition waste before it is fed to WTP's Pretreatment Facility. This capability is necessary to feed tank waste to the Pretreatment Facility predictably (in accordance with the waste acceptance criteria) and is expected to help resolve the pending technical issues by ensuring high level wastes have physical and chemical characteristics that can be safely processed by the Pretreatment Facility. At this time, the mission need statement for the TWCS project is still in the initial review process; thus, it has not received Critical Decision-0, *Approve Mission Need,* approval. While DOE has performed bounding analyses for assessing a Rough Order of Magnitude Cost Estimate, the formal alternatives analysis and subsequent selection of an alternative will not be conducted until after the Critical Decision-0 approval. DOE is following its project directives governing project management in implementing the TWCS project, and consideration will be given to the full range of reasonable alternatives that might satisfy mission need.

See comment 9

The Department has followed and will continue to follow DOE Guide 413.3-21, *Cost Estimating Guide*, for both the LAWPS and TWCS projects; the DOE guide is consistent with the March 2009 GAO-09-3SR, *GAO Cost Estimating and Assessment Guide* and the May 2012 GAO-12-120G, *GAO Schedule Assessment Guide.*

Response to the Recommendations

The following provides the Department's response to the five recommendations contained in the report.

Recommendation 1: ***Revise the statements of the mission need for the two proposed projects to allow DOE to consider a variety of alternatives without limiting potential solutions, consistent with the DOE requirement that mission need statements should not identify particular solution such as equipment, facility, or technology.***

See comment 10

LAWPS: In compliance with DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets,* the LAWPS project mission need was carefully considered and approved by the Department. In addition, prior to requesting approval of CD-1, *Approve Alternative Selection and Cost Range*, an external expert review team commissioned by the Office of Environmental Management evaluated the range of reasonable alternatives that satisfy mission need and determined LAWPS was the appropriate project for the particular mission need created by the technical issues that delay the WTP Pretreatment Facility.

See comment 11

TWCS: At this time, the mission need statement for the TWCS project is still in the initial review process; thus, has not received approval of CD-0, *Approve Mission Need.* DOE will follow DOE Order 413.3B for the TWCS project as is required for all capital asset projects, and full consideration will be given to the range of reasonable alternatives that might satisfy the mission need. In addition, the analysis of alternatives will incorporate the best practices identified by the Government Accountability Office (GAO) in their report GAO-15-37, *DOE and NNSA Project Management: Analysis of Alternatives Could Be Improved by Incorporating Best Practices* dated December 11, 2014.

Recommendation 2: ***In assessing the alternatives, revise cost and schedule estimates for the Low Activity Waste Pretreatment System and the Tank Waste Characterization and Staging facility in accordance with industry best standards.***

See comment 12

The Department has followed the DOE Guide 413.3-21, *Cost Estimating Guide* for both LAWPS and TWCS projects and also is in observance with the March 2009 GAO-09-3SP, *GAO Cost Estimating and Assessment Guide* and the May 2012 GAO-12-120G, *GAO Schedule Assessment Guide*.

The draft GAO report does not appear to take issue with DOE's cost estimating methodology, but rather is concerned the ROM estimates may not reflect the full project scope. DOE does not include costs that are associated with programmatic elements in project cost estimates. Rather, these costs are captured as part of the Office of River Protection, tank farms operating budget. Examples would include upgrades to waste feed

delivery systems that will provide feed to the LAWPS facility.

LAWPS: The cost estimate and schedule continues to be revised and updated in accordance with the DOE Order 413.3B process and DOE Guide 413.3-21. In March 2015, the Department's Office of Acquisition and Project Management completed an Independent Cost Estimate of the LAWPS project.

TWCS: The Department is still in the initial review process for the TWCS project and a mission need determination has not been made. As was done with the cost estimate range for the CD-0 for LAWPS, the CD-0 package for TWCS will include the Rough Order of Magnitude (ROM) cost estimate range that complies with the DOE Guide 413.3-21 as well as the discussed GAO Guides.

Recommendation 3: ***In accordance with DOE's Office of River Protection's quality assurance policy, conduct an extent of condition for HLW and LAW facilities' systems that have not been reviewed by DOE.***

See comment 13

The Department initiated Design & Operability Reviews for the HLW and LAW facilities to assess systems that are not common commercial construction systems or those the Department determined needed additional screening to meet operational requirements. Based on the results of these reviews, the Department will be assessing the balance of the systems for the LAW facility, as well as assessing the systems for the Analytical Laboratory Facility and the Balance of Facilities.

Recommendation 4: ***Consider whether or to what extent construction activities for High Level Waste and Low Activity Waste Facilities should be further limited until aggressive risk mitigation strategies are developed and employed to address technical challenges that DOE, the contractor, and others have identified but not yet resolved.***

See comment 14

The Department has already restricted construction for the High Level Waste (HLW) Facility and implemented risk mitigation strategies. The contractor is only permitted to do production engineering, sustainment activities to preserve the facility and safety components, and minor civil construction in areas that are unaffected by the technical issues or any possible solution to issues. A specific set of criteria has been established for resumption of HLW construction.

See comment 15

With regard to the LAW Facility, construction is nearly complete. The WTP Federal Project Director has a detailed risk register for the LAW Facility for each remaining risk, which is regularly being addressed and proactively mitigated as the LAW Facility approaches completion.

See comment 16

Recommendation 5: ***Enlist the services of another agency or external entity to serve as the owner's agent to assist the Office of River Protection in reviewing and evaluating the WTP contractors' design and approach to mitigating design and challenges.***

The Department has made improvement in its oversight and management over the WTP in the last two years, as evidenced by the Design & Operability reviews acknowledged by the GAO. The Department is committed to further improvement to ensure the completion of the WTP project is done in an efficient manner, while accounting for the significant complexities posed by a project of this magnitude. While the Department cannot abrogate its owner's responsibilities to another agency or external entity, the Office of River Protection has utilized the services of other agencies and external entities to assist with oversight and management of WTP. As an example, the Department has used the U.S. Army Corps of Engineers to assist with the evaluation of contract change proposals, preparation of cost estimates, and assisting with baseline reviews.

The Department believes that an independent review and evaluation capability can add value to effective project management, and the Office of River Protection will pursue alternatives to secure the benefits of an owner's agent capability. To that end, the Office of River Protection will develop and analyze alternatives to enhance the capability and effectiveness of the Office's oversight responsibilities. Then, after the best alternative is selected, it will be expeditiously implemented.

If you have any questions, please contact me or Mr. Kenneth G. Picha, Jr., Deputy Assistant Secretary for Tank Waste and Nuclear Material, at (202) 586-9982.

Sincerely,

Mark Whitney
Acting Assistant Secretary
for Environmental Management

The following are GAO's comments on the Department of Energy's (DOE) letter dated April 10, 2015.

GAO Comments

1. DOE's statement misses an important nuance in our finding and recommendation. We did not state that DOE had to "re-evaluate" alternatives to the Low Activity Waste Pretreatment System and Tank Waste Characterization and Staging facilities. Rather, we found that because the Office of River Protection first selected the projects and then developed narrow statements of mission need to help ensure the projects' approval, DOE effectively excluded other potential solutions from being considered at CD-1, a project phase that neither project has yet reached, in contrast to requirements in DOE's project management order. As a result of our finding, we therefore recommend that the department revise the two proposed projects' statements of mission need to allow DOE a variety of alternatives without limiting potential solutions before significant resources are invested.
2. DOE states that a phased approach to the WTP construction is the only practical and permanent way to address the concerns associated with tank waste. Our report does not assess a phased approach to WTP construction. However, we found that the department has chosen to implement technical solutions to significant technical challenges that together will likely cost more than $1 billion, but did so based on narrow statements of mission need that precluded full consideration of other potential options. As noted in the report, DOE itself evaluated other ways to address the concerns associated with tank waste in its 2012 Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, which analyzed 11 alternatives for retrieval, treatment, and disposal of tank waste. We acknowledge that the state of Washington at that time did not support all of these alternatives, but since the 2012 assessment was issued, significant technical challenges have eluded resolution, which could add years to the WTP's schedule and, as the department recently found, a double-shell tank has started leaking. Indeed, DOE has not assessed the option of focusing all its efforts and resources on solving the technical challenges at the Pretreatment facility already under construction, rather than beginning the construction of new facilities that could themselves encounter technical challenges.
3. DOE states that proceeding with a direct-feed process for the Low Activity Waste facility will have the benefit of creating double-shell tank space and facilitate the retrieval of single-shell tank waste. As we state in our report, other options that the department has previously

analyzed would also create double-shell tank space and do so cheaper and quicker. For example, some of the alternatives that DOE analyzed in 2012 involve building new double-shell tanks, each of which cost about $80 million. Such tanks would give the department additional tank space sooner than if it had to wait for the Low Activity Waste Pretreatment System to begin processing waste.

4. DOE notes that our report does not recognize that DOE cannot unilaterally abandon or reject the legal obligations imposed on it. We note that DOE can—and is—petitioning for a change in the legal obligations imposed upon it, in large part because, as DOE acknowledges, it will not meet the current consent decree milestones. Given that the consent decree is currently being renegotiated, the department has a present opportunity, albeit in a potentially slim window of time, when it could propose technical solutions that are not primarily driven by schedule milestones and are instead driven by technological and cost effectiveness. Furthermore, DOE does not explain why considering alternatives to the two proposed facilities, as required by DOE order, would be inconsistent with any of its existing legal obligations. Moreover, there is a process for amending the consent decree, which DOE and Washington State have been following recently, so the legal framework can be changed in light of subsequent analyses.
5. DOE states in its letter that our report appears to emphasize documents, such as the Framework, that are now almost 18 months old, instead of more recent court filings, such as its October 2014 motion to modify the 2010 consent decree; and as such our report does not accurately portray the department's current and ongoing efforts and path forward for the WTP. DOE identified no specific substantive differences between the approaches described in its September 2013 "Framework" document and its October 2014 motion to modify the 2010 consent decree. DOE also did not identify any specific ways in which our report inaccurately portrayed the agency's position as currently reflected in the ongoing litigation. We have nevertheless made technical clarifications in the report, where appropriate.
6. As we reported, DOE did not comply with its project management order with respect to its definition of mission need because, while the project management order states that the statements of mission need do not identify a particular solution, the department defined the mission need in light of a specific technological solution.
7. DOE's letter states that the department developed an alternatives analysis that considered the full range of reasonable options,

including at-tank, in-tank, and near-tank capabilities to facilitate the direct-feed low-activity waste process, and that two independent reviews of these alternatives were performed. DOE's statements in this regard reflect the department's mischaracterization of our finding. At the CD-0 stage, DOE's project management order states that the department must develop statements of mission need that do not identify a particular solution such as equipment, facility, or technology, to allow DOE the flexibility to explore a variety of alternatives without limiting potential solutions. DOE's statement—that it considered at-tank, in-tank, and near-tank capabilities in its alternatives analysis—clearly demonstrates that the mission need was so narrowly drawn that construction of a direct-feed low-activity waste system was the only possible solution. DOE's alternatives analysis involved examining the engineering details of the direct-feed low-activity waste solution—while such an analysis is important, it did not explore any alternatives to the construction of direct-feed low-activity waste facilities.

8. As we state in our report, the department's draft statement of mission need for the Tank Waste Characterization and Staging facility is narrowly constructed, contrary to the requirements of DOE's project management order. Specifically, the draft statement of mission need specifies that the Hanford site needs a tank waste characterization and staging capability to safely and reliably mix and sample tank contents, meet the Pretreatment facility waste acceptance criteria, supply the WTP with waste feed, and potentially deliver high-level waste directly from the tank farms to the WTP High Level Waste facility. Such a statement limits the opportunities to consider alternatives.

9. DOE noted in its letter that the department has followed and will continue to follow DOE Guide 413.3-21, Cost Estimating Guide, for both of its recently proposed projects, and that this guide is consistent with GAO's Cost and Schedule guides. This statement is inaccurate. We found in November 2014 that DOE's cost estimating requirements and guidance for projects generally do not follow industry best practices, such as those we describe in GAO's Cost Guide; and since these are included only in DOE guidance neither contractors nor project managers must follow them. In addition, as we state in our report, DOE's Office of Acquisition and Project Management conducted an independent cost estimate of the Tank Waste Characterization and Staging facility—using best practices in GAO's Cost Guide as assessment criteria—and found that the cost should, at least, be nearly twice what Office of River Protection CD-0 documents list as the minimum rough-order-of-magnitude cost. Had the Office of River Protection used the Office of Acquisition and Project

Management's cost estimate, it may have triggered additional reviews and controls, as called for in DOE's project management order for major projects—projects with a total cost of more than $750 million.

10. DOE appears to disagree with our recommendation to revise the statements of mission need for the two proposed projects, stating that it complied with the department's project management order. We reported that DOE developed a statement of mission need that is not consistent with the requirements of its project management order, which calls for a statement of mission need that is "independent of a particular solution, and should not be defined by equipment, facility, technological solution, or physical end-item." DOE's statement that the Low Activity Waste Pretreatment System's mission need was "carefully considered" does not explain why the department believes the mission need definition was consistent with its project management order.

11. See comment 10. We are encouraged by DOE's intention to follow its project management order in conducting an analysis of alternatives for the Tank Waste Characterization and Staging facility. However, as we noted in our report, a key requirement is to have a statement of mission need that does not presuppose a technical solution to enable the assessment of possible solutions. If the mission need statement is too narrowly constructed, other potential solutions to meet mission requirements may not be considered.

12. See comment 9. DOE appears to disagree with our recommendation that it revise cost and schedule estimates for the two recently proposed projects. DOE's letter further notes that in March 2015, department officials completed an independent cost estimate for the Low Activity Waste Pretreatment System. Office of River Protection officials told us in April 2015 that the results of this independent estimate increased the upper bound of the cost range by about $90 million.

13. DOE states that it has initiated design and operability reviews and implies that these reviews are responsive to our recommendation that it conduct extent-of-condition reviews. These are not the same. According to a DOE engineer at the Hanford site, an extent-of-condition review involves examining how all items are affected by a given condition. An extent-of-condition review may mean limiting the production of new design documents and reviewing all of the existing design documents in a logical order. According to the Office of River Protection's quality assurance processes, the extent-of-condition must be known in order to develop and implement effective corrective actions. In contrast, the design and operability reviews for the High

Level Waste facility and Low Activity Waste facility referred to by DOE in its comment examined a subset of some systems—not all systems—and not all calculations, data sheets, or interfaces between systems were examined.

14. DOE appears to disagree with our recommendation to consider further limiting construction activities until aggressive risk mitigation strategies are developed and employed to address significant unresolved technical challenges. DOE notes that activities are already limited and states that a specific set of criteria has been established for resuming construction on the High Level Waste facility. However, as we note in our report, an extent-of-condition review has not been performed on the remainder of the facility's systems, and recommendations from the facility's design and operability review have not been implemented. Furthermore, according to documents obtained from the Office of River Protection during the course of our audit, DOE is considering authorizing the contractor to resume full construction on the High Level Waste facility.

15. DOE's letter states that construction on the Low Activity Waste facility is nearly complete, that the WTP Federal Project Director has a detailed risk register, and that each remaining risk is being proactively mitigated. This statement, however, does not fully reflect the extent or potential seriousness of the technical risks that remain. For example, according to a November 2014 letter from the Office of River Protection to the contractor, the Low Activity Waste facility Design and Operability Review team documented several concerns related to the control strategy for the facility's ventilation system and acknowledged that the possible development of safety-significant controls for the system at this late date in facility design and construction will have significant budgetary and schedule impacts on completion of the Low Activity Waste facility. The team has also noted that there are numerous interactions between the ventilation system and other systems for which no safety-related controls have yet been identified. As we note in the report, the contractor recently estimated mitigation measures for this issue would cost from $10 million to $928 million, with $525 million as the most likely scenario.

16. We are encouraged by DOE's statement that the Office of River Protection will examine options to enhance its capability and effectiveness, but it is unclear whether and to what extent DOE plans to implement our recommendation. We continue to believe that given the scope of technical and design issues that continue to face WTP, that DOE should enlist the services of another entity to independently

review and evaluate the WTP contractor's approach to mitigating remaining design challenges.

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the individual named above, Nathan Anderson (Assistant Director), Brian Bothwell, Scott Fletcher, Rich Johnson, Katherine Killebrew, Jason T. Lee, Jennifer Leotta, Cynthia Norris, and Kathy Pedalino made key contributions to this report. Also contributing were Mike Armes, John Bauckman, Mark Braza, Jennifer Echard, Ellen Fried, Ron Schwenn, and Kiki Theodoropoulos.