

GAO

Report to the Subcommittee on Energy
and Water Development, Committee on
Appropriations, House of
Representatives

July 2008

NUCLEAR MATERIAL

DOE Needs to Take Action to Reduce Risks Before Processing Additional Nuclear Material at the Savannah River Site's H-Canyon



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Highlights

Highlights of [GAO-08-840](#), a report to the Subcommittee on Energy and Water Development, Committee on Appropriations, House of Representatives

Why GAO Did This Study

During the Cold War, the Department of Energy (DOE) produced nuclear materials for nuclear weapons at its Savannah River Site (SRS) by dissolving highly radioactive spent nuclear fuel from reactors in a facility known as H-Canyon. DOE planned to end H-Canyon operations in 2007 but now plans to continue H-Canyon operations until 2019 to process additional nuclear material. GAO was asked to (1) identify the types of nuclear materials DOE will process using H-Canyon and its associated costs of operation, (2) determine whether SRS's radioactive waste storage tanks and associated nuclear waste facilities are capable of handling the additional waste generated by H-Canyon, and (3) describe H-Canyon's compliance with safety and environmental requirements. To conduct its work, GAO reviewed DOE's plans to process nuclear material using H-Canyon and visited SRS to observe the canyon and associated radioactive waste treatment facilities.

What GAO Recommends

GAO recommends that DOE (1) ensure that all of the HEU and plutonium that DOE identifies as suitable for processing using H-Canyon is included in the department's plans, (2) develop a comprehensive cost estimate that includes all associated costs to operate the canyon, and (3) develop a plan to ensure sufficient staff are available to complete safety analyses in a timely manner. In its comments, DOE cited the actions that it is taking to address these recommendations.

To view the full product, including the scope and methodology, click on [GAO-08-840](#). For more information, contact Gene Aloise at (202) 512-3841 or aloise@gao.gov.

NUCLEAR MATERIAL

DOE Needs to Take Action to Reduce Risks Before Processing Additional Nuclear Material at the Savannah River Site's H-Canyon

What GAO Found

DOE plans to process 23 metric tons of highly enriched uranium (HEU) and plutonium using H-Canyon; however, its cost estimate of \$4.3 billion to \$4.6 billion to process these materials through 2019 does not include all associated costs. First, DOE may identify additional HEU and plutonium as suitable for processing using H-Canyon, which could delay H-Canyon's planned 2019 shutdown and increase operational costs. Second, the estimate does not include the cost of storing and treating the waste generated by H-Canyon operations—approximately \$253 million according to DOE.

SRS's waste tanks are nearing capacity, and SRS cannot manage the projected waste from planned H-Canyon operations without critical enhancements. DOE is developing new technologies and building new facilities to meet these challenges. The most critical of these facilities—the Salt Waste Processing Facility—was originally scheduled to begin operating in 2009 but has been delayed twice and is now not projected to begin operations until as late as November 2013. If the facility is not completed on schedule, SRS will continue to face waste storage capacity challenges, which could affect the H-Canyon operating schedule. In addition, several potential events could significantly impede waste processing at SRS. For example, storage capacity could be reduced if critical equipment that reduces the amount of water volume in waste tanks malfunctions or if tank leaks develop.

DOE has determined that H-Canyon is operating safely, and with minimal environmental impact, and DOE expects it will continue to do so in the future. However, DOE must complete further safety and environmental analyses prior to processing additional nuclear material using H-Canyon. Some of these analyses have been delayed by as much as 2 years because SRS lacks sufficient technical staff to conduct them. If these delays persist, the processing of nuclear material using H-Canyon could be delayed.

H-Canyon at DOE's Savannah River Site



Source: DOE.

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Abbreviations

ARP/MCU	Actinide Removal Process/Modular Caustic-Side Solvent Extraction Unit
DDA	Deliquification, Dissolution, and Adjustment
DOE	Department of Energy
DWPF	Defense Waste Processing Facility
HEU	highly enriched uranium
LEU	low enriched uranium
NNSA	National Nuclear Security Administration
SRS	Savannah River Site
SWPF	Salt Waste Processing Facility

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United States Government Accountability Office
Washington, DC 20548

July 25, 2008

The Honorable Peter J. Visclosky
Chairman
The Honorable David L. Hobson
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
House of Representatives

As demand for new nuclear weapons diminished following the end of the Cold War, the United States was faced with the need to dispose of nuclear materials left over from nuclear weapons production. When weapons were manufactured during the Cold War, the Department of Energy's (DOE) Savannah River Site (SRS) in South Carolina recovered nuclear materials, primarily highly enriched uranium (HEU) and plutonium for the U.S. nuclear weapons programs. It did so by dissolving highly radioactive spent nuclear fuel from the site's nuclear reactors in large, heavily shielded chemical separation facilities known as "canyons." These canyons used acids and other chemicals to extract HEU, plutonium, and other nuclear material from the fuel. Following the end of the Cold War, DOE began to use the two canyon facilities at SRS—F-Canyon and H-Canyon—to treat nuclear materials that were unstable and posed potential environmental, public safety, and health risks if left untreated. F-Canyon completed its mission in 2002 and has since shut down. As recently as 2004, DOE planned to end H-Canyon operations in 2007 following the completion of its mission. In 2006, however, DOE proposed continuing to operate H-Canyon until 2019 to process spent nuclear fuel from research reactors and enriched uranium and other materials from across DOE's nuclear weapons complex. DOE expects that processing these materials will cost several billion dollars.

DOE's processing of this material in H-Canyon results in several potential benefits. First, it makes the material less usable in nuclear weapons and, therefore, may reduce associated security costs. For example, HEU recovered as a result of H-Canyon processing can be converted into low enriched uranium (LEU), which cannot be used in nuclear weapons but

can be used as fuel in commercial nuclear power plants.¹ Second, using H-Canyon allows DOE to further consolidate excess nuclear materials from multiple sites across the nuclear weapons complex and support the department's efforts to transform the complex into a smaller, safer, more secure, and more cost-effective complex for the future. Third, using H-Canyon provides DOE with an opportunity to dispose of certain types of nuclear material that have no other currently defined means for permanent disposal. Specifically, certain nuclear materials at different DOE sites are in forms that cannot readily be disposed of at existing disposal locations. When these materials are processed in H-Canyon, the HEU is recovered, and the nuclear materials are converted into a form that can be permanently disposed of in the same way and in the same facilities as other radioactive waste at SRS.

Although the Congress requires DOE to keep H-Canyon operating, continued operations present several potential challenges to the department.² First, H-Canyon costs approximately \$220 million annually to operate in fiscal year 2006 dollars. Second, concerns have been raised about whether SRS's liquid radioactive waste storage tanks and treatment facilities have enough capacity for the additional waste generated by extended H-Canyon operations. Third, because H-Canyon processes highly radioactive materials, a catastrophic accident at H-Canyon could result in serious environmental, safety, and health consequences. H-Canyon is more than 50 years old and, therefore, has a higher risk of major equipment or other failures that could impair its operations.

In this context, you asked that we (1) identify the types of nuclear materials DOE will process at H-Canyon and the associated costs of continuing H-Canyon operations through 2019, (2) determine whether SRS's radioactive waste storage tanks and associated nuclear waste facilities are capable of handling the additional waste generated from continued H-Canyon operations, and (3) describe H-Canyon compliance with current safety and environmental requirements.

¹HEU, which is used in some nuclear weapons, is uranium enriched in the isotope uranium-235 to 20 percent or greater. In contrast, LEU, which is used in commercial nuclear power reactors, contains less than 20 percent uranium-235.

²Under section 3137 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (Pub. L. No. 106-398) and section 3115 of the National Defense Authorization Act for Fiscal Year 2004 (Pub. L. No. 108-136), DOE must continue operations and maintain a high state of readiness at H-Canyon as well as provide necessary technical staff to operate the facility.

To identify the types of nuclear materials that DOE will process using H-Canyon and the potential costs, we reviewed DOE's nuclear material disposition plans for HEU and plutonium. We also reviewed DOE's project management guidance, which describes how DOE estimates costs, determines milestones, and monitors project performance. We also interviewed officials with DOE's Office of Environmental Management. In addition, we spoke with officials from the National Nuclear Security Administration (NNSA), a separately organized agency within DOE that is in charge of the day-to-day management of many of the nuclear materials the department plans to process in H-Canyon. We also interviewed two independent peer reviewers the department used to review its plans and officials with DOE's Office of Inspector General. To determine whether SRS's radioactive waste storage tanks and associated nuclear waste facilities are capable of handling additional waste, we reviewed SRS's waste management plans and risk management analyses, as well as business plans and integrated project management documents that outline the approach SRS officials use to meet canyon processing and waste management goals. We also visited SRS to observe H-Canyon and its supporting infrastructure, as well as the site's radioactive waste management facilities. To describe whether H-Canyon complies with safety and environmental requirements, we reviewed DOE regulations, orders, and guidance outlining the department's safety standards. We also examined safety analyses and implementation plans for safety improvements prepared by SRS officials. In addition, we reviewed reports prepared by, and interviewed officials with, the Defense Nuclear Facilities Safety Board (Safety Board), an independent federal agency established by the Congress in 1988 to provide advice and recommendations to the Secretary of Energy regarding public health and safety issues at DOE's defense nuclear facilities.

We conducted this performance audit from October 2007 to July 2008 in accordance with generally accepted government auditing standards. These 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.

Results in Brief

DOE plans to process 23 metric tons of HEU and plutonium at H-Canyon, but its cost estimate for processing this material does not include all associated costs. Nuclear materials included in DOE's plans consist of

-
- approximately 19,500 spent nuclear fuel assemblies containing about 13.5 metric tons of HEU from domestic and foreign research and test reactors,
 - approximately 7.5 metric tons of various HEU materials currently stored at five DOE facilities across the nuclear weapons complex, and
 - approximately 2 metric tons of plutonium.

DOE estimates it will cost approximately \$4.3 billion to \$4.6 billion to process these materials through 2019. However, this estimate does not include several costs DOE expects will be associated with canyon operations. According to DOE and NNSA officials, more HEU and plutonium may be identified as suitable for processing using H-Canyon, which could delay its shutdown and increase its operational costs. In addition, the estimate does not include the cost of storing and treating the waste generated by H-Canyon operations through 2019—approximately \$253 million according to DOE.

SRS's waste tank farms are nearing capacity, and SRS cannot manage the projected waste from planned H-Canyon operations through 2019 without critical enhancements. DOE is developing new technologies and building new facilities to meet these challenges. The most critical of these facilities—the Salt Waste Processing Facility (SWPF)—will provide the additional tank space needed to ensure continued SRS waste processing operations. The SWPF, originally scheduled to begin operating in 2009, has been delayed because of design concerns and is now projected to begin operation between September 2012 and November 2013. If the facility is not completed on schedule, SRS will continue to face waste storage capacity challenges, which could affect the H-Canyon operating schedule. Before the SWPF begins operating, SRS is working to optimize H-Canyon operations to minimize the canyon's impact on the waste storage tanks. For example, since 2007, SRS has reduced the amount of waste flowing into SRS's storage tanks from H-Canyon by approximately 450,000 gallons. Despite these measures, several potential events or waste management risks could significantly impede waste processing at SRS. For example, storage capacity could be reduced if critical equipment that reduces the amount of water in the waste tanks malfunctions or if tank leaks develop.

DOE has determined that H-Canyon is operating safely and with minimal environmental impact, and DOE expects it will continue to do so in the future. H-Canyon must comply with a variety of nuclear safety requirements to protect workers, the public, and the environment from any consequences associated with an accident at the facility. H-Canyon is

routinely reviewed and inspected for compliance with these requirements. DOE has determined through safety and environmental reviews and inspections that H-Canyon can continue to operate without endangering the health and safety of the public, the workers, or the environment. According to DOE officials, H-Canyon continues to pass all required inspections. Furthermore, DOE officials point to the facility's history of operating for nearly 50 years with no serious radiation-related accidents. The department has also taken several steps to ensure the continued safe operations of the canyon, including installing new safety equipment and updating H-Canyon's standard operating procedures to comply with revised DOE regulations and safety standards. However, DOE must complete further safety and environmental analyses prior to processing additional nuclear material using H-Canyon. Some of these analyses have been delayed by as much as 2 years because SRS lacks sufficient technical staff to conduct them. If these delays persist, the processing of nuclear material using H-Canyon could be delayed.

We are making a series of recommendations to DOE to develop a more complete, accurate estimate of all associated costs for processing the materials it expects H-Canyon to handle and to complete safety analyses in a timely manner to prevent delays in H-Canyon operations. We also provided DOE with a draft of this report for its review and comment. In its written comments, DOE cited the actions that are underway or that it plans to take to address the report's recommendations.

Background

H-Canyon is one of two chemical separation facilities constructed at SRS during the early 1950s to recover HEU, plutonium, and other nuclear material from nuclear fuel irradiated in SRS reactors for the U.S. nuclear weapons program. (See fig. 1.) With the end of the Cold War, nuclear material processing at the canyons was phased out, but some nuclear materials that had been introduced into the processing line at the canyons were left in place when DOE decided to cease canyon operations in 1992. In response to studies conducted by the department and by the Safety Board showing the potentially significant health, safety, and environmental risks posed by these unstable materials, DOE returned F and H-Canyons to service, in 1995 and 1997, respectively, to address these risks.

Figure 1: H-Canyon at DOE's Savannah River Site



Source: DOE.

The end of nuclear weapons production also left a significant amount of nuclear materials at SRS and other DOE sites without a means of permanent disposal. Among these materials are spent nuclear fuel rods from domestic and foreign research and test reactors. DOE and its predecessor agencies provided nuclear fuel to these reactors. In some cases, this fuel contained HEU. Since 1996, DOE has had a program to return U.S.-origin HEU in foreign research reactor fuel to the United States. These spent fuel rods are currently stored at SRS in water-filled pools. The water both cools the fuel rods and provides shielding from the radiation that they emit. Since the 1990s, DOE has had three different strategies for disposing of this material. DOE initially planned to develop a new technology—known as “melt-and-dilute”—to convert the material into a form that would render it unusable in nuclear weapons. Because of budget shortfalls and risks associated with DOE research and development for this approach, DOE abandoned this effort in 2002. Next, DOE considered removing the rods from the pools, drying them,

packaging them in storage containers, and storing the containers at SRS until they could be disposed of at DOE's planned permanent geological repository at Yucca Mountain. Now DOE plans to process this spent fuel in H-Canyon, which is consistent with legal requirements to keep the canyon operating.

In addition, DOE has identified other nuclear materials that lack options for disposal but that could also be processed using H-Canyon. For example, DOE stores about 50 metric tons of plutonium that the United States no longer needs for nuclear weapons. The majority is in the form of pits (the spherical core of a nuclear weapon), clean metal, and oxides while the remainder is in nonpit forms such as contaminated metal, oxides, solutions, and residues remaining from the nuclear weapons production process.³ DOE plans to dispose of the surplus plutonium that is in pit, clean metal, and oxide forms by fabricating it into mixed uranium and plutonium oxide fuel that can be used in commercial nuclear power plants. This process will take place in a new Mixed-Oxide Fuel Fabrication Facility that is currently under construction at SRS. Some of DOE's nonpit plutonium, however, is not suitable to be converted into mixed-oxide fuel. Although final decisions have not been made, DOE's current plans call for some of this nonpit plutonium to be fabricated into mixed-oxide fuel and some to be prepared for permanent disposition through vitrification—a process that would stabilize the plutonium by mixing it with molten glass and then pouring it into small metal canisters where it hardens. The smaller canisters containing vitrified plutonium would then be placed into larger canisters, which would then be filled with radioactive waste. Plutonium vitrification would take place at another facility DOE plans to construct at SRS. A smaller amount of plutonium, however, is unsuitable to be processed using either of these methods because it does not meet the technical requirements of these facilities. DOE plans to process this plutonium using H-Canyon.

The canyon operations produce radioactive waste that is stored in a series of underground tanks at SRS known as the F and H Area Tank Farms. In total, there are 51 tanks on these farms that contain approximately 36.5 million gallons of radioactive waste. Waste has been removed from 2 of these tanks, and the tanks have been operationally closed, leaving 49 tanks still in service. Radioactive waste generally comes in a variety of physical

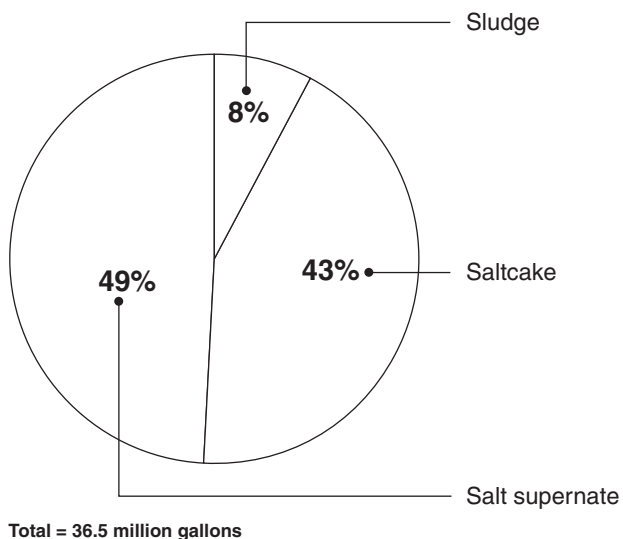
³The exact amount of plutonium in either pit or nonpit forms is considered classified information.

forms and layers inside the underground tanks, depending upon the physical and chemical properties of the waste components. As figure 2 shows, the waste in the tanks takes the following three main forms:

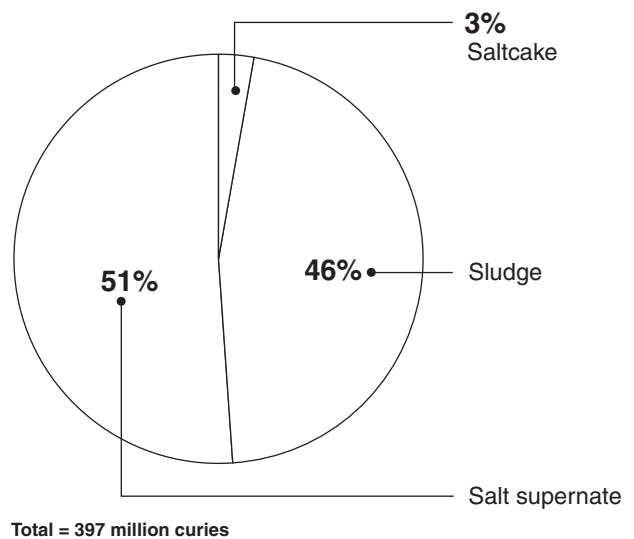
- *Sludge*: The denser, water insoluble components of the waste generally settle to the bottom of the tank to form a thick layer known as sludge, which has the consistency of peanut butter. Although sludge is only 8 percent of the total volume of the tank waste at SRS, it has about 46 percent of the tanks' total radioactivity.
- *Saltcake*: Above the sludge may be water-soluble components such as sodium salts that crystallize or solidify out of the waste solution to form a moist sandlike material called saltcake.
- *Salt supernate*: Above or between the denser layers may be liquids comprising water and dissolved salts that is called supernate. This represents about 50 percent of both the total volume and total radioactivity in the tanks.

Figure 2: Waste Components in SRS Storage Tanks as of March 2008

Percentage of total volume by waste type



Percentage of total radioactivity by waste type



Source: DOE.

Note: Radioactivity is measured in curies—the unit of measurement most commonly used in the United States. The corresponding international standard unit, the Becquerel (Bq) is the activity equal to one radioactive disintegration per second. One Bq=2.7 X 10⁻¹¹ curies.

SRS uses different methods to stabilize the waste and prepare it for permanent disposal. In the case of sludge, SRS stabilizes the material through vitrification at SRS's Defense Waste Processing Facility (DWPF). Canisters of vitrified radioactive waste produced at DWPF are stored at SRS for future disposition at DOE's planned permanent geological repository at Yucca Mountain, in Nevada. Sludge processing also produces significant amounts of low-radioactivity waste, called "DWPF recycle," that is returned to the SRS tank farms for storage. In fact, DWPF recycle makes up the largest portion of liquid waste added to the tank farms annually.

Because of the large volumes of lower-radioactivity saltcake and salt supernate (known collectively as "salt waste") stored at SRS, glass vitrification of all of this waste without reducing its volume would produce too many canisters to be disposed of at the Yucca Mountain facility and would inappropriately use the facility to dispose of low-level waste. Therefore, SRS is constructing facilities to separate higher radioactivity waste from the remainder of the lower activity waste. One facility, the SWPF, will separate the higher radioactivity waste in the salt waste from the low radioactivity waste. In the interim, before the SWPF is constructed, DOE is using three interim processes to separate the lower-radioactivity waste. The higher-radioactivity waste will then be mixed with sludge for vitrification at the DWPF. The remaining low-radioactivity waste will be stabilized by combining it with cement at another SRS facility called the Saltstone Facility. This mixture, called grout, will then be permanently disposed of at SRS in a series of on-site vaults at the Saltstone Facility.

DOE Has Not Determined the Complete Cost of Processing 23 Metric Tons of Highly Enriched Uranium and Plutonium in H-Canyon

DOE currently plans to process 23 metric tons of HEU and plutonium using H-Canyon, but, according to DOE and NNSA officials, it is likely that more HEU and plutonium will be identified as suitable for processing using the canyon. DOE has estimated that processing the 23 metric tons of nuclear material in its current plans will cost approximately \$4.3 billion to \$4.6 billion through 2019. However, this cost estimate is incomplete. For example, the estimate does not include the costs of storing and treating the waste generated by H-Canyon operations. According to DOE officials, it will cost approximately \$253 million to process the liquid radioactive waste expected to be produced as a result of H-Canyon operations.

DOE Is Likely to Identify Other Nuclear Material Needing Processing in H-Canyon, Making the Project More Costly and Possibly Delaying H-Canyon's Shutdown

DOE plans to process 23 metric tons of HEU and plutonium at H-Canyon. The following three categories of weapons-usable HEU and plutonium material are included in DOE's plans:

- Approximately 19,500 spent nuclear fuel assemblies containing 13.5 metric tons of weapons-usable HEU from domestic and foreign research and test reactors. This spent fuel consists of irradiated aluminum-clad HEU and LEU fuel, most of which is currently stored at either SRS or Idaho National Laboratory.
- Approximately 7.5 metric tons of various weapons-usable HEU materials DOE had used for research and development that are currently stored at NNSA's Y-12 National Security Complex in Tennessee, Los Alamos National Laboratory in New Mexico, Lawrence Livermore National Laboratory in California, Sandia National Laboratory in New Mexico, and Idaho National Laboratory.
- Approximately 2 metric tons of nonpit plutonium currently stored at SRS, some of which cannot be disposed of using either the Mixed-Oxide Fuel Fabrication Facility or the proposed plutonium vitrification facility.

HEU recovered from H-Canyon will be blended with natural uranium to produce LEU that can be used as fuel in the Tennessee Valley Authority's commercial nuclear power plants. According to a 2007 DOE estimate, sale of this uranium to the Tennessee Valley Authority will provide \$481 million in revenues to the U.S. Treasury. However, this estimate is subject to great variation because of volatility in the price of uranium. Plutonium processed in H-Canyon will not be recovered. Instead, it will be introduced into SRS's liquid radioactive waste management system. Processing this HEU and plutonium reduces the risks associated with storage of such materials at multiple sites, helps reduce storage and security costs, and furthers nuclear non-proliferation objectives.

Beyond the 23 metric tons of HEU and plutonium DOE has identified for processing using H-Canyon, depending on future decisions, DOE and NNSA officials told us they may identify additional plutonium that is suitable to be processed using H-Canyon. Specifically, these additional materials are likely to include an extra 3 metric tons of plutonium that was going to be processed for final disposal at SRS's proposed plutonium vitrification facility, according to DOE and SRS officials. Although the addition of this plutonium to the H-Canyon processing plan is unlikely to delay the canyon's planned shutdown, it will increase the canyon's operational costs. According to DOE officials, if this plutonium is added,

one of H-Canyon's processing lines—the HB-Line—will have to continue operating beyond its currently planned shutdown date. DOE originally estimated to have completed HB-Line operations in 2014. However, the HB-Line will need to continue operating until at least 2019 at a cost of approximately \$60 million per year if H-Canyon were to be used to process additional plutonium beyond that already planned. DOE officials noted that the costs of operating HB-Line between 2014 and 2019 was included in their original \$4.3 to \$4.6 billion cost estimate. However, they also acknowledged that between \$240 and \$300 million in H-Canyon costs could be saved by not processing this additional 3 metric tons of plutonium using H-Canyon.

Other nuclear materials may be identified for processing using H-Canyon, further extending the canyon's operations. In October 2007, DOE authorized NNSA to review whether additional quantities of nuclear material from foreign countries could be recovered for disposition at DOE sites. For example, DOE and NNSA officials told us that more spent nuclear fuel, HEU materials, and plutonium still stored at foreign research and test reactors may be suitable for processing using H-Canyon. Specifically, NNSA has identified approximately 1,000 kilograms of HEU and approximately 50 kilograms of plutonium that potentially could be returned to the United States. If these materials are brought to the United States, DOE is considering adding them to the scope of materials included in the H-Canyon processing plan, which may delay the canyon's planned shutdown. In addition, according to DOE officials, other materials currently stored at DOE facilities might be added to DOE's plan. For example, DOE might add HEU and/or plutonium currently stored at DOE research facilities that are no longer in use.

DOE's Estimate for Processing Nuclear Material Using H-Canyon Is Incomplete

DOE estimates that it will cost between approximately \$4.3 billion and \$4.6 billion to process 23 metric tons of HEU and plutonium using H-Canyon. However, DOE's cost estimate for processing nuclear material at H-Canyon does not include all of the costs associated with continued H-Canyon operations. Most notably, the cost of storing and treating the waste generated by H-Canyon operations is not included in DOE's estimate.

H-Canyon produces up to approximately 300,000 gallons of liquid radioactive waste annually, which is added to SRS's tank farms for storage and must eventually be treated using SRS's liquid waste processing facilities. Processing this waste will increase the amount of time that the radioactive liquid waste facilities are required to operate, which increases

the cost for SRS liquid waste system life cycle cost. Because DOE's estimate did not include these costs, we asked DOE to estimate the additional costs of storing and treating the waste generated by the department's plans to process 23 metric tons of HEU and plutonium using H-Canyon. In response, DOE estimated that it will cost approximately \$253 million to store and treat the additional radioactive waste resulting from H-Canyon's operations through 2019. DOE estimated some of these costs to include

- approximately \$40 million to store the additional radioactive waste produced by H-Canyon in the SRS tank farms;
- approximately \$25 million to operate the SWPF for the additional 6 months DOE estimates will be necessary to separate higher and low radioactivity wastes in the additional salt waste that will be produced by H-Canyon;
- approximately \$140 million to treat the additional higher radioactivity waste using the DWPF;⁴ and
- approximately \$30 million to treat and dispose of the additional low radioactivity waste at the Saltstone Facility.⁵

⁴DOE estimates that operating H-Canyon through 2019 will add 297 canisters to the approximately 6,300 vitrified high radioactivity waste canisters required to dispose of SRS's high radioactivity waste.

⁵DOE estimates that operating H-Canyon through 2019 will add an additional two Saltstone Facility vaults to the 36 planned vaults required to dispose of SRS's low radioactivity waste.

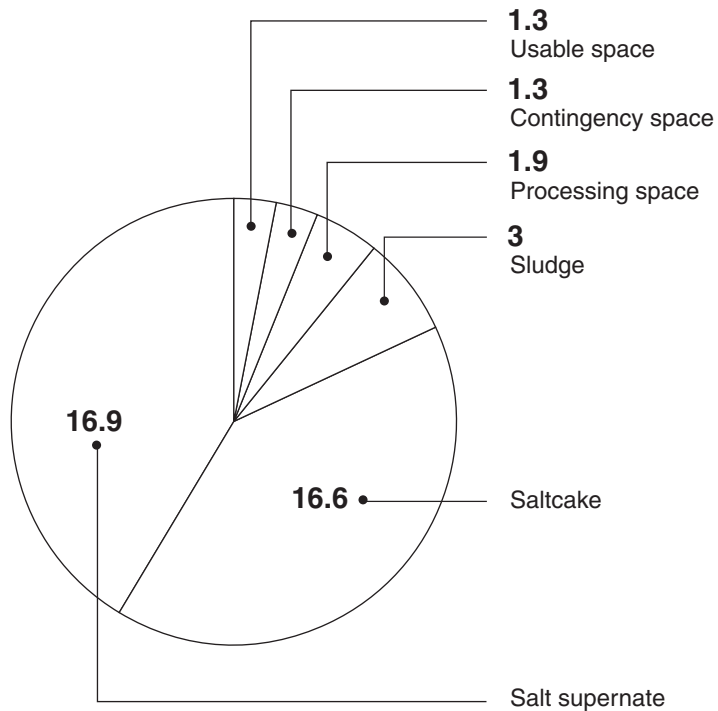
More Radioactive Waste at SRS Will Be Generated as a Result of Continued H-Canyon Operations, Requiring Critical Technological Enhancements to the Site's Liquid Radioactive Waste Treatment System

Although H-Canyon processing produces a relatively small portion of SRS's liquid radioactive wastes, SRS storage tanks are nearing capacity and do not currently have the space necessary to store all of the waste H-Canyon will produce through 2019. DOE must modify current facilities and develop new technologies to successfully store and treat all radioactive waste at SRS. Certain elements of DOE's SRS waste management plan, such as the construction of the SWPF, have faced delays. Furthermore, despite DOE efforts to monitor and mitigate risks, a number of events could potentially disrupt planned waste management activities at SRS.

Continued H-Canyon Operations Will Add Waste to the SRS Tank Farms, Which Are Already Nearing Capacity

More than 140 million gallons of radioactive waste have been produced at SRS since canyon operations began in the 1950s. Fifty-one storage tanks were constructed at SRS to hold these waste products; 49 of these tanks remain in service, providing approximately 41 million gallons of storage capacity. Currently, approximately 36.5 million gallons of radioactive waste are stored in these tanks. Another 1.3 million gallons of space is kept open as contingency space for use during an emergency, and 1.9 million gallons remains available as space used to prepare waste for processing. As a result, only 1.3 million gallons of space remain as usable space for additional waste storage. Figure 3 shows how tank space is used at SRS.

Figure 3: Breakdown of SRS Waste Tank Storage as of March 2008



Millions of gallons
Source: DOE.

Waste disposition activities must be meticulously planned and scheduled to maximize use of the small amount of available tank space. H-Canyon operations contribute up to 300,000 gallons of liquid radioactive waste annually to the tanks. In addition, approximately 1.5 million gallons of radioactive waste is added per year as a result of SRS waste processing activities to close waste storage tanks. Specifically, closing tanks requires the removal of radioactive waste stored in the tanks by adding water to redissolve saltcake or to prepare insoluble sludge for transfer to another tank or waste processing facility. Adding this water, however, reduces the amount of space available for additional liquid radioactive waste. Other salt removal operations result in another 1.5 million gallons of waste flowing into the tanks annually. Furthermore, the vitrification process used at DWPF produces the most significant annual inflows of waste to the tank farms; approximately 2 million gallons of DWPF recycle annually. Table 1 details the annual liquid inflows to SRS's tank farms.

Table 1: Tank Farm Waste Sources

Source	Approximate annual volume
H-Canyon	0.3 million gallons
Sludge washing	1 million gallons
Salt removal activities	1.5 million gallons
Tank closure activities	1.5 million gallons
DWPF recycle	2 million gallons

Source: DOE.

More liquid radioactive waste is generated annually than SRS's tanks can store. However, because water makes up a portion of the liquid radioactive waste, SRS uses evaporators—heated tanks that evaporate water from waste material—to conserve tank space. Three evaporator systems are currently operating at SRS. One evaporator—the 2H evaporator—is used solely to reduce the quantity of DWPF recycle entering the tanks while two other evaporators—the 2F and 3H evaporators—are used for H-Canyon waste and other waste processing activities. Operation of these evaporators allows SRS to successfully manage the inflows of liquid radioactive waste in the limited space available in the tanks.

DOE Must Modify Its Waste Management System to Deploy New Technologies in Order to Successfully Treat SRS's Liquid Radioactive Waste

DOE is taking a number of steps to ensure the availability of storage tank space for continued waste processing and H-Canyon operations. Critical among these initiatives is development of salt waste processing technologies that will significantly reduce the amount of salt waste stored in SRS tank farms. The most important of these is the SWPF. H-Canyon and waste management staff are also working to minimize the amount of liquid radioactive waste transferred to the tank farms by changing operating procedures and redirecting this waste. Nevertheless, DOE must continue to manage several potential risks to ensure uninterrupted H-Canyon and SRS waste management operations.

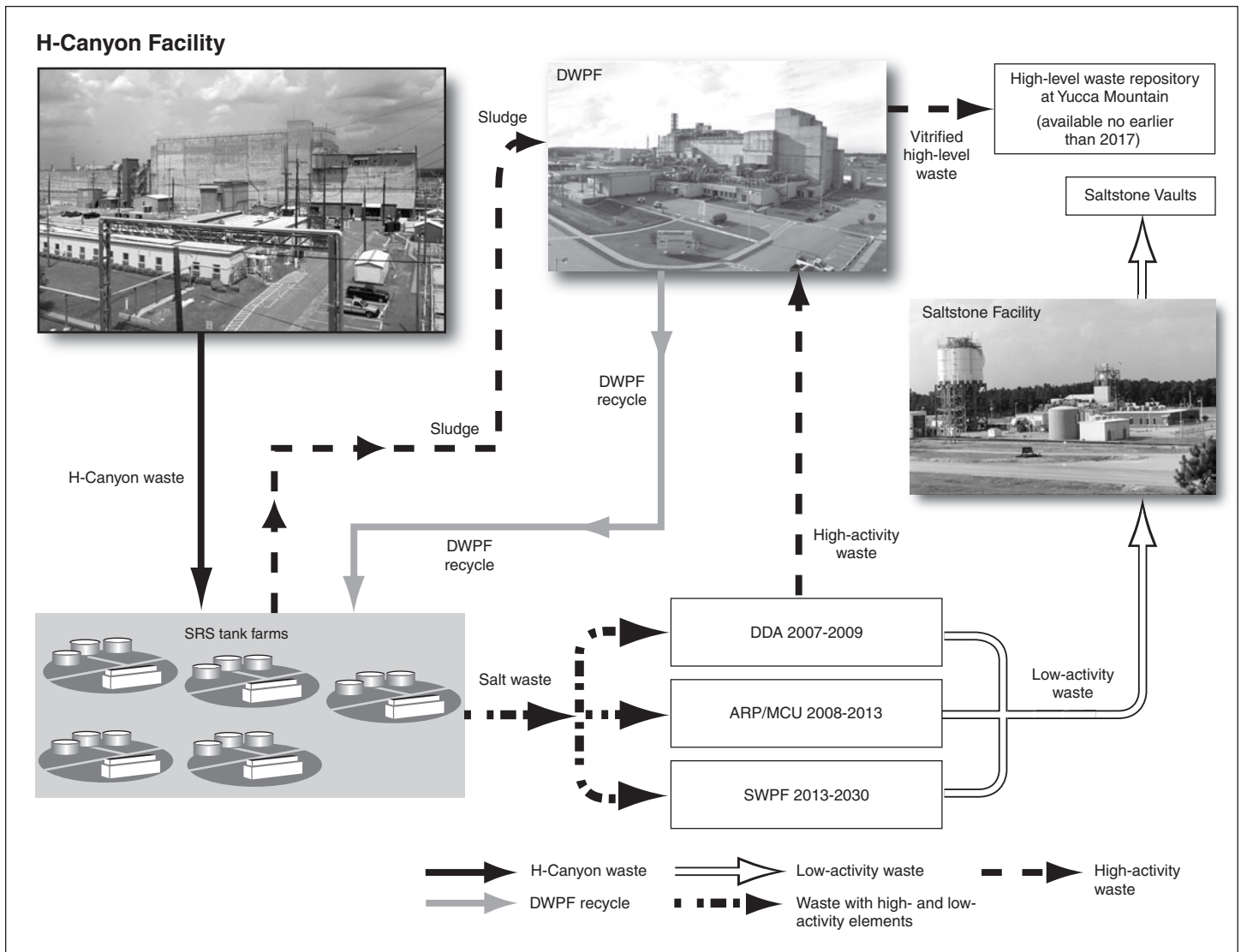
DOE Has Developed Plans for Processing Salt Waste

DOE plans to process the majority of SRS's salt waste using the yet to be constructed SWPF. Before SWPF begins operations, however, two other facilities currently operate at SRS that provide interim salt waste processing capability. These facilities are intended to provide the necessary tank space to support H-Canyon operations, tank closure activities, and DWPF operations. Specifically, these interim facilities are the following:

-
- The *Deliquification, Dissolution, and Adjustment* (DDA) facility, which began operation in March 2007 and had treated 1.35 million gallons of salt waste through April 2008. This technology mixes saltcake with low radioactivity waste and transfers it to the Saltstone Facility for processing into grout. According to DOE officials, the DDA facility will process another 800,000 gallons of waste before it completes its mission in 2009.
 - The *Actinide Removal Process/Modular Caustic-Side Solvent Extraction Unit* (ARP/MCU) is a small-scale version of the permanent SWPF, according to DOE officials. In May 2008, DOE began operating the ARP/MCU. The facility will process approximately 1.2 million gallons of salt waste per year until SWPF becomes operational.

In the long term, DOE describes SWPF as an essential capability to process salt waste at SRS and increase the amount of tank space available for continued operations. Using the same technology as the ARP/MCU facility, SWPF is expected to process 6 million gallons of salt waste each year when fully operational and, in total, treat approximately 90 percent of the salt waste at SRS. SWPF is expected to operate through 2030; however, this date may change based on adjustments in waste volumes. Figure 4 illustrates SRS's liquid radioactive waste processing system.

Figure 4: Liquid Radioactive Waste Processing at SRS



Source: DOE.

Design of the SWPF facility began in January 2004, and the facility was originally scheduled for completion in 2009. However, the project has been delayed twice, substantially delaying its completion. In November 2005, the Safety Board reviewed the plans for the facility and suggested that the SWPF be designed to meet more robust construction specifications than originally planned. To meet these more stringent specifications, the facility was redesigned, which resulted in extending the facility's completion date

to 2011. More recently, a change in construction seismic standards forced another delay, resulting in a revised estimated completion date of between September 2012 and November 2013. Additionally, DOE is in the process of preparing a existing waste storage tank that will be used to store materials being prepared for processing at SWPF. DOE is having challenges finding a contractor that can perform this work within budget. Failure to prepare this tank on schedule could negatively impact SRS waste management activities by reducing the volume of salt waste SWPF would be able to process when it begins operation.

DOE Is Undertaking Initiatives to Minimize H-Canyon Waste

DOE is developing ways to reduce the amount of liquid radioactive waste that H-Canyon contributes to SRS's tank farms annually. For example, to neutralize the acidic waste from H-Canyon so that the waste will not corrode tank linings, DOE adds a material called "caustic" before the liquid waste is transferred to the tanks. Adding caustic, however, increases the volume of waste H-Canyon generates. DOE has determined a way to reduce the quantity of caustic added while still ensuring the waste does not cause corrosion in the tanks. This, in turn, has reduced the volume of waste H-Canyon contributes to the tank farms. In addition, piping changes at the canyon will allow the separation of high radioactivity and low radioactivity wastes, allowing the low radioactivity waste to bypass the tank farms altogether. Low radioactivity waste will be sent directly to SRS's Saltstone Production Facility for disposal rather than to the tank farm as has been done in the past. According to a DOE official, waste minimization efforts implemented at SRS have reduced high radioactivity waste production by 450,000 gallons through April 2008. Finally, DOE plans to first process approximately 7.5 metric tons of HEU from other nuclear complex facilities and a portion of the approximately 2 metric tons of plutonium before processing the approximately 13.5 metric tons of spent nuclear fuel because the HEU materials and plutonium generate less radioactive waste than processing spent nuclear fuel. In 2010, once additional tank space is available through waste minimization activities and/or salt waste processing, DOE plans to start processing spent nuclear fuel at H-Canyon.

DOE Could Still Face Delays in Waste Management Operations

Despite efforts to control the amount of liquid waste, DOE faces a number of potential obstacles that could reduce the tank space and potentially delay waste management operations. For example, insufficient tank space continues to be a high risk that DOE must monitor. As discussed, SRS uses evaporators to reduce the amount of water in the tanks to conserve tank space. SRS's *2007 Life-cycle Liquid Waste Disposition System Plan* outlines how an unanticipated extended outage of certain evaporator

systems could delay DWPF operations, tank closure activities, and H-Canyon operations.⁶ According to the risk management plan for SRS's liquid radioactive waste management system, the 2H evaporator system that reduces the amount of DWPF recycle in the tanks may encounter problems that could negatively affect tank space availability. The risk management plan indicates that malfunctions in this evaporator could delay waste processing activities for up to 1 year at a cost of \$550 million. A similar risk has been noted for the 2F and 3H evaporators that support, among other things, H-Canyon operations, but this risk has been deemed less likely to occur and to have less significant consequences for waste management operations.

One of the highest risks that DOE must manage is the potential for tank leaks. While DOE considers a leak that will require the use of tank farm contingency space unlikely, 12 tanks without secondary containment have a history of leakage.⁷ Sufficient liquid waste has been removed from these tanks so that there are currently no active leak sites. Although DOE considers the likelihood of a new tank leak of high radioactivity waste to be low, the potentially severe impact of such a leak requires DOE to monitor it as a high risk. A tank leak would require DOE to use most of the available contingency space in the tank farm system and would complicate transfers necessary for future waste processing. If a leak occurred, waste management operations would cease immediately until the leak and its implications are understood, and new contingency space became available. Such a situation, though improbable because DOE has removed sufficient liquid waste from tanks without secondary containment, would likely result in a delay of approximately 5 years to the liquid waste stabilization and disposition activities and cost approximately \$2.25 billion, according to DOE's plans.

⁶DOE-SRS, *SRS Liquid Waste Planning Process: Life-cycle Liquid Waste Disposition System Plan, Rev. 14*. October 18, 2007.

⁷Tanks that meet Environmental Protection Agency standards have a metal liner on the outer tank wall that is referred to as a secondary containment. Of the 49 tanks currently in service at SRS, 25 tanks have full secondary containment while the remaining 24 have only partial or no secondary containment.

DOE Has Taken Steps to Ensure the Continued Safe Operation of H-Canyon but Faces Challenges to Completing Safety and Environmental Analyses on Time

H-Canyon must comply with a variety of nuclear safety requirements to protect workers, the public, and the environment from any consequences associated with an accident at the facility. DOE has determined that H-Canyon complies with current safety standards, and the department has taken several steps to ensure the continued safe operations of the canyon. However, DOE must take several additional steps prior to processing additional nuclear material using H-Canyon, including completing required safety and environmental analyses. DOE is currently behind schedule in preparing some of these analyses and, if these delays persist, the processing of nuclear material using H-Canyon could be delayed.

According to DOE and SRS Officials, H-Canyon Operations Comply with Current DOE Safety Standards

H-Canyon operations must comply with rigorous nuclear safety requirements established in Title 10 of the *Code of Federal Regulations* and associated DOE directives. These requirements address programs such as, among other things, protecting the public and workers from radiation, emergency response procedures, and fire protection in nuclear facilities. H-Canyon is routinely reviewed and inspected for compliance with these requirements. DOE has determined through this process that H-Canyon can continue to operate without endangering the health and safety of the public, the workers, or the environment. Furthermore, DOE officials point to the facility's history of operating for nearly 50 years with no serious radiation-related accidents.

In addition, DOE continues to maintain and improve safety systems at H-Canyon. During the last decade, DOE has made some significant safety upgrades to the facility, including installing a new safety electrical system with backup diesel generators. DOE has also upgraded H-Canyon's ventilation system, which will better protect workers, the public, and the environment in the event of a release of radioactive material. Moreover, prior to processing any additional nuclear material using H-Canyon, DOE needed to ensure that H-Canyon's standard operating procedures were updated and complied with the relevant DOE regulations and safety standards for nuclear facilities. These updates were completed in 2007.

Late Completion of Safety and Environmental Analyses Could Delay H-Canyon Operations

Federal regulations require DOE to prepare documented safety analyses that detail potential accident conditions that might lead to the release of radioactive or other hazardous materials. These analyses also identify safety systems and processes to protect workers, the public, and the environment from any adverse consequences of a release of this material. DOE developed a strategy in April 2007 for updating H-Canyon's documented safety analyses to ensure that they comply with applicable regulations and DOE standards.⁸ This strategy established specific milestones for completing required analyses. While some analyses have been completed as scheduled so that SRS can continue processing some types of nuclear material using H-Canyon, DOE is behind schedule completing other required documented safety analyses. Specifically, an accident analysis that identifies the consequences of accidents involving the nuclear material DOE plans to process using H-Canyon, as well as another analysis—called a mitigated hazard analysis—that identifies the specific safety systems to prevent such accidents have been delayed. While these analyses were to be completed in September and November 2007, respectively, DOE now estimates the analyses will not be completed until fiscal year 2009. DOE officials attribute this delay to the limited technical staff available to conduct safety analyses at SRS.

Delays completing these analyses could negatively affect H-Canyon operations. In particular, DOE has developed a stringent schedule for processing different types of nuclear material using H-Canyon. For example, completing the processing of spent nuclear fuel by 2019, as is currently scheduled, requires SRS to begin processing the fuel in 2010. If delays completing required safety analyses continue, SRS may have to delay beginning the processing of spent nuclear fuel beyond 2010 and, as a result, H-Canyon may have to operate beyond the planned 2019 shutdown date to make up for the disruption in the processing schedule.

In addition to completing required safety analyses, DOE must also update environmental analyses required by the National Environmental Policy Act. DOE previously issued environmental impact statements and records of decision regarding the spent nuclear fuel, HEU, and plutonium that the department now plans to process using H-Canyon. For example, in an environmental impact statement and record of decision that DOE issued in

⁸Specifically, documented safety analyses must comply with requirements in Part 830 of Title 10 of the *Code of Federal Regulations* and DOE Standard 3009-94 "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses."

2000, DOE decided to dispose of up to 33 metric tons of surplus plutonium as mixed-oxide fuel and approximately 17 metric tons of plutonium using an immobilization process.⁹ A subsequent 2002 decision cancelled DOE's plans to build an immobilization facility and left the department without a means for processing some of this plutonium into a form suitable for permanent disposition. In March 2007, DOE announced that it was preparing a supplemental environmental impact statement that would examine alternative plutonium disposition methods, including the disposal of some of the surplus plutonium using H-Canyon. Although DOE's March 2007 announcement stated that a draft supplemental environmental impact statement was planned to be issued in January 2008, and the final supplemental environmental impact statement and associated record of decision would be issued in the summer of 2008, neither the draft nor the final supplemental environmental impact statement has been issued. DOE officials stated that the department will issue the draft supplemental environmental impact statement in September 2008 and the final supplemental environmental impact statement in 2009.

DOE is engaged in a similar effort to update the environmental analyses prepared for permanently disposing of the department's surplus HEU and for the treatment, long-term storage, and eventual disposition of DOE's spent nuclear fuel. A supplemental analysis for processing and disposing of aluminum-clad spent nuclear fuel and other HEU materials using H-Canyon was completed in January 2008 and is undergoing review and concurrence. DOE expects to complete the remainder of its environmental analyses by the end of fiscal year 2008.

Conclusions

DOE's plan to continue processing nuclear material using H-Canyon has several potential benefits, such as decreasing the amount of spent nuclear fuel to be disposed of at Yucca Mountain in the event that the repository eventually opens. To achieve these benefits, DOE will have to carefully manage the significant risks associated with the canyon's operation; namely, the generation of large quantities of additional radioactive waste that will further stress SRS's already strained waste processing capabilities. It is not currently possible to determine if DOE's plan to use H-Canyon to process nuclear material through 2019 is the most advantageous plan because DOE's cost estimate for operating H-Canyon is

⁹Immobilization involves mixing the plutonium with ceramics, placing the mixture in large canisters, and filling the canisters with vitrified high-level radioactive waste.

incomplete. Specifically, the estimate does not account for all the nuclear material that DOE now believes it may process using H-Canyon, and the estimate does not include costs such as those associated with storing and treating the waste generated as a result of H-Canyon operations. Without a comprehensive understanding of the inventory of materials suitable for H-Canyon processing, it is unclear whether DOE can complete nuclear material processing and successfully shut down H-Canyon by 2019 as the department currently plans. Furthermore, DOE has not developed a reliable estimate of the canyon's total life cycle costs, including the costs associated with treating the additional radioactive waste.

H-Canyon has an established record of operating safely for five decades. However, continued operations of the canyon could be delayed if required safety analyses are not completed in a timely manner. While SRS has pledged to complete analyses in time to have operations proceed on schedule and has met some deadlines for the completion of these analyses, it has missed others by as much as 2 years. Other projects at SRS continue to compete for the necessary engineering expertise to complete these analyses. Further delays could cause the canyon's operations to be extended beyond its planned 2019 closure and result in increased costs. An unforeseen accident could also lead to significant, potentially catastrophic, consequences. It is therefore critical that DOE and SRS ensure that adequate resources are devoted to completing these required analyses before additional nuclear material is processed using H-Canyon.

Recommendations for Executive Action

To ensure that DOE is effectively able to use H-Canyon's capabilities to process and dispose of nuclear material, we recommend that the Secretary of Energy take the following three actions:

- Ensure that the efforts of NNSA and other offices within DOE to identify additional HEU, plutonium, and other nuclear materials that may be suitable for processing using H-Canyon are coordinated in order to make sure that these materials are included in SRS's processing plans and that any additional material added does not unduly delay H-Canyon's planned 2019 shutdown.
- Develop a comprehensive cost estimate for continuing to operate H-Canyon that includes all waste treatment costs and contingency costs for any additional nuclear materials that will be included in the processing plans.

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- Direct SRS to develop a plan to ensure that sufficient technical staff are available to complete the required safety analyses in a timely manner so that H-Canyon operations can proceed on schedule.

Agency Comments and Our Evaluation

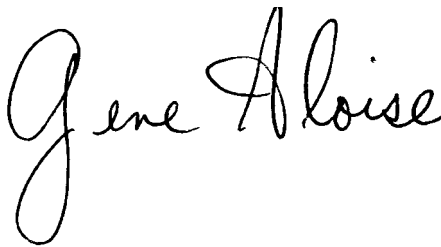
We provided DOE with a draft of this report for its review and comment. In their written comments, DOE outlined the actions that are underway or that it plans to take to address the draft report's recommendations. The complete text of DOE's comments are presented in appendix I. DOE also provided technical clarifications, which we incorporated into the report as appropriate.

To address the report's recommendations, DOE stated it will work closely with NNSA's recently established Office of Nuclear Material Integration to ensure that future decisions to process additional materials at H-Canyon are coordinated to minimize the impact to the canyon's planned shutdown. In addition, DOE stated that it would formally document the H-Canyon cost estimate that includes the resultant impact of planned H-Canyon operations to the SRS liquid waste system. Moreover, DOE stated that it has directed the contractor operating SRS to complete the required safety analyses to support scheduled H-Canyon operations and that the department will monitor the contractor's progress.

In its comments, DOE stated that the draft report's title implied that certain actions are not being taken expeditiously to reduce nuclear risks. Contrary to DOE's assertion, we do not imply that the canyon is currently being operated unsafely. Our draft report detailed the actions DOE is taking to reduce the risks associated with continued H-Canyon operations. DOE also noted that the use of the term "nuclear waste" in the draft report's title was inaccurate because H-Canyon does not process nuclear waste. We used the term nuclear waste to refer to surplus spent nuclear fuel, HEU materials, and plutonium for simplicity. This is because—with the exception of uranium recovered from the spent nuclear fuel and HEU materials—all of the nuclear materials processed using H-Canyon will ultimately be permanently disposed of as nuclear waste. However, we acknowledge DOE's concern and have clarified the report's title accordingly.

We are sending copies of this report to the appropriate congressional committees; the Secretary of Energy; and the Director, Office of Management and Budget. We also will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staffs have any questions about this report, please contact me at (202) 512-3841 or aloisee@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 major contributions to this report are listed in appendix II.

A handwritten signature in black ink that reads "Gene Aloise". The signature is written in a cursive style with a large, looped initial "G".

Gene Aloise
Director, Natural Resources and Environment

Appendix I: Comments from the Department of Energy



Department of Energy

Washington, DC 20585

July 11, 2008

Mr. Gene Aloise
Director, Natural Resources and Environment
Government Accountability Office
Washington, D.C. 20548

Dear Mr. Aloise:

Thank you for your June 27, 2008, letter to the Secretary of Energy providing the draft report, "*DOE Needs to Take Action to Reduce Risks Before Processing Additional Nuclear Waste at Savannah River Site's H-Canyon,*" and requesting written comments from the Department of Energy (DOE). Your draft report contains three recommendations for executive action: 1) ensure that efforts by the National Nuclear Security Administration (NNSA) and other offices to identify additional materials for processing in H-Canyon are coordinated and do not unduly delay H-Canyon shutdown; 2) develop a comprehensive cost estimate for operating H-Canyon that includes all waste treatment costs and contingency costs for any additional materials that will be included in processing plans; and 3) direct the Savannah River Site (SRS) to develop a plan to ensure technical staff are available to complete required safety analyses to support scheduled H-Canyon operations.

With respect to your first recommendation, DOE established the Nuclear Materials Disposition and Consolidation Coordination Committee (NMDCCC) to provide a forum to perform cross-cutting nuclear materials disposition and consolidation planning. The committee, which includes members from my office and NNSA, has been working to coordinate DOE activities associated with nuclear material consolidation and disposition, such as the ongoing surplus plutonium consolidation effort. The committee is expected to complete its agenda by the end of this year and its coordinating function will be transferred to the recently established Office of Nuclear Material Integration (ONMI) within NNSA. My staff will work with NNSA to ensure that the responsibilities of the newly established ONMI include continuing the coordination role that the NMDCCC has been performing. Close coordination within DOE, together with DOE Order 413.3 and its associated manual, will ensure future decisions to process additional materials, beyond the Enriched Uranium (EU) Disposition Project scope, will be coordinated to minimize impacts to H-Canyon disposition activities completion.



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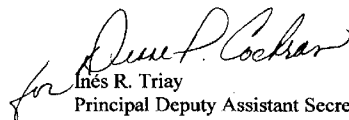
In regard to your second recommendation, I have directed my staff to formally document the H-Canyon cost estimate provided to your audit team and congressional staff that implements the scope of the EU Disposition Project and the resultant impacts to the SRS liquid waste system.

For your third recommendation, the Savannah River Operations Office (SR) Manager Jeffrey Allison, by letter dated July 2, 2008, directed the SRS contractor to upgrade the H-Canyon safety analyses to be consistent with the DOE-STD-3009 format and content supporting the schedule to maintain the facility's planned operations. Mr. Dae Chung, Deputy Assistant Secretary for Safety Management and Operations, and his staff will continue to follow the progress made by both the contractor and federal staff in the preparation and review of safety documentation to ensure completion of the required documentation to support approval and initiation of spent nuclear fuel processing. Spent nuclear fuel processing is scheduled to begin in 2010.

At the recent Exit Conference with your staff, we provided comments on the bulk of the draft report, and although your draft report includes several revisions in response to those comments, we believe it contains some inaccuracies and misleading statements. For example, the title of the draft report, "*DOE Needs to Take Action to Reduce Risks Before Processing Additional Nuclear Waste at Savannah River Site's H-Canyon*," implies certain actions are not being taken expeditiously to reduce nuclear risks. As you are aware, that is not a true statement and there has never been any dispute regarding the fact that H-Canyon is currently being safely operated and in compliance with all existing safety requirements. Additionally, and contrary to that statement, H-Canyon does not process nuclear waste, and it is not permitted to do so. Enclosed is a mark-up of your draft report that contains our comments. We respectfully request they be considered as you finalize your report.

If you have any questions, please contact me at (202) 586-5216 or Mr. Gary DeLeon, Director, Office of Nuclear Materials Disposition, at (301) 903-7668.

Sincerely,


Inés R. Triay
Principal Deputy Assistant Secretary for
Environmental Management

Enclosure

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Gene Aloise, (202) 512-3841, or aloisee@gao.gov

Staff Acknowledgments

In addition to the individual named above, Ryan T. Coles, Assistant Director; Naba Barkakati; Don Cowan; Mehrzad Nadji; Omari Norman; Peter Ruedel; Rebecca Shea; Carol Herrstadt Shulman; and Tom Twambly made key contributions to this report.

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