Report on Separate Disposal of Defense High-Level Radioactive Waste

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EXECUTIVE SUMMARY

Purpose

This report considers whether a separate repository for high-level radioactive waste (HLW) resulting from atomic energy defense activities ("Defense HLW Repository") is "required" within the meaning of Section 8(b)(2) of the Nuclear Waste Policy Act of 1982 (NWPA).

In 1985, the U.S. Department of Energy (DOE) and President Reagan considered this question and found no basis to conclude, based on the circumstances at the time, that a separate Defense HLW repository was required. Therefore, in the ensuing decades, DOE has planned to dispose of Defense HLW in a common repository with other DOE-managed waste and with commercial HLW and spent nuclear fuel (SNF), sited and developed under the process set forth in the NWPA ("Common NWPA Repository").[1] Over time, however, the circumstances on which the 1985 finding was based have changed materially. In light of that, the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (the "Strategy") indicated the issue of using a single repository for disposal of both commercial and defense wastes (i.e., the Common NWPA Repository approach) would be the subject of further analysis. To that end, this report considers the factors identified in the NWPA to determine if a separate repository for Defense HLW is required. This report also devotes particular attention to ways in which the circumstances have changed since 1985.

Nuclear Waste Policy Act

Section 8(b)(1) of the NWPA requires that "[n]ot later than 2 years after the date of the enactment of this Act, the President shall evaluate the use of disposal capacity at one or more repositories to be developed under subtitle A of title I for the disposal of high-level radioactive waste resulting from atomic energy defense activities." The NWPA states that this evaluation shall take into consideration six factors: cost efficiency; health and safety; regulation; transportation; public acceptability; and national security.

Section 8(b)(2) provides that:

> Unless the President finds, after conducting the evaluation required in paragraph (1), that the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required, taking into account all of the factors described in such subsection, the Secretary shall proceed promptly with arrangement for the use of one or more of the repositories to be developed under subtitle A of title I for the disposal of such waste.

Section 8(b) thus contemplates two pathways for disposal of Defense HLW. In the absence of a Presidential finding that a Defense HLW Repository is required, the Secretary must develop one or more Common NWPA Repositories. Alternatively, if the President finds that a Defense HLW Repository is

[1] This report uses the following terms when referring to repositories: "Common NWPA Repository" means a repository developed under subtitle A of title I of the NWPA for the disposal of Defense HLW, other DOE-managed waste, and commercial HLW and SNF; "Defense HLW Repository" means a repository developed by DOE under the Atomic Energy Act for the disposal of Defense HLW.

required, the development of a separate repository is authorized. In developing a Defense HLW Repository, the Secretary would be subject to U.S. Nuclear Regulatory Commission licensing, but would not be subject to the NWPA's siting provisions, apart from the state and tribal participation provisions specified in Section 101 of the NWPA.

The Presidential finding in Section 8(b) is necessary only for the separate disposal of Defense HLW. Section 8(b) does not limit the Secretary's authority to dispose of Defense SNF, or HLW and SNF resulting from the Department's research and development activities. The Department's authority to dispose of these waste forms separately derives from the Atomic Energy Act of 1954 and is implicitly recognized by the NWPA. Therefore, this report considers only the impacts associated with the separate disposal of Defense HLW.

Significant Changes Since 1985

In 1985, DOE completed the evaluation required by Section 8(b)(1) of the NWPA. Based on that evaluation, President Reagan found "no basis to conclude that a defense only repository is required." In the ensuing decades, the circumstances on which that finding was based have changed materially as follows:

- ***Repository Availability***—The 1985 evaluation assumed the NWPA schedule would be met, and that the first repository would become available in 1998 and the second before the capacity of the first repository reached its limit. The largest delay contemplated in the 1985 evaluation was two years, a time frame that would have imposed minimal impacts on defense waste management plans. As a result, no schedule advantages were anticipated for a Defense HLW Repository. At present, however, a Common NWPA Repository is not anticipated to be available before 2048. In contrast, a Defense HLW Repository could be sited, licensed, constructed, and opened more quickly, creating a significant schedule advantage.

- ***Evolution Toward a Phased, Adaptive, and Consent-Based Approach for Repository Siting***—Since 1985, there has been an evolution in thinking toward a phased, adaptive, and consent-based approach for repository siting. A Defense HLW Repository developed under existing authority could demonstrate such a process and provide useful experience that could reduce the time and cost required to site future repositories. This phased, adaptive, and consent-based approach has been endorsed by the Administration's Strategy, the Blue Ribbon Commission on America's Nuclear Future, and the National Academies, and has been demonstrated successfully by other nations, including Sweden, Finland, and France.

- ***End of the Cold War***—In 1985, DOE assumed that weapons production and the resulting generation of Defense HLW would continue indefinitely. It is now clear that the volume of Defense HLW is essentially fixed. This fact simplifies the planning required to site and construct a Defense HLW Repository and obviates the benefit of a larger Common NWPA Repository to accommodate increasing volumes of Defense HLW.

- ***New Environmental Obligations***—Since 1985, the applicability of certain environmental laws and regulations to DOE's storage of mixed wastes has been made clear. DOE is now required to achieve certain cleanup objectives by specific dates, and in some cases DOE (and, by extension, American taxpayers) is exposed to fines if timely compliance is not achieved. The earlier availability of a Defense HLW Repository would help DOE comply with these obligations more quickly and at lower total cost to taxpayers when all the relevant costs are taken into account.

Analysis of the Six Statutory Factors

Cost Efficiency—The 1985 evaluation concluded that, of the six factors, cost efficiency was the only differentiator. That evaluation concluded that including Defense HLW in a Common NWPA Repository would cost approximately $1.5 billion less than developing two separate facilities. This report concludes that separate disposal of Defense HLW would allow greater flexibility in the selection of geologic media for the two facilities, which has the potential to mitigate the incremental cost of constructing two facilities instead of one. Moreover, the earlier availability of a Defense HLW Repository could reduce Defense HLW storage, treatment, and management costs at DOE sites and may reduce the cost of developing future repositories by providing experience that can inform their design, siting, development, and operation. Although there is substantial uncertainty, on balance, cost efficiency favors development of a Defense HLW Repository.

***Health and Safety*—**Design, construction, and operation of either a Defense HLW Repository or Common NWPA Repository would be subject to a rigorous licensing review by the U.S. Nuclear Regulatory Commission to ensure protection of human health and the environment. Therefore, in their design and operation, either type of repository would be held to a high standard of health and safety. Nevertheless, developing a Defense HLW Repository, which would allow deep geologic disposal of Defense HLW sooner, would advance long term health and safety by eliminating the need for active human control and maintenance of waste at various DOE sites.

***Regulation*—**Regulatory considerations strongly support development of a separate Defense HLW Repository. The availability of a Defense HLW Repository would greatly assist DOE in fulfilling its regulatory obligations related to the present storage of Defense HLW at DOE sites. Developing a Defense HLW Repository also could simplify the licensing of a subsequent repository by providing important lessons learned, providing an early focal point and rationale for the U.S. Environmental Protection Agency and U.S. Nuclear Regulatory Commission to update their applicable regulations, and reducing the total volume of waste and the diversity of waste forms remaining to be disposed of in a subsequent repository.

***Transportation*—**Transportation costs and risks are affected by the quantity of waste shipped, the distance traveled, and mode of transportation, and are generally independent of whether the destination repository contains defense and commercial waste separately or together. Nevertheless, while not a strong factor, the development of a Defense HLW Repository would have the advantage of providing an earlier opportunity to develop the institutional processes for the transportation of waste prior to the development of a subsequent repository.

***Public Acceptability*—**Experience in the United States and other nations indicates that a phased, adaptive, consent-based siting approach may have greater prospects for success in achieving public acceptance than prior top-down approaches to site designation. Because a Defense HLW Repository could be developed using such an approach and would provide useful experience in siting future facilities, this factor strongly supports a Defense HLW Repository.

National Security—National security objectives can be achieved whether Defense HLW is disposed of in a Common NWPA Repository or separately and, therefore, do not factor strongly. Nevertheless, the likely earlier availability of a Defense HLW Repository could provide additional support to national security objectives by demonstrating progress in meeting environmental obligations imposed on DOE at sites that store Defense HLW and by minimizing potential delays that could impact ongoing national security operations if deadlines are not met.

Summary of Conclusions

A geologic repository for permanent disposal of Defense HLW could be sited, licensed, constructed, and operated more quickly than a Common NWPA Repository and would provide valuable experience to reduce the cost of a future repository and the time needed to develop it. In consideration of the six statutory factors cumulatively, this report concludes that a strong basis exists to find that a Defense HLW Repository is required.

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Acronyms

DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HLW	high-level radioactive waste
MTHM	metric tons of heavy metal
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982
SNF	spent nuclear fuel
WIPP	Waste Isolation Pilot Plant

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1 INTRODUCTION

This report considers whether a factual basis exists to conclude that a separate repository for high-level radioactive waste (HLW) resulting from atomic energy defense activities ("Defense HLW Repository") is "required" within the meaning of Section 8(b)(2) of the Nuclear Waste Policy Act of 1982 (NWPA).

In 1985, the U.S. Department of Energy (DOE) and President Reagan considered this question and, based on the circumstances at the time, found "no basis to conclude that a defense only repository is required."[1] Therefore, in the ensuing decades, DOE has planned to dispose of Defense HLW in a common repository with other DOE-managed waste and with commercial HLW and spent nuclear fuel (SNF), sited and developed under the process set forth in the NWPA ("Common NWPA Repository").[2] Over time, however, the circumstances on which the 1985 finding was based have changed materially. In light of that, the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* (DOE 2013a) (the "Strategy") indicated the issue of using a single repository for disposal of both commercial and defense wastes (i.e., the Common NWPA Repository approach) would be the subject of further analysis.[3] To that end, this report examines the factors identified by the NWPA to determine if a separate repository for Defense HLW is required. This report also devotes particular attention to ways in which the circumstances relevant to this decision have and have not changed since 1985.

Nuclear Waste Policy Act

Section 8(b)(1) of the NWPA requires that "[n]ot later than 2 years after the date of the enactment of this Act, the President shall evaluate the use of disposal capacity at one or more repositories to be developed under subtitle A of title I for the disposal of high-level radioactive waste resulting from atomic energy defense activities."[4] The NWPA states that this evaluation shall take into consideration six factors specified in Section 8(b)(1): cost efficiency, health and safety, regulation, transportation, public acceptability, and national security.

Section 8(b)(2) provides that:

> Unless the President finds, after conducting the evaluation required in paragraph (1), that the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required, taking into account all of the factors described in such subsection, the Secretary shall proceed promptly with arrangement for the use of one or more of the repositories to be developed under subtitle A of title I for the disposal of such waste.[5]

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[1] Memorandum from President Reagan for the Honorable John S. Herrington, The Secretary of Energy, *Disposal of Defense Waste in a Commercial Repository* (April 30, 1985).

[2] This report uses the following terms when referring to repositories: "Common NWPA Repository" means a repository developed under subtitle A of title I of the NWPA for the disposal of Defense HLW, other DOE-managed waste, and commercial HLW and SNF; "Defense HLW Repository" means a repository developed by DOE under the Atomic Energy Act of 1954 for the disposal of Defense HLW.

[3] The Administration's Strategy (DOE 2013a, p. 8) noted that the Common NWPA Repository approach (referred to in the Strategy as "commingling") "will be the subject of analysis moving forward."

[4] 42 U.S.C. § 10107(b)(1).

[5] 42 U.S.C. § 10107(b)(2).

Section 8(b) thus provides that in the absence of a finding that a Defense HLW Repository is required, the Secretary shall proceed promptly with plans to dispose of Defense HLW in a Common NWPA Repository. Alternatively, if the President finds that a Defense HLW Repository is required, the Secretary may develop a Defense HLW Repository under his Atomic Energy Act of 1954 authority.[6] In developing a Defense HLW Repository, the Secretary would be subject to U.S. Nuclear Regulatory Commission (NRC) licensing authority,[7] but would not be subject to the NWPA's siting provisions, apart from the State and tribal participation provisions specified in Section 101 of the NWPA.[8]

Although Section 8(b)(1) of the NWPA required the President to conduct an evaluation within two years of enactment, it does not impose a deadline on when the President may take the next step of issuing a finding that a Defense HLW Repository is required. Nor does it limit what the President may consider in making the finding to the contents of the initial evaluation.[9] Therefore, the President remains free to issue a finding now based on an updated consideration of the six factors.

The finding concerns whether a Defense HLW Repository is "required." The President may determine that a Defense HLW Repository is required if it is compelled by consideration of the six factors identified in the NWPA. In some contexts, a required action is one that is legally mandatory or one for which no practical alternative exists. In other contexts, "required" has a broader meaning. In the context of the NWPA, it is important to note that that the President's decision respecting separate disposal of Defense HLW requires consideration of six factors: cost efficiency, health and safety, regulation, transportation, public acceptability, and national security. With respect to each of these factors, the President could ascertain important advantages in pursuing a Defense HLW Repository without concluding that a Common NWPA Repository is legally or practically impossible. Therefore, to permit full consideration of the factors the NWPA states must be taken into account, the word "required" is best understood as relating to a judgment on the application of those factors and not to a judgment that a Common NWPA Repository is legally or practically impossible.

Scope and Organization

This report discusses the significant changes since 1985 that are relevant to whether a Defense HLW Repository is required. The report evaluates the six factors described in NWPA Section 8(b)(1) with respect to two options: (1) disposal of Defense HLW with other materials including commercial SNF and HLW in a Common NWPA Repository, and (2) disposal of Defense HLW in a Defense HLW Repository and the disposal of other DOE-managed waste and commercial SNF and HLW in a separate repository.

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[6] *See* Atomic Energy Act of 1954 §§ 3 (describing the purpose of the Atomic Energy Act as "providing for … a program for Government control of the possession, use, and production of atomic energy and special nuclear material, whether owned by the Government or others"), 32 (authorizing and directing the Atomic Energy Commission to conduct research and development activities relating to atomic energy and radioactive material), 91(a)(3) (authorizing the Atomic Energy Commission to "provide for safe storage, processing, transportation, and disposal of hazardous waste (including radioactive waste) resulting from nuclear materials production, weapons production and surveillance programs, and naval nuclear propulsion programs"), 161 (authorizing the Atomic Energy Commission to "make such disposition as it may deem desirable of (1) radioactive materials, and (2) any other property, the special disposition of which is, in the opinion of the Commission, in the interest of the national security"). 42 U.S.C. §§ 2013, 2052, 2121(a)(3), 2201. This authority was transferred from the Atomic Energy Commission to DOE by the Energy Reorganization Act of 1974 and the DOE Organization Act.

[7] Energy Reorganization Act of 1974 § 202, 42 U.S.C. § 5842.

[8] 42 U.S.C. § 10121.

[9] We note that the 1985 report from DOE to the President (DOE 1985) described itself in the Preface as but "one analytical input to that evaluation."

The Presidential finding in Section 8(b) is necessary only for the separate disposal of Defense HLW. The NWPA does not limit the Secretary's authority to dispose of Defense SNF, or HLW and SNF resulting from the Department's research and development activities. The Department's authority to dispose of these waste forms separately derives from the Atomic Energy Act of 1954 and is implicitly recognized by the NWPA.[10] The *Assessment of Disposal Options for DOE-Managed High-Level Radioactive Waste and Spent Nuclear Fuel* ("the Assessment") contemplates a Defense HLW Repository that may also include thermally cooler DOE-managed SNF (DOE 2014, p. 1).[11] As the Assessment describes, there may be additional benefits in disposing of Defense HLW with other cooler DOE-managed SNF in a Defense HLW Repository (DOE 2014, p. 2). This report does not assume any benefits among the six factors that might result from a subsequent decision to combine Defense HLW and cooler DOE-managed SNF in a Defense HLW Repository and considers only the impacts associated with the separate disposal of Defense HLW.

Repository Design and Operational Considerations

This report does not assume a particular repository design or geologic medium. Its conclusions are intended to apply broadly to a range of repository designs and geologic media.

Design and Operation of a Common NWPA Repository—There are multiple ways to design and operate a Common NWPA Repository capable of accommodating a broad range of waste types. The 1985 evaluation considered a hypothetical design in which Defense HLW and commercial waste were emplaced in separate regions within the repository, sharing common access shafts and drifts, but not occupying the same disposal drifts (DOE 1985, Figure 2-1). Repository design work performed since 1985 has confirmed that this approach is viable. Safety assessments conducted since 1985 have indicated that an alternative design in which Defense HLW and commercial waste would be emplaced in the same disposal drifts, in waste packages directly adjacent to each other in alternating sequences, also has the potential to provide excellent long-term isolation of the wastes (DOE 2008a, Section 1.3.1.2.5).

The 1985 report evaluated repository concepts constructed in two categories of geologic media: salt and "hard rock" (DOE 1985, Section 2.3.1.1). Research since 1985 in both the United States and other nations indicates that repositories could be designed and constructed in multiple geologic media, and that all commercial and defense HLW and SNF could be disposed of, with appropriate treatment and packaging, in multiple mined repository concepts (SNL 2014).

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[10] *See* NWPA §§ 8(a) ("Subject to the provisions of subsection (c), the provisions of this Act shall not apply with respect to any atomic energy defense activity or to any facility used in conjunction with any such activity.") and 8(c) ("The provisions of this Act shall apply with respect to any repository not used exclusively for the disposal of high-level radioactive waste or spent nuclear fuel resulting from atomic energy defense activities, research and development activities of the Secretary, or both."). 42 U.S.C. §§ 10107(a) and (c).

[11] The Assessment, published in October 2014, considers whether DOE-managed HLW and SNF should be disposed of with commercial SNF and HLW in one geologic repository, or whether there are advantages to developing a separate repository for some DOE-managed HLW and SNF. The Assessment recommends that DOE pursue options for disposal of DOE-managed HLW from defense activities and some thermally cooler DOE-managed SNF, potentially including cooler naval SNF, separately from disposal of commercial SNF and HLW. Other DOE-managed HLW and SNF, including HLW and SNF of commercial origin and naval SNF with relatively higher heat output, would be disposed of with commercial SNF and HLW. The Assessment also recommends that DOE retain the flexibility to consider options for disposal of smaller DOE-managed waste forms in deep boreholes rather than in a mined geologic repository.

Design and Operation of a Defense HLW Repository—The 1985 evaluation did not explicitly identify a design concept for a Defense HLW Repository, but assumed that the "design and operational characteristics" of such a repository would "in most respects, be similar to those of a commercial repository" (DOE 1985, Section 3.2). This assumption is no longer valid. The design and operation of a Defense HLW Repository would likely be substantially simpler than those of a Common NWPA Repository for four reasons. First, a Defense HLW Repository would contain a smaller quantity of waste. Second, Defense HLW has had most of the fissile material removed, simplifying design from a criticality standpoint. Third, the decay heat of Defense HLW is significantly less than that of commercial SNF, potentially simplifying repository design and operation in multiple ways, including: lower ventilation requirements, easier handling of canisters, greater flexibility in the use of backfill, closer spacing of disposal drifts and closer emplacement of canisters within the drifts, and reduced need for surveillance and monitoring due to a shorter period before permanent closure. And, fourth, Defense HLW could be disposed of without repackaging in most mined repository concepts, whereas a Common NWPA Repository would likely need to have the capability to open canisters and handle or repackage commercial SNF at a facility either onsite or offsite.

2 SIGNIFICANT CHANGES SINCE 1985

Based on the 1985 evaluation, President Reagan found "no basis to conclude that a defense only repository is required." As described below, many of the assumptions upon which the 1985 evaluation was premised are no longer valid today.

2.1 It Is Now Clear a Defense HLW Repository Could Be Available Earlier than a Common NWPA Repository

The 1985 evaluation assumed that the repository siting schedule in the NWPA would be met, and that two repositories would be available for both commercial and defense wastes—the first in 1998 and the second before the first repository reached the 70,000 metric tons of heavy metal (MTHM) statutory limit. The largest delay contemplated in the 1985 evaluation was two years, a time frame that would have imposed minimal impacts on defense waste management plans (DOE 1985, pp. 2-8 and 2-16). As a result, no schedule advantages were anticipated for a Defense HLW Repository (DOE 1985, p. E-9).

The path to a first and second repository as envisioned under the NWPA has been significantly more controversial, costly, and delayed than was anticipated in 1985. When the Act was amended in 1987 to focus on a single repository site at Yucca Mountain, it reflected a growing frustration in Congress over the increasing cost and delay. There was a strong belief at the time that focusing on a single site would alleviate these issues. That did not prove to be the case—cost escalation and delays continued, while state opposition and legal challenges mounted. In 2009, with the timeline for opening a repository pushed back by two decades, and no end to opposition in sight, the Department determined the site to be unworkable. There have been no funds appropriated for work at the site since fiscal year 2010.

The Administration's Strategy laid out a timeline for siting, construction, and operation of a geologic repository, with initial opening in 2048. This stands in contrast to the expectation in 1985, when one repository was assumed to open in 1998 and the second was assumed to open in time to allow the disposal of HLW and SNF to continue without interruption once the 70,000-ton limit on the first repository was reached (DOE 1985, pp. 2-8 and 1-10).

There are several reasons to believe a Defense HLW Repository could be sited, licensed, constructed, and opened earlier than a Common NWPA Repository. First, a Defense HLW Repository can be developed under existing statutory authority. Second, the technical characteristics of Defense HLW would simplify the design and operation of a Defense HLW Repository compared to a Common NWPA Repository. Compared to the commercial SNF that would be disposed of in a Common NWPA Repository, Defense HLW is smaller in volume, less radioactive, thermally cooler, less likely to require repackaging, and meets criticality requirements without additional controls. Third, these technical characteristics would also simplify the licensing of a Defense HLW Repository. Fourth, achieving public acceptance of a Defense HLW Repository could likely be achieved more quickly than for a Common NWPA Repository because the public may be more likely to accept a limited-focus repository. Finally, because Defense HLW canisters could be shipped by truck without the need for additional rail equipment and infrastructure or rate negotiations with rail companies, disposal at a Defense HLW Repository could begin sooner.

2.2 Thinking Has Evolved Towards a Phased, Adaptive, and Consent-Based Approach

The final report of the Blue Ribbon Commission on America's Nuclear Future (BRC) called for a new approach to repository siting. The BRC examined the efforts at siting nuclear waste facilities and found (BRC 2012, p. 49):

> In sum, U.S. experience to date clearly underscores the inherent complexity and difficulty of siting nuclear waste facilities, particularly in the face of state-level opposition. At the same time, the record, along with input received from a number of parties during the BRC's deliberations, provides grounds for optimism that it can be done.

Among the developments since 1985 that the BRC considered was the National Academies' 2003 report, *One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste* (National Research Council 2003), which outlined a phased approach for repository development. The National Academies' report identified several key attributes of adaptive staging in the development of nuclear waste facilities: commitment to systematic learning, flexibility, reversibility, transparency, auditability, and integrity.

The BRC also examined the experience of other countries, including Sweden, Finland, and France, and found that "the experience of these countries provides strong support for the … conclusion that a transparent, consent-based approach built on a solid understanding of societal values has the best odds of achieving success in siting, constructing, and operating key waste management facilities" (BRC 2012, p. 49). Using a phased, adaptive, and consent-based approach, these nations generally have proceeded with less controversy, and better results, than has the United States.

A Defense HLW Repository would require appropriations from Congress, but otherwise could be developed under existing authority. A Defense HLW Repository, therefore, presents an important opportunity to demonstrate the feasibility of a phased, adaptive, consent-based approach. One of the benefits of a phased, adaptive approach is that later phases adopt lessons learned from earlier ones. Developing a Defense HLW Repository will provide additional, step-wise experience with respect to consent-based siting, stakeholder consultation, and regulatory compliance that could ease the siting and development of a subsequent repository.

2.3 End of the Cold War

In 1985, DOE's atomic weapons production program remained active, including the reprocessing of Defense SNF to recover usable materials for weapons production. It was expected that Defense SNF from all sources (weapons plutonium production reactors, naval propulsion reactors, and test reactors) would be reprocessed to recover materials for weapons production and that considerable quantities of Defense HLW requiring long-term disposal would continue to be generated. Thus, the volume of Defense HLW was expected to continue to increase.

The United States is no longer reprocessing SNF or generating Defense HLW associated with weapons production. As a result, DOE's Defense HLW inventory is essentially fixed. It is now known that the total volume of Defense HLW after treatment will be small compared to the total inventory of HLW and SNF requiring disposal. This fact simplifies the planning required to site and construct a Defense HLW Repository in contrast to that required for a Common NWPA Repository.

2.4 New Environmental Cleanup Obligations

Since 1985, the applicability of certain environmental laws and regulations to DOE's storage of mixed wastes containing both hazardous and radioactive waste, including mixed Defense HLW, has been made clear. In 1992, the Federal Facility Compliance Act was enacted. This Act explicitly waived the sovereign immunity of the United States. As a result, the Department has entered into a number of environmental compliance agreements with States and the U.S. Environmental Protection Agency (EPA) that establish milestones for compliance with the Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation, and Liability Act requirements. These agreements generally require DOE to achieve cleanup objectives by specific dates and, in some cases, include commitments to treat HLW and/or remove SNF from a particular site by a specific date. Some of these agreements expose the federal government (and, by extension, American taxpayers) to financial liability.

For example, one court-approved agreement, the Idaho Settlement Agreement, executed in 1995 and amended in 2008, establishes 2035 as the deadline for the treatment of all HLW and the removal of all SNF from the State of Idaho, with the exception of a working volume of 9 MTHM of naval SNF. The Idaho agreement provides that unless all covered SNF is removed by January 1, 2035, the federal government shall pay the State for each day such requirement has not been met. This requirement is subject to the Anti-Deficiency Act.

The 1989 Tri-Party Agreement at Hanford, involving DOE, EPA, and the State of Washington, addresses vitrifying the HLW stored in tanks at the Hanford Site and closure of the tanks. The Tri-Party Agreement also requires DOE to develop a disposition plan for the cesium and strontium capsules stored at the Hanford Site. In 2010, the Department entered into a Consent Decree with the State of Washington requiring operation of the Waste Treatment and Immobilization Plant by a date certain. Over the last three years, the Department has notified the State of Washington that a serious schedule risk had arisen and that it may be unable to meet milestones under the Consent Decree. On October 3, 2014, the Department and the State of Washington each filed separate motions to amend this Consent Decree.

2.5 Conclusions on Changed Circumstances Since 1985

Developments since 1985 strongly support the conclusions that a Defense HLW Repository can be developed sooner than a Common NWPA Repository—and that a Defense HLW Repository is required. The circumstances discussed above support a decision to move ahead quickly with the disposal of Defense HLW in a manner that advances DOE's waste management mission. The opening of a Defense HLW Repository also would help pave the way for a subsequent repository. The earlier development of a Defense HLW Repository and its likely positive effects on development of a subsequent repository are key elements of the advantages of a Defense HLW Repository, as more fully discussed in the following analyses of the six NWPA-required factors.

3 Analysis of the Six NWPA-Required Factors

This section analyzes whether a Defense HLW Repository is required, taking into account the six factors identified in Section 8(b)(1) of the NWPA. The discussion of each factor includes: (1) a summary of the 1985 evaluation conclusions; (2) a discussion of post-1985 changes and new information bearing on that factor; and (3) conclusions as to whether the factor currently supports a finding that a Defense HLW Repository is required.

3.1 Cost Efficiency

"Cost efficiency" is a synonym for "cost-effectiveness,"[12] a term that captures both the cost of an action and its benefits. Therefore, consideration of this factor should weigh the cost of each option in relation to the value it provides and not simply favor the lowest cost option. Further, while repository costs are an important element of total waste management costs, this factor should weigh the full range of cost effects that may result from the decision to pursue a Defense HLW Repository or a Common NWPA Repository, including potential reductions in pre-disposal storage and treatment costs and other costs as explained below.

3.1.1 1985 Evaluation

Focusing solely on repository costs, the 1985 evaluation concluded that cost efficiency favored a Common NWPA Repository. The 1985 evaluation estimated that the cost of construction, operations, and decommissioning would be approximately $1.5 billion less for a Common NWPA Repository than for two separate facilities.

3.1.2 Post-1985 Information

This report considers several updated cost factors including:

- **Additional geologic media**—One driver of the cost of developing a repository is the type of geologic medium in which the repository is constructed. The 1985 evaluation assessed only two potential media: salt and "hard rock," where the hard rock estimate was based on an analysis of volcanic tuff (DOE 1985, Section 2.3.1.1). U.S. and international studies and new experience with other geologic media allow this report to evaluate a broader range of media (DOE 2014, Section 4.2 and Table 3).

- **Larger inventory of commercial SNF**—This report evaluates the cost of disposing of all currently forecast commercial SNF, assuming full license extensions for all existing light-water reactors (141,423 MTHM; DOE 2013b), and not just the 70,000 MTHM used for the 1985 evaluation.

- **Relatively fixed inventory of Defense HLW**—Most Defense HLW in DOE's current inventory is from defense programs at the Hanford and Savannah River sites, and has either already been

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[12] "Cost-efficient." *OxfordDictionaries.com*. http://www.oxforddictionaries.com/us/definition/american_english/cost-efficient (defining "cost-efficient" as "[a]nother term for cost-effective");
"Cost-effective." *OxfordDictionaries.com*. http://www.oxforddictionaries.com/us/definition/american_english/cost-effective (defining "cost-effective" as "[e]ffective or productive *in relation to its cost*") (emphasis added).

vitrified or is planned to be vitrified, as was also expected in 1985. DOE also manages Defense HLW in calcine form at the Idaho National Laboratory. Other smaller-volume defense wastes managed by the DOE at the Hanford Site include 30 canisters of glass containing cesium and strontium prepared in 1986 and 1987 to support thermal testing proposed at that time by the Federal Republic of Germany, and 1,936 capsules containing cesium and strontium. The cesium and strontium capsules are noteworthy because of their small size (individual cylinders are less than 9 cm in diameter and less than 56 cm in length) and highly concentrated radioactivity. In aggregate, the 1,936 cesium and strontium capsules contain approximately one-third of the total radioactivity (in curies) at the Hanford Site, but in their current form they occupy a total volume of less than 4 cubic meters, which is less than 0.03% of the total projected volume of approximately 14,000 cubic meters of HLW at the Hanford Site after vitrification is complete (SNL 2014). Estimates of projected quantities of Defense HLW that are used for cost evaluations in this report are presented in Table 1.

Table 1. Sources and Projected Quantities of Defense HLW Canisters

Storage Site	Projected Quantity of Canisters
Savannah River Site, SC	7,824
Idaho National Laboratory, ID	4,391
Hanford Site, WA	11,079
TOTALS	23,294

Source: DOE 2014, Table 1.

3.1.2.1 Cost Assumptions and Methodology

As was the case in 1985, the cost for disposal of radioactive waste in a geologic repository is influenced by numerous variables including the geologic medium, the quantity of waste, the emplacement method and configuration, how heat-dissipation is managed, and the depth of the repository.

Rough Order of Magnitude estimates for mined geologic disposal concepts shown in Section 3.1.2.2 are calculated using the following assumptions, guidelines, and methodologies. All Rough Order of Magnitude estimates are for the cost of the constructing and operating the repository only and exclude storage, transportation, repository siting, and other tasks. These estimates are extrapolated from existing studies (Hardin et al. 2012; DOE 2013b). Costs for the Common NWPA Repository are estimated assuming all commercial SNF would be emplaced in a single repository, consistent with the 2013 Fee Adequacy Assessment (DOE 2013b). Where precise cost data are unavailable, scaling factors were used to establish general ranges.[13] The U.S. Government's share of costs for a Common NWPA Repository is assumed to be approximately 20%.[14] Cost escalation was added, as appropriate, using the rate of 1.74%.[15]

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[13] The cost estimates documented in the January 2013 Fee Adequacy Assessment (DOE 2013b) are used as reference costs for scaling factors. These costs were derived from the 2008 Total System Life Cycle Cost estimate (DOE 2008b), with modifications to remove costs that were specific to the Yucca Mountain site and to account for the increase in the total amount of commercial SNF to be disposed.

[14] In accordance with the Total System Life Cycle Cost estimates (DOE 2008b) and in accordance with the methodology published in the August 20, 1987, Federal Register notice (52 FR 31508).

[15] *See* Department of Commerce, Bureau of Economic Analysis, Table 1.1.9, Implicit Price Deflators for Gross Domestic Product, *available at* http://www.bea.gov/iTable/iTable.cfm?reqid=9&step=3&isuri=1&903=13#reqid=9&step=3&isuri=1&903=13.

3.1.2.2 Repository Cost Estimates

Rough Order of Magnitude costs for design, construction, start-up, operations, closure, and monitoring for a Common NWPA Repository and a Defense HLW Repository are summarized in Table 2 and Table 3, respectively. The large ranges reflect inherent uncertainties involved in calculating costs into the future, making comparisons less reliable.

Table 2. Costs for Option 1: Common NWPA Repository (Billions of 2013$)

Geology	Low Range	High Range
Crystalline	$73	$96
Bedded Salt	$29	$39
Clay/Shale	$71	$95
Shale Unbackfilled	$30	$40
Sedimentary Backfilled	$38	$51

Source: DOE 2014, Table 3.

Table 3. Costs for Option 2: Defense HLW Repository + Common NWPA Repository excluding Defense HLW (Billions of 2013$)

Geology	Defense HLW Repository		Common NWPA Repository: No Defense HLW	
	Low Range	High Range	Low Range	High Range
Crystalline	$33	$44	$64	$85
Bedded Salt	$13	$18	$25	$34
Clay/Shale	$32	$43	$63	$84
Shale Unbackfilled	$14	$18	$27	$36
Sedimentary Backfilled	$17	$23	$34	$45

Source: DOE 2014, Table 3.

Table 2 and Table 3 show that, within each type of geologic media, developing two repositories is generally more expensive than one. However, the tables also show substantial cost differences across the categories of geologic media. Separate disposal of Defense HLW would allow greater flexibility in selection of geologic media for the two repositories. For that reason, the incremental cost of an additional repository could be mitigated substantially to the point of being relatively small when compared to overall repository costs. Further, to the extent that earlier development of a Defense HLW Repository made it possible for a subsequent repository to be located in a less expensive geologic medium (for example, by reducing the overall volume of waste or through the accumulation of experience working in that medium), the separate disposal of Defense HLW could potentially reduce overall repository costs.

3.1.2.3 Deep Borehole Disposal

Separate disposal of Defense HLW not only would allow flexibility in selection of geologic media, but would also allow flexibility to consider deep borehole disposal for smaller waste forms. The Assessment published in October 2014 discusses the potential for deep borehole disposal at greater length (DOE 2014, Section 3.3). The Assessment defines the smaller waste forms eligible for deep borehole disposal as those waste forms that can be packaged in a disposal container 0.30 m (12 inches) or less in diameter. The Assessment identifies several forms of Defense HLW that could potentially be disposed of in this manner, including the cesium and strontium capsules stored at the Hanford Site (which, again, contain approximately one-third of the total radioactivity at that site), the untreated calcine HLW stored at Idaho National Laboratory, and salt wastes from electrometallurgical treatment of sodium-bonded fuels.

Deep borehole disposal relies on currently available commercial drilling technology, and thus holds significant promise as a method for disposal of certain forms of Defense HLW quickly, safely, and at relatively lesser expense. Although deep borehole disposal has been studied for decades, it has yet to be demonstrated through field testing. On October 24, 2014, the Department issued a request for information announcing its intention to conduct a multi-year deep borehole field test that will evaluate the safety and feasibility of the concept before proceeding further with implementation.[16]

3.1.2.4 Impact of Early Repository Availability on Cost Efficiency

As discussed previously, developments since 1985 suggest that a Defense HLW Repository could be developed sooner than a Common NWPA Repository. An important aspect of cost efficiency, and one that was not considered in the 1985 evaluation, is the benefits of this earlier availability of a Defense HLW Repository. While these benefits cannot be readily quantified, they are potentially significant. These benefits can be divided into three groups: (1) avoided Defense HLW storage and treatment costs; (2) benefits as they relate to the overall cleanup mission of DOE's Office of Environmental Management; and (3) lower development costs for a subsequent repository.

3.1.2.4.1 Avoided Defense HLW Storage and Treatment Costs

Cleanup of the environmental legacy of the Cold War is estimated to cost taxpayers over $350 billion. The estimated life-cycle cost for Defense HLW management at the Hanford Site, the Savannah River Site, and Idaho National Laboratory is over $107 billion. DOE's fiscal year 2015 defense cleanup appropriation (Consolidated and Further Continuing Appropriations Act, 2015) is over $5 billion. Of this amount, Congress has authorized over $2 billion for cleanup at the Hanford Site, over $1.1 billion for work at the Savannah River Site, and about $380 million at Idaho National Laboratory. At these sites, DOE is authorized to spend about 56%, 63%, and 22% respectively of available funding on tank wastes. Although appropriations vary each year, in fiscal year 2014 DOE spent over $2 billion on tank waste and over $3 billion on other vital cleanup activities.

Over the decades to come, these cleanup and storage costs will rival the costs associated with permanent disposal, such that even a small reduction in these costs in percentage terms could materially impact the overall cost-efficiency of pursuing separate disposal for Defense HLW. There is, however, reason to believe that the earlier availability of a repository for Defense HLW could have more than a small impact on storage and treatment costs. A significant driver of the cost estimates for treating Defense HLW is the uncertainty as to what waste forms and packages will ultimately be acceptable for disposal. Defense HLW currently has to be treated and packaged to be acceptable for disposal in the full range of geologic media and repository designs, which leads to inevitable cost inefficiencies. The earlier availability of a Defense HLW Repository could result in significant cost efficiencies by removing uncertainty about the treatment and packaging of Defense HLW required for disposal.[17] Knowing the characteristics of the Defense HLW Repository site and design would enable DOE to develop specific criteria for acceptable

[16] The "Request for Information (RFI)—Deep Borehole Field Test" is available at https://www.fbo.gov/index?s=opportunity&mode=form&id=d3ff93b06490ac4383e0ba41509dc46a&tab=core&tabmode=list&.

[17] In some cases, the Department is contractually obligated to treat certain waste forms in a certain manner. The Department will honor those obligations. The earlier availability of a Defense HLW Repository, however, could obviate the need for further treatment and thus provide an opportunity to modify those obligations by mutual assent.

waste forms and packages, including the chemical, thermal, and radiological characteristics required for disposal. Having these criteria would enable DOE to focus its treatment and packaging of Defense HLW to meet these specific criteria, subsequently reducing the extent of maintenance and repairs to treatment and packaging infrastructure, accelerating the work, and resulting in significant cost savings.

In addition to avoided treatment and packaging costs, the earlier availability of a Defense HLW Repository would reduce storage costs. A significant amount of Defense HLW already exists in final form at the Savannah River Site (3,339 canisters out of a projected total of 7,824 to be produced at that site). The availability of a Defense HLW Repository earlier than a Common NWPA Repository would create savings to taxpayers from avoided costs for safely storing inventories of immobilized Defense HLW.[18] The resulting savings could be redirected to other high-priority cleanup activities at the Savannah River Site, the Hanford Site, and Idaho National Laboratory. In addition, the earlier availability of a repository for some Defense HLW could help keep Defense HLW disposition costs and schedules within the baseline estimates by reducing uncertainty in acceptable final waste forms, reducing the extent of maintenance and repairs to infrastructure, and accelerating the work.

3.1.2.4.2 Benefits to the Cleanup Mission of DOE's Office of Environmental Management

The availability of a Defense HLW Repository would provide benefits to the Department's overall cleanup mission. These benefits include improved cooperation among DOE and State regulators, enhanced public acceptability of DOE's mission within the local communities around the complex, potentially increased funding for other priority cleanup activities, and increased likelihood in meeting consent and compliance agreement milestones. The availability of a Defense HLW Repository would also represent significant progress towards completing DOE's cleanup mission and addressing the Department's Cold War legacy. As cleanup proceeds and DOE's footprint reduction continues, these once-contaminated sites can be transformed into valuable assets for the Nation's future and will provide economic development opportunities for the States and host communities.

3.1.2.4.3 Lower Development Costs for a Subsequent Repository

The siting, development, and operation of a Defense HLW Repository could lead to cost savings in the siting, development, and operation of a subsequent repository. This is due to the "learning curve" associated with prior development of a Defense HLW Repository and is an important element of the phased, adaptive approach to repository siting described above. Any unexpected technical difficulties or cost issues encountered in developing a less complex and smaller Defense HLW Repository would provide valuable lessons learned that could reduce the cost of a larger future repository for remaining waste forms including commercial HLW and SNF. In addition, institutional procedures for siting, evaluating, licensing, and regulating the operation of a repository would be developed and optimized for the initial Defense HLW Repository and could be transferred in large part to a subsequent repository. This will likely reduce costs for siting, evaluating, licensing, and operating any subsequent repository.

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[18] The Assessment (DOE 2014, Section 4.2) states, "Potential savings to taxpayers could be significant due to avoided costs for safely storing inventories of immobilized tank waste if a repository for some DOE-managed HLW and SNF is available earlier… In addition, the earlier availability of a repository for some DOE-managed HLW and SNF could help keep tank waste disposition costs and schedules within the baseline estimates by reducing uncertainty in final waste form treatment approaches, reducing the extent of maintenance and repairs to infrastructure, and accelerating the work. From these perspectives, a common repository for both commercial and defense waste may be the least cost-effective option."

Further, proceeding in a phased, adaptive and consent-based manner would greatly aid in obtaining public acceptance of a subsequent repository, especially if the public has had an opportunity to see the prior facility successfully constructed and operated. While public acceptance is an end in itself and is discussed separately below, greater public acceptance also helps to reduce costs by reducing delays and uncertainties, and by enabling consideration of a wider set of potential sites.

3.1.3 Conclusions as to Cost Efficiency

The 1985 evaluation concluded that cost efficiency favors a Common NWPA Repository, but reached that conclusion based solely on repository costs, which were analyzed using a small number of potential geologic media. There now appears little reason to conclude that a Common NWPA Repository is the more cost-effective course of action, and substantial reason to believe that pursuing a Defense HLW Repository will ultimately prove more cost effective in accomplishing the overall mission of managing and disposing of the DOE-managed SNF and HLW. In particular, the earlier availability of a Defense HLW Repository relative to a Common NWPA Repository is an important cost driver that was not considered in the 1985 evaluation because that evaluation assumed the NWPA deadlines would be met. This earlier availability could result in avoided Defense HLW treatment and storage costs. Separate disposal of Defense HLW would allow greater flexibility in the selection of geologic media, as well as the potential for use of deep borehole disposal for smaller waste forms. This greater flexibility has the potential to mitigate the incremental cost of constructing and operating two facilities instead of one.

3.2 Health and Safety

3.2.1 1985 Evaluation

The 1985 evaluation divided health and safety into short-term and long-term effects. For short-term effects, the evaluation considered both radiological and non-radiological health and safety impacts during both the construction and operations phases of a Common NWPA Repository (DOE 1985, Section 2.3.2.2). Non-radiological impacts included both accidents and the health effects of pollutant emissions. The 1985 evaluation concluded "the estimated number of health and safety impacts [is] related both to the capacity of the repository and to the particular choice of geologic media but not to whether defense or commercial waste is emplaced in the geologic repository" (DOE 1985, p. 2-33).

With respect to long-term effects, the 1985 evaluation concluded that releases of radiation from Defense HLW in a Defense HLW Repository might be lower than from Defense HLW in a Common NWPA Repository due to lower leaching and degradation rates of the waste form at lower temperatures. However, the authors further noted that the difference (a factor of five) was likely to be less than the overall uncertainty associated with a realistic assessment and, therefore, that "the health and safety impacts of disposal of defense high-level waste in a defense-only repository can be considered to be the same as for disposal of defense waste in a commercial repository" (DOE 1985, p. 3-9).

3.2.2 Post-1985 Information

Construction and Operation—Information since 1985 confirms that the operational risks associated with disposal are roughly equivalent regardless of whether Defense HLW is disposed of in a Common NWPA Repository or in a Defense HLW Repository. Operational risks are a function of repository size and geologic medium. Radiological exposures following accidents during waste emplacement operations will be a function of the properties of the waste and could reasonably be expected to be greater for the higher-activity SNF than for Defense HLW. Overall, risks associated with constructing a repository under either option would be low and would be mitigated by operational safety practices to ensure that they remain below regulatory limits. To the extent that the earlier construction of a Defense HLW Repository produces lessons learned that apply to a subsequent repository, it may reduce risks in the construction phase.

Storage of Defense HLW at the DOE Sites—Geologic disposal is the best method for permanently disposing of HLW and SNF, thus eliminating the burden of continued care on future generations. Geologic disposal would permanently isolate the waste after final emplacement by reliance on the passive operation of the natural environment and engineered barriers rather than human control and maintenance. Thus, proceeding with a geologic repository for Defense HLW earlier would advance long-term health and safety by eliminating the need for active human control and maintenance of waste at various DOE sites.

Long-Term Effects—New information developed since 1985 in the United States and other nations confirms that deep geologic disposal in multiple geologic media has the potential to provide safe long-term isolation of both HLW and SNF (DOE 2014, Section 3). Long-term radiation doses are estimated to be below regulatory limits for repositories containing both HLW and SNF. Specific to the United States, analyses indicate that the largest contribution to the long-term peak dose will come from commercial SNF, primarily because of its greater radioactivity (DOE 2008a).

3.2.3 Conclusions as to Health and Safety

Design, construction, and operation of either a Defense HLW Repository or Common NWPA Repository would be subject to a rigorous licensing review by the NRC to ensure protection of human health and the environment. Therefore, in their design and operation, either type of repository would be held to a high standard of health and safety. Nevertheless, developing a Defense HLW Repository, which would allow deep geologic disposal of Defense HLW sooner, would advance long-term health and safety by eliminating the need for active human control and maintenance of waste at various DOE sites.

3.3 Regulation

3.3.1 1985 Evaluation

The 1985 evaluation's consideration of regulatory issues associated with a Common NWPA Repository focused on whether the higher thermal output of the commercial waste might present a technical problem for the Defense HLW packages to provide the "substantially complete containment" required by NRC regulations during the first several hundred years following permanent closure of a geological repository, when radiation and thermal levels would be high and the uncertainties in assessing repository performance would be large. The 1985 evaluation found that temperature can be adjusted by repository design (e.g., spacing of emplacement holes) if desired, and that acceptable containment performance can be assured by appropriate selection of waste package design and repository design. Therefore, the evaluation concluded that a Common NWPA Repository could meet the applicable regulations on repository performance. The 1985 report recognized that a Defense HLW Repository would be subject to the same NRC regulations (10 CFR Part 60) as a Common NWPA Repository. The report noted that the technical part of 10 CFR Part 60 permits adjustment of the engineered barrier system and geologic setting requirements to account for the effect of waste characteristics and the repository ambient conditions. The report pointed out, for example, that the thermal output of Defense HLW is substantially lower than that of commercial waste, so that regulatory considerations might allow use of a lower cost overpack or no overpack for Defense HLW in a Defense HLW Repository.

3.3.2 Post-1985 Information

A Defense HLW Repository will help DOE meet regulatory obligations imposed on it since 1985. The availability of a Defense HLW Repository earlier than a Common NWPA Repository would, as discussed in Section 3.1, create cost savings that could be redirected to help DOE meet its cleanup obligations. The earlier availability of a Defense HLW Repository could also help DOE meet its milestones by reducing uncertainty in acceptable final waste forms, reducing the extent of maintenance and repairs to infrastructure, and accelerating the work at the sites.

The licensing process for a Defense HLW Repository is likely to be more straightforward than for a Common NWPA Repository (DOE 2014, Section 3.2). All other aspects of repository design being the same, long-term radiation releases from a Defense HLW Repository could reasonably be expected to be smaller because of the smaller radionuclide inventory, simplifying analyses of long-term performance. The significantly lower thermal output of Defense HLW would further simplify both the design of the repository and analyses of its long-term performance. In addition, demonstration of compliance with requirements specific to controlling criticality in the waste during both operational and long-term performance will be more straightforward for Defense HLW, which has had most of the fissile material removed during reprocessing.

Developing a Defense HLW Repository would also facilitate the future licensing of a Common NWPA Repository by providing both lessons learned and a catalyst for the development of the regulatory framework governing a Common NWPA Repository. Although regulations that would apply to any deep geologic repository at any location other than Yucca Mountain (40 CFR Part 191 and 10 CFR Part 60) remain in force, they date from the 1980s, and it is likely that the EPA and the NRC would update them, as recommended by the BRC.[19] A decision by DOE to proceed with development of a Defense HLW Repository would provide an early focal point and rationale for efforts by the EPA and the NRC to conduct this update.

3.3.3 Conclusions as to Regulation

Regulatory considerations strongly support a Defense HLW Repository. Although both disposal options could meet applicable regulatory requirements, it is likely that regulatory compliance for a Defense HLW Repository would be simpler to demonstrate thus allowing a Defense HLW Repository to be licensed sooner. Consistent with the benefits of a phased, adaptive approach, the successful licensing of a Defense HLW Repository could make the licensing process for a subsequent repository easier. Finally, the process of developing a Defense HLW Repository would provide an early focal point and rationale for EPA and NRC to update their generic repository regulations, which the BRC identified as a key near-term step to support repository siting.

3.4 Transportation

3.4.1 1985 Evaluation

The 1985 evaluation (DOE 1985, p. E-10) concluded that:

[19] For example, in the supplementary information provided by the NRC at publication of its regulations for disposal of SNF and HLW at Yucca Mountain, the NRC stated that, “The Commission recognized that its generic part 60 requirements will need updating if applied to sites other than Yucca Mountain” (66 FR 55732, p. 55736).

> With respect to any designated defense or commercial repository, the cost of shipping defense high-level waste to that site and the associated risks do not depend on whether the site is a defense-only or a commercial repository. Therefore the transportation considerations are not a basis for the selection of one of the two disposal options.

The 1985 evaluation (DOE 1985, Sections 2.3.4 and 3.3.4) discussed three factors for transportation cost and risk: quantity of waste, distance traveled, and mode of transportation. The evaluation analyzed transportation of a fixed amount of waste to five repository sites using two transportation modes (rail and legal-weight truck) and several assumptions. It was assumed that 20,000 canisters would be transported. The schedule for the transportation of these canisters to a repository would be "such that the receipt of commercial wastes at the repository would not be altered" (DOE 1985, p. 2-53). It was assumed that the Defense HLW canisters would be shipped from three locations: the Savannah River Site, the Hanford Site, and Idaho National Laboratory. The DOE was committed to transporting Defense HLW in NRC-certified casks "to the extent that such casks are available" (DOE 1985, p. 2-52). Because a repository location was unknown, calculations were performed for five potential repository regions. Two transportation scenarios were investigated: the first assumed that all shipments would be made by rail using five-canister casks; the second that all shipments would be made by truck using single-canister casks.

3.4.2 Post-1985 Information

Since 1985, significantly more information about the cost and risk of transportation has been produced, including: a General Accounting Office (now Government Accountability Office) report (GAO 2003); a report of the National Research Council (2006); and an NRC report (NRC 2012). These reports are not limited to Defense HLW, but provide insights on the transportation of Defense HLW. The new information does not change the 1985 conclusion that transportation cost and risk do not depend on the nature of the destination repository. The Department also has gained significant experience transporting defense transuranic waste to the Waste Isolation Pilot Plant (WIPP). This experience confirms that large-scale transportation to a repository limited to defense waste can be accomplished safely. The federal government began shipping defense transuranic waste by truck to WIPP in March 1999. The waste is shipped in NRC-certified casks. The WIPP transportation safety program was designed to ensure the "safe and uneventful" movement of the waste. To achieve this objective, the DOE worked cooperatively with citizen groups to develop a comprehensive transportation safety program that uses stringent protocols, principles, and procedures along with a robust shipping container. Since WIPP opened, each element of the transportation safety program has been reviewed annually and updated and changed as necessary, to reflect best practices and ongoing needs. More than 10,000 shipments of transuranic waste have been transported safely to New Mexico from DOE sites. There have been a few minor accidents involving these shipments, but none resulted in a release of radioactive materials.

The development of a Defense HLW Repository would provide an early opportunity to develop and exercise institutional procedures specific to transportation. Starting with a Defense HLW Repository allows the institutional procedures to be developed and tested on a relatively simple case—shipments from three Defense HLW storage sites (the Hanford Site, the Savannah River Site, and Idaho National Laboratory). DOE can build on its track record of safely transporting nuclear waste. The BRC commended the technical and institutional aspects of the WIPP transportation system and recommended that the same institutional provisions used for WIPP be applied to transportation of HLW and SNF to a repository as well (BRC 2012, pp. 86–87). A Defense HLW Repository would also allow disposal to begin sooner than a Common NWPA Repository because Defense HLW canisters could be shipped by truck without the need for rail transportation equipment or possible construction of an expensive rail spur to access the repository site. Truck shipments would also avoid the need to negotiate shipping/haulage rates with rail companies.

3.4.3 Conclusions as to Transportation

In general, transportation considerations do not weigh heavily in selecting between the two options. The risks of transportation are low, regardless of which option is selected. The total costs and risks of transportation depend on several factors, including the quantity of waste shipped, the distance traveled, and mode of transportation. These factors generally do not depend on the nature of the destination repository. However, the development of a Defense HLW Repository would provide an early opportunity to develop and exercise the institutional procedures for transportation of waste. A Defense HLW Repository would also enable DOE to build upon its track record of safely transporting nuclear waste, and enable an earlier start of disposal compared to a Common NWPA Repository because Defense HLW could be shipped by truck without the need for additional rail transportation equipment and infrastructure.

3.5 Public Acceptability

3.5.1 1985 Evaluation

The 1985 evaluation considered the perspectives of several groups, including federal agencies, states, tribes, local officials, nuclear utilities and pro-nuclear groups, nuclear critics, citizen groups, and the general public. The evaluation concluded that the primary factors influencing the public acceptability of a Common NWPA Repository were: (1) the potential public perception that disposal of both commercial and defense waste would add technical complexity and increase confusion and therefore may result in further delay; (2) the level of confidence in the technical analysis supporting the safety analysis and licensing decisions; and (3) diverse perspectives on the relative economic and safety impacts and benefits from common disposal. Some federal agencies were perceived to favor common disposal as a low cost option, but other federal agencies were considered not to because of the possibility that added complexity would cause delay. States, tribes, and local communities would be concerned about increased health and safety risks from the addition of defense wastes to the commercial spent fuel to be disposed; however, these groups were also understood to weigh the potential economic benefits from additional jobs, impact assistance and increased business activity. Nuclear utilities were understood to be concerned about the fairness of cost allocations between commercial and defense related waste disposition and that "…placing defense waste in the commercial repository can be perceived as another complicating factor" (DOE 1985, p. 2-64).

The 1985 evaluation of a Defense HLW Repository was based primarily on information presented by Nealey et al. (1983), considering the same stakeholder groups listed above. The evaluation concluded that a Defense HLW Repository may be perceived as presenting the least technical challenge. Further, a Defense HLW Repository may be seen as having lower risks and impacts because of the smaller volume and lower total amount of radioactivity involved. Analysis of risks and any economic impacts and benefits would be an important consideration in public positions. Concerns were also expressed about the potential for differences in standards that might be applied to separate repositories.

3.5.2 Post-1985 Information

Based on public preference research and international experience, a consent-based approach is now recognized as more likely to achieve public acceptance than previous approaches (DOE 2013a, p. 9; Jenkins-Smith et al. 2012a; BRC 2012, Section 6).

The successful consent-based siting and operation of a Defense HLW Repository would serve as a proof-of-concept and thereby could expedite siting for a subsequent repository. Further, by improving trust and confidence in repositories generally, a Defense HLW Repository could facilitate public acceptability of a subsequent repository. There is good reason to believe that a Defense HLW Repository would be an appropriate next step toward developing a consent-based approach. The public may be more likely to accept a limited-focus repository for waste that is relatively small in volume (after treatment) and radioactivity and that derives from national defense activities.[20] A Defense HLW Repository would be limited to defense waste that is smaller in volume and generally less radioactive than commercial SNF.

In addition, from a public acceptability standpoint, the earlier development of a Defense HLW Repository also has the benefit of earlier removal of this Defense HLW from DOE sites. This removal would be well-received by the communities and states hosting DOE sites and would build public confidence that final resolution of the HLW and SNF disposal problem is underway.

3.5.3 Conclusions as to Public Acceptability

Public acceptability considerations strongly support a Defense HLW Repository. The development of a Defense HLW Repository would serve as a proof-of-concept for consent-based siting and would help to improve trust and confidence in repositories generally, both of which could help achieve public acceptance for the siting of a subsequent repository. Further, a Defense HLW Repository would enable DOE to begin permanent disposal of the Defense HLW now in storage at DOE sites, which would be well-received in those communities and would build public confidence that final resolution of the HLW and SNF disposal problem is underway.

3.6 National Security

3.6.1 1985 Evaluation

The 1985 evaluation identified two national security priorities relevant to geologic disposal (DOE 1985, Section 2.3.6): (1) there must be no interruption of or delay or NRC involvement in the defense material production process or nuclear weapons activities; and (2) there must be no disclosure of classified information.

With respect to defense production activities, the 1985 report concluded that sufficient interim waste storage could be provided to allow continuous operations at defense facilities. With respect to concerns about the release of classified information, the report noted that because "the waste inventory is unclassified and the subsequent immobilization steps at each of the three DOE sites will be unclassified, immobilized waste destined for a repository will not reveal classified information" (DOE 1985, Section 2.3.6).

3.6.2 Post-1985 Information

The national security concerns raised in the 1985 evaluation no longer factor in this decision. DOE is no longer producing nuclear material for weapons. Therefore, concerns about impacts of delays in disposal of Defense HLW on the production of nuclear materials are no longer relevant. Unauthorized release of classified information is also not anticipated to be an issue for the licensing or regulation of a Defense HLW Repository or a Common NWPA Repository. DOE's experience from WIPP and elsewhere has

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[20] As stated in the Assessment (DOE 2014, p. 25), "Available information indicates that a repository limited to DOE-managed HLW and SNF not of commercial origin could be more likely to gain public acceptance than a repository that includes commercial waste, all other factors being equal."

demonstrated that a repository limited to defense waste can be designed and, in the case of WIPP, operated, without unauthorized disclosure of classified information.

A new national security concern has arisen since 1985 relating to disposal of naval SNF. The DOE and the Navy have entered an agreement with the State of Idaho to remove SNF from the state by 2035. Although a 2008 Addendum to the agreement limits the 2035 removal deadline to Navy SNF in Idaho prior to 2026, and allows the Navy to retain a working volume of 9 MTHM after the deadline, the Addendum retains the imposition of penalties for missed deadlines. Failure of the DOE and Navy to meet this deadline would subject the federal government to penalties, and shipments of SNF to Idaho National Laboratory after this deadline may be suspended. Should Idaho refuse SNF from the Navy, the Navy could be unable to complete refueling operations of the nuclear fleet, which would raise national security concerns, according to Navy officials (GAO 2011).[21] Near-term progress on disposing of Defense HLW could help expedite a process for ultimately removing all naval SNF from Idaho.

A Defense HLW Repository could also promote improved cooperation among DOE and State regulators, and help enhance public acceptability of DOE's mission within the local communities around the complex. These benefits would reduce opposition by State and local communities to using the DOE complex to achieve national security objectives such as the Reduced Enrichment for Research and Test Reactors program.[22]

3.6.3 Conclusions as to National Security

National security objectives can be achieved under either option. However, a Defense HLW Repository would likely be operational sooner than a Common NWPA. This earlier availability would support national security objectives by mitigating the risk of interference with refueling operations of the nuclear fleet. In addition, a Defense HLW Repository would promote improved cooperation between DOE and communities around the complex. These benefits would reduce opposition by State and local communities to using the DOE complex to achieve national security objectives.

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[21] The agreement with Idaho does not require naval SNF be sent to a geologic repository, but only that it be removed from Idaho. Therefore, transfer to an interim storage facility would also comply with that agreement.

[22] In an effort to reduce the amount of highly enriched SNF from foreign research and test reactors, DOE initiated the Reduced Enrichment for Research and Test Reactors program. The program addresses national security objectives; namely global nuclear material threat reduction, by allowing foreign reactor operators to return highly enriched SNF (which has the potential to be diverted and used for weapons material) of U.S. origin in exchange for low-enriched fuels. The program, which was initiated in 1978, is ongoing today. During the program's existence, over 40 research reactors have been converted from highly enriched uranium to low-enriched uranium fuels, and processes have been developed for producing radioisotopes with low-enriched uranium targets.

4 OVERALL CONCLUSIONS

Circumstances have changed significantly in the nearly 30 years since the Department and the President last considered whether to pursue a Defense HLW Repository. At that time, the Department assumed that a Common NWPA Repository would be available by 1998 and that production of Defense HLW would continue indefinitely. Because of those assumptions, the Department could identify only one material discriminating factor between the two options: the cost of repository construction. Since 1985, it has become clear there would continue to be schedule delays and other obstacles in opening a repository. This fact has had a number of consequences that materially affect the decision whether to pursue a Defense HLW Repository. First, since the enactment of the 1987 amendments to the NWPA, the National Academies, the BRC, and the Administration have all advocated for a phased, adaptive, consent-based approach to repository siting. A Defense HLW Repository would be a good first step along that path. Second, the delayed availability of a repository has had a decisive impact on the balance of costs and benefits of pursuing a Defense HLW Repository.

This report has considered the six factors that must be taken into account according to the NWPA:

- ***Cost Efficiency***—The 1985 evaluation concluded that, of the six factors, cost efficiency was the only differentiator. That evaluation concluded that including Defense HLW in a Common NWPA Repository would cost approximately $1.5 billion less than developing two separate facilities. This report concludes that separate disposal of Defense HLW would allow greater flexibility in the selection of geologic media for the two facilities, which has the potential to mitigate the incremental cost of constructing two facilities instead of one. Moreover, the earlier availability of a Defense HLW Repository could reduce Defense HLW storage, treatment, and management costs at DOE sites and may reduce the cost of developing future repositories by providing experience that can inform their design, siting, development, and operation. Although there is substantial uncertainty, on balance, cost efficiency favors development of a Defense HLW Repository.

- ***Health and Safety*—**Design, construction, and operation of either a Defense HLW Repository or Common NWPA Repository would be subject to a rigorous licensing review by the NRC to ensure protection of human health and the environment. Therefore, in their design and operation, either type of repository would be held to a high standard of health and safety. Nevertheless, developing a Defense HLW Repository, which would allow deep geologic disposal of Defense HLW sooner, would advance long-term health and safety by eliminating the need for active human control and maintenance of waste at various DOE sites

- ***Regulation*—**Regulatory considerations strongly support development of a separate Defense HLW Repository. The availability of a Defense HLW Repository would greatly assist DOE in fulfilling its regulatory obligations related to the present storage of Defense HLW at DOE sites. Developing a Defense HLW Repository also could simplify the licensing of a subsequent repository by providing important lessons learned, providing an early focal point and rationale for EPA and NRC to update their applicable regulations, and reducing the total volume of waste and the diversity of waste forms remaining to be disposed of in a subsequent repository.

- ***Transportation*—**Transportation costs and risks are affected by the quantity of waste shipped, the distance traveled, and mode of transportation, and are generally independent of whether the destination repository contains defense and commercial waste separately or together. Nevertheless, while not a strong factor, the development of a Defense HLW Repository would have the advantage of providing an earlier opportunity to develop the institutional processes for the transportation of waste prior to the development of a subsequent repository.

- ***Public Acceptability*****—**Experience in the United States and other nations indicates that a phased, adaptive, consent-based siting approach may have greater prospects for success in achieving public acceptance than prior top-down approaches to site designation. Because a Defense HLW Repository could be developed using such an approach and would provide useful experience in siting future facilities, this factor strongly supports a Defense HLW Repository.

- ***National Security***—National security objectives can be achieved whether Defense HLW is disposed of in a Common NWPA Repository or separately and, therefore, do not factor strongly. Nevertheless, the likely earlier availability of a Defense HLW Repository could provide additional support to national security objectives by demonstrating progress in meeting environmental obligations imposed on DOE at sites that store Defense HLW and by minimizing potential delays that could impact ongoing national security operations if deadlines are not met.

A geologic repository for permanent disposal of Defense HLW could be sited, licensed, constructed, and operated more quickly than a Common NWPA Repository and would provide valuable experience to reduce the cost of a future repository and the time needed to develop it. In consideration of the six statutory factors cumulatively, this report concludes that a strong basis exists to find that a Defense HLW Repository is required.

5 References

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