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The U.S. Nuclear Weapons Complex: Overview of Department of Energy Sites

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SUMMARY

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The U.S. Nuclear Weapons Complex: Overview of Department of Energy Sites

Responsibility for U.S. nuclear weapons resides in both the Department of Defense (DOD) and the Department of Energy (DOE). DOD develops, deploys, and operates the missiles and aircraft that deliver nuclear warheads. It also generates the military requirements for the warheads carried on those platforms. DOE, and its semiautonomous National Nuclear Security Administration (NNSA), oversee the research, development, testing, and acquisition programs that produce, maintain, and sustain the nuclear warheads.

To achieve these objectives, the facilities that constitute the nuclear weapons complex produce nuclear materials, fabricate nuclear and nonnuclear components, assemble and disassemble nuclear warheads, conduct scientific research and analysis to maintain confidence in the reliability of existing warheads, integrate components with nuclear weapons delivery vehicles, and conduct support operations.

The Trump Administration, in testimony before Congress and in the 2018 Nuclear Posture Review (released in February 2018), has raised concerns about the aging infrastructure of facilities in the nuclear weapons complex. While the Obama Administration proposed, and Congress funded, budget increases for these facilities in the past decade, the Trump Administration has argued that "the United States has not pursued the investments needed to ensure that the infrastructure has the capacity to not only maintain the current nuclear stockpile but also to respond to unforeseen technical or geopolitical developments."

The nuclear weapons complex—what NNSA currently refers to as the Nuclear Security Enterprise—consists primarily of nine government-owned, contractor-operated sites in seven states, and a Tennessee Valley Authority (TVA) nuclear reactor used to produce tritium for nuclear weapons. The complex began with the establishment of the Manhattan Engineer District in 1942, then grew in size and complexity during the Cold War, before evolving into the current configuration during the 1990s.

Facilities at the current nine sites include three laboratories, five component fabrication/materials production plants, one assembly and disassembly site, a geologic waste repository, and one testing facility that now conducts research but was previously the location for U.S. underground nuclear tests. This report summarizes the operations at each of these sites.

As Congress conducts oversight of DOE's and NNSA's management, operations, and programs, and as it authorizes and appropriates funds for the Nuclear Security Enterprise, it may address a wide range of issues related to the nuclear weapons complex. These include questions about organization and management at NNSA, infrastructure recapitalization, plutonium pit production, and concerns about access to necessary supplies of tritium.

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Introduction

The U.S. nuclear weapons complex, which the Department of Energy (DOE) refers to as the Nuclear Security Enterprise,[1] is the current incarnation of an evolving infrastructure designed to meet the requirements mandated by the Atomic Energy Act[2] to "ensure ... the [U.S. nuclear] stockpile is safe, secure, and reliable to perform [as intended] as the Nation's nuclear deterrent."[3] These requirements include

- production of nuclear materials;
- fabrication of nuclear components;
- fabrication of nonnuclear components;
- assembly and disassembly of nuclear warheads;
- integration of components with nuclear weapons delivery vehicles; and
- support operations.

Some of the functions within this complex have changed over time. The United States no longer produces highly enriched uranium or plutonium for use in nuclear weapons, although DOE continues to reuse materials removed from retired weapons. In addition, although the United States instituted a moratorium on explosive nuclear testing in 1992, several of the facilities in the complex now conduct science-based research and testing in support of the stockpile stewardship program.

The sites in this complex, and their locations within the United States, appear in **Figure 1**. The functions at each site are displayed in **Table 1**.

Responsibility for U.S. nuclear weapons resides in both the Department of Defense (DOD) and the DOE. DOD develops, deploys, and operates the missiles, submarines, and aircraft that deliver nuclear warheads.

It also generates the military requirements for the warheads carried on those platforms.[4] This report, however, focuses on the facilities managed by the DOE and its semiautonomous National Nuclear Security Administration (NNSA). NNSA oversees the research, development, test, and acquisition programs that produce, maintain, and sustain the nuclear warheads. DOE is responsible for storing and securing the warheads that are not deployed with DOD delivery systems, securing special nuclear materials, and dismantling warheads that have been retired and removed from the stockpile.

The current nuclear weapons complex (i.e., the major facilities within the Nuclear Security Enterprise that are used to meet the requirements for maintaining the nuclear weapons stockpile) consists of nine government-owned, contractor-operated sites in seven states, and a Tennessee Valley Authority (TVA) nuclear reactor used to produce tritium for nuclear weapons. Facilities at

[1] This report uses the phrase nuclear weapons complex interchangeably with Nuclear Security Enterprise. While both terms essentially refer to the same set of sites and facilities, NNSA has adopted the phrase Nuclear Security Enterprise to indicate that, while these facilities support the U.S. nuclear weapons program, many also support U.S. nonproliferation research and other national security goals.

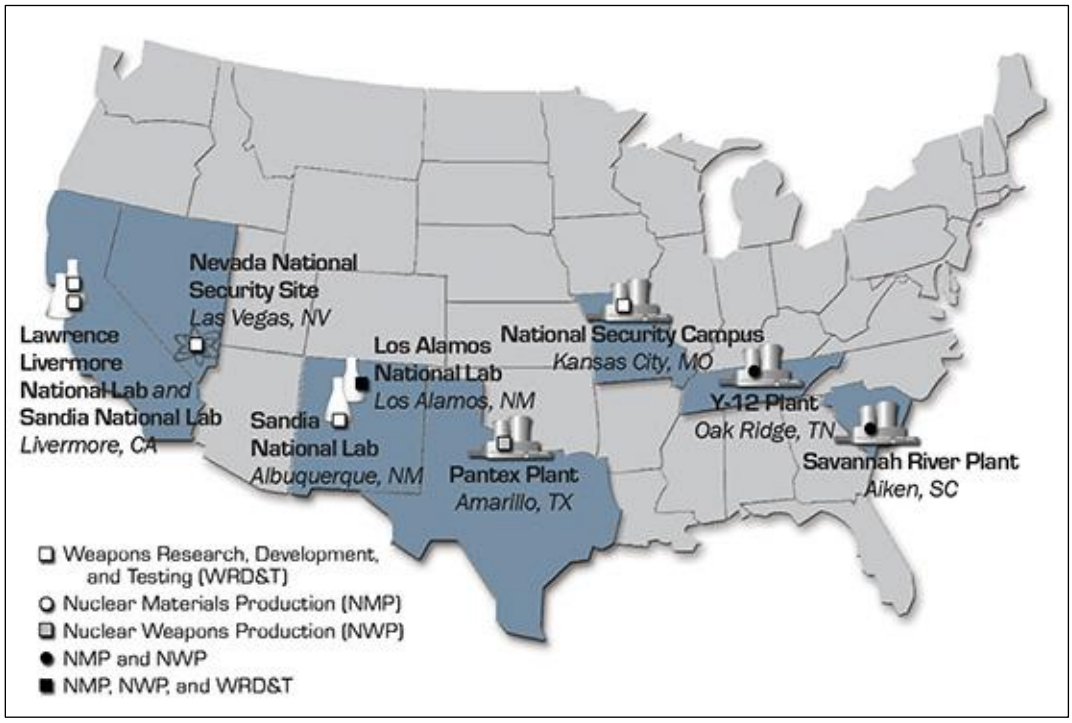
[2] 42 USC 2021(b).

[3] Office of the Deputy Assistant Secretary of Defense for Nuclear Matters. Nuclear Matters Handbook, 2016, https://www.acq.osd.mil/ncbdp/nm/nmhb/chapters/chapter_5.htm.

[4] For a description of these programs, see CRS Report RL33640, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*, by Amy F. Woolf.

these sites include three laboratories, five component fabrication/materials production plants, one assembly and disassembly site, a geologic waste repository, and one testing facility that now conducts research but was previously the location for U.S. underground nuclear tests.

Figure 1. NNSA Nuclear Security Enterprise



Source: Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook, 2016*.

Note: This map does not include two facilities that are relevant to meeting the current nuclear warhead requirements: the Tennessee Valley Authority Watts Bar reactor, used for tritium production, and the Waste Isolation Pilot Plant in New Mexico, used for managing plutonium waste generated during ongoing nuclear warhead stockpile support operations. The map also does not include Alaska and Hawaii, as neither houses a facility in the Nuclear Security Enterprise.

The 2018 Nuclear Posture Review (NPR), prepared by DOD and released in early February 2018, notes that

> Over the past several decades, the U.S. nuclear weapons infrastructure has suffered the effects of aging and underfunding. Over half of NNSA's infrastructure is over 40 years old, and a quarter dates back to the Manhattan Project era.[5]

In addition, the 2018 NPR notes that each of the Nuclear Posture Reviews completed since the end of the Cold War (in 1994, 2001, and 2010) has "highlighted the need to maintain a modern nuclear weapons infrastructure." However, it argues that the United States has not pursued the investments needed to ensure that the infrastructure can maintain the current nuclear stockpile as

[5] Department of Defense, *Nuclear Posture Review*, Washington, DC, February 2, 2018, p. 61, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

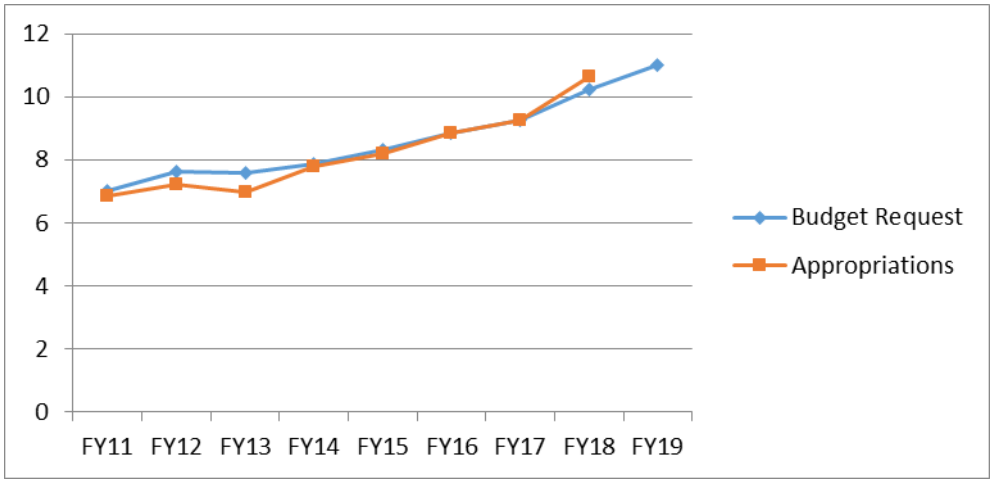
well as respond to unforeseen technical or geopolitical developments[6] by providing the United States with sufficient capacity to sustain and replace its nuclear forces.

After declining during the first two decades after the Cold War, funding for nuclear weapons activities at NNSA has increased steadily in recent years.[7] In a 2010 editorial, then-Vice President Biden noted that U.S. nuclear laboratories and facilities had been "underfunded and undervalued" for more than a decade.[8] He stated that President Obama's budget request for FY2011 would include "$7 billion for maintaining our nuclear-weapons stockpile and complex, and for related efforts," an amount that was $600 million more than Congress appropriated for FY2010.[9] He also stated that the Administration would "boost funding for these important activities by more than $5 billion" over the next five years.[10]

While the passage of the Budget Control Act in 2011 slowed the increases in NNSA budgets, appropriations for NNSA's weapons activities have grown in each of the subsequent years, reaching $9.25 billion in FY2017, the last year of the Obama Administration. The Trump Administration, in its budget for FY2018, requested an additional $1 billion for NNSA weapons activities over the level appropriated in FY2017. The Trump Administration's budget for FY2019 continues to fund increases in NNSA's weapons activities, requesting $11.02 billion, an increase of nearly $400 million over the funding enacted in FY2018. These amounts do not include site overhead costs (e.g., site security, maintenance, administration) paid through the Environmental Management (EM) program funding for certain sites (e.g., the Savannah River Site, where EM funding provided 70% of the site budget).

Figure 2. Funding for NNSA Nuclear Weapons Activities

Requested and Appropriated, FY2011-FY2019 (billions of current dollars)



Source: NNSA budget requests, congressional appropriations reports, CRS estimates.

These funding increases have not, however, assuaged concerns about the aging facilities in the nuclear weapons infrastructure. In testimony before the Senate Armed Services Committee in

[6] Ibid., p. 61.

[7] For details on the programs funded through the Nuclear Weapons Activities, and recent appropriations activities, see CRS Report R44442, *Energy and Water Development Appropriations: Nuclear Weapons Activities*, by Amy F. Woolf.

[8] Joe Biden, "The President's Nuclear Vision," *Wall Street Journal*, January 29, 2010.

[9] Ibid.

[10] Ibid.

2016, General Frank G. Klotz, who was then the Administrator of NNSA, noted that "the age and condition of NNSA's infrastructure will, if not addressed, put the mission, the safety of our workers, the public, and the environment at risk."[11] At a hearing held by the Strategic Forces Subcommittee of the House Armed Services Committee, General Klotz noted that the resources available to maintain NNSA's infrastructure "have historically not kept pace with growing needs." Further, press reports indicate that, in late 2015, then-Secretary of Energy Ernest Moniz requested a $5.2 billion increase in the planned budget for NNSA between FY2018 and FY2021 to address "programmatic gaps." He noted, in a letter described in the *Wall Street Journal*, that "a majority of NNSA's facilities and systems are well beyond end-of-life" and that "infrastructure problems such as falling ceilings are increasing in frequency and severity."[12]

Lisa E. Gordon-Hagerty, the current Administrator of NNSA, echoed the concerns raised by General Klotz during her testimony before the Strategic Forces Subcommittee of the House Armed Services Committee in March 2018.[13] She stated that NNSA's FY2019 budget request of $3 billion for Infrastructure and Operations represented a 7% increase over the FY2018 request. She asserted that this funding would support both NNSA's deferred maintenance problem in existing facilities and its need to construct new facilities, including the Uranium Processing Facility at Oak Ridge, TN, and the Chemistry and Metallurgy Research Replacement (CMRR) project at Los Alamos National Laboratory in New Mexico. In May 2018, NNSA announced that it was recommending a strategy to achieve the goal of producing 80 nuclear pits per year, which would both maximize pit production at Los Alamos within the CMRR project and repurpose the Mixed Oxide (MOX) Fuel Fabrication Facility at the Savannah River Site in South Carolina. NNSA argued that "this two-prong approach—with at least 50 pits per year produced at Savannah River and at least 30 pits per year at Los Alamos—is the best way to manage the cost, schedule, and risk of such a vital undertaking."[14]

> Plutonium pits are a critical core component of modern nuclear weapons. The nuclear fission energy produced when the pit is compressed by explosives initiates the process that produces the much larger fusion reaction. NNSA has argued that the United States needs to produce at least 80 pits per year in order to replace aging pits in the U.S. stockpile over the next 50 years.

As funding for NNSA continues to rise, interest has grown in U.S. nuclear policy, in general, and in the facilities and programs managed by NNSA, in particular. This report provides details about each of the sites within the complex.[15] It begins with a brief history of the nuclear weapons

[11] U.S. Congress, Senate Armed Services, Strategic Forces, *Department of Energy Atomic Energy Defense Activities and Programs*, Hearing, 114th Cong., 2nd sess., February 23, 2016, Statement of Lt. Gen. Frank G. Klotz, USAF (Ret), p. 5.

[12] "Mr. Moniz's Nuclear Warning," *Wall Street Journal*, January 12, 2016, https://www.wsj.com/articles/mr-monizs-nuclear-warning-1452644053.

[13] U.S. Congress, House Armed Services, Strategic Forces, *Fiscal Year 2019 Budget Request for Nuclear Forces and Atomic Energy Defense Activities*, Hearing, 115th Cong., 2nd sess., March 22, 2018. Statement of Lisa Gordon Hagerty, p. 6.

[14] Ellen M. Lord and Lisa Gordon-Hagerty, *Recapitalization of Plutonium Pit Production*, National Nuclear Security Administration, Joint Statement, Washington, DC, May 10, 2018, https://www.energy.gov/nnsa/articles/joint-statement-ellen-m-lord-and-lisa-e-gordon-hagerty-recapitalization-plutonium-pit.

[15] This report addresses only the major sites currently used for nuclear weapons production and funded largely through the NNSA's Weapons Activities account. Several other DOE facilities, including many of its other 14 national laboratories (https://science.energy.gov/laboratories/), receive funding from NNSA that supports nonproliferation and other national security programs, but are not considered by NNSA to be a part of the nuclear security enterprise.

complex and then reviews current issues that Congress may address during the annual authorizations and appropriations process.

Background

Interest in the development of nuclear weapons was evident in discussions among academic scientists and federal officials shortly before the United States entered World War II. The nuclear weapons program, in an effort known as the Manhattan Project, began in 1942.[16] Many of the sites and facilities established early in the program to support the design, development, and production of the first nuclear weapons remain in operation today as a part of the DOE nuclear security enterprise.

The end of the Cold War saw numerous changes to the nuclear enterprise. The number of sites involved in nuclear warhead production declined, as the United States reduced the number of warheads in the stockpile while maintaining the capability to sustain the remaining nuclear weapons. In addition, the focus of the work shifted away from weapons research, development, and production—the core mission during the Cold War—toward a science-based stockpile stewardship program designed to enable the United States to sustain and maintain its warheads without conducting explosive nuclear testing.

The enterprise has also increased its focus on research into technologies and processes that can prevent, counter, and respond to threats of nuclear proliferation while addressing the degradation remaining from the environmental contamination and waste generated during the Cold War.[17] These goals are not addressed in this report.

Origins and Organization of the Nuclear Weapons Enterprise

In August 1939, Albert Einstein signed a letter to President Franklin Roosevelt to inform him that recent scientific research conducted at U.S. universities indicated that large amounts of power could be produced by a chain reaction using uranium and that, by harnessing this power, the construction of "extremely powerful bombs" was conceivable. The letter urged the U.S. government to support research in this area, in part, because the German government was doing so.

President Roosevelt responded to Einstein in October 1939, and informed him that he had set up a committee to study uranium. The President's Advisory Committee on Uranium first met in October 1939, and recommended that the government fund limited research into uranium.[18] The effort expanded in 1940, after the German invasion of Poland, when President Roosevelt reorganized the Uranium Committee into a scientific body known as the National Defense Research Committee. Over the next few years, this organization supported funding for scientists

[16] "The Manhattan Engineer District (MED) was established, effective August 16, 1942, by Office of the Chief of Engineers General Order 33, dated August 13, 1942 …. Development of Substitute Materials." War Department, Office of the Chief of Engineers, Manhattan Engineer District, August 16, 1942-August 15,1947, Organization Authority Record, https://catalog.archives.gov/id/10510246; and Fowle, Barry W., ed. *Builders and Fighters: U. S. Army Engineers in World War II*, Fort Belvoir, VA: Office of History, U. S. Army Corps of Engineers, 1992, p. 147.

[17] U.S. Department of Energy, National Nuclear Security Administration, *Comments on the Final Report of the Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise*, Report to Congress, Washington, DC, May 2015, p. 3.

[18] F.G. Gosling, *The Manhattan Project: Making the Atomic Bomb*, U.S. Department of Energy, Washington, DC, January 2010, p. 6, http://energy.gov/sites/prod/files/Manhattan_Project_2010.pdf.

who were exploring alternative processes that would produce the fissionable materials needed for a nuclear bomb.

By mid-1942, with research proceeding on several different processes, the committee decided that it was time to advance to the pilot plant stage and to full-production planning for the atomic bomb. In June 1942, President Roosevelt approved a plan giving the Army Corps of Engineers the responsibility for producing an atomic weapon before the end of the war, and the Army established the Manhattan Engineer District (MED).

With Brigadier General Leslie R. Groves in charge, the Manhattan Engineer District joined major industrial partners with scientists and academia to research, develop, and produce an atomic bomb.[19] The Army owned and managed the MED from 1942 through 1946.

After World War II, the Atomic Energy Act of 1946 established a policy to develop atomic energy for military and peaceful purposes. The act established the Atomic Energy Commission (AEC), an independent civilian agency, and moved the weapons program from the Army to the AEC. The act stipulated that, with certain exceptions, a civilian agency "shall be the exclusive owner of all facilities for the production of fissionable material," including "all materials, facilities, equipment, items, and property related to atomic energy research"; this placed nuclear energy, and the U.S. nuclear weapons program, firmly under civilian control.[20]

The decision on whether to place nuclear energy under civilian or military control was bitterly contentious in 1946.[21] Some feared that military control would impede or prevent the development of atomic energy for peaceful purposes, would impede the free international exchange of information on the basic science of atomic energy, would stifle independent inquiry, and would impede efforts to have international control of atomic energy. The armed services and some Members of Congress, however, were concerned about the need to preserve secrecy and to ensure the responsiveness of the nuclear weapons program to the needs of the services. Those concerns were raised as arguments for continued military control over nuclear energy.

> Nuclear explosions are produced by initiating and sustaining nuclear chain reactions in highly compressed material that can undergo both fission and fusion.
>
> "Little Boy"—the nuclear weapon used against Hiroshima in 1945—was a "gun-type" weapon that initiated fission by shooting a hollow uranium-235 cylinder at a target "plug" of the same material.
>
> Most existing U.S. nuclear weapons use a nuclear package with two assemblies: the "primary," which is used as the initial source of energy, and the "secondary," which provides additional explosive power. The primary contains a central core, called the "pit," typically composed of plutonium-239 and/or highly enriched uranium (HEU) and other materials. Plutonium-239 and HEU are fissile materials, capable of sustaining a chain reaction. HEU contains large fractions of uranium-235. The pit is surrounded by a layer of high explosive.
>
> **Source:** Department of Energy, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences*, DOE/EM-0319, January 1997, p. 13.

The Atomic Energy Act (42 U.S.C. 2121(b)) institutionalized civilian control. It authorized the AEC to conduct research and development on the military applications of nuclear energy and to

[19] Department of Energy, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences*, DOE/EM-0319, January 1997.

[20] 42 U.S.C. 2161. Also see Kevin O'Neill, "Building the Bomb," in *Atomic Audit*, ed. Stephen I. Schwartz (Washington, DC: Brookings Institution Press, 1998), p. 61.

[21] This, and several subsequent paragraphs, are drawn from CRS Report 95-1162F, *Nuclear Weapons Complex Facilities: Background and Profiles*, by Jonathan Medalia, William Boseman, and Mark Holt (available to congressional clients upon request from the author of this report).

produce nuclear weapons and their components, but "only to the extent that the express consent and direction of the President of the United States has been obtained." The act gave the President further control:

> The President from time to time may direct the Commission (1) to deliver such quantities of fissionable materials or weapons to the armed forces for such use as he deems necessary in the interest of national defense or (2) to authorize the armed forces to manufacture, produce, or acquire any equipment or device utilizing fissionable material or atomic energy as a military weapon.[22]

The act also established a Military Liaison Committee and directed the AEC to "to coordinate nuclear defense activities between the War and Navy Departments and the AEC."[23] The council was expected to "advise and consult with the Committee on all atomic energy matters which the Committee deems to relate to military applications."

In the early years, civilian control extended to custodianship over operational nuclear weapons. With early weapon designs, the fissile core of the weapon was separated from the rest of the weapon to address safety concerns; AEC personnel maintained custody of the cores. This practice continued until the mid-1950s, when integrated warheads were designed, produced, and turned over to DOD.[24]

In the Energy Reorganization Act of 1974 (P.L. 93-438), Congress dissolved the AEC and created the Nuclear Regulatory Commission and the Energy Research and Development Administration (ERDA).[25] ERDA became the lead agency in the energy R&D program and the repository of the weapons program.[26] That program was moved again by the Department of Energy Organization Act of 1977, which dissolved ERDA and created the Department of Energy.

Congress, in passing the National Defense Authorization Act for Fiscal Year 2000 (P.L. 106-65, Title XXXII), established the National Nuclear Security Administration (NNSA). NNSA is a semiautonomous agency operating within DOE. According to NNSA, its mission, among other things, is to maintain and enhance "the safety, security, and effectiveness of the U.S. nuclear weapons stockpile without nuclear explosive testing"; work to "reduce the global danger from weapons of mass destruction"; provide the U.S. Navy "with safe and effective nuclear propulsion"; and respond to "nuclear and radiological emergencies in the U.S. and abroad."[27]

---

[22] 42 U.S.C. 2121(b).

[23] The MLC was the forerunner of the Nuclear Weapons Council, which is a "DoD-DOE activity responsible for facilitating cooperation and coordination, reaching consensus, and establishing priorities between the two Departments as they fulfill their dual-agency responsibilities for U.S. nuclear weapons stockpile management." See Office of the Deputy Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016*, Washington, DC, Appendix A, https://www.acq.osd.mil/ncbdp/nm/NMHB/chapters/Appendix_A.htm.

[24] Thomas Cochran, William Arkin, and Milton Hoenig, *Nuclear Weapons Databook: Volume I, U.S. Nuclear Forces and Capabilities*, Cambridge, MA, Ballinger, 1984, p. 6, note 13.

[25] This legislation was, in large part, a response to the energy crisis of 1973 and an effort to "assure the coordinated and effective development of all energy sources" by bringing together "Federal activities relating to research and development on the various sources of energy, to increase the efficiency and reliability in the use of energy, and to carry out the performance of other functions, including but not limited to the Atomic Energy Commission's military and production activities and its general basic research activities." See P.L. 93-438.

[26] U.S. Congress, Office of Technology Assessment, *An Analysis of the ERDA Plan and Program*, Washington, DC, U.S. Government. Printing Office, October 1975, p. vii, 311.

[27] National Nuclear Security Administration (NNSA), "About NNSA," https://www.energy.gov/nnsa/about-nnsa.

The Nuclear Weapons Complex

The eight sites that NNSA identifies as composing the current U.S. Nuclear Security Enterprise reflect the most recent in a series of expansions and contractions in the structure of the nuclear weapons complex for carrying out the functions required to maintain the nuclear weapons stockpile. Generally, the enterprise has been structured and operated in three phases. Although the locations of the facilities have changed, the essential functions have mostly remained the same because warhead designs have largely remained the same.

First, during the 1940s, the Manhattan Project included three well-known primary "government-owned, contractor-operated" (GOCO) facilities that were used during World War II and immediately afterward. These included the laboratory at Los Alamos, NM (called Site Y in World War II, now Los Alamos National Laboratory), which designed nuclear weapons; the Hanford Engineering Works (later known as the Hanford Reservation or Hanford Site) near Richland, WA, which produced plutonium; and three major sites at Oak Ridge, TN, which produced uranium enriched in the fissile isotope 235.[28] The nuclear weapons complex also incorporated hundreds of smaller "contractor-owned, contractor-operated" (COCO) facilities that allowed for rapid increases in production in the early years of the nuclear weapons program.[29] In some cases, these facilities performed nonnuclear materials production and fabrication operations; in other cases, they performed operations with radioactive materials alongside ongoing nonnuclear civilian operations.

Hanford

Hanford produced the first plutonium for U.S. nuclear weapons during World War II and eventually made most of the plutonium for tens of thousands of weapons produced by the United States during the Cold War. Nine plutonium production reactors eventually operated at Hanford, and large processing facilities were built to chemically separate the plutonium from other elements produced in the reactors. Plutonium production at Hanford ended in the mid-1980s, and the reactors were shut down by 1987. The United States no longer produces plutonium for nuclear weapons. Hanford remains severely contaminated with nuclear and chemical wastes, and remedial action and waste management operations are expected to continue through 2060, with an estimated life-cost of over $100 billion, to be followed by indefinite long-term stewardship.

In the second phase, during the early 1950s, the Atomic Energy Commission consolidated many of these functions into a smaller number of larger GOCO facilities constructed throughout the United States. This consolidation reduced the AEC's reliance on the smaller COCO facilities and was expected to result in economies of scale at a time when overall production increased dramatically to meet the need of the Cold War stockpile buildup. Many facilities performed multiple functions. To provide sufficient capacity to meet the needs of the expanding stockpile, some operations were performed at multiple facilities. By late 1952, the AEC had several new production plants planned or under construction, and it was expanding existing plants. These

[28] Natural uranium from the earth consists of more than 99% uranium 238 and less than 1% uranium 235. Natural uranium is this same 0.07% U-235 before it is removed from the earth. For certain key nuclear weapons components, uranium typically is enriched to more than 90% U-235. Uranium enriched to greater than 20% uranium-235 is called highly enriched uranium. The enrichment process leaves large quantities of uranium with almost all U-235 removed, called depleted uranium.

[29] See https://www.energy.gov/lm/sites/lm-sites/considered-sites. Also, many of the sites used in support of nuclear weapons production operations during this period have been analyzed as part of the petition evaluation process for the Energy Employees Occupational Illness Compensation Program Act (42 U.S.C. 7384 et seq.) See https://www.dol.gov/owcp/energy/ and https://www.cdc.gov/niosh/ocas/ocaseeoi.html and https://ehss.energy.gov/Search/Facility/findfacility.aspx.

included plants at Savannah River, SC; Oak Ridge, TN; Hanford, WA; Fernald and Miamisburg, OH; Rocky Flats, CO; Largo, FL; Albuquerque, NM; and Kansas City, MO.

The third phase of the U.S. nuclear weapons complex coincided roughly with the end of the Cold War. With President George H. W. Bush's 1991 decision to withdraw most nonstrategic nuclear weapons from deployment, the cancellation of several ongoing warhead programs, and the signing of arms control agreements that limited the numbers of deployed nuclear forces, the need for new nuclear warheads diminished and the number of warheads in the U.S. nuclear stockpile began to decline sharply.[30] In addition, in 1992, Congress enacted a moratorium on U.S. nuclear weapons testing when it attached the Hatfield-Exon-Mitchell amendment to the 1993 Energy and Water Development Appropriations Act.[31] President George H. W. Bush signed the bill into law (P.L. 102-377) and President Clinton extended the moratorium three times before signing the Comprehensive Nuclear Test Ban Treaty (CTBT) in 1996.[32] Although the Senate declined to consent to ratification of the CTBT in 1999, the United States has not conducted any explosive nuclear tests since September 1992, before the moratorium entered into force.[33] The United States also has not designed or produced a new nuclear warhead since production of the W88 warhead ended in 1992.

Regulatory challenges and concerns regarding environmental, safety, and health issues at existing nuclear weapons facilities, along with reductions in the size of the stockpile and growing public scrutiny, prompted a significant reduction in the number of facilities producing nuclear warheads and associated nuclear materials.[34] By the mid-1990s, the number of sites working to maintain U.S. nuclear weapons had declined to the current nine sites, and a TVA reactor, in seven states. The remaining facilities not only continued to operate, but they often sought budget increases to address urgent safety and environmental issues and to repair and replace aging infrastructure. With the heightened focus on environmental and health issues, in FY1995, for the first time, the DOE budget for Environmental Management exceeded

Rocky Flats

During the Cold War, the Rocky Flats Plant, located about 16 miles northwest of Denver, Colorado, produced plutonium pits and other components for the primary stage of nuclear warheads, along with associated chemical processing of plutonium scraps for reuse. It produced around 1,000 pits per year and supplied most of the pits used in U.S. nuclear weapons. In June 1989, the FBI executed a search warrant (widely reported as a law enforcement "raid") at the site, based on evidence of violations of environmental laws. DOE halted plutonium pit production operations at Rocky Flats in December 1989 largely because of a lack of waste storage capacity. Without Rocky Flats, the United States does not have an industrial-scale capability to manufacture new plutonium pits. Los Alamos Laboratory has the ability to fabricate small numbers of pits, and Rocky Flats' responsibilities for non-nuclear primary components have been transferred to Y-12 and Kansas City.

[30] See **Appendix A**.

[31] The United States conducted 1,054 nuclear weapons test explosions between 1945 and 1992. See **Appendix B** and U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, *United States Nuclear Tests: July 1945 through September 1992*, Las Vegas, NV, September 2015, p. xv, https://www.nnss.gov/docs/docs_LibraryPublications/DOE_NV-209_Rev16.pdf.

[32] This amendment banned testing before July 1, 1993; set conditions on a resumption of testing; and then banned testing after September 1996 unless another nation tested.

[33] For details on the CTBT and the Senate debate on its ratification, see CRS Report RL33548, *Comprehensive Nuclear-Test-Ban Treaty: Background and Current Developments*, by Mary Beth D. Nikitin.

[34] William Lanouette, *Tritium and the Times: How the Nuclear Weapons-Production Scandal Became a National Story*, Harvard JFK School, Shorenstein Center, May 1990, https://shorensteincenter.org/wp-content/uploads/2012/03/r01_lanouette.pdf?x78124.

DOE's budget for nuclear weapons production.

When these nuclear weapons operations shut down, there was typically no clear plan in place for follow-up operations. Perhaps most significantly, the Rocky Flats Plant in Colorado ceased plutonium productions operations in June 1989 without clear plans to restore pit capacity elsewhere. In addition, when operations ceased at Hanford, Rocky Flats, and the Savannah River Site, significant amounts of special nuclear materials were in the midst of processing activities, which posed significant safeguards, security, and safety challenges. When DOE's efforts to restart the K-reactor at the Savannah River Site failed and caused tritium contamination in the Savannah River in 1991, a new tritium productions capacity had to be developed using commercial power reactors.

Over time, DOE developed the capacity at alternative facilities to meet most of the stockpile needs. For example, new nonnuclear hydrodynamic testing facilities were constructed at Los Alamos and Livermore National Laboratories. The Tennessee Valley Authority nuclear power reactors provided tritium production capacity. Further, in the absence of nuclear weapons testing, the United States has adopted a science-based program to maintain and sustain confidence in the reliability of the U.S. nuclear stockpile. This program, established in the National Defense Authorization Act for Fiscal Year 1994 (P.L. 103-160) and amended by the National Defense Authorization Act for Fiscal Year 2010 (P.L. 111-84, §3111), is designed to ensure "that the nuclear weapons stockpile is safe, secure, and reliable without the use of underground nuclear weapons testing." However, as discussed below, plutonium pit capacity at LANL has not been able to keep pace with NNSA's stated needs for the stockpile.

Table 1. U.S. Nuclear Weapons Complex

Sites and Functions

	Materials Production	Component Fabrication	Research, Development and Testing	Assembly and Disassembly
Current Sites				
Livermore National Lab			x	
Los Alamos National Lab		x	x	
Sandia National Lab		x	x	
Pantex Plant				x
Oak Ridge Y-12		x		x
Savannah River Site	x			
Kansas City National Security Complex		x		
Nevada National Security Site			x	
Supporting Sites				
TVA Watts Bar	x			
WIPP	[a]	[a]	[a]	[a]

Source: National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, November 2017.

a. WIPP does not perform these operations, but it plays a vital role in the disposal of transuranic waste generated by facilities and operations performing these functions, thereby ensuring compliance with AEA and other legal obligations and allowing continued operations at these sites.

The Current Nuclear Weapons Complex

The current nuclear weapons complex, which NNSA refers to as the Nuclear Security Enterprise, includes "NNSA Headquarters (located in Washington, DC; Germantown, Maryland; and Albuquerque, New Mexico), the NNSA field offices, the three national security laboratories (two of which also have production missions), the four nuclear weapons production facilities, and the Nevada National Security Site."[35] Two other facilities are essential for maintaining the stockpile: (1) the TVA's Watts Barr nuclear power reactor in Tennessee, which produces tritium, a relatively short-lived nuclear material vital to modern nuclear warheads, and (2) the WIPP site in New Mexico, which is used to manage, isolate, and store plutonium-bearing wastes from the warhead operations at other sites.[36] The site descriptions that follow do not describe the headquarters or field offices, but focus instead on the laboratories, testing, production, and support facilities more commonly known as the nuclear weapons infrastructure. The sites are largely government-owned, contractor-operated facilities.[37]

According to NNSA, the primary mission of national security laboratories "is to develop and sustain nuclear weapons design, simulation, modeling, and experimental capabilities and competencies to ensure confidence in the stockpile without nuclear explosive testing." The laboratories also "engage in long-term research, development, test, and evaluation (RDT&E) activities" for the nuclear weapons mission, as well as "apply science, engineering, and technology to solve other national challenges."[38]

Five production facilities produce and assemble materials and components for nuclear weapons. Some weapon components must be replaced on a regular basis (e.g., tritium produced by TVA reactors and processes at Savannah River Site), while others are produced on an as-needed basis, as part of the program to extend the life of the nuclear arsenal. Two of the facilities—the Pantex Plant near Amarillo, TX, and Y-12 in Oak Ridge, TN—are also responsible for dismantling retired weapons and storing most of the plutonium and highly enriched uranium that exists outside of weapons.

The Nevada National Security Site near Las Vegas, formerly a test site, no longer conducts nuclear explosive tests, but it still maintains several facilities needed for other types of testing critical to the stockpile stewardship program. The site also maintains the capability to resume nuclear explosive testing in a two- to three-year time frame, if ordered to do so by the President.

The Waste Isolation Pilot Plant (WIPP) in New Mexico manages plutonium-contaminated (transuranic) waste produced by nuclear weapons facilities, such as Los Alamos National Laboratory, Savannah River Site, and Pantex. Without WIPP, nuclear warhead operations generating plutonium-contaminated waste would be restricted because of the limited quantity of such waste that can be stored onsite.[39] WIPP's strategic plan prioritizes the management of newly generated wastes from ongoing nuclear warhead missions.

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[35] U.S. Department of Energy, National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, Report to Congress, Washington, DC, November 2017, pp. 1-6, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[36] WIPP also manages and stores waste shipped from other DOE sites, as a part of the Environmental Support mission.

[37] For a description of this arrangement, see Sandia National Laboratories, *Government Owned/Contractor Operated Heritage*, Fact Sheet. https://www.sandia.gov/about/history/goco.html.

[38] National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, p. 1-6, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[39] Department of Energy, *WIPP Strategic Plan Operations Through 2050, 15-GM.14, Rev. 0*, June 17, 2016.

National Security Laboratories

NNSA operates three national security laboratories whose primary mission is to "develop and sustain nuclear weapons design, simulation, modeling, and experimental capabilities and competencies."[40] Historically, two of the three laboratories—Los Alamos and Livermore—were responsible for the design of all U.S. nuclear weapons. Specifically, they designed the physics package, which is the integrated nuclear warhead. The warhead includes the primary (plutonium pit and related initiators, high explosive lenses, reflectors), the secondary (consisting largely of lithium deuteride and a booster gas canister), and the supporting case surrounding these components. Today, all three laboratories are engaged in activities that help "ensure confidence in the stockpile without nuclear explosive testing." According to NNSA, the laboratories also "apply science, engineering, and technology to solve other national challenges."[41] For decades, the Livermore and Los Alamos labs were run as nonprofit entities managed by the University of California. Since 2006, each has been managed by a for-profit limited liability company.

Los Alamos National Laboratory

Los Alamos National Laboratory (LANL), known as the birthplace of the U.S. nuclear weapons program, was established in 1943 as part of the Manhattan Project.[42] The laboratory is located on approximately 34.7 square miles in northern New Mexico, about 35 miles from Santa Fe. According to NNSA, Los Alamos "is a design laboratory responsible for the safety and reliability of the nuclear explosives package in nuclear weapons."[43] Although it shares warhead design responsibilities with Livermore National Laboratory, Los Alamos is solely responsible for the nuclear design and engineering of the B61, W76, W78, and W88 warheads. It also manages the life extension and alteration programs affecting the W76 warhead, the B61-12 bomb, and the W88 warhead.[44] These programs replace aging components in existing warheads with "newly manufactured and sometimes modernized components."[45]

In addition to its work on nuclear warheads design and life extension, Los Alamos develops and sustains "design, simulation, modeling, and experimental capabilities and competencies to ensure stockpile confidence without nuclear testing."[46] It conducts regular evaluations of warheads, with its surveillance data and experimental and computational simulations informing annual

[40] U.S. Department of Energy, National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, Report to Congress, Washington, DC, November, 2017, p. 1-6. https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[41] U.S. Department of Energy, National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan, Report to Congress*, Washington, DC, November, 2017, p. 1-6. https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[42] Union of Concerned Scientists, *Los Alamos National Laboratory*, Fact Sheet, October 2013, p. 1, https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/nuclear-weapons-complex/los-alamos-fact-sheet.pdf.

[43] https://www.energy.gov/nnsa/locations.

[44] NNSA, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, p. 1-7, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[45] Union of Concerned Scientists, *Los Alamos National Laboratory*, Fact Sheet, October 2013, p. 1, https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/nuclear-weapons-complex/los-alamos-fact-sheet.pdf.

[46] NNSA, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, p. 1-7, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

assessments of the nuclear stockpile. According to NNSA, it "possesses unique capabilities in neutron scattering, enhanced surveillance, radiography, and plutonium science and engineering."

Los Alamos has the unique capability within the weapons complex for plutonium processing and fabrication. It maintains the capability to work with special nuclear materials—plutonium and highly enriched uranium—and maintains the capability to produce limited numbers of plutonium pits (the explosive cores of nuclear weapons). Although it maintains the capacity to produce up to 30 pits per year, it has rarely succeeded in producing more than 10-15 per year, as a result of safety and operational concerns. In 2013, safety issues led to a shutdown at the PF-4 building at Los Alamos, and it has not produced any operational pits since that time.[47]

Over the years, Los Alamos has faced a number of questions about its safety culture, with numerous incidents that could have caused significant problems, including "criticality" episodes.[48] The lab sits on a seismic fault, leading to concerns that an earthquake, and subsequent damage to or fire in the facilities, could lead to the release of radiation, although this has not happened since its inception.

Los Alamos National Laboratory currently employs about 11,700 people, with 8,324 working directly for the company managing the laboratory. In FY2017, it had an operating budget of $2.55 billion, with $1.6 billion (62%) allocated to nuclear weapons activities.[49] The budget request for FY2019 seeks $2.2 billion, with $1.9 billion (86%) allocated to weapons activities.

In 2006, NNSA awarded the management and operations contract for LANL to Los Alamos National Security (LANS)—a Limited Liability company (LLC) comprising the University of California; Bechtel National, Inc.; the Babcock & Wilcox company; and URS Corporation. The contract with this LLC is due to expire on September 30, 2018, but will be extended to allow for a four-month transition period to a new contractor, Triad National Security.[50] NNSA announced, on June 8, 2018, that it had awarded the management and operating contract for LANL to this new LLC, which consists of Battelle Memorial Institute, the Regents of the University of California, and the Regents of Texas A&M University.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL) was established in 1952, as a companion and sometime competitor to Los Alamos National Laboratory in the research and development of nuclear weapons. The laboratory's main facilities are on a 1.3-square-mile site in Livermore, CA, about 45 miles east of San Francisco; a second site, known as Site 300, is located about 15 miles east of Livermore and is used for testing explosives.

Livermore designed the first nuclear warhead for a U.S. submarine-launched ballistic missile and the first warheads for multiple independently targeted reentry vehicles (MIRVs). Within the active stockpile, it is solely responsible for nuclear design activities for the B83 bomb, W80 warhead,

[47] R. Jeffrey Smith and Patrick Malone, *Safety Problems at a Los Alamos Laboratory Delay U.S. Nuclear Warhead Testing and Production*, Center for Public Integrity, Washington, DC, June 20, 2017, https://apps.publicintegrity.org/nuclear-negligence/delayed-warheads/.

[48] The Defense Nuclear Facilities Safety Board (DNFSB) has identified numerous defects related to Seismic Safety. See DNFSB, *Technical Report 39: Opportunities for Risk Reduction at the Los Alamos National Laboratory Plutonium Facility through the Minimization of Material-at-Risk*, September 21, 2015. More recently, the DNFSB found that these seismic risks may pose long-term concerns with criticality safety and fire suppression in plutonium facilities. See https://www.dnfsb.gov/sites/default/files/document/3590/ltr_201713_32311.pdf.

[49] http://www.lanl.gov/about/facts-figures/budget.php.

[50] https://www.lanl.gov/about/leadership-governance/index.php.

and W87 warhead. It is also responsible for the life extension program for the W80-4 cruise missile warhead and for the development of the first interoperable warhead (IW1).[51]

As is the case with Los Alamos National Laboratory, Livermore develops and sustains design, simulation, modeling, and experimental capabilities and competencies to ensure stockpile confidence without nuclear testing.[52] It conducts regular evaluations of warheads, with its surveillance data and experimental and computational simulations informing annual assessments of the nuclear stockpile. According to NNSA, Livermore's "core capabilities include high performance computing, high energy density physics, plutonium research and development, hydrodynamic and weapons engineering environmental tests, advanced manufacturing and materials science, and tritium target development and fabrication."[53]

Livermore is also home to the National Ignition Facility (NIF), "the world's largest and highest-energy laser." According to NNSA, NIF "is designed to perform experimental studies of fusion ignition and thermonuclear burn, the phenomenon that powers the sun, the stars, and modern nuclear weapons."[54] As part of NNSA's Stockpile Stewardship program, NIF is intended to "enable researchers to gain fundamental understanding of extreme temperatures, pressures and densities—knowledge that helps ensure the current and future nuclear stockpile is safe and reliable." During its construction, NIF faced significant delays and cost overruns. Although NIF allows for significant scientific research, it has not yet reached "ignition," the sustained, high-energy-yield nuclear fusion reaction present in a nuclear weapon.[55] Some in DOE have questioned whether it can ever achieve this goal.[56]

Livermore National Laboratory employs approximately 6,500 people. In FY2017, it had an operating budget of $1.92 billion, with $1.26 billion (63%) allocated to nuclear weapons activities.[57] The FY2019 budget request includes $1.3 billion for nuclear weapons activities at Livermore National Laboratory.

Livermore National Laboratory is managed and operated by the Lawrence Livermore National Security, LLC. This LLC, which took over management in 2007, includes Bechtel National, University of California, Babcock & Wilcox, the Washington Division of URS Corporation, and Battelle.

Sandia National Laboratories

Sandia National Laboratories (SNL) was established in 1949 to conduct the nonnuclear engineering development associated with nuclear weapons. Its primary location, including its executive management offices and larger laboratory complex, is located in Albuquerque, NM.

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[51] Testimony Before the Strategic Forces Subcommittee Committee on Armed Services U.S. House of Representatives Fiscal Year 2016 Budget Request for Nuclear Forces Witness Statement of Dr. Arthur T. Hopkins, Principal Deputy Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs April 15, 2015.

[52] LLNL, "Stockpile Stewardship at 20 Years," *Science and Technology Review*, July 2015.

[53] National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, November 2017, p. 1-6.

[54] https://lasers.llnl.gov/news/papers-presentations.

[55] National Nuclear Security Administration, Office of Defense Programs, *2015 Review of the Inertial Confinement Fusion and High Energy Density Science Portfolio: Volume I*, Washington, DC, March 2016, p. 8, http://www.firefusionpower.org/ICF_HED_Review_Report_2015_Update.pdf.

[56] David Kramer, "NIF May Never Ignite, DOE Admits," June 17, 2016, https://physicstoday.scitation.org/do/10.1063/PT.5.1076/full/.

[57] https://www.llnl.gov/about.

SNL has a principal laboratory in Livermore, CA, immediately south of the Lawrence Livermore Lab. Sandia operates at a number of other locations, as well, including the Tonopah Test Range (TTR) between Reno and Las Vegas, NV; the Weapons Evaluation Test Laboratory (WETL) at Pantex Plant near Amarillo, TX; and five additional sites around the country.[58]

While Los Alamos and Livermore National Laboratories design the nuclear explosive packages for U.S. nuclear weapons, Sandia designs, develops, and tests the nonnuclear components that are required to arm, fuze, and fire a weapon to military specifications. Sandia is also responsible for the systems integration of U.S. nuclear weapons, including integration with DOD's nuclear-capable delivery vehicles. In addition, Sandia participates in the warhead life extension programs, as it is responsible for the nonnuclear components of each weapon. It also manufactures some specialized components, like neutron generators, and maintains a backup capability to produce batteries and high-explosive components. In addition, similar to LLNL and LANL, Sandia contributes to the annual stockpile assessment process, providing annual safety, security, and reliability assessments of the nonnuclear components in U.S. nuclear weapons. It operates a number of specialized test facilities, including the Z machine, which Sandia identifies as "the world's most powerful and efficient laboratory radiation source. It uses high magnetic fields associated with high electrical currents to produce high temperatures, high pressures, and powerful X-rays for research in high energy density science." According to information provided by Sandia, Z allows scientists to study materials under conditions similar to those produced by the detonation of a nuclear weapon, and it produces key data used to validate physics models in computer simulations.[59]

Sandia National Laboratories employs approximately 9,840 people. Sandia's budget, in FY2017, totaled $3.2 billion. Within this total, $1.8 billion was provided by NNSA, and $1.56 billion was allocated to nuclear weapons activities. The FY2019 budget request includes $1.9 billion for weapons activities at Sandia.

Sandia National Laboratories was managed by Sandia Corporation from 1949 to 2017. Originally a wholly owned subsidiary of Western Electric, Sandia Corporation was a Lockheed Martin company from 1993 to 2017. Since 2017, it has been managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc.

Testing and Research

Nevada National Security Site

The Nevada National Security Site (NSSS) is located about 65 miles northwest of Las Vegas, on a 1,300-square-mile tract surrounded by the federally owned Nevada Test and Training Range. In total, it sits on an unpopulated area of more than 5,400 square miles, nearly the size of the state of Connecticut.[60] Its remote location and large size were important factors when, in 1950, the Atomic Energy Commission concluded that the Las Vegas Bombing and Gunnery Range in Nevada satisfied nearly all of the established criteria for a continental proving ground for U.S.

[58] http://www.sandia.gov/locations/index.html.

[59] http://www.sandia.gov/z-machine/index.html.

[60] Union of Concerned Scientists, *Nevada National Security Site*, October 2013, https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/nuclear-weapons-complex/nevada-national-security-fact-sheet.pdf.

nuclear weapons tests.[61] In 1955, the name changed from the Nevada Proving Grounds to the Nevada Test Site (NTS). In 2010, the name changed again, to the Nevada National Security Site, to better reflect the evolving mission of the site in an era when the United States no longer conducts explosive nuclear tests.[62]

The United States conducted its first atmospheric nuclear test at the NTS on January 27, 1951, and conducted 100 atmospheric tests at the site through July 1962. Atmospheric testing ended in 1963, after the United States signed the Limited Test Ban Treaty, but underground nuclear testing continued at the site through 1992. The United States conducted 828 underground tests at the NTS, with the last occurring on September 23, 1992. The United States has not conducted any explosive testing since that time because Congress passed, and President George H. W. Bush signed, a moratorium on nuclear testing.

Nuclear Weapons Tests

The United States conducted 1,054 nuclear weapons test explosions between 1945 and 1992 underground, above ground, above and below the ocean, in the atmosphere, and in space. Twenty-four of these tests were in cooperation with the United Kingdom (see **Appendix B**). The 1963 Limited Test Ban Treaty prohibited all but underground nuclear tests. These were the primary means by which the United States both determined whether its nuclear weapons designs would work and confirmed that the weapons remained reliable and effective as they aged.

In early 1995, the Clinton Administration announced it would extend the moratorium until the Comprehensive Test Ban Treaty (CTBT) entered into force, assuming it was signed by September 30, 1996.[63] The United States signed the CTBT in 1996, but the Senate did not give its advice and consent to ratification in 1999. Nevertheless, each subsequent Administration has reaffirmed the U.S. commitment to abide by a moratorium on nuclear testing. The Trump Administration reaffirmed this position in the 2018 Nuclear Posture Review, stating that "the United States will not seek Senate ratification of the Comprehensive Nuclear Test Ban Treaty, but will continue to observe a nuclear test moratorium that began in 1992."[64]

The United States now maintains confidence in the safety and reliability of its nuclear stockpile through science-based stockpile stewardship, but it maintains the ability to resume underground nuclear testing, "if required, for the safety and effectiveness of the Nation's stockpile, or if otherwise directed by the President."[65] According to NNSA, the amount of time it would take to prepare for and conduct a test would depend on the details of the test, and any test "would be conducted only when the President has declared a national emergency … and only after any necessary waiver of applicable statutory and regulatory restrictions." NNSA estimates that it

[61] Prior to establishing the test site at the Nevada Proving Ground, the United States had conducted tests in seven other states and other locations in Colorado (including the first nuclear explosion, the Trinity Test, near Alamagordo, NM). It also conducted three atmospheric tests in the South Atlantic and 106 tests in the South Pacific (primarily at Bikini Atoll, Christmas Island, Enewetak Atoll, and Johnston Island). See U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, *United States Nuclear Tests: July 1945 through September 1992*, Las Vegas, NV, September 2015, p. xv, https://www.nnss.gov/docs/docs_LibraryPublications/DOE_NV-209_Rev16.pdf.

[62] https://www.nnss.gov/pages/about.html.

[63] For details, see CRS Report RL33548, *Comprehensive Nuclear-Test-Ban Treaty: Background and Current Developments*, by Mary Beth D. Nikitin.

[64] Department of Defense, *Nuclear Posture Review*, Report, Washington, DC, February 2, 2018, p. 63, https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF.

[65] Department of Energy, National Nuclear Security Administration, *FY 2018 Stockpile Stewardship and Management Plan*, Report to Congress, Washington, DC, November 2017, pp. 3-26, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

could conduct a simple test within 6 to 10 months and a fully instrumented test to address stockpile needs within 24-36 months of a decision to proceed.[66]

Since the cessation of underground testing in 1992, the nuclear weapons mission at NNNS "has evolved to include subcritical experiments and other Stockpile Stewardship Programs designed to ensure the Nation's remaining nuclear weapons remains safe, secure, and effective without full-scale nuclear testing."[67] These include nuclear and nonnuclear experiments essential to maintaining the stockpile. According to NNSA, the site is not only the primary location where experiments using radiological and other high-hazard materials can occur, but is also the only location where "highly enriched-driven plutonium experiments" can be conducted.

The Nevada National Security Site employs approximately 1,900 people. Its budget in FY2018 was $447 million, of which $357.9 million was allocated to nuclear weapons activities.

The Nevada National Security Site is managed and operated by National Security Technologies, LLC (NSTec). The company was formed in 2006, as a joint venture between Northrop Grumman Corporation and corporate partners AFCOM, CH2M Hill, and Babcock & Wilcox.

Production

Kansas City National Security Campus

The original facility known as the Kansas City Plant provided aircraft engines for Navy fighters in World War II; it began producing nonnuclear components for nuclear weapons in 1949. Originally located at the Bannister Federal Complex, in Kansas City, MO, the facility moved in 2013 to the new Kansas City National Security Campus (NSC), about eight miles south of the original facility, with the relocation completed in mid-2014. According to NNSA, it invested in the new site because aging facilities and increasing maintenance and operations costs impeded operations at the old site.[68]

The Kansas City NSC is responsible for the procurement and manufacturing of nonnuclear mechanical, electronic, and engineered material components for nuclear weapons. While some of these components are produced at Los Alamos National Laboratories, about 85% are produced at Kansas City. According to NNSA, the NSC is also responsible for evaluating and testing nonnuclear weapon components.[69]

The Kansas City NSC employs approximately 2,500 people. Its budget in FY2017 totaled $533 million; the budget request for FY2019 includes $797 million, with $770 million allocated to the weapons activities account.

The Kansas City NSC is managed and operated by Honeywell Federal Manufacturing & Technologies, LLC. The contract was renewed in 2015.

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[66] Ibid., pp. 3-26.

[67] https://www.nnss.gov/pages/about.html.

[68] NNSA, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, p. 1-9, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf. See also Union of Concerned Scientists, *Kansas City Plant*, Fact Sheet, October 2013, https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/nuclear-weapons-complex/kansas-city-plant-fact-sheet.pdf.

[69] NNSA, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, p. 1-9, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

Savannah River Site (SRS)

The 310-square-mile Savannah River Site is located near Aiken, SC, along the Savannah River, which forms the state's border with Georgia. It was constructed during the early 1950s to produce the tritium and plutonium-239 needed for U.S. nuclear weapons.[70] Five reactors operated at the site from 1953 to 1988 to produce these materials.[71] The site also operated a number of support facilities, including two chemical separations reprocessing plants, a heavy-water extraction plant, a nuclear fuel and target fabrication facility, a tritium extraction facility, and waste management facilities.[72]

Although DOE hoped to resume reactor operations at SRS, this did not happen. During a test run of the K-reactor in "late December 1991, a leak in one of the … heat exchangers released 150 pounds of tritiated water into the Savannah River, …[and] public utilities downstream from the Site closed their intake valves until the contaminated water had passed." After a brief start-up in 1992, DOE announced a permanent shutdown in 1993.[73]

During the 1980s, work at SRS began to shift from the production of nuclear materials to waste management and environmental remediation, including operation of the Defense Waste Processing Facility to encapsulate part of the 37 million gallons of radioactive liquid waste stored in 49 underground tanks. As a result of this shift in emphasis, the Department of Energy's Office of Environmental Management is the landlord at the SRS; NNSA is a tenant. The tritium organization within the Savannah River Tritium Enterprise (SRTE) performs most of the weapons activities at the site.

SRS no longer operates its nuclear reactors, and, therefore, no longer produces tritium. It does, however, recycle tritium from dismantled warheads. It also extracts tritium from tritium-producing burnable absorber rods irradiated in the Tennessee Valley Authority's (TVA's) Watts Barr commercial power reactor in Tennessee.[74] DOD sends depleted tritium reservoirs to the SRS, where they are emptied and refilled with a mixture of tritium and deuterium gases. SRS then sends the refilled reservoirs back to DOD. SRS is the only facility in the nuclear security enterprise that has the capability to extract, recycle, purify, and reload tritium.[75]

SRS also provides interim storage for much of the excess plutonium in the United States and maintains responsibility for the surplus plutonium disposition program, although this effort is in flux. Under this program, the DOE planned to blend surplus plutonium removed from U.S. nuclear weapons with uranium to make mixed oxide (MOX) fuel for commercial nuclear reactors.

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[70] Tritium is a radioactive form of hydrogen needed to boost the yield of nuclear weapons. Because it has a half-life of 12.4 years and degrades at a rate of 5.5% per year, the tritium in nuclear weapons must be replenished regularly.

[71] DOE restarted the K-reactor briefly in 1990 after several years of upgrade investments. After tritium contamination was discovered in the Savannah River and downstream drinking water sources, however, the reactor was again shutdown, never to restart.

[72] https://www.srs.gov/general/about/history1.htm.

[73] See DOE, *Savannah River Site at Fifty, Stewardship and Legacy*, 2003, p. 518, https://www.srs.gov/general/about/50anniv/Chapter%2020.pdf. DOE had initially decided to operate all three remaining reactors (see Record of Decision; Continued Operation of K, L, and P Reactors, Savannah River Site, Aiken, SC. February 11, 1991, 56 *Federal Register* 5584), but newly confirmed Secretary Hazel R. O'Leary decided to cease operations at the final reactor (i.e., K) on September 24, 1993.

[74] Tennessee Valley Authority, Production of Tritium in Commercial Light Water Reactors, Record of Decision, 82 *Federal Register* 16653 (April 5, 2017).

[75] See Savannah River Tritium Enterprise, February 2013 - 11PA00218, at https://www.srs.gov/general/news/factsheets/tritium_esrs.pdf.

The fuel fabrication process was expected to take place at the Mixed Oxide Fuel Fabrication Facility (MFFF) at the SRS. Although construction on the MFFF began in 2007, the program has faced delays and escalating costs. Because of the cost increases, the Obama Administration slowed the project in FY2013 and FY2014 to consider "alternative plutonium disposition strategies." The original plutonium disposition plan developed in the Clinton Administration had similarly involved alternatives to MOX for plutonium disposition.

The Trump Administration, in its FY2018 request to Congress, supported the proposal to "terminate the MOX project and pursue the dilute and dispose strategy as an alternative."[76] Under this strategy, DOE would dilute the surplus plutonium with other materials and dispose of it in the WIPP facility in New Mexico.[77] In May 2018, NNSA announced that it planned to "repurpose the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site in South Carolina to produce plutonium pits while also maximizing pit production activities at Los Alamos National Laboratory in New Mexico."[78]

In addition to the activities described above, the SRS stores, processes, and eliminates radioactive wastes left over from the production of nuclear materials. DOE's Environmental Management Program is pursuing extensive environmental remediation, waste management, and facility decommissioning at the SRS. DOE expects this process to be complete by 2065.[79]

The Savannah River Site employs approximately 12,000 people. Most are employed on environmental clean-up projects; fewer than 1,500 of SRS's employees work in the tritium extraction program. SRS has an annual budget of around $1.7 billion. Within this total, $654 million is funded by NNSA, with $328.5 million allocated to the weapons activities account. Approximately 70% of the SRS budget for FY2018 is appropriated for Environmental Management activities, at a total life-cycle cost of $97-$115 billion.

During the Cold War, the SRS was managed and operated by the Dupont Corporation. Currently, it is managed and operated by Savannah River Nuclear Solutions, LLC, a partnership including Fluor Daniel, Newport News Nuclear, and Honeywell.

Pantex Plant

The Pantex Plant is located on a 25-square-mile site 17 miles northwest of Amarillo, TX, in a region referred to as the Texas panhandle. During World War II, it served as an Army munitions plant, responsible for assembling artillery shells and bombs. It closed after the war, but reopened in 1951 "as a facility to handle nuclear weapons, high explosives, and non-nuclear component assembly operations."[80] Since 1975, it has been the only facility in the United States where

[76] For details on the MOX program, see CRS Report R43125, *Mixed-Oxide Fuel Fabrication Plant and Plutonium Disposition: Management and Policy Issues*, by Mark Holt and Mary Beth D. Nikitin.

[77] As it had in the FY2018 National Defense Authorization Act (P.L. 115-91), Congress mandated in the FY2019 NDAA (P.L. 115-232) that the Secretary of Energy continue to "carry out construction and project support activities relating to the MOX facility," but it again authorized the Secretary of Energy to waive this requirement if the Secretary meets a number of requirements stated in the FY2018 NDAA. See John S. McCain National Defense Authorization Act for Fiscal Year 2019, P.L. 115-232, §3119. Also, see Conference Report to Accompany H.R. 5515; H.Rept. 115-874; Pages 658 and 1119. July 15, 2018, https://www.congress.gov/bill/115th-congress/house-bill/5515/actions.

[78] Department of Energy, National Nuclear Security Administration, *Joint Statement from Ellen M. Lord and Lisa E. Gordon-Hagerty on Recapitalization of Plutonium Pit Production*, Washington, DC, March 10, 2018, https://www.energy.gov/nnsa/articles/joint-statement-ellen-m-lord-and-lisa-e-gordon-hagerty-recapitalization-plutonium-pit.

[79] DOE, FY2019 Budget Request DOE/CF-0142 (March 2018), vol. 5, p. 110.

[80] Union of Concerned Scientists, *Pantex Plant*, Fact Sheet, October 2013.

nuclear weapons are assembled and disassembled. During the Cold War, Pantex would return the components of nuclear weapons to either Rocky Flats (plutonium primaries) or the Y-12 plant (uranium secondaries) after dismantling the warheads. Because Rocky Flats closed in 1992, Pantex now stores thousands of excess plutonium pits.

Because the United States no longer produces new nuclear warheads, the mission at Pantex has shifted from assembling nuclear weapons to refurbishing existing warheads, as a part of the Life Extension programs, and disassembling retired weapons. Pantex is also responsible for the development, testing, and fabrication of high-explosive components.

According to NNSA, Pantex has 3,246 employees.[81] NNSA has requested a budget of $825 million for Pantex for FY2019, with $814.4 million allocated to the weapons activity account.

Pantex is managed and operated by Consolidated Nuclear Security, LLC, a corporate subsidiary of Bechtel National, Lockheed Martin Services, ATK Launch Systems, and SOC, LLC.

Y-12 National Security Complex

The Y-12 National Security Complex is located on a 5.3-square-mile site in the Oak Ridge Reservation, about 20 miles west of Knoxville, TN. As part of the original Manhattan Project, Y-12 was built in 1943 to enrich uranium in the isotope U-235. It produced the uranium used in the "Little Boy" bomb dropped on Hiroshima in 1945. In addition to the Y-12 site, DOE also operates the Oak Ridge National Laboratory (known as "X-10") about 10 miles southwest of Y-12. During the Cold War, the facility included a third site, known as K-25, which was responsible for enriching uranium through a gaseous diffusion process.

The Y-12 site continues to manufacture nuclear weapons components from uranium and lithium. It manufactures all U.S. nuclear weapons secondaries, canned subassemblies (CSAs), and radiation cases, and it is the only source for enriched uranium components for nuclear weapons. It also contributes to life extension programs by producing refurbished, replaced, and upgraded weapon components. In addition, Y-12 serves as the main storage facility for highly enriched uranium; conducts dismantlement, storage, and disposition of highly enriched uranium; and supplies highly enriched uranium used in naval reactors.[82]

> U.S. nuclear weapons have two stages: a primary (the plutonium pit) and a secondary. The secondary contains highly enriched uranium and is contained within a canned subassembly. A uranium-lined radiation case encloses both the primary and canned subassembly.

NNSA is currently building a new Uranium Processing Facility (UPF) at Y-12. Intended to replace aging infrastructure at Y-12, this facility is projected to be completed by 2025 and to cost $6.5 billion. However, as is the case with many NNSA construction projects, the facility has experienced delays and increases in its expected costs. When completed, the facility is expected to be capable of producing 50-80 canned secondaries per year.[83]

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[81] Department of Energy, National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan, Report to Congress*, Washington, DC, November 2017, p. E-51, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[82] Department of Energy, National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan, Report to Congress*, Washington, DC, November 2017, p. E-66, https://www.energy.gov/sites/prod/files/2017/11/f46/fy18ssmp_final_november_2017%5B1%5D_0.pdf.

[83] The original 2004 estimate expected costs of between $600 million and $1.1 billion. Costs escalated, in part, because NNSA had to redesign the facility after discovering, in October 2012, that not all the necessary equipment would fit in

The Y-12 National Security Complex employs approximately 4,678 people. NNSA has requested $1.78 billion for Y-12 in its budget for FY2019, of which about $703 million is allocated to the UPF project.

The Y-12 National Security Complex is managed and operated by Consolidated Nuclear Security, LLC, which is a corporate subsidiary of Bechtel National, Lockheed Martin Services, ATK Launch Systems, and SOC, LLC.

Tennessee Valley Authority's Watts Barr Reactor (TVA)

As noted above, when the last of the reactors at the Savannah River Site ceased operations in the early 1990s, DOE lost the capacity to produce tritium within the nuclear weapons complex. It can still recycle tritium from dismantled warheads at SRS; according to NNSA, the process of recovering and recycling tritium provides the majority of the inventory needed to meet current requirements. This will be insufficient to maintain the stockpile in the future, as current stocks of tritium continue to degrade. As a result, since 2003, NNSA has been producing tritium by irradiating Tritium-Producing Burnable Absorber Rods (TPBARs) in the Watts Bar Unit 1 (WBN1) nuclear power reactor owned by the Tennessee Valley Authority (TVA).[84] In addition to producing tritium, this reactor burns domestically produced low-enriched uranium and produces electricity for domestic use.

NNSA has been extracting tritium from the TPBARs since FY2007. According to NNSA estimates, Watts Barr will need to produce 2,800 grams of tritium over two 18-month reactor cycles by 2025 to meet the needs of the stockpile. As a result, the NNSA is seeking approval from the NRC to use a second reactor at Watts Barr for tritium production, with the irradiation of TPBARs to begin in early FY2021.[85]

Support

Waste Isolation Pilot Project (WIPP)

The Waste Isolation Pilot Plant is located on a 10,000-acre site near Carlsbad, NM. It serves as the disposal facility for plutonium-contaminated transuranic waste from nuclear weapons production facilities. Transuranic waste can be dangerously radioactive for thousands of years. The waste shipped to WIPP is stored in specialized casks and placed in caverns excavated from thick salt beds 2,150 feet below the earth's surface. The salt beds are used for this purpose because they are free of flowing water, easily excavated, impermeable, and geologically stable.[86]

The first shipment of such transuranic waste arrived at WIPP from Los Alamos in 1999. Subsequently, substantial quantities of waste have been moved there from Livermore, Rocky Flats, Savannah River, Hanford, Idaho National Laboratory, and other DOE sites. While NNSA does not currently list WIPP as a part of the National Security Enterprise, it serves a vital role in

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the planned building. Union of Concerned Scientists, *Y-12 National Security Complex*, Fact Sheet, 2013, https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/nuclear-weapons-complex/y-12-complex-fact-sheet.pdf.

[84] Tritium is produced by irradiating lithium-aluminate pellets with neutrons. TPBARs are similar in dimension to reactor fuel rods; with irradiation, the tritium is produced and captured on getters.

[85] Department of Energy, National Nuclear Security Administration, *FY 2019 Congressional Budget Request*, vol. 1, Washington, DC, March 2018, p. 117, https://www.energy.gov/sites/prod/files/2018/03/f49/FY-2019-Volume-1.pdf.

[86] http://wipp.energy.gov/geologic-disposal-safety-case.asp.

the disposal of transuranic waste generated by the facilities in the enterprise, and is therefore essential to ongoing operations across the weapons complex.

NNSA has faced long-standing questions about whether WIPP will be able to meet the future needs of the nuclear security enterprise. Questions have been raised about the site's eventual disposal capacity: some disposal rooms that were contaminated with radioactivity after an incident in 2014 remain off limits;[87] ceilings in some rooms have collapsed sooner than expected; and compliance-related disposal from INL and Hanford, along with the potential disposal of diluted plutonium removed from weapons, has strained WIPP's capacity. DOE has sought to address this problem by adjusting the volume capacity calculations so that it could increase the amount of disposal without triggering a potentially lengthy and contentious permit modification, but New Mexico's review of NNSA's request has been delayed until 2019.

Issues for Congress[88]

As Congress conducts oversight of DOE's and NNSA's management, operations, and programs, and as it authorizes and appropriates funds for the Nuclear Security Enterprise, it may address a wide range of issues that have been of concern, and contentious, some for years. This section reviews five topics that Congress has addressed in hearings and legislation relating to the nuclear weapons complex and NNSA: (1) the Defense Nuclear Facilities Safety Board, (2) organization and management at NNSA, (3) infrastructure recapitalization, (4) plutonium pit production, and (5) concerns about access to necessary supplies of tritium.

The Defense Nuclear Facilities Safety Board

The Department of Energy has recently altered the authorities of the Defense Nuclear Facilities Safety Board, which, according to press reports, could affect public and congressional access to information about incidents at the facilities in the nuclear security enterprise.[89]

Congress created the Defense Nuclear Facilities Safety Board (DNFSB) in 1988, as an independent oversight organization to provide advice and recommendations to the Secretary of Energy regarding public health and safety at the defense nuclear facilities managed by the Department of Energy.[90] According to the DNFSB, its mission is "to inform the Secretary, in the role of the Secretary as operator and regulator of the defense nuclear facilities of the Department of Energy, in providing adequate protection of public health and safety at such defense nuclear facilities."

[87] In 2014, an underground vehicle fire and an incident where a drum storing plutonium waste burst open, releasing radiation, led to the closure of WIPP for three years. See DOE, Accident Investigation Report: Phase 1 Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014 (April 2014); also see https://www.epa.gov/radiation/2014-radiological-event-wipp.

[88] Issues related to waste management (e.g., plutonium disposition), environmental contamination and safety challenges within the nuclear weapons complex, associated costs (now expected to exceed $400 billion), and safety limitations to operations are outside the purview of this report and therefore not addressed in this section.

[89] Patrick Malone, *The Trump Administration Reins in a Nuclear Weapons Safety Watchdog*, Center for Public Integrity, Washington, DC, August 30, 2018, https://www.publicintegrity.org/2018/08/30/22191/trump-administration-reins-nuclear-weapons-safety-watchdog.

[90] For details on the history of the Defense Nuclear Facilities Board, see U.S. Library of Congress, *Defense Nuclear Facilities Board: The First Twenty Years*, prepared by the Federal Research Division, Library of Congress, September 2009, https://www.dnfsb.gov/sites/default/files/page/DNFSB%20Twenty%20Year%20Report.pdf.

Historically, the board has had access to the all the sites in the nuclear weapons complexes "to assess accidents or safety concerns that could pose a grave risk to workers and the public." However, according to recent press reports, DOE issued a new order in May 2018 that "outlines new limits on the Defense Nuclear Facilities Safety Board—including preventing the board from accessing sensitive information and imposing additional legal hurdles on board staff."[91] Critics of this order argue that it is an effort to limit transparency and weaken the board's ability to conduct oversight; this recent action follows reports, from 2017, indicating that the chairman of the board had recommended "downsizing or abolishing the group," a position supported by some of the contractors managing sites within the nuclear weapons complex.[92]

Organization and Management at NNSA

As noted earlier, responsibility for the nuclear weapons program has moved, over the years, from the Army, to the Atomic Energy Commission, to the Energy Research and Development Administration, and then to the Department of Energy in 1977. In 2000, Congress established the semiautonomous National Nuclear Security Administration as part of DOE to manage both the nuclear weapons complex and nonproliferation activities. The NNSA has also sometimes included the Office of Environmental Management. These reorganizations stem, in part, from long-standing concerns about the management of the nuclear weapons complex. Many reports and legislative provisions have been written over the past several decades to address this issue.[93]

In the National Defense Authorization Act for Fiscal Year 2013 (P.L. 112-239), Congress established the Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise and directed the panel to make recommendations on "the most appropriate governance structure, mission, and management of the nuclear security enterprise." In its report to Congress, the panel stated the following:

> The panel finds that the existing governance structures and many of the practices of the enterprise are inefficient and ineffective, thereby putting the entire enterprise at risk over the long term. These problems have not occurred overnight; they are the result of decades of neglect. This is in spite of the efforts of many capable and dedicated people who must nonetheless function within the confines of a dysfunctional system.…
>
> One unmistakable conclusion is that NNSA governance reform, at least as it has been implemented, has failed to provide the effective, mission-focused enterprise that Congress intended.[94]

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[91] Rebecca Moss, "Trump Administration Neuters Nuclear Safety Board," *Santa Fe New Mexican*, July 22, 2018, https://www.propublica.org/article/nuclear-safety-board-information-access-trump-administration.

[92] Patrick Malone and R. Jeffrey Smith, "GOP chair of nuclear safety agency secretly urges Trump to abolish it," *The Center for Public Integrity*, October 19, 2017, https://www.publicintegrity.org/2017/10/19/21217/gop-chair-nuclear-safety-agency-secretly-urges-trump-abolish-it.

[93] See, for example, Department of Energy, *Audit Report on "Management of the Nuclear*," Washington, DC.., September 2000, https://www.energy.gov/sites/prod/files/igprod/documents/CalendarYear2000/ig-0484.pdf; Department of Defense, *Report of the Defense Science Board Task Force on Nuclear Capabilities, Report Summary*, Washington, DC, December, 2006, https://www.defense.gov/Portals/1/features/defenseReviews/NPR/DSB_Nuclear_Capabilities_Foster_Welch.pdf; and William J. Perry, Chairman and James R. Schlesinger, Vice Chairman. *America's Strategic Posture—The Final Report of the Congressional Commission on the Strategic Posture of the United States*, Washington, DC, 2009, https://www.usip.org/sites/default/files/America's_Strategic_Posture_Auth_Ed.pdf; and GAO, *High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others* GAO-17-317 (February 15, 2017).

[94] Congressional Advisory Panel on the Governance of the Nuclear Security Enterprise. See Hearing before the Subcommittee on Strategic Forces of the Committee on Armed Services House of Representatives, 113-94; Hearing Held (March 26, 2014), at https://www.gpo.gov/fdsys/pkg/CHRG-113hhrg87857/pdf/CHRG-113hhrg87857.pdf.

The panel's recommendations included

- strengthening presidential guidance and oversight of the nuclear enterprise;
- establishing new congressional mechanisms for leadership and oversight of the enterprise;
- replacing NNSA with a new Office of Nuclear Security within DOE, renamed to the Department of Energy and Nuclear Security, with the Secretary responsible for the mission; and
- building a culture of performance, accountability, and credibility.

NNSA, in its review of the report, supported many of the suggested changes in management and contracting within NNSA, but it did not support the proposed changes in the name and structure of the organization or its leadership.

Congress has recently expressed continuing concerns with NNSA's organization and management, and has noted its lack of progress in implementing many of the recommendations from the 2014 report. For example, the Senate version of the FY2019 Defense Authorization Bill sought to address these issues by clarifying the roles and authorities of the National Nuclear Security Administration in a way that would provide NNSA with greater authority to act without oversight from the Department of Energy. The Senate Armed Services Committee, in its report on the Senate version of the legislation, (S.Rept. 115-262) states that "delays and cost overruns in the NNSA's weapons programs and recent disagreements about major programs associated with weapons activities evince the tensions inherent in the current organizational structure." Therefore, according to the committee report, the legislation would "implement a number of recommendations of the Augustine-Mies panel and other studies" by making "the Administrator of the NNSA responsible for a number of duties currently assigned to the Secretary of Energy, clarify the lines of authority at the DOE to emphasize the role of Administrator, and expand the remit and authority of the Administrator in statute."[95]

The conference report on the FY2019 Defense Authorization Act (H.R. 5515) struck the Senate language from the final bill. However, the conferees did review the long-standing congressional concerns with NNSA management and highlighted several of the reports that called for change in NNSA's organization and management procedures. The report noted that "almost 4 years have elapsed since the Augustine-Mies Panel made its recommendations, and almost 6 years have elapsed since the 2013 statement of managers described the nuclear security enterprise as broken."

The conferees then argued that "continued cost overruns on major projects, critical capital acquisition decisions mired in dispute, ongoing safety and security concerns, and delayed infrastructure modernization projects indicate that significant progress has not been made." They concluded by noting that they expected "appropriate levels of engagement by the Secretary of Energy, the Deputy Secretary of Energy, and the Administrator for Nuclear Security with the committees of jurisdiction on priority atomic energy defense programs to ensure that the NNSA meets the military requirements set by the Department of Defense while making efficient and responsible use of taxpayer dollars."[96]

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[95] For more details on this provision, see Matthew Daly, "Defense bill would curb Cabinet control of nuclear agency," *Military Times*, July 23, 2018, https://www.militarytimes.com/news/pentagon-congress/2018/07/22/defense-bill-would-curb-cabinet-control-of-nuclear-agency/?utm_source=Sailthru&utm_medium=email&utm_campaign=ebb%2023.07.18&utm_term=Editorial%20-%20Early%20Bird%20Brief.

[96] H.Rept. 115-874, John S. McCain National Defense Authorization Act for Fiscal Year 2019, Conference Report to Accompany H.R. 5515.

Infrastructure Recapitalization

As mentioned earlier, the 2018 Nuclear Posture Review noted that "the U.S. nuclear weapons infrastructure has suffered the effects of aging and underfunding" over the past several decades. NNSA's administrators have testified to Congress about the backlog in deferred maintenance, and about the need to invest promptly to replace aging facilities so that the United States can maintain a "safe, secure, and effective" nuclear arsenal. There is little question that Congress, at this point, understands and generally supports the need for attention to this problem, but questions remain about whether NNSA has placed a high enough priority on this effort in its budget proposals and program management.

NNSA's recapitalization projects are funded through its budget for Infrastructure and Operations (I&O). The budget for this activity has shown steady growth over the past few years, with Congress often adding funds above the budget request. For example, NNSA requested nearly a 20% increase in funding for I&O funding between FY2016 and FY2017, and Congress further increased this amount by $86.4 million. NNSA did not request an increase in I&O funding for FY2018, but Congress provided $3,117.8 million in the Consolidated Appropriations Act, 2018 (P.L. 115-141), an increase of more than 10% and more than triple the increase from FY2016 to FY2017. NNSA has requested $3,002.7 million for this program area in FY2019. At this time, the House has further increased that budget, while the Senate has reduced it.

Table 2. NNSA Funding for Infrastructure and Operations

Millions $

	FY2016	FY2017	FY2018	FY2019
Infrastructure and Operations (I&O)				
Budget Request[a]	$2,126.2	$2,722	$2,808	$3,003
Enacted	$2,279	$2,808	$3,118	$3,118.6 (House) $2,749 (Senate)
Recapitalization (within I&O)				
Budget Request	$257.7	$667.3	$427.3	$540.7
Enacted[b]	$352.5	$743.1	$612.6	$612.6 (House) $425 (Senate)

Source: NNSA Budget Documents, congressional appropriations reports.

a. In FY2016, Congress combined parts of the Readiness in Technical Base and Facilities budget line with the Infrastructure and Safety budget line to form I&O. The budget request on this table represents the equivalent of what would be included in the I&O budget line in future years.

b. The House and Senate have not yet reconciled their appropriations bills for FY2019; this table displays the funding approved in each of the individual bills.

Within the I&O budget, funding for recapitalization, the program that NNSA claims is key to arresting the declining state of NNSA infrastructure, has shown mixed results. NNSA requested $667.3 million for recapitalization in FY2017, an increase of almost 90% over the appropriated level of $352.5 million in FY2016. In the Consolidated Appropriations Act of 2017, Congress provided $743.1 million, but NNSA requested only $427.3 million in FY2018. Budget documents note that this reduction reflected the completion of the work at the Bannister Federal Complex in

Kansas City. Congress, however, provided $612.6 million for this program area, noting it had included "funds above the budget request to address the NNSA's high-risk excess facilities and deferred maintenance." NNSA has requested $540.7 million in FY2019. The House has recommended $612.6 million, to restore funding to the FY2018 level, but the Senate has reduced the request to $425 million.

Pit Production

On May 10, 2018, NNSA announced that the Nuclear Weapons Council (NWC) had approved its plan to meet the requirement of producing a minimum of 80 plutonium pits per year by repurposing "the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site in South Carolina to produce plutonium pits while also maximizing pit production activities at Los Alamos National Laboratory in New Mexico." According to NNSA, this alternative would provide capacity for "at least 50 pits per year produced at Savannah River and at least 30 pits per year at Los Alamos." NNSA claimed that this approach "is the best way to manage the cost, schedule, and risk of such a vital undertaking" and "represents a resilient and responsive option to meet Department of Defense (DOD) requirements."[97]

The United States has sought to establish a significant and reliable pit production capability in the years since the Rocky Flats plant ceased plutonium operations. In 2014, CRS found many projects had been proposed over the years, but none had been successfully completed. Moreover, key parameters, such as cost, schedule, proposed facility site, and capacity, had changed from one proposal to the next.[98]

Currently, the United States has the capacity to produce small numbers of pits in the PF-4 building at Los Alamos National Laboratory. The facilities needed to support this effort at Los Alamos are aging, with one particular building, the Chemistry and Metallurgy Research Facility (CMR), dating from the early 1950s. The facilities at Los Alamos have been unable to produce anywhere near the requisite 15-30 pits per year, and it ceased operations entirely in 2013, following a safety lapse. It has slowly begun to restore its production capability, producing one demonstration pit in recent years.

The Obama Administration proposed a plan to replace the aging CMR with a new Chemistry and Metallurgy Research Replacement Facility (CMRR) to expand the capacity for pit production at Los Alamos to 30-50 pits per year. However, escalating cost estimates and budget reductions led first to a delay and then to the cancellation of the CMRR. Instead, NNSA planned to expand capacity at Los Alamos by constructing smaller buildings, known as modules, both to control costs and to expand the facilities in a timely manner. This plan remains in place, but it has been joined by a plan to repurpose the MFFF facility at Savannah River to expand capacity from 30-50 pits per year to a minimum of 80 pits per year.

As Congress reviews the Administration's plan for pit production, it may address a number of questions, including

[97] Department of Energy, National Nuclear Security Administration, *Joint Statement from Ellen M. Lord and Lisa E. Gordon-Hagerty on Recapitalization of Plutonium Pit Production*, Washington, DC, May 10, 2018, https://www.energy.gov/nnsa/articles/joint-statement-ellen-m-lord-and-lisa-e-gordon-hagerty-recapitalization-plutonium-pit.

[98] CRS Report R43406, *U.S. Nuclear Weapon "Pit" Production Options for Congress*, by Jonathan E. Medalia, p. 18.

- the expected total cost of the plan, along with the relative cost of repurposing MFFF for pit production as compared with the construction of new modules at Los Alamos;
- the rationale for ramping up pit production by 2030, when many experts argue that existing pits could remain effective for more than 80 years; and
- whether the plan will, as NNSA claims, improve "the resiliency, flexibility, and redundancy of our Nuclear Security Enterprise by not relying on a single production site."[99]

Congress may also address the question of why the United States needs to produce a minimum of 80 pits per year. DOD and the NNSA argue that the United States will need new pits to support some warhead life extension programs (LEPs) and to replace pits in weapons as they age. However, the pit production capacity that NNSA has considered necessary has varied greatly. During the George W. Bush Administration, NNSA sought to construct a modern pit facility with the capacity to produce from 125 to 450 pits per year in single-shift operation.[100] In 2005, Congress rejected the Modern Pit Facility, viewing this capacity as excessive.

During the Obama Administration, the Nuclear Weapons Council determined that, to meet the likely demands of future LEPs, NNSA would need a pit production capacity of 50 to 80 pits per year. In testimony before the Senate Armed Services Committee in April 2013, Andrew Weber, then the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, stated that "there is no daylight between the Department of Energy and the Department of Defense on the need for both a near-term pit production capacity of 10 to 20 and then 30 by 2021, and then in the longer term for a pit production capacity of 50 to 80 per year."[101] But, as noted above, the Nuclear Weapons Council has now certified that NNSA needs to produce a minimum of 80 pits per year by 2030. Neither the NPR nor NNSA's recent announcement indicates why the goal has increased.

Congress has sought some of the information needed to answer these questions in the National Defense Authorization Act for Fiscal Year 2019 (H.R. 5515). In Section 3120, Congress mandated that DOD seek an independent assessment of NNSA's preferred plutonium strategy from a federally funded research and development center (FFRDC). It also mandated that NNSA submit a report to Congress that detailed a plan to produce 30 pits per year at Los Alamos National Laboratory by 2026 and a detailed plan for designing and carrying out production of plutonium pits 31-80 at Los Alamos National Laboratory, in case the repurposed MFFF facility at Savannah River was not operational and producing pits by 2030.

The legislation also mandates that the Chairman of the Nuclear Weapons Council and the NNSA Administrator brief Congress on the implementation plan for the plutonium strategy, and that the Chairman certify, annually through 2025, that the plutonium pit production plan is on track to meet the military requirement of 80 pits per year by 2030. The final version of the bill did not,

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[99] Department of Energy, National Nuclear Security Administration, *Joint Statement from Ellen M. Lord and Lisa E. Gordon-Hagerty on Recapitalization of Plutonium Pit Production*, Washington, DC, May 10, 2018, https://www.energy.gov/nnsa/articles/joint-statement-ellen-m-lord-and-lisa-e-gordon-hagerty-recapitalization-plutonium-pit.

[100] U.S. Department of Energy, National Nuclear Security Administration, "Site Alternatives: Modem Pit Facility," October 2002, p. 2-27.

[101] Testimony of Andrew Weber, Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, in U.S. Congress, Senate Committee on Armed Services, Subcommittee on Strategic Forces, Hearing to Receive Testimony on Nuclear Forces and Policies in Review of the Defense Authorization Request for Fiscal Year 2014 and the Future Years Defense Program, April 17, 2013, p. 15.

however, include two reporting requirements that were included in the House version of the bill. One requested a report on the rationale for the Nuclear Posture Review's change in the annual plutonium pit requirement from 30-50 pits to "at least 80 pits" from a previous requirement of "50-80 pits," and the second requested a study on the potential to reuse existing plutonium pits.

Tritium Production

Tritium, a radioactive form of hydrogen, is used to boost the yield (the amount of energy released upon detonation) of nuclear weapons. Because it has a half-life of 12.4 years and degrades at a rate of 5.5% per year, the tritium in nuclear weapons must be replenished regularly. As noted above, the U.S. nuclear weapons program currently uses tritium produced at the TVA Watts Bar reactor and processed at the SRS. To meet the demand for tritium in the weapons program in the future, DOE is seeking to add tritium production to a second reactor at Watts Barr.

Long-standing U.S. policy has sought to separate domestic nuclear power plants from the U.S. nuclear weapons program—this is not only an element of U.S. nuclear nonproliferation policy but also a result of foreign "peaceful-use obligations" that constrain the use of foreign-origin nuclear materials.[102] This issue became a concern when DOE decided to use the Watts Bar reactor to produce tritium for nuclear weapons, as the reactor also produces electricity for the domestic market. As a result, the reactor is required to burn U.S.-origin low-enriched uranium.

The United States, however, no longer has the capacity to enrich uranium for use in nuclear power plants. The last U.S. enrichment facility, a gaseous diffusion plant in Paducah, KY, closed in 2013. With two reactors operating to produce tritium for nuclear weapons, NNSA expects that hat existing stocks of U.S.-origin low-enriched uranium will begin to run out in the mid-2020s. NNSA is currently examining plans to extend the stockpile until around 2030.[103] NNSA has not yet articulated a strategy to acquire the fuel needed to produce tritium in the long term. Options for acquiring low-enriched uranium could include building a new centrifuge plant inside the United States, at the possible cost of billions of dollars over more than 10 years; blending down highly enriched uranium, at the risk of depleting stocks needed to fuel naval nuclear reactors; and using foreign-origin low-enriched uranium, with potential implications for U.S. nonproliferation policy.[104]

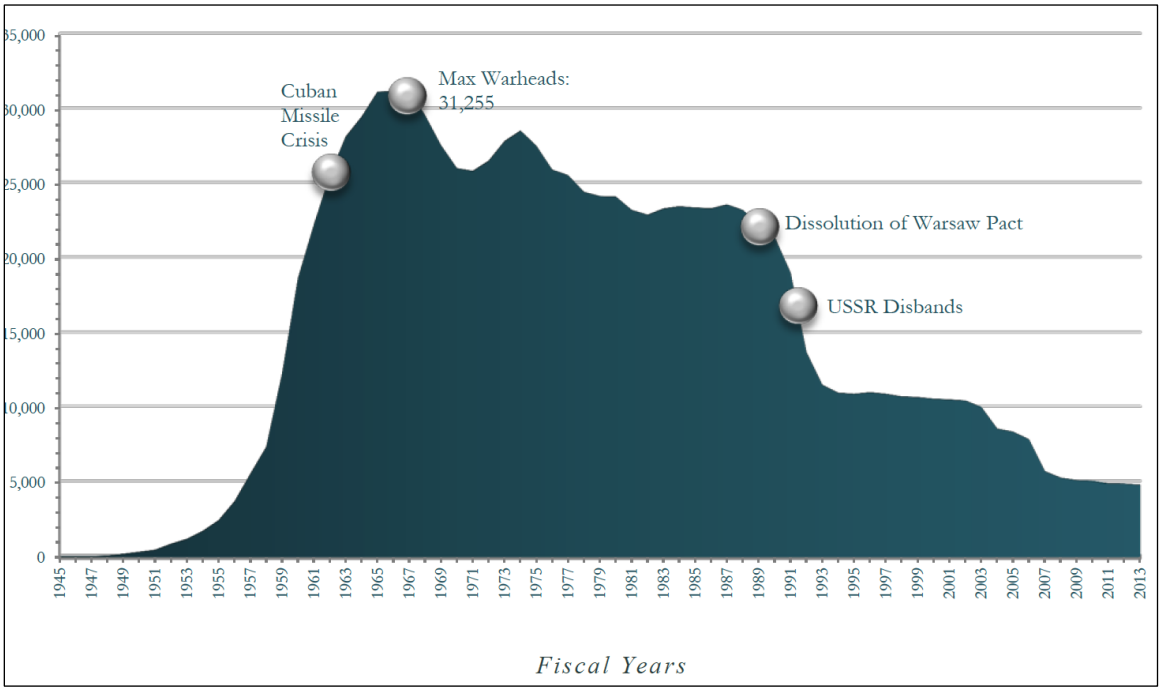
[102] U.S. Department of Energy, *Tritium and Enriched Uranium Management Plan through 2060*, Report to Congress, Washington, DC, October 6, 2015, p. 11, http://fissilematerials.org/library/doe15b.pdf.

[103] U.S. Government Accountability Office, *NNSA Should Clarify Long-Term Uranium Enrichment Mission Needs and Improve Technology Cost Estimates*, GAO-18-126, February 2018, https://www.gao.gov/assets/700/690143.pdf. See, also, https://www.tva.gov/Environment/Environmental-Stewardship/Environmental-Reviews/Production-of-Tritium-in-a-Commercial-Light-Water-Reactor; https://www.energy.gov/nepa/eis-0161-tritium-supply-and-recycling.

[104] Franklin C. Miller and John R. Harvey, "Commentary: The looming Crisis for US Tritium Production," *Defense News*, March 6, 2017, https://www.defensenews.com/opinion/commentary/2017/03/06/commentary-the-looming-crisis-for-us-tritium-production/.

Appendix A. U.S. Nuclear Stockpile

Figure A-1. U.S. Nuclear Weapons Stockpile: 1945-2014



Source: U.S. State Department, Fact Sheet, April 29, 2014.

Table A-1. Current U.S. Nuclear Weapons and Associated Delivery Systems

Warhead Type	Delivery System	Design Laboratory	Service
W78 reentry vehicle warhead	Minuteman III ICBM	LANL/SNL	Air Force
W87 reentry vehicle warhead	Minuteman III ICBM	LLNL/SNL	Air Force
W76-0/1 reentry body warhead	Trident D-5 SLBM	LANL/SNL	Navy
W88 reentry body warhead	Trident D-5 SLBM	LANL/SNL	Navy
B61-3/4/10 Non-strategic bomb	F-15, F-16	LANL/SNL	U.S. Air Force Select NATO Forces
B61-7 strategic bomb	B-52 and B-2 bombers	LANL/SNL	Air Force
B61-11 strategic bomb	B-2 bomber	LANL/SNL	Air Force
B83-1 strategic bomb	B-52 and B-2 bombers	LLNL/SNL	Air Force
W80-1 Air-launched cruise missile warhead	B-52 bomber	LLNL/SNL	Air Force

Source: National Nuclear Security Administration, *Fiscal Year 2018 Stockpile Stewardship and Management Plan*, November 2017, p. 1-3.

Appendix B. U.S. Nuclear Testing

Table B-1. U.S. Nuclear Weapons Tests: 1945-1992

By Location of Test

Location	U.S.	U.S. and U.K.
Total	**1,026**	**28**
Total South Atlantic	**3**	**0**
Total Pacific	**106**	**0**
Bikini Atoll	23	0
Christmas Island	24	0
Enewetak Atoll	43	0
Johnston Island	12	0
Other	4	0
Other (within U.S.)	**13**	**4**
Near Alamagordo, NM	1	0
Amchitka Island, Alaska	3	0
Near Carlsbad, NM	1	0
Central Nevada	1	0
Near Fallon Nevada	1	0
Near Farmington, NM	1	0
Near Parachute, CO	1	0
Near Hattiesburg, MI	2	0
Nevada Test and Training Range	1	4
Near Meeker, CO	1	0
Nevada National Security Site	**904**	**24**
Atmospheric	100	0
Underground	804	24

Source: U.S. Department of Energy, NNSA Nevada Field Office, United States Nuclear Tests: July 1945 through September 1992. DOE/NV-209-Rev 16, September 2015.

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