RETHINKING PLUTONIUM:

A Review of Plutonium Operations in the U.S. Nuclear Weapons Complex

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PREFACE

As a result of safety and environmental problems, the United States currently lacks the capacity to produce nuclear warheads - a situation that has persisted for more than two years. Moreover, for the first time since the Manhattan Project, the U.S. has no immediate plans to produce additional warheads. Nonetheless, the Department of Energy (DOE) is proposing a major rebuilding of the nuclear weapons complex.

The current production hiatus provides an excellent opportunity to look beyond DOE's proposals and fundamentally review the role of the nuclear arsenal and the vast industrial complex which created it. Many of the most important issues to be addressed concern the facilities and operations used to produce and manage plutonium - an extremely hazardous and long-lived element used almost solely for nuclear weapons. A substantial portion of the nuclear weapons complex has been devoted to plutonium operations, which have created vast amounts of waste and contamination. Hence, it is crucial that any review of the complex's future consider a number of questions regarding plutonium.

- Is surplus plutonium an asset or a liability?
- What plutonium processing facilities and operations, if any, will be needed in the post-Cold War era?
- When and how will existing plutonium facilities be decontaminated and decommissioned?

This report addresses these and other questions in an effort to stimulate a broader dialogue before billions of dollars are spent developing a new generation of plutonium facilities, dealing with the existing stockpiles of plutonium and plutonium-bearing materials, and managing the vast amounts of plutonium-contaminated waste. The report is divided into four chapters:

> <u>Chapter One</u> reviews current plutonium operations and DOE's plans for the future. Also discussed are the relationship between national security and the need for additional processing, issues linked to the dismantlement of nuclear warheads, and options for the current inventory of plutonium and plutonium-bearing materials, including a brief discussion of proposals for the use of plutonium in commercial reactor fuel.
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> <u>Chapter Two</u> briefly explains the production of new plutonium and the types of plutonium processing.
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> <u>Chapter Three</u> describes the primary plutonium processing sites, focusing on DOE's plans to relocate plutonium operations.
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> <u>Chapter Four</u> contains several recommendations.

Material for this report has been gathered from numerous documents prepared by DOE and its contractors, other government agencies, and several public interest groups. Readers are encouraged to review cited documents for a more thorough analysis of the issues presented. Any mistakes, overlooked information, or misinterpreted facts are strictly the responsibility of the author.

Considerable appreciation goes to the staff of the Natural Resources Defense Council's (NRDC) Nuclear Project. Without their many years of effort to collect and disseminate information on DOE's nuclear weapons complex, this report would not have been possible. In particular, thanks goes to Randy Booker who, as an intern at NRDC in 1990-91, conducted much of the initial research for this report and co-authored the first drafts. James Werner and Dan Reicher supplied numerous documents, invaluable editing, and guidance throughout the year and a half that this report was being prepared. Finally, Thomas Cochran, Stan Norris, and Christopher Paine provided timely analyses of the dramatic changes in the composition of the U.S. nuclear arsenal, as well as comments on several of the technical points raised herein.

Representatives of several local and national groups involved in work around DOE facilities, and a few other concerned citizens, provided documents and/or reviewed drafts of this report. These individuals include: Beatrice Brailsford of the Snake River Alliance (ID), Tom Clements of Greenpeace (GA), Tim Connor of the Energy Research Foundation (WA), John Creed of the Carolina Peace Resource Center (SC), Dan Hirsch of the Committee to Bridge the Gap (CA), Wendy Hur, a mechanical engineering student at the University of South Carolina, Daryl Kimball of Physicians for Social Responsibility (DC), Arjun Makhijani of the Institute for Energy and Environmental Research (MD), LeRoy Moore of the Rocky Mountain Peace Center (CO), Tom Rauch of the American Friends Service Committee (CO), Jason Salzman of Greenpeace (CO), Steve Schwartz of the Military Production Network (DC), John Stroud of Concerned Citizens for Nuclear Safety (NM), Jim Thomas of the Hanford Education Action League (WA), James C. Warf (CA), and Tom Zamora of Friends of the Earth (DC).

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Brian Costner
Energy Research Foundation

LIST OF ACRONYMS AND ABBREVIATIONS

ACNFS	Advisory Committee on Nuclear Facility Safety
AEDA	Atomic Energy Defense Activities
CBR	Congressional Budget Request
CPDS	Construction Project Data Sheets
DOE	Department of Energy
DOR	Direct Oxide Reduction
DP	Defense Programs
EDL	Economic Discard Limit
EIS	Environmental Impact Statement
ERF	Energy Research Foundation
EU	Enriched Uranium
EWDA	Energy and Water Development Appropriations
FY	Fiscal Year
HAC	House Appropriations Committee
HASC	House Armed Services Committee
HEU	Highly-Enriched Uranium
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MSE	Molten Salt Extraction
NRDC	Natural Resources Defense Council
NSR	New Special Recovery
PEIS	Programmatic Environmental Impact Statement
PFP	Plutonium Finishing Plant
PRF	Plutonium Reclamation Facility
PRMP	Plutonium Recovery Modification Project
Pu	Plutonium
PUREX	Plutonium-Uranium Extraction
R&D	Research and Development
REP	Residue Elimination Project
RFP	Rocky Flats Plant
SNM	Special Nuclear Materials
SRP	Savannah River Plant
SRS	Savannah River Site
TA	Technical Area
U	Uranium
UCNI	Unclassified Controlled Nuclear Information

CHAPTER ONE. PLUTONIUM OPERATIONS: AN UNCERTAIN FUTURE

This chapter provides a history of plutonium operations in the U.S. nuclear weapons complex and an overview of the Department of Energy's (DOE) plans for the future of these operations. Several policy issues are discussed, including: the assessment of plutonium needs, the impacts of ongoing arms reductions, and DOE's plans for excess plutonium and plutonium-bearing materials.

A primary responsibility of the nuclear weapons complex is production of the materials which make up nuclear warheads. Two processes provide the explosive power in nuclear weapons: fission (the splitting of atoms) and fusion (the joining of atoms). The fissile materials used in weapons are plutonium and highly-enriched uranium (HEU); tritium and deuterium (forms of hydrogen) and lithium are the fusion materials. Each of these materials can be recycled from old warheads into new ones.

Fusion only occurs at very high temperatures; hence, fusion weapons are often referred to as "thermonuclear weapons." Early fusion weapons were sometimes called hydrogen bombs because deuterium and tritium were their principal fuels. By the mid-1950's, the U.S. had learned to design thermonuclear weapons using lithium deuteride; these weapons require less tritium.

Most modern nuclear weapons rely on both fission and fusion explosions. Chemical high-explosives initiate the fission of plutonium and/or HEU. Tritium is often used to boost the explosion, thus increasing the "yield" of the weapon. In many warheads, this boosted explosion triggers a fusion reaction in the lithium deuteride. A more complete discussion of the working of nuclear warheads is contained in chapter two.

HEU and lithium for nuclear warheads were produced in specialized enrichment facilities until the early 1960's. Deuterium production continued until the closing of the heavy water[1] plant at the Savannah River Site (SRS) in 1982. Tritium, a gas, was produced in reactors at SRS until mid-1988. Because of tritium's decay rate (about 5.5% per year) DOE intends to maintain a tritium production capability well into the 21st Century.

Plutonium, a metal, was also produced in reactors until 1988. After being produced, the plutonium was chemically processed and then fabricated into components for nuclear weapons. In the past, DOE also provided plutonium for use in nuclear weapons by recycling plutonium components from warheads retired from the arsenal and by extracting, or "recovering," plutonium from a wide variety of contaminated materials generated during production processes.

Plutonium is a key fissile material in nuclear weapons.

Plutonium has been produced and processed at the Hanford Reservation in Washington

[1] Heavy water is water made of oxygen and deuterium.

State and the Savannah River Site in South Carolina. Colorado's Rocky Flats Plant (RFP) has had primary responsibility for recycling plutonium components from retired weapons and fabricating plutonium components for new weapons. In addition, each of these sites has recovered plutonium from contaminated materials.

Warhead design, as well as plutonium-related research and development, is conducted at the Los Alamos National Laboratory (LANL) in New Mexico and the Lawrence Livermore National Laboratory (LLNL) in California. LANL has laboratory-scale facilities to conduct all types of plutonium operations. Nuclear warheads are assembled, and disassembled after retirement, at the Pantex Plant near Amarillo, Texas.

As described below, DOE has no plans to continue producing new plutonium and has acknowledged that most plutonium recovery operations are no longer necessary for national security. Additionally, the U.S. currently has no nuclear warheads scheduled for production. As a result, DOE has no immediate plans for plutonium fabrication.

However, DOE does intend to continue chemically processing plutonium and to maintain the capability to resume plutonium fabrication. The Energy Department contends that - even lacking national security requirements - plutonium should be treated as a valuable asset. DOE also assumes that Defense Department plans will require additional production of nuclear warheads at some point in the future.

History of Plutonium Operations

Plutonium (Pu) was discovered in 1941 by a group of scientists in Berkeley, California. Soon after its discovery, they recognized that the isotope Pu-239 would be particularly effective in atomic bombs.[2] The plutonium in modern weapons contains about 93 percent Pu-239, 6.5 percent Pu-240, and very small quantities of other isotopes (including Pu-241).[3]

Plutonium is often referred to as one of the most dangerous substances known, and plutonium operations involve substantial risk. Plutonium must be closely safeguarded to ensure that it is not diverted to groups or nations desirous of nuclear weapons or nuclear materials. It must also be stored and handled in a way that prevents a criticality accident - a spontaneous chain reaction resulting in a large, potentially lethal, energy release. Criticality accidents can occur from merely having too much plutonium in a given area, if the plutonium is also arranged in a favorable geometry. Additionally, fine particles of plutonium are pyrophoric - they can ignite spontaneously in the presence of air. Larger pieces of plutonium metal will burn when heated, and one piece can ignite its neighbor. Plutonium fires are particularly worrisome because they disperse plutonium particles into the air.

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[2] James C. Warf, *All Things Nuclear* (Los Angeles: Southern California Federation of Scientists, 1989), p. 15, and Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1986), pp. 348-56. Note: "Isotope" refers to atoms of the same element which have different numbers of neutrons (e.g., all plutonium atoms have 94 protons, but Pu-239 has 145 neutrons, while Pu-240 has 146 neutrons).

[3] Interservice Nuclear Weapons School (Kirtland AFB: Department of Defense, 1975), Glossary, p. 56, as quoted in Thomas B. Cochran, et al., *Nuclear Weapons Databook, Volume II, U.S. Nuclear Warhead Production* (Cambridge: Ballinger Publishing Company, 1987), p. 136. Hereafter *Nuclear Weapons Databook, Volume II.*

The radiation released from plutonium atoms, called "alpha particles," is the least penetrating of all radiation types, unable to even penetrate a sheet of paper. But once in the body - by being ingested, inhaled, or taken in through an open wound - the emissions from alpha particles are considered to be several times more harmful than more penetrating types of radiation (x-, beta-, and gamma-radiation). This is because alpha particles release their energy in a more compact space, with greater potential for damaging surrounding tissue.

If inhaled or ingested, plutonium can be lethal. DOE's own documents refer to plutonium as a "potent cancer producer."[4] DOE-funded experiments with beagle dogs demonstrate that inhalation of less than 16 millionths of a gram of Pu-239 oxide results in an incidence of lung cancer approaching 100 percent.[5] Plutonium has also been shown to cause bone cancers (particularly osteosarcomas) and leukemia.[6]

DOE: Plutonium is a "potent cancer producer."

Plutonium operations were developed primarily at the Hanford Reservation and the Los Alamos National Laboratory. During World War II, Hanford produced and processed plutonium. The Los Alamos National Laboratory developed plutonium processing techniques and designed and fabricated the fission weapons in which the plutonium would be used.

After World War II, scientists at LANL also developed designs for "boosted" fission weapons and thermonuclear weapons. In 1950, the Savannah River Site was selected as the location for tritium production facilities; plutonium processing plants were also built at SRS. The Rocky Flats Plant was built during the 1950's to mass produce the plutonium components, called "pits" and "triggers," for nuclear weapons.

Fueled by the Cold War, the United States rapidly increased the size of its nuclear arsenal during the 1950's and 1960's - building as many as 15 nuclear weapons per day.[7] SRS expanded its plutonium operations significantly during this time; this expansion has continued ever since. The number of nuclear warheads peaked in the 1967 at about 32,500 and declined to about 21,000 by 1990. Arms control initiatives of the last year could reduce that number to about 6,300 warheads by the year 2000.[8]

During most of the last two decades, as nuclear weapons were removed from the arsenal they have been replaced by fewer but more modern weapons. This stockpile modernization program placed significant pressures on the aging production facilities. Environmental and safety problems became increasingly apparent throughout the complex. The extremely hazardous properties of plutonium focused attention on related operations, particularly at the Rocky Flats Plant which is located near the city of Denver.

Throughout the 1980's, DOE sought to sustain weapons production by prolonging the

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[4] "Final EIS for Rocky Flats Plant Site" (DOE, April 1980), DOE/EIS-0064, Vol. 2, p. G-3-1

[5] J.F. Parks, "Inhaled Plutonium Oxide in Dogs," *Pacific Northwest Laboratory Annual Report for 1985 to the DOE Office of Energy Research*, Part 1, Biomedical Sciences, February 1986, pp. 3-17.

[6] National Research Council, *The Effects of Exposure to Low Levels of Ionizing Radiation: 1980* (Washington, DC: National Academy Press, 1980).

[7] Thomas B. Cochran, et al., *Nuclear Weapons Databook, Volume I, U.S. Nuclear Forces and Capabilities* (Cambridge: Ballinger Publishing Company, 1984), pp. 11-2 & 15.

[8] Ibid., and Colin Powell (Chair, Joint Chiefs of Staff), transcript of press briefing, January 29, 1992, p. 11.

life of existing facilities. But the severity of problems forced the shutdown of one facility after another, and by late 1989 production had come to a standstill at most DOE sites.

Concurrently, planning began for the construction of facilities to replace aging weapons plants throughout the country. In January 1991, DOE outlined several scenarios for rebuilding production capacity in its *Nuclear Weapons Complex Reconfiguration Study*.[9] The Energy Department's goal is to create a new generation of nuclear weapons plants - which it refers to as "Complex-21." Some of the most significant changes being proposed will affect plutonium operations.

The plutonium stockpile will decay by only about 3% in the next 1,000 years.

The United States has approximately 100 metric tons of weapon-grade plutonium; most of this is in the warheads themselves or stockpiled in a relatively pure form.[10] The remainder is contained in various types of scrap, oxide, and processing residue. In the past, DOE has recovered plutonium from many such materials for use in nuclear weapons. Pu-239 has a half-life of about 24,300 years. Consequently, the plutonium stockpile will decay by only about three percent in the next 1,000 years.

In 1990, DOE decided to forego future production of new plutonium and soon thereafter acknowledged that plutonium recovery from most existing material is unnecessary for national security as well. In January 1992, the Department announced that fabrication of plutonium weapon components was being suspended. If nuclear warhead production resumes, plutonium will be provided by recycling and/or re-using plutonium components from existing warheads. These decisions were based on an assessment of need.

Assessing Plutonium Need

The need for plutonium is determined by projections set forth in the Nuclear Weapons Stockpile Memorandum. Periodically, the Energy and Defense Departments submit a revised Stockpile Memo through the National Security Council to the President. Upon receiving the President's signature, this document becomes a work order for DOE, estimating the types and numbers of weapons to be manufactured and maintained over the next fifteen years, and consequently how much plutonium and other materials DOE needs to supply. The Stockpile Memo is top secret, as are the calculations and assumptions on which it is based.

However, there are numerous public indications of plutonium requirements. In 1988 testimony before a House Appropriations Subcommittee, then-Secretary of Energy John Herrington observed that, "We're awash in plutonium. We have more plutonium than we need."[11] In 1989, the National Research Council (an arm of the National Academy of Sciences) also acknowledged the plutonium surplus:

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[9] *Nuclear Weapons Complex Reconfiguration Study* (Washington, DC: DOE, January 1991), DOE/DP-0083. Hereafter *Reconfiguration Study*.

[10] *Nuclear Weapons Databook, Volume II*, pp. 74-5.

[11] John Herrington (DOE Secretary), HAC Subcommittee on Interior and Related Agencies, February 23, 1988.

> The national stockpile contains several tens of thousands of nuclear weapons. The plutonium in these devices, plus that in the supply chain, is obviously sufficient to supply a nuclear deterrent of the existing size or even greater.[12]

But it was not until March 1990 that DOE announced a shift away from the production of new plutonium, stating:

> Current plutonium requirements can now be met totally through recycle of material from retired weapons and recovery from accumulated residues; therefore, no reactor production of plutonium has been planned for the foreseeable future.[13]

Less than a year later, DOE reassessed its need for plutonium and began examining four stockpile sizes - representing reductions of 30 to 85 percent from 1990 levels - which "bound the reasonable range of possibilities" for planning the future of the nuclear weapons complex.[14] This reassessment confirmed DOE's earlier statement and went one step further:

> ...no additional reactor production of plutonium will be required. For all stockpile cases, plutonium requirements are reduced sufficiently to be satisfied by plutonium [recycled] from retired weapons alone....Consequently, all residues, wastes, and plutonium oxide currently existing, or produced from future operations, do not need to be reprocessed [to recover the plutonium] for weapons production.[15]

Thus, DOE cancelled future production of new plutonium and acknowledged that most plutonium recovery operations were unnecessary to supply national security requirements. In early 1991, DOE still intended to recycle plutonium components from existing warheads for re-fabrication into components for new weapons and was planning to continue operating many of its plutonium facilities.

Since early 1991, the nuclear arsenal has been cut dramatically. An analysis of the Strategic Arms Reduction Treaty and additional cuts announced by President Bush on September 27, 1991 and in his January 28, 1992 State of the Union address shows the nuclear arsenal dropping from 19,420 to 12,245 active warheads by late 1992, and then to 6,300 active warheads in the year 2000.[16] Thus, the nuclear arsenal is being reduced by more than 35 percent in less than two years and is expected to fall by two-thirds before the end of the decade. As explained below, with DOE's current dismantlement capacity it will take until the end of the decade to fully retire weapons being removed from the arsenal.

As part of his latest cuts, President Bush cancelled additional construction of a new warhead, the W88, for the Trident II missile.[17] As Energy Secretary Watkins noted, "This

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[12] *The Nuclear Weapons Complex: Management for Health, Safety and the Environment* (Washington: National Academy Press, 1989), p. 84. Hereafter *The Nuclear Weapons Complex*.
[13] Richard Starostecki (DOE Acting Dep. Asst. Sec., Nuclear Materials), HAC, FY91 EWDA, Pt. 6, p. 1129.
[14] *Reconfiguration Study*, pp. 48-9.
[15] Ibid., pp. 65 & 159.
[16] Analysis prepared by NRDC, October 1991 and February 1992.
[17] James D. Watkins (DOE Secretary), transcript of press briefing, January 29, 1992, pp. 18-9.

means that for the first time since the beginning of the Cold War the United States will not have a nuclear warhead in production."[18]

> **For the first time since the beginning of the Cold War the U.S. will not have a nuclear warhead in production.**

Still, many observers are calling for even deeper cuts. For example, the National Academy of Sciences recently concluded that it seems "reasonable" that multilateral agreements could reduce U.S. strategic forces to 1,000-2,000 nuclear warheads.[19] At least one Member of Congress is calling for "a step-by-step plan to reduce our nuclear arsenal, with the ultimate goal of complete [global] elimination of nuclear weapons."[20]

The swiftness and degree of cuts raise many questions about DOE's plans. Possibilities for deeper cuts create doubts about the huge investments in infrastructure needed to rebuild the nuclear weapons complex. The rapid rate at which weapons are being retired from the arsenal places significant new pressures on a system geared more to build nuclear weapons than to disassemble them. And regardless of the arsenal size, safety and environmental problems caused by past nuclear weapons production will pose hazards to workers and the public for many decades.

Future Plutonium Production

When DOE released its *Reconfiguration Study* in February 1991, the Department assumed that as weapons were retired, some number of new weapons would be brought into the arsenal as replacements. Plutonium for these new weapons would be provided by recycling plutonium components from older weapons. This recycling has been a key element of operations in the nuclear weapons complex since the 1950's.

In recycling, first the plutonium components are removed from warheads during disassembly. The plutonium is then chemically processed. This processing prepares the plutonium for re-fabrication and removes contaminants. The primary contaminant of concern is americium which is created by the decay of Pu-241, which has a half-life of 14.3 years. Americium emits a very penetrating form of radiation, called "gamma radiation," necessitating heavier shielding than would be required if working with the plutonium alone.

After processing, the plutonium metal is re-fabricated, or re-shaped, according to the specifications of the new warhead's design. Most warhead designs have required customized components. However, such customization is not necessary, and DOE is now exploring standardized designs.[21] The process of recycling and re-fabricating plutonium components "generates significant amounts of waste and exposes workers to radiation."[22]

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[18] James D. Watkins, prepared testimony, House Committee on Energy and Commerce, Subcommittee on Energy and Power, February 25, 1992, p. 15.

[19] "The Future of the U.S.-Soviet Nuclear Relationship" (Washington, DC: National Academy Press, 1991), p. 3.

[20] Hon. Pete Stark, letter to Hon. Les Aspin, February 14, 1992, p. 6.

[21] *Reconfiguration Study*, pp. 108-10.

[22] J. Tyler, "The W89 Warhead Development Program," Energy & Technology Review, July-August 1991, p. 7.

DOE'S RECONFIGURATION PROPOSAL

In addition to changes in plutonium operations, DOE's *Reconfiguration Study* details proposals to relocate the Pantex Plant and/or the Oak Ridge Y-12 Plant, eliminate duplication among national laboratories, transfer production of some non-nuclear components to private industry, consolidate the remaining non-nuclear component production at a central DOE facility, and other actions. In November 1991, DOE announced that provisions for new tritium production capacity would be considered along with other elements of the reconfiguration proposal.

Prior to making a final decision on any of these actions, DOE must complete a Programmatic Environmental Impact Statement. Preparation of the Reconfiguration PEIS began in February 1991. The current schedule calls for completion of the Draft Reconfiguration PEIS late in 1992, followed by a series of public hearings to solicit comments on the Draft. A final decision on the Reconfiguration PEIS could be made in mid to late 1993.

Decisions regarding the management of wastes from past and future nuclear weapons production activities are being considered in an Environmental Restoration and Waste Management PEIS. Public hearings on a draft of this PEIS are expected in early 1993, with the PEIS being finalized early in 1994.

Following completion of the PEIS process, DOE will begin implementing components of its proposal. This will involve developing detailed designs, performing additional environmental analyses (including additional EIS's), requesting funds from Congress, and constructing and operating new facilities. DOE expects to complete the reconfiguration by 2015; cleanup and waste management activities will continue well beyond that date.

In the past, recycling and fabrication have been the responsibility of the Rocky Flats Plant. However, Rocky Flats has experienced numerous safety and environmental problems. Operations at RFP have been stopped since November 1989 pending resolution of these problems. Additionally, for nearly two decades pressure has been mounting to relocate Rocky Flats' operations away from the Denver metropolitan area (see chapter three).

DOE and the Congress are now committed to ending plutonium processing at Rocky Flats. Plans have already been made for the temporary transfer of some responsibilities. If the need arises, SRS is slated to take over the recycling of plutonium from retired warheads.[23] As described in chapters two and three, the Los Alamos National Laboratory has the capability to perform all of Rocky Flats' functions, though on a smaller scale. However, there is resistance within DOE to the notion of depending on a laboratory for production operations.

Ultimately, DOE intends to complete the relocation of Rocky Flats' operations by constructing a new chemical processing plant and plutonium metal foundry at another site.

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[23] *Reconfiguration Study, p. 160.*

Five candidate sites are being considered: SRS, Hanford, Pantex, the Idaho National Engineering Laboratory (INEL), and the Oak Ridge Reservation in Tennessee.

DOE expects the new facilities could contain two million square feet of manufacturing, chemical processing, and support operations. Approximately 65 percent of this area would contain plutonium in various forms.[24] Construction, at a cost of at least $3 billion, could take eight or more years, and DOE estimates operations could employ up to 5,400 scientists, engineers, technicians, and administrative staff.[25]

Meanwhile, scientists at the Lawrence Livermore National Laboratory are pursuing an option which would allow retired pits to be reused in new weapon designs without first being chemically processed or re-fabricated. Research into pit reuse was prompted by the 1989 shutdown of the plutonium foundry at Rocky Flats. This effort:

> ...includes a potentially revolutionary new primary design [i.e., the warhead component containing the plutonium] which reuses the pits from stockpile weapons which are being retired. This approach eliminates the need for plutonium processing and manufacture and generates no Pu waste....Extensive reuse of major nuclear components from retired weapons could profoundly affect the design and size of the future nuclear weapons complex.[26]

In 1991, a nuclear test was conducted which "clearly demonstrated that this idea could work," and more tests are scheduled to explore the feasibility of pit reuse.[27] Research into this possibility is currently focused on two major weapon systems - the Short-Range Attack Missile and the Trident II. LLNL clearly feels this approach has broader applications.

DOE is also exploring other concepts which could significantly impact future plutonium operations. One option calls for the development of warhead designs "based on plutonium cast to final shape [which] may eliminate or significantly reduce the waste that results from plutonium-machining processes."[28] Another option would use technology developed in the mid-1980's for a Special Isotope Separation plant. The plant was cancelled in 1990, but DOE scientists believe it could be modified to handle plutonium recycling and fabrication.[29]

Before finalizing its relocation plans, DOE must complete an Environmental Impact Statement (EIS). Under the National Environmental Policy Act, any federal agency proposing an action which may significantly affect the quality of the human environment must analyze the impacts of and alternatives to its proposed action.

Several EIS's are currently underway concerning DOE proposals, including a Programmatic EIS (PEIS) on the Department's long-term plans for reconfiguration of the

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[24] "Invitation for Site Proposals for the Nuclear Weapons Complex Reconfiguration Site" (Washington, DC: DOE, February 1991), p. A-13. Hereafter "Invitation for Site Proposals."
[25] Ibid., p. A-8.
[26] John H. Nuckolls (Director, LLNL), HASC, DOE Defense Nuclear Facilities Panel, March 21, 1991, p. 8.
[27] John H. Nuckolls, "The State of the Laboratory," Energy & Technology Review, July-August 1991, p. 2.
[28] K.D. McKinley, "Nuclear Weapons Production Complex of the Future," Energy & Technology Review, July-August 1991, p. 11.
[29] L. Gray, "Plutonium Processing Technology for Complex 21," Energy & Technology Review, July-August 1991, pp. 34-5.

entire complex. The Reconfiguration PEIS covers issues associated with future facilities for nuclear weapons research, testing, and production - including the Rocky Flats relocation effort. Another PEIS is examining complex-wide plans for environmental restoration and waste management. DOE agreed to prepare both PEIS's in the wake of litigation brought by 21 citizen organizations, including ERF and led by NRDC.

Warhead Dismantlement

A shrinking nuclear arsenal demands that DOE safely dismantle thousands of nuclear weapons. The *Reconfiguration Study* devotes less than one page to a discussion of dismantlement, stating that retirement rates "may be significant when compared with DOE's current throughput" and that retirement schedules "may not coincide with DOE requirements and capabilities for weapons retirement processing."[30]

Capacity

As a result of DOE's capacity limitations, nuclear warheads are being returned to Defense Department sites where they are held prior to disassembly at DOE's Pantex Plant. DOE recently increased Pantex's dismantlement capacity to 2,000 warheads per year (see table).[31] Still the Department expects it will take until the end of the decade to complete the dismantlement of those warheads scheduled for retirement as of January 1992.[32]

DOE Nuclear Warhead Dismantlement

Fiscal Year	# of Warheads Dismantled
1987	280
1988	562
1989	830
1990	967
1991	1,573
1992	1,800*
1993	2,000*

*anticipated rate

Once a warhead is disassembled, its non-nuclear components are destroyed, except for those parts which have potential for reuse. Tritium is returned to the Savannah River Site for recycling back into the remaining stockpile. Highly-enriched uranium components are shipped to the Oak Ridge Y-12 Plant for processing or storage.[33] As for plutonium components, the *Reconfiguration Study* concluded:

Storage of retired pits [i.e., plutonium components] not needed for new pit manufacture is

[30] *Reconfiguration Study*, p. 161.
[31] James D. Watkins, letter to Senator Carl Levin, February 24, 1992, enclosure, p. 1.
[32] James D. Watkins, transcript of press briefing, January 29, 1992, p. 29.
[33] James D. Watkins, letter to Senator Carl Levin, February 24, 1992, enclosure, p. 2.

probably the most cost-effective course of action....Since the nuclear components are small and do not have any explosive parts, storage requirements and restrictions are small in comparison with those for storing complete warheads. A single DOE storage facility, preferably located at the weapon disassembly site, should be sufficient to serve all DOE interim requirements for fissile components.[34]

Retirements announced as of January 1992 could generate over 66,000 kilograms (about 145,000 pounds) of plutonium.[35] DOE plans to store this plutonium at Pantex, in "igloos" originally designed to contain accidental blasts from gunpowder, until more permanent plans can be developed.[36] The Energy Department is also preparing facilities at the Savannah River Site to store plutonium metal, possibly including components from retired warheads.[37]

To increase the safety of storing these plutonium components, it is possible to fill the components with a neutron absorber, such as boron. This would reduce the chance of a criticality accident - which could be caused by storing too many plutonium components in close proximity - and reduce the total amount of storage space needed. Further, if the boron were mixed with an epoxy, reusing the plutonium could not be accomplished without additional processing.[38]

A more elaborate possibility involves placing the plutonium components in prefabricated aluminum tubes and mildly crushing the tubes to render the components unusable if recovered. The components could then be surrounded with a mixture of, perhaps, cast iron and borax (a neutron absorber), and the tube enclosed in reinforced concrete. The resulting "logs" could be handled and "stacked as close as one would like, immersed in water," without any possibility of a criticality accident.[39]

Verification

President Bush's recent announcements are unilateral and lack the formality of a negotiated treaty. While Russia is reciprocating with cuts of its own, no mechanisms are in place for verifying the storage or elimination of warhead components. This has some arms control experts concerned that nuclear weapons materials in the now independent republics of the former Soviet Union may not be appropriately accounted for or adequately protected from proliferation. Some experts are also concerned that the U.S. may be foregoing an opportunity

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[34] *Reconfiguration Study*, pp. 161-2.

[35] Analysis prepared by NRDC, February 1992, assumes 4.5 kilograms of plutonium per warhead.

[36] Keith Schneider, "Nuclear Disarmament Raises Fear on Storage of 'Triggers'," New York Times, February 26, 1992, p. A8.

[37] "Environmental Assessment, Storage of Plutonium Metal in Building 247-F Vault" (DOE-SR, March 1992), DOE/EA-0497, Draft.

[38] "Report on the Third International Workshop on Verified Storage and Destruction of Nuclear Warheads held in Moscow and Kiev, December 16-20, 1991" (available from NRDC), p. 32. Hereafter FAS/NRDC Report.

[39] R.L. Garwin (IBM Research Division), letter by fax to Thomas Cochran (NRDC), February 26, 1992, as quoted in "Report on the Fourth International Workshop on Nuclear Warhead Elimination and Nonproliferation held in Washington, D.C., February 26-27, 1992" (available from NRDC), pp. 9-10.

for a new era of international controls:

> It is puzzling that the [Bush] administration would shy away from rigorous inspection measures for the storage and elimination of warheads at the very moment when the need and opportunity for such measures is greatest. In the current fluid political climate, a U.S.-Soviet inspection regime could lay the groundwork for a universal nuclear inspection regime under the U.N. Security Council....A universal, effective verification system could make it possible for the nuclear powers to slash their arsenals to a few hundred weapons each. But some elements of the administration are apparently trying to preserve U.S. freedom of action with respect to nuclear materials and warhead production facilities.[40]

Officials of the former Soviet Union cite U.S. willingness to participate in verification measures as a "precondition for further progress in this field."[41] Failure to implement verification measures may mean that "nations that now have, or may acquire, nuclear weapons may lack the confidence to reduce and ultimately eliminate their nuclear weapons, because they will lack convincing, objective evidence that the U.S. and former Soviet weapons have been similarly reduced or eliminated."[42]

Options for Surplus Plutonium

The U.S. has not developed long-term plans for the large stockpile of plutonium being created by disarmament actions. It appears that prior to settling on a course of action a fundamental question must be answered - is plutonium an asset or a liability? The answer to this question will substantially guide decisions about what processing the plutonium will eventually undergo, the types of facilities (handling, storage, processing, etc.) which will be needed, costs, and many other issues.

An official at the Lawrence Livermore National Laboratory described the long-term options for plutonium, as well as highly-enriched uranium, in a November 1991 paper:

> Most common ideas on disposition include converting fissile material [i.e., Pu and HEU] from retired warheads to reactor fuel, or disposing of it as a form of nuclear waste. The latter sometimes include[s] a provision to dilute or denature the materials to make their use in a weapon impossible or at least as difficult as obtaining virgin material.
>
> Disposal as waste would appear to be unacceptable. Not only has a strategy for the disposal of nuclear waste not been implemented, but in the future, some innovative uses for plutonium and highly enriched uranium, including, but not limited to, advanced (safer,

[40] Christopher Paine and Thomas B. Cochran, "So Little Time, So Many Weapons, So Much To Do," The Bulletin of the Atomic Scientists, January/February 1992, p. 15.
[41] FAS/NRDC Report, p. 31.
[42] Ibid.

smaller) reactors might emerge.[43]

DOE's present leadership apparently concurs with this conclusion. As Energy Secretary Watkins has said:

> At some point...it will be decided whether or not [plutonium] is a source of energy....So the best thing to do, in my opinion, is to take those pits [i.e., plutonium components] and store them and leave them there until such time....as we decide whether these are an asset or a liability. I'm not sure yet. I believe they're a potential asset if we manage our world nuclear situation properly....we might decide one day plutonium is good.[44]

Currently, the U.S. commercial nuclear power industry does not use plutonium in reactor fuel, nor do they plan to begin using it. The possibility was considered throughout the 1970's but was abandoned in 1979. However, DOE has recently resumed studying the issue, and the Nuclear Regulatory Commission is reviewing policies in this regard. If used, the plutonium, as an oxide, would be mixed with uranium oxide to form what is known as mixed oxide fuel.

DOE and the Nuclear Regulatory Commission are also exploring the use of highly-enriched uranium from retired warheads in commercial reactor fuel. This report does not address issues associated with HEU's use in detail. However, it is important to note that using HEU in commercial reactors could be implemented quicker and cheaper than the use of plutonium. Moreover, as noted below there is currently "no shortage" of commercial reactor fuel. Adding as much as 500 metric tons of HEU (the approximate U.S. stockpile[45]) to the uranium market would eliminate any need for using plutonium in commercial fuel for the foreseeable future.

A recent DOE study on possible uses of plutonium from retired weapons concluded that converting commercial reactors to mixed oxide fuel would take "at least five years to be implemented on a large scale" and then 17 large commercial reactors could "retire" about five metric tons of plutonium per year.[46]

Some observers question the economic value of such an approach:

> [The] economic motives to convert [nuclear weapons] material into commercial nuclear fuel are weak for a number of reasons. With the stagnant status of the nuclear power industry, there is no shortage of fuel, and the uranium mining and uranium enrichment industries are underutilized. In addition, only a few percent of the cost of electricity from nuclear power plants derives from the cost of fissionable material; the bulk of the costs come from the very high capital costs and the time necessary to bring a plant on line.

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[43] W.G. Sutcliffe, "Warheads and Fissile Materials: Declarations and Counting" (LLNL, November 5, 1991), prepared paper for the IEEE 1991 Nuclear Science Symposium and Medical Imaging Conference, UCRL-JC-108073, CTS-27-91, p. 7.

[44] James D. Watkins, transcript of press conference, December 16, 1991, p. N-1-7 #2.

[45] *Nuclear Weapons Databook, Volume II*, p. 75.

[46] C.H. Bloomster, et al, "Options and Regulatory Issues Related to Disposition of Fissile Materials from Arms Reduction" (Richland, WA: Pacific Northwest Laboratory, December 1990), PNL-SA-18728, pp. 1 & 16. Hereafter Bloomster, 1990.

> Thus, the primary motive for conversion of weapon-grade fissionable material to commercial fuel is arms control, not economics.[47]

It is important to note that the statement above makes no mention of the environmental and public health impacts associated with uranium mining and enrichment.

The arms control value of using plutonium in commercial reactors relies on the difficulty of recovering weapon-grade plutonium from the mixed oxide fuel. However, prior to irradiation in a reactor, plutonium recovery could be accomplished in less than a year using established processes and existing facilities. Thus, careful safeguarding of the fuel would be necessary; safeguards would increase the costs associated with the use of plutonium in fuel. After irradiation, recovery would become more difficult (though still technically possible) because of high radiation levels in the fuel and the high content of Pu-240 which could make the recovered plutonium poorly suited for use in weapons.[48]

Some observers have suggested that any arms control benefits produced by the use of mixed oxide fuel would be off-set by proliferation concerns:

> The existence of weapons-grade materials for civilian purposes provides a rationale for all the international "bad actors," such as Iraq and North Korea, to develop their own capability to produce these materials. Even if their facilities were under safeguards, these countries could still legally acquire large stocks of weapons-grade nuclear materials, which they could then in a matter of months, between [International Atomic Energy Agency] inspections, divert to weapons purposes.[49]

Whether or not the U.S. pursues the use of mixed oxide fuel, long-term plans to store or dispose of plutonium must be developed. Among the options which have been considered are: placement in a monitored and secured storage facility, disposal in a permanent repository (underground, under the seabed, etc.), detonation in underground nuclear explosions, transmutation, or conversion, into radionuclides with shorter half-lives, and sending the plutonium into space.[50] Prior to permanent disposal, observers have recommended diluting the plutonium with other radioactive elements, mixing the plutonium with waste scheduled for glassification, and other steps to make the plutonium difficult to recover. All options face serious political, economic, and/or technical hurdles. At the very least, these obstacles would delay implementation for a number of years.

A monitored and secured storage facility has been suggested to "provide interim storage until other more permanent solutions can be implemented." The two primary criticisms of such a facility as a permanent solution are cost and the ease with which plutonium could be removed and placed back into weapons. However, it has also been noted that storage is

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[47] Spurgeon M. Keeny, Jr and Wolfgang K.H. Panofsky, "Controlling Nuclear Warheads and Materials: Steps Toward a Comprehensive Regime," Arms Control Today, January/February 1992, p. 6.
[48] Bloomster, 1990, p. 19.
[49] Hon. Pete Stark, letter to Hon. Les Aspin, February 14, 1992, p. 5.
[50] Bloomster, 1990, p. 1 & Appendix A, and Arjun Makhijani, "Options for Plutonium from Dismantled Nuclear Weapons," Science for Democratic Action, Winter 1992, pp. 1-4.

"probably the most benign [option] from the standpoint of safety and environmental risk."[51] Until one or more of the options described above is implemented, plutonium components from retired weapons will continue to be stored at the Pantex Plant, and perhaps at other DOE facilities.

Managing Plutonium-Bearing Materials

Producing new plutonium is a costly process. Consequently, DOE has historically recovered and recycled plutonium from a wide variety of materials for use in weapons (see chapter two). While the U.S. was maintaining a large nuclear arsenal, it was assumed that plutonium recovered from these materials (scrap, oxide, and residue) would be needed.

As discussed above, plutonium requirements have changed drastically, but DOE continues to view plutonium as a valuable resource. As with plutonium from dismantled warheads, the Department is considering potential uses for the plutonium contained in its existing inventory of plutonium-bearing materials.

DOE views plutonium-bearing materials as a valuable resource.

However, the costs and complexities of recovering plutonium from materials with high levels of impurity and/or low quantities of plutonium differ greatly from the costs and complexities associated with recycling plutonium components from retired warheads (see chapter two for more details). Thus, the economic argument for continuing plutonium recovery in support of possible future commercial use is weaker than that for retired warhead components. Moreover, as explained above, there is no need to use plutonium in commercial reactor fuel anyway.

The basis for determining when to recover plutonium from what materials varies from site to site. The one complex-wide policy in this regard is a formula which establishes economic discard limits (EDL). As originally written, these EDL's suggested when to treat plutonium-bearing materials as waste (i.e., when not to recover the plutonium) by comparing the cost of reactor production to the cost of recovery operations. In response to past problems with the use of EDL's and the discontinuation of reactor production, DOE is currently updating the formula.

Discard Limits

In 1976, DOE's predecessor, the Energy Research and Development Administration, issued a policy on the use of economic discard limits for plutonium recovery. DOE's Office of Inspector General described the EDL formula in a 1988 report:

The EDL formula is expressed as a fraction. Basically, the numerator is comprised of labor

[51] Bloomster, 1990, pp. 7 & 11.

rates, processing time, waste disposal and other costs associated with reclaiming plutonium from existing scrap material. The denominator is the cost of producing new plutonium and is provided by Department Headquarters. The formula measures the cost to recover one gram of plutonium from one kilogram of scrap versus the cost of producing one new gram of plutonium. If the cost to recover is less than the cost to produce new, the scrap is held for plutonium recovery. Conversely, if the cost to produce new is less than the cost to recover, the scrap is prepared for ultimate burial as waste.[52]

Recovery costs vary widely depending on the capability and capacity of individual facilities and the nature of the feedstock.

The Inspector General report concluded that EDL's were being used improperly throughout the complex, perhaps resulting in sites disposing of "considerable" quantities of plutonium-bearing material which should have been considered economically recoverable.[53] Problems arose from the fact that the four plutonium processing sites - Rocky Flats, Los Alamos, Hanford, and the Savannah River Site - failed to update their costs of plutonium processing or even to consistently apply the EDL policy.

Additionally, DOE Headquarters had not updated the cost of reactor production since the EDL policy was originally issued. When Headquarters finally revised the cost estimate in 1986, the memorandum announcing the change "did not clearly describe the EDL policy and was vaguely written in a non-directive tone."[54] Apparently due to the memorandum's lack of clarity, the updated guidance was not acted upon by contractors and DOE field offices.

DOE responded to the Inspector General report by indicating its intention to update the EDL policy and better ensure the consistent application of EDL's. However, as explained earlier the Department has since determined that national security needs no longer justify reactor production of plutonium or plutonium recovery from most sources.

According to an SRS official, DOE intends to replace the EDL policy with one establishing Plutonium Discard Limits sometime in 1992. The new discard limits will still be based on an economic formula, but the new formula will compare the cost of recovery to that of stabilization and storage without recovery. It is expected that the new formula will generally lead to a decision to process materials containing greater than 7% plutonium.[55]

Continuing Recovery

DOE has presented at least three arguments for continuing recovery operations despite the lack of any national security requirement to do so. The first two are consistent with the Department's view of plutonium from retired warheads; the third at least begins to address the need to reduce the number of operating facilities in the nuclear weapons complex.

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[52] "Report on Economic Discard Limits for Plutonium Recovery" (DOE Office of Inspector General, February 1988), DOE/IG-0250, p. 2.

[53] Ibid., p. 6.

[54] Ibid., p. 3.

[55] J.G. McKibbin (Mgr., Separations Operations, WSRC), interview with Brian Costner (ERF), April 8, 1992.

First, DOE suggests continuing recovery operations to stockpile plutonium as a valuable resource. For example, according to the Department's proposal for Rocky Flats, which has a large backlog of plutonium-bearing materials:

> ...plutonium-bearing materials would be turned into storable plutonium oxide with radioactive mixed and unmixed waste as by-products. The plutonium oxide would be placed in retrievable storage at a facility yet to be determined. Retrievable storage is suggested to support the country's investment in plutonium, which could conceivably be required in the future for weapons or power generation.[56]

Processing techniques to recover plutonium oxide for storage are essentially the same as techniques to recover plutonium metal for use in weapons (see chapter two). Indeed, DOE is proposing to conduct these operations in facilities built or planned for weapons work. However, as explained in chapter three, existing facilities designed for recovery operations are plagued by safety and environmental problems and are becoming increasingly expensive to operate. New facilities will cost billions of dollars, offsetting the potential economic return from commercial use of the recovered plutonium. Additionally, storage of plutonium oxide would require essentially the same safeguards, monitoring, and other controls as storage of retired warhead components - as well as the same costs.

Second, officials contend that recovery operations could reduce the volume of material treated as transuranic waste.[57] Packaging requirements for transuranic waste limit the total quantity of plutonium in a single container. Because of the high percentage of plutonium in some materials, treating the entire existing inventory of plutonium-bearing materials as transuranic waste would require a large number of containers; though many of the containers would actually contain very little material.

Recovered plutonium would be subject to the same safeguards, monitoring, and costs as plutonium from retired warheads.

Some recovery operations extract 90-95% of the plutonium and reduce the volume of the remaining material (through dissolution and/or incineration) as much as 50%. The resulting transuranic waste could be placed in fewer drums because much of the plutonium has been removed. The drums would then be placed in retrievable storage.[58] DOE intends to ship retrievably stored transuranic waste to a permanent repository in southern New Mexico. However, opening of the repository - called the Waste Isolation Pilot Plant - has been repeatedly delayed by environmental and regulatory concerns. The recovered plutonium would be converted to an oxide and be subject to the same considerations (safeguards, monitoring, costs, etc.) as any other stockpile of relatively pure plutonium.

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[56] *Reconfiguration Study*, p. 160.

[57] Since 1984, DOE has defined transuranic waste as material contaminated with elements with an atomic number higher than that of uranium and half-lives of more than 20 years, and at concentrations above 100 nanocuries per gram. A nanocurie is one billionth of a curie, which is a standard unit of radiation.

[58] J.G. McKibbin, interview with Brian Costner, April 8, 1992.

These first two proposals are intended for materials deemed economically recoverable through the application of the discard limits described above. The Energy Department does not consider the plutonium in other materials worth the cost of recovery, so the materials would be prepared for storage without undergoing recovery operations. Depending on the nature of these materials, DOE would repackage them in appropriate containers, stabilize them in concrete, glass, or resin, or otherwise prepare them for retrievable storage.[59]

Finally, DOE has proposed continuing recovery operations so that facilities can "clean themselves up."[60] This implies limited operations to allow plutonium-bearing materials in existing facilities to be prepared for storage. To ready the facilities for long-term standby or shutdown other steps would also need to be taken, including the removal of processing chemicals from the buildings. While this option has been proposed for some buildings at the Rocky Flats Plant and Hanford, DOE remains in the early stages of planning for the shut down of its production facilities and their eventual decontamination and decommissioning.

[59] Ibid.

[60] James D. Watkins, transcript of press briefing, January 29, 1992, p. 18.

CHAPTER TWO. PLUTONIUM PROCESSING TECHNOLOGIES

This chapter describes five basic operations used to produce and process plutonium for nuclear weapons: reactor production, separation of plutonium from other radioactive elements, fabrication of plutonium components for new weapons, recycling of retired weapon components, and recovery of plutonium from a wide variety of scrap, oxide, and residue.

Producing New Plutonium

Reactor Production

DOE's production reactors operated much as commercial power reactors - by splitting, or "fissioning," uranium atoms. However, only one of the 14 production reactors (Hanford's N-Reactor) was designed with the ability to co-generate electricity. Instead, production reactors were designed to produce radioactive materials, such as plutonium and tritium.

Plutonium production began at the Oak Ridge Reservation in 1943, but it was quickly shifted to the Hanford Reservation. Built in the 1940's as part of the Manhattan Project, Hanford supplied the plutonium used in the world's first atomic explosion - "Trinity" - and the third - "Fat Man," the bomb dropped on Nagasaki, Japan.[60]

Plutonium has been produced in reactors at the Hanford Reservation in Washington state and the Savannah River Site in South Carolina.

Nine reactors were built at Hanford. The first eight reactors were constructed between 1943 and 1955. These were designed exclusively for plutonium production and used natural uranium (U-238) as a fuel. The last of these was shut down in 1971. Hanford's N-Reactor was built between 1959 and 1963 and used low-enriched uranium (~1% U-235) fuel elements. The fission reaction produced by the fuel released large amounts of energy in the form of heat and radiation. So, the fuel elements were sealed, or "clad," in a zirconium-tin alloy to prevent corrosion and contain some of the radioactivity. N-Reactor ceased operation in 1987.[61]

The Savannah River Site was constructed between 1951 and 1956 primarily to produce tritium. However, the SRS reactors have been used to produce plutonium as well. Three of the five reactors at the site are now permanently shut down. None has operated since 1988. If restarted, the SRS reactors would be used for tritium production. DOE has no plans to resume

[60] The second atomic bomb, "Little Boy," was dropped on Hiroshima, Japan. It was fueled by highly-enriched uranium produced at the Oak Ridge Reservation in Tennessee.

[61] Thomas B. Cochran, et al., *Nuclear Weapons Databook, Volume III, U.S. Nuclear Warhead Facility Profiles* (Cambridge: Ballinger Publishing Company, 1987), pp. 13-4 & 19-23. Hereafter *Nuclear Weapons Databook, Volume III.*

reactor production of plutonium.

SRS' production reactors contain "targets" in addition to the reactor's fuel. During the fission reaction, neutrons released from U-235 in the fuel irradiate these targets, forming new radioactive materials. Target assemblies made of U-238 are used to produce plutonium; after capturing a neutron the U-238 becomes U-239 which decays into Pu-239. Similarly, lithium targets are used to produce tritium.

Chemical Separation

After irradiation, the fuel and target assemblies contain uranium, plutonium and fission products; nearly all of these are radioactive. These assemblies are thermally hot and intensely radioactive, so they are allowed to cool in large ponds for several months or more before chemical processing. During this time many short-lived fission products decay away.

Chemical processing, or "separation," techniques are then used to extract the plutonium and uranium. Since the mid-1950's, the plutonium-uranium extraction (PUREX) process has been the basic separation technology employed at Hanford and SRS.[62] Over the years, this

BRIEF TECHNICAL DESCRIPTION OF THE PUREX PROCESS AND PLUTONIUM METAL CONVERSION

The first step in the separation process is to dissolve the irradiated components in a boiling nitric acid solution. The second step, solvent extraction, involves concentrating the plutonium and uranium in an organic solvent to separate them from other radioactive elements. Dilute nitric acid is then added to the organic solution of uranium and plutonium to separate out the uranium. The plutonium solution is next subjected to ion exchange in which the plutonium is absorbed into an organic resin, leaving the impurities in solution. The plutonium is removed from the resin with dilute nitric acid; this creates a purified plutonium nitrate solution.

The plutonium nitrate solution must be converted to plutonium metal for use in weapons. First, the plutonium is separated, or precipitated, from the nitric acid solution. The plutonium is then heated in a stream of hot air, yielding plutonium dioxide. The plutonium dioxide is converted to plutonium tetrafluoride by the introduction of hydrogen fluoride (either as a gas or in aqueous solution), a process known as hydrofluorination. Finally, through reaction with metallic calcium the plutonium tetrafluoride is reduced to plutonium metal.

The undesirable elements generated during production and separation processes are subjected to additional extraction to isolate any residual plutonium and uranium before being stored as high-level waste.

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[62] For a more detailed description of chemical separation see *Nuclear Weapons Databook, Volume II*, pp. 138-40 and *The Nuclear Weapons Complex*, pp. 118-22.

process has been modified to facilitate processing a wide variety of materials.

In simplest terms, the chemical separation process begins by dissolving the assemblies in boiling nitric acid. Through a series of chemical steps, plutonium is then separated from other elements. This process generates a purified plutonium nitrate solution and a vast volume of highly radioactive liquid waste.

The chemical separation facility at Hanford is known as the PUREX Plant. There are two separation plants at SRS - F-Canyon and H-Canyon; nearly all Pu-239 processing at SRS is performed in the F-Canyon. Each of these facilities is over 800 feet long, 100 feet wide, and 60 feet high. The canyon facilities provide for remote-controlled operations to protect workers from radiation exposure and contain the dangerous materials.

The plutonium nitrate solution generated in the canyons must be converted to plutonium metal to be used in weapons or plutonium oxide for storage. At Hanford, this conversion is performed at a facility located about five miles from the canyon called the Plutonium Finishing Plant, in the Remote Mechanical C Line. At SRS the operation takes place in the FB-Line, located on the roof of F-Canyon.

The canyons at SRS and Hanford have generated over 100 million gallons of highly radioactive liquid waste. This waste is stored on-site in huge underground tanks. Separation processes have also generated vast quantities of transuranic and low-level radioactive waste, hazardous waste, and mixed waste (containing both hazardous and radioactive constituents).

Fabrication

After separation and conversion to metal, the plutonium must be fabricated into the appropriate size and shape for a nuclear weapon. The dimensions of the final product vary from weapon to weapon and are specified by a weapon's designers. The plutonium metal is shipped from the separation canyons to the foundry for fabrication as "hand-sized, disk-shaped pieces," called "buttons."[63]

Fabrication of plutonium components is similar to many other metal fabrication processes requiring production to very tight tolerances. Among the techniques employed are: metal casting, rolling and forming, high-precision machining, welding, and chemical and metallurgical analyses.

However, hazards associated with plutonium require activities to be "conducted in closed, controlled environment systems referred to as glove boxes" which eliminate direct contact with the plutonium. Additionally, the toxic nature of plutonium "requires extensive environmental protection and monitoring programs for the health and safety of the workforce and the offsite general populace."[64]

The only production-scale plutonium foundry in the complex is Building 707 at the Rocky Flats Plant. Since November 1989, a substantial portion of Rocky Flats' operations, including Building 707, has been shut down due to environmental and safety problems. The

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[63] Congressional Research Service, "Rocky Flats and U.S. Nuclear Weapons Programs: Alternatives for the Future," February 1991, 91-276F, p. 7. Hereafter CRS, 1991.

[64] "Invitation for Site Proposals," p. A-8.

Los Alamos National Laboratory has facilities to fabricate plutonium components for test weapons but lacks RFP's production capacity.[65] The actual production capacity of LANL is not publicly available, but the number of nuclear tests is known. The number of tests peaked at 98 in 1962. Since 1970, the U.S. has conducted less than two dozen tests per year.[66]

Components have been fabricated for more than 70 types of warheads.[67] These warheads are of two general categories - fission weapons and thermonuclear weapons. The plutonium component is found in the core, or "pit," of implosion type fission weapons. The pit - generally a hollow, plutonium shell - is surrounded by high explosives. Detonation of the high explosives compresses the pit, initiating a chain reaction and setting off the nuclear explosion. This is the basic design of most fission weapons. Some older fission weapons use highly-enriched uranium instead of, or in addition to, plutonium.

Deuterium and tritium are often used to "boost" fission weapons. The deuterium-tritium gas is released from its reservoir part way through the fission explosion. The deuterium and tritium begin to fuse, releasing high energy neutrons which cause more of the plutonium or HEU to fission, thus adding to the explosive force, or "yield," of the weapon.

In thermonuclear weapons, the boosted plutonium pit, sometimes called the "fission primary," triggers a secondary component containing lithium deuteride and HEU. During the explosion, the lithium deuteride breeds additional tritium which fuses with deuterium, creating a fusion explosion. In this case, plutonium components are often referred to as "triggers."[68]

Fabrication processes have generated tremendous quantities of transuranic and low-level radioactive waste, hazardous waste, and mixed waste. This waste, combined with that from chemical separation processes, poses one of the most serious environmental and public health risks associated with the production of nuclear weapons.

For decades, much of the waste (other than the high-level liquid waste) from plutonium production, separation, and fabrication was dumped into unlined pits and basins. This practice resulted in contamination of soils, ground and surface waters, and air. More recently, some waste has been put in steel containers and placed in storage facilities which provide a better - although still temporary - degree of environmental protection. All the while, a portion of the contaminated material generated through plutonium operations has itself been processed to extract, or "recover," the residual plutonium. These recovery processes also generate radioactive and hazardous waste.

Processing Old Plutonium

Techniques to recycle plutonium from retired weapons and recover plutonium from scrap, oxide, and residue have been in use since the 1940's. These operations supplemented reactor production and were driven by the desire to accumulate large quantities of weapon-

[65] John Tuck (DOE Under Sec. and Acting Asst. Sec., Defense Programs), HAC, FY91 EWDA, March 12, 1990, Pt. 6, p. 606.

[66] *Nuclear Weapons Databook, Volume II*, Appendix B.

[67] Ibid., p. 5.

[68] Ibid., pp. 38-40 and *All Things Nuclear*, pp. 107-10.

grade plutonium.

As described in chapter one, reactor production has recently been halted due to a plutonium surplus. DOE now intends to rely solely on recycling plutonium from a portion of the retired weapons - and perhaps reusing some plutonium components without recycling - for any future warhead production. Meanwhile, techniques to recover plutonium from contaminated materials are being viewed as a means of sotckpiling plutonium and managing the existing inventory of plutonium-bearing materials.

The Los Alamos National Laboratory has primary responsibility for the development of new recycle and recovery techniques. Additional research and development (R&D) is carried out at the Lawrence Livermore National Laboratory and laboratories located at DOE's plutonium processing sites. Production-scale recycle and recovery operations have been centered at the Rocky Flats Plant, with additional capacity at the Savannah River Site and Hanford. However, SRS is now positioned to be the primary plutonium processing site for future operations. The capabilities of individual facilities are discussed in the next chapter.

Recycle and recovery operations process materials ranging from plutonium metal from retired warheads to bulk materials containing small amounts of plutonium residue. Many of these materials, or "feedstocks," require different processing techniques.

Recycle and Recovery Feedstocks

There are more than 100 categories and sub-categories of plutonium-bearing materials.[69] The purity, or assay, of a given material determines in large part whether and how it is processed. Assay is defined as the weight or percentage of nuclear material in a given item.[70] The higher the assay, the lower the percentage of impurities.

Examples of high assay feedstocks include plutonium components from retired weapons, plutonium scrap, and plutonium oxide. Retired plutonium components contain mostly pure plutonium metal. Contaminants, predominantly americium, are removed during recycle operations, but the primary purpose of recycling these components has been to prepare the plutonium for re-fabrication. Scrap plutonium and impure oxide often have a wider range of impurities, but the total amount of impurity is small.

Low-assay materials contain small amounts of plutonium relative to the bulk of the feedstock. Typically, these leaner feedstocks contain roughly 7-12% plutonium, sometimes more.[71] Low-assay feedstocks include laboratory crucibles and liquid residues, combustible material such as wipes and bags, insulation, filters, glass, plastics, and many other materials which come into contact with plutonium. Recovering plutonium from low-assay feedstocks is often more difficult, time consuming, and expensive than recovery from high-assay sources.

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[69] J.G. McKibbin, interview with Brian Costner, April 8, 1992.
[70] "Nuclear Materials Safeguards Procedure Manual" (EG&G Rocky Flats, Inc., March 1990), Glossary, p. 2.
[71] J.G. McKibbin, interview with Brian Costner, April 8, 1992.

RECYCLE AND RECOVERY FEEDSTOCKS

Retired Warheads -- When warheads are retired from the nuclear arsenal, the plutonium metal components can undergo chemical processing, referred to as "recycling," to remove contamination and prepare the metal for re-fabrication into new components.

Scrap -- When plutonium components are fabricated, shavings and other scraps of plutonium metal are produced. Plutonium can be recovered from this scrap, as it can from irregular plutonium buttons and any other form of plutonium metal not meeting weapon specifications.

Impure Oxide -- Plutonium oxides are generated at several steps in the production process. Foundry oxide is produced during fabrication. Plutonium solutions are converted to oxide during processing. Oxide is also produced during laboratory operations. Often these oxides contain high levels of impurities, which can be removed by recovery operations.

Residues -- Plutonium contaminates much of the equipment and material used during processing and fabrication. Residue feedstocks include processing chemicals, glass, glove-box gloves, crucibles, metal parts, graphite molds, filters, insulation, and combustibles (any plutonium-bearing material that may be burned).

Secondary Residues -- Recycle and recovery operations create by-products which contain residual plutonium, including processing chemicals and salts, glass, combustibles, scrap metal, crucibles, and other materials.

Recycle and Recovery Processes

Recycle and recovery are chemical operations involving aqueous or pyrochemical processes, or some combination of the two. The separation and extraction steps included in the PUREX process are examples of aqueous processing techniques. Pyrochemical operations involve chemical reactions at temperatures above the boiling point of water in a dry environment. Examples of pyrochemical operations are the gaseous hydrofluorination and reduction to metal steps described above. Facilities throughout the complex have different capabilities and capacities for carrying out these operations.

Aqueous Processes

Aqueous processes have been used at LANL, RFP, SRS, and Hanford. When used for recycle or recovery, the process is essentially as described under **Chemical Separation**. Any specialization generally occurs at the front-end of the process where feedstocks may not be suitable for the same dissolution techniques used for fuel and target assemblies. The unique requirements of the feedstocks can alter processing rates by a factor of 300.[72]

Dissolution can be particularly demanding in the case of low-assay solid residues which may require multiple passes through dissolvers, but relatively pure plutonium metal can also be difficult to dissolve. Some feedstocks dissolve more efficiently in a solution other than nitric acid (e.g., sulfamic acid).

Other feedstocks - such as insulation, filters, and glove-box gloves - are "washed" rather than dissolved. The wash solution then undergoes processing while the original material is treated as low-level or transuranic waste. In the case of materials such as fire bricks and graphite molds, the material might be ground and placed in a dissolver. The plutonium is then leached from the material, and the ground material is stored as radioactive waste. Regardless of the unique characteristics of dissolution, the end result is a plutonium nitrate solution compatible with subsequent chemical separation and conversion to oxide or metal.

Pyrochemical Processes

The most common use of pyrochemistry is conversion of plutonium dioxide to metal. This conversion is often a two step process - hydrofluorination followed by reduction to metal. Hydrofluorination converts plutonium dioxide to plutonium fluoride by subjecting the oxide to hydrogen fluoride gas (sometimes hydrofluoric acid is used in place of hydrogen fluoride gas in which case the hydrofluorination is considered an aqueous process). Though considered to be efficient and reliable, hydrogen fluoride is highly toxic, and plutonium fluoride can be a significant source of radiation exposure.[73]

Pyrochemical processes have been developed which do not use hydrogen fluoride and which avoid other difficulties associated with more traditional processing techniques. These newer processes include direct oxide reduction (DOR), electrorefining, and molten salt extraction (MSE). Each has been used at the Los Alamos and Lawrence Livermore National Laboratories and the Rocky Flats Plant, but neither has been implemented at SRS or Hanford. DOE will likely integrate these processes into any new plutonium plant built as part of Complex-21.

DOR was developed at LANL in the mid-1970's. The process eliminates the need for hydrofluorination, thus reducing waste generation and worker exposure. Calcium and plutonium dioxide are melted, along with a salt (calcium chloride), in an electric furnace. The mixture is then stirred to bring the calcium and plutonium dioxide into contact. The calcium removes the oxygen from plutonium dioxide, leaving the plutonium in its metal form.[74]

As originally developed, DOR produced about six kilograms of plutonium-contaminated waste for each kilogram of plutonium. Los Alamos reports that in 1988 it was able to demonstrate a technique for reducing waste generation to one-sixth of earlier levels.[75]

In practice, DOR apparently results in a plutonium metal with levels of impurity which do not meet weapon specifications. So, the plutonium metal is further purified by

[72] W.R. Dworzak, et al., "Technology Assessment of the Operability Plan for the Savannah River Plant New Special Recovery Process" (DOE's MMEC Technology Exchange Steering Committee, February 27, 1987) p. 40.
[73] *The Nuclear Weapons Complex*, p. 87.
[74] "Safer, More Efficient Plutonium Recovery," Research Highlights 1989 (LANL), pp. 40-1.
[75] Ibid.

electrorefining.[76] The impure metal is cast into an ingot which serves as the positive terminal for an electrolytic reaction. An inert material is added to the crucible containing the plutonium ingot, and the crucible is heated until the contents melt. A negative terminal is then inserted into the molten solution; an electric current is applied, and a pure plutonium metal separates from the solution.[77]

Through its extensive use at Rocky Flats, molten salt extraction has become the preferred technique for recycling plutonium components from retired warheads. DOE's preference for MSE is due in part to difficulties involved in dissolving relatively pure plutonium metal for aqueous processing. Instead of dissolution, MSE melts the old plutonium components and removes impurities directly from the molten plutonium metal. If contaminants other than americium are present, the resultant metal may require electrorefining to meet weapon specifications.

[76] "The PRMP Process," fact sheet prepared by DOE, Rocky Flats Office, 1990, p. 2.

[77] "Recycling Plutonium," LANL Annual Report, 1981, p. 22.

CHAPTER THREE. PLUTONIUM PROCESSING SITES

This chapter provides an overview of several sites in the nuclear weapons complex. The Rocky Flats Plant is discussed, with particular attention paid to the reasons its production mission is being discontinued. Operations at the Los Alamos National Laboratory and the Hanford Reservation are briefly described. Substantial detail is provided on the evolution of plutonium processing at the Savannah River Site. Finally, other sites being proposed for the relocation of Rocky Flats' operations are mentioned. Note: each of these sites also performs operations which are not described.

Rocky Flats Plant

Rocky Flats' plutonium facilities include: Building 771 (aqueous processing), Building 776 (pyrochemical processing), Building 707 (fabrication), and Building 559 (support laboratory).

Construction of the Rocky Flats Plant, located 16 miles northwest of Denver, Colorado, began in 1951. The 11 square mile site has had primary responsibility for fabricating plutonium metal and recycling retired warhead components during most of the last four decades. RFP's operations generate large amounts of plutonium scrap, oxide, and residue, so recovery facilities are located there as well.

Plutonium operations are concentrated in three facilities: Building 771 which houses aqueous processing facilities and was built in 1952; Building 776, completed in 1957, where pyrochemical operations are performed; and the plutonium foundry, Building 707, which was built from 1970 to 1972. Support for RFP's plutonium operations is provided by a laboratory located in Building 559 (constructed in 1968), as well as several waste handling facilities.

Capabilities

Chemical processing capacity at the Rocky Flats Plant has been dedicated primarily to recycling plutonium components from retired weapons. After disassembly, the components are subjected to a spray leach (rather than dissolution) in Building 771. This separates uranium from the plutonium metal. The uranium is sent to the Y-12 Plant at the Oak Ridge Reservation for further processing, and the prepared plutonium metal is sent to Building 776.

Molten salt extraction is used in Building 776 to remove americium from the plutonium and prepare the plutonium for re-fabrication. Impure metal resulting from this process undergoes electrorefining. The purified plutonium, in the form of metal "buttons," is sent to Building 707 for fabrication into weapon components. Plutonium components were fabricated in Building 776 prior to the completion of Building 707, and some fabrication has probably been conducted in Building 776 since 1972.

Warhead production requirements of the 1970's and 1980's left RFP with limited processing capacity beyond that used for recycling retired weapon components. Consequently, a backlog of plutonium-bearing materials developed at Rocky Flats. What excess capacity was available, mostly in Building 771, was used to process relatively pure scrap, oxide, and residue generated on-site. Also to help relieve the oxide backlog, some of the capacity in Building 776, normally used for MSE, was diverted to the development of direct oxide reduction.[78]

Additionally, during the 1980's Rocky Flats began shipping material, particularly oxides, to the Los Alamos National Laboratory, the Savannah River Site, and the Hanford Reservation.[79] This relieved much of the oxide backlog by the end of the decade. But there remains an estimated 140,000 kilograms (308,000 pounds) of plutonium-bearing material at RFP; the quantity of plutonium in this material is classified.[80]

As of Fall 1991, Rocky Flats also had 1,093 cubic yards of transuranic waste stored on-site.[81] DOE does not consider the plutonium in this waste worth the cost of recovery. As mentioned in chapter one, the Department intends to send the waste to southern New Mexico for permanent disposal. However, opening of the disposal facility has been delayed several years due to environmental and regulatory concerns. DOE has constructed a "Supercompactor" to reduce the volume of waste at Rocky Flats, but its startup has been delayed by mechanical problems.[82]

DOE has agreed with the State of Colorado to limit the total amount of transuranic waste accumulated at RFP to 1,601 cubic yards. Without the Supercompactor or the opening of a waste disposal facility, continued operation of Rocky Flats would approach this limit at the rate of 84 cubic yards per month.[83]

Problems at RFP

Like facilities throughout the nuclear weapons complex, the Rocky Flats Plant has been plagued with problems. Fires are considered the "greatest operational safety hazard" at the plant. Since operations began, there have been over 600 fires at RFP. Yet in many cases, fire detection systems are "antiquated."[84]

In addition to fires, "From 1959 to 1969, storage drums containing plutonium-contaminated machine oil leaked and contaminated soil off-site....Also, in 1973 a small quantity of tritium was accidentally released with waste water into the water supply for the

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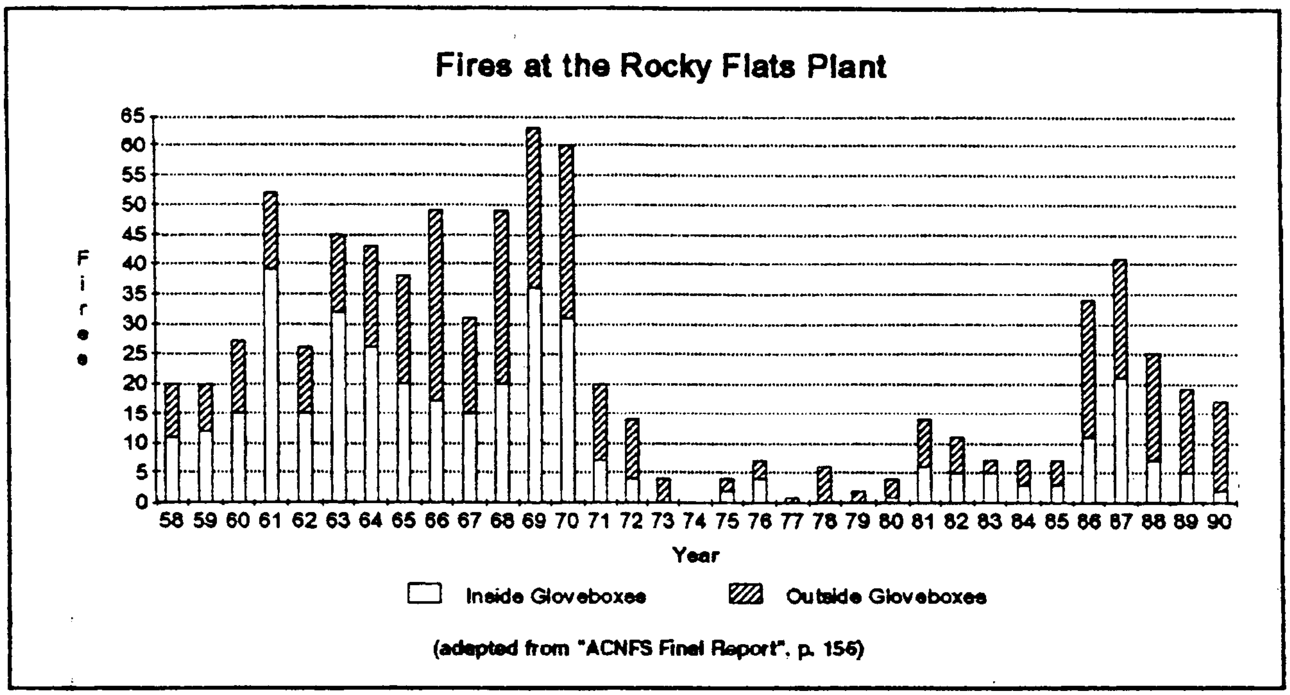
[78] "DOE Residue Processing Capabilities" (attachment to communication from DOE Albuquerque Operations Office to the Rocky Flats Environmental Monitoring Council, July 5, 1990), PRMP:FRL:7473.
[79] HAC, FY91 EWDA, Pt. 6, pp. 1120 & 1129.
[80] "Mass Balance Summary," fact sheet prepared by DOE, Rocky Flats office, 1990.
[81] Advisory Committee on Nuclear Facility Safety, "Final Report on DOE Nuclear Facilities," (Washington, DC: DOE, November 1991), p. 141. Hereafter "ACNFS Final Report."
[82] Ibid., p. 158.
[83] Ibid., pp. 140-1.
[84] Ibid., pp. 155-6.



nearby city of Broomfield, Colorado (population 17,000)."[85] There have been other problems as well.

The amount of releases, and potential effects, from these accidents is the subject of controversy. Such controversy is often heightened by the lack of reliable data. For example, during a fire in 1957, filters designed to trap plutonium in Building 771 burned. Monitoring equipment was not operating, and estimates of the releases range from "slight" to between 14 and 20 kilograms (30-44 pounds).[86]

These accidents and the controversy surrounding them raised public concern and led to establishment of the Rocky Flats Task Force in 1974. The Task Force, comprised of state and county officials as well as private citizens, concluded that "the Rocky Flats Plant should be reassessed as a nuclear weapons manufacturing facility, with consideration given to gradually phasing out its present operations, possibly transferring those operations to a more suitable site."[87]

The federal government, though, was moving ahead with plans to upgrade Rocky Flats' capabilities. In 1970, Congress approved a $113 million proposal for a new plutonium

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[85] "Nuclear Materials: Alternatives for Relocating Rocky Flats Plant's Plutonium Operations" (Washington, DC: U.S. General Accounting Office, April 1987), GAO/RCED-87-93, p. 13. Hereafter "Alternatives for Relocating Rocky Flats."

[86] Harvey Wasserman, et al., *Killing Our Own: The Disaster of America's Experience with Atomic Radiation* (New York: Dell Publishing, 1982), pp. 168-9.

[87] "Alternatives for Relocating Rocky Flats," p. 13.

processing facility, Building 371. The facility was to replace Buildings 771 and 776 and be more efficient and safer to operate. Much of the increase in safety would be attained through the use of remote-controlled processing equipment instead of the traditional gloveboxes. Construction began in 1973 and was completed in 1981 at a final cost of $215 million.[88]

After operating briefly, the building's aqueous processing line proved faulty and a large section of the building became contaminated with plutonium. Operators also experienced problems with the facility's remote-controlled equipment. Throughout the 1980's, DOE considered plans to repair the building. Design and material flaws in the original construction were extensive, and repairs were estimated at more than $300 million.[89]

Plutonium Recovery Modification Project

Near the end of the decade, DOE settled on a $500-600 million renovation plan for Building 371. The Plutonium Recovery Modification Project (PRMP) would decontaminate about 20% of the existing structure and add approximately 200,000 square feet, to consolidate all recycle and recovery processing at RFP under one roof.

In a December 1989 report, the National Research Council (an arm of the National Academy of Sciences) challenged DOE's decision to develop the PRMP, stating:

> The Department of Energy should concentrate on making better use of the existing plutonium processing capacity as required and postpone plans to construct additional capabilities.[90]

The report specifically recommended use of recovery and recycle capabilities at the Los Alamos National Laboratory and the Savannah River Site.

A $65 million request for PRMP was deleted from the FY91 budget by Congress in July 1990. DOE has repackaged the PRMP in its *Reconfiguration Study*. Now called the Residue Elimination Project (REP), the facility would be used to "clean up" Rocky Flats by recovering plutonium from scrap, oxide, and residue. Unlike PRMP, REP would only be designed to process material to the plutonium oxide stage. As described in chapter one, the plutonium oxide would be put into retrievable storage rather than converted to metal. DOE considers it "unlikely" that a decision on whether to proceed with the REP will be made prior to completion of the Reconfiguration PEIS in 1993.[91]

The 1989 Shutdown

Buildings 707, 771, and 776 continued operating throughout the 1980's despite growing hazards. Then, "Seventy FBI agents raided Rocky Flats, on June 6, 1989, in search of evidence that plant managers had deliberately violated environmental laws and had attempted

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[88] Ibid., p. 8.

[89] Ibid., p. 3.

[90] *The Nuclear Weapons Complex*, p. 85.

[91] "Implementation Plan, Nuclear Weapons Complex Reconfiguration Programmatic Environmental Impact Statement" (Washington, DC: DOE, February 1992), DOE/EIS-0161IP, p. 3-8. Hereafter R-PEIS IP.

to hide violations from State and Federal environmental regulators."[92]

In September 1989, an independent assessment of RFP reported "significant quantities of plutonium" in several of the plant's exhaust ducts and found evidence that plutonium had been discovered in ventilation systems during past renovations.[93] The amount of plutonium in the ductwork was later estimated at approximately 28 kilograms (nearly 62 pounds).[94]

In November 1989, DOE halted plutonium operations at RFP. Though the shutdown was originally reported to be for routine maintenance, significant environmental, safety, and health problems have prevented restart of these facilities.

In early 1990, DOE concluded that Buildings 771 and 776 are "outdated and unreliable" and "cannot be upgraded to meet today's environmental and safety criteria."[95] Nonetheless, the Department sought funding to restart RFP's three main plutonium processing buildings (707, 771, and 776) and Building 559 in 1992. Laboratory facilities in Building 559 were needed to characterize contamination problems in the other buildings. Congress authorized a supplemental budget request of $283 million in March 1991, raising the total amount appropriated for restart to over $1 billion.

DOE's Advisory Committee on Nuclear Facility Safety (ACNFS) responded cautiously:

> Much remains to be done to make safety and operations at Rocky Flats consistent with the standards being adopted at the Department of Energy's nuclear reactor facilities, and it is not clear that this will ultimately be achievable under the current program....[Additionally] Once plutonium processing begins at Rocky Flats, however, it will not continue for long. Limitations on waste accumulation at the Rocky Flats may force another suspension of these processes unless some way to reduce the volume of waste on site is found. ...Therefore, the Advisory Committee wonders whether it makes sense to resume plutonium operations, if these operations may be stopped again only a few months later.[96]

Skepticism was also raised outside DOE, particularly by observers questioning the need for restart. As described in chapter one, the U.S. nuclear arsenal has been cut dramatically in response to changing relations between the United States and the former Soviet Union. By September 1991, there remained only one warhead - the W88 for the Trident II missile - scheduled for production, and scientists at the Lawrence Livermore National Laboratory were exploring the possibility of reusing an older warhead in place of the W88. Thus, many observers saw little need for resuming plutonium processing and fabrication.

In his January 1992 State of the Union address, President Bush discontinued construction of the W88. Energy Secretary Watkins responded by announcing that, "plutonium manufacturing operations at Rocky Flats are now terminated."[97]

However, DOE contends that restart is still necessary so the facilities can "clean

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[92] CRS, 1991, p. 1.
[93] SCIENTECH, Inc., "An Assessment of Criticality Safety at the Department of Energy Rocky Flats Plant, Golden, Colorado," SCIE-DOE-201-89, July-September 1989, pp. ES-1-2.
[94] "Rocky Flats Plutonium in Ductwork Fact Sheet" (Golden, CO: DOE, Rocky Flats Office, April 24, 1990).
[95] John Tuck, HAC, FY91 EWDA, Pt. 6, p. 560.
[96] "ACNFS Final Report," pp. 141 & 158.
[97] James D. Watkins, transcript of press briefing, January 29, 1992, p. 18.

themselves up" and to facilitate long-term decontamination prior to decommissioning of the plant. Building 707 will be one of the last buildings decommissioned in order to retain a contingency pending a final decision on the construction of a new plutonium foundry.[98] Building 559 restarted in late February. A plan for the transition of the Rocky Flats Plant from production to cleanup is scheduled to be completed in the summer of 1992.

Los Alamos National Laboratory

The Los Alamos National Laboratory is a research and development complex, occupying about 43 square miles and located approximately 25 miles north of Santa Fe, New Mexico.[99] LANL is operated by the University of California. The Laboratory is organized into "technical areas," each responsible for a specific set of functions.

Originally charged in 1943 with developing the first atomic bomb, LANL's primary mission remains research and development relating to all aspects of nuclear weapons technology. Within this role, LANL is the focus of the special nuclear materials (SNM) R&D program for the entire nuclear weapons complex. Emphasizing plutonium-related activities, this program has three components:

1) "research into materials science, including metallurgy, chemistry, and behavior under extreme conditions,"
2) "process development and subsequent technology transfer to the production plants," and
3) "plutonium recovery from scrap generated during the fabrication process of nuclear test devices and from the weapons production lines."[100]

At LANL, TA-55 houses facilities to develop and demonstrate plutonium processing technology, as well as to recycle and recover plutonium.

Plutonium activities are primarily located in two areas - the Chemistry and Metallurgy Research Building at Technical Area-3 and the Plutonium Processing Facility at Technical Area-55 (TA-55). The Chemistry and Metallurgy Research Building is nearly 40 years old, has never had a major renovation, and does not meet current environment, safety, and health requirements.[101] Operations in this building focus on materials research in support of activities at TA-55.

TA-55 houses facilities to develop and demonstrate plutonium processing technology, as well as to recycle and recover plutonium.[102] LANL has pyrochemical and aqueous processing capabilities, and some capacity for plutonium metal fabrication (at least enough to support the

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[98] Ibid., pp. 18-9.
[99] *Nuclear Weapons Databook, Volume III*, p. 53.
[100] "Los Alamos National Laboratory Institutional Plan, FY 1989 - FY 1994," September 1989, p. 11.
[101] "Fiscal Year 1993 Defense Programs Capital Assets Management Process" (DOE, FIN-93-DEF, April 1991), p. 45. Hereafter FY93 CAMP.
[102] DOE FY91 CBR, CPDS, p. 139.

production of several test weapons each year). The Plutonium Processing Facility is only about ten years old, but already 25 percent of the facility and some of its waste lines are "worn out" because TA-55 "has been used for production, for which it was not designed."[103]

Production Support

LANL's role in providing back-up production capacity for the nuclear weapons complex is controversial. The total capacity of the Laboratory's facilities is not publicly available. However, in a single year Los Alamos "produced 1.5 metric tons of high-purity plutonium metal" demonstrating a single production process - electrorefining.[104]

During the debate over upgrading facilities at the Rocky Flats Plant, particularly during discussion of the Plutonium Recovery Modification Project, LANL's potential for production-scale operations was considered. In 1989, the National Research Council described TA-55 as:

> ...an efficient and productive operation for scrap recovery. This facility operating for the most part on a one-shift, 5-day schedule, can process almost half as much plutonium as Rocky Flats can (even if Building 371 were to be renovated) and turn out a purer product.[105]

DOE's Advisory Committee on Nuclear Facility Safety also praised TA-55, commenting that its processing capabilities "are a significant but under-utilized asset" and represent "substantial improvements over equipment and procedures in use elsewhere in the DOE complex." The ACNFS recommended "that serious consideration be given to how capabilities at TA-55 could be used to provide broader benefits to the complex."[106]

However, DOE and LANL officials appear unreceptive to the prospect of the Laboratory conducting production-scale recycle and recovery operations. In a direct response to the National Research Council recommendation, DOE stressed that:

> TA-55 is a laboratory facility, not a production facility....TA-55 is efficient to support the laboratory-scale processing. It would be extremely inefficient in a pure production mode because...capacities are considerably lower than RFP...[and the] mission design of LANL is R & D, not production. LANL has no demonstrated production experience.[107]

Upgrades

Meanwhile, the Energy Department has pursued plans to enhance LANL's capabilities.

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[103] FY93 CAMP, p. 45.
[104] "Recycling Plutonium," LANL Annual Report, 1981, p. 22.
[105] *The Nuclear Weapons Complex*, p. 84.
[106] John F. Ahearne (Chairman, ACNFS), letter to Energy Secretary James D. Watkins, November 6, 1990, p. 2.
[107] DOE response to National Research Council, January 4, 1990, p. 5.

DOE received funding in 1988 to begin relocating most activities from the Chemistry and Metallurgy Research Building to a new 115,000 square foot Special Nuclear Materials Laboratory. The SNM Laboratory would be constructed at TA-55, supported by four new buildings and integrated with the existing plutonium facility. According to DOE, the facility would allow greater interaction and cooperation between analytic chemists and plutonium processing researchers, and increase efficiency through consolidation and integration.[108]

Some observers wondered if the SNM Laboratory would take over much of the processing from Rocky Flats. In response, DOE insisted that the facility "is not intended to, nor could it, provide plutonium production capacity capable of supplanting the Rocky Flats operation."[109]

Amid uncertainty over the need for additional plutonium processing capacity, Congress eliminated funding for the SNM Laboratory in the FY91 budget. DOE included no funds for the facility in its FY92 budget request, stating that the project "is on hold." The Department does not expect to make a final decision about proceeding with the laboratory until after the Reconfiguration PEIS is completed in 1993.[110]

DOE does not consider LANL a candidate site for the permanent relocation of Rocky Flats' operations. However, the *Reconfiguration Study* does indicate that DOE is retaining LANL as a back-up option for future processing.[111] And in FY91, Congress appropriated $7.325 million for LANL to maintain "a modest level of production support" by processing plutonium residues from Rocky Flats and elsewhere.[112] However, DOE sought no funds for plutonium recovery at LANL in its FY92 or FY93 budget requests.[113]

As the size of the nuclear arsenal is reduced, DOE's concerns about the capacity of LANL's processing facilities may diminish. This could result in renewed pressure to place a heavier reliance on LANL as a production facility.

Hanford Reservation

The primary role of the 560 square mile Hanford Reservation has been the production and separation of plutonium. While most of this plutonium has been weapon-grade, Hanford has also produced significant quantities of fuel grade plutonium - which has a higher content (7-19%) of Pu-240. Production has occurred in nine reactors at the plant. Plutonium separation and processing are centered around two facilities - the PUREX Plant and the Plutonium Finishing Plant (PFP).

The PUREX Plant began operating in January 1956. The plant employs aqueous processing techniques. The original design of the facility did not include hydrofluorination or reduction to metal capabilities. So, plutonium nitrate solution was shipped from PUREX to

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[108] DOE FY91 CBR, CPDS, p. 139.

[109] John Tuck, HAC, FY91 EWDA, Pt. 6, p. 564.

[110] R-PEIS IP, p. 3-8.

[111] *Reconfiguration Study*, p. 63.

[112] DOE FY92 CBR, AEDA, February 1991, Vol. 1, p. 211.

[113] DOE FY93 CBR, Vol. 1, p. 234.

PFP for conversion to oxide or metal.

Operations at PFP began in 1949. Conversion of the plutonium nitrate solution occurred in the Remote Mechanical C Line. PFP also houses aqueous plutonium recovery operations which generate an additional stream of plutonium nitrate solution for conversion to plutonium oxide or metal. In 1964, the capabilities of PFP were improved with the completion of the Plutonium Reclamation Facility (PRF). PRF expanded the variety of feedstocks which PFP could process for recovery. Until 1965, PFP fabricated weapon components from plutonium metal, a role since dominated by Rocky Flats.

At Hanford, plutonium processing is centered around the PUREX Plant and the Plutonium Finishing Plant. Within PFP, plutonium is recovered from scrap in the Plutonium Reclamation Facility, and the Remote Mechanical C Line converts plutonium nitrate solution to plutonium oxide or metal.

By 1971, eight of Hanford's nine reactors had been shut down. This sharply reduced the need for the PUREX Plant, so it was placed on standby in 1972. Throughout the 1970's, facilities in PFP were closed as the backlog of material from PUREX was processed. Conversion of plutonium to metal stopped in 1972, and in 1979, the Plutonium Reclamation Facility was placed on standby.

PUREX & PFP

In 1978, DOE instituted a ban on the shipment of liquid plutonium nitrate. So equipment was added to the PUREX Plant for the conversion of plutonium nitrate solution to plutonium oxide, and PUREX was restarted in November 1983. Since the Remote Mechanical C Line was still closed, weapon-grade plutonium oxide was sent to the Los Alamos National Laboratory for conversion to metal. Fuel-grade plutonium oxide was sent to the Savannah River Site, blended with so-called "supergrade" plutonium (2-3% Pu-240) to bring it to weapon-grade, and then converted to metal.[114]

After its restart, operations at the PUREX Plant were halted numerous times for safety problems, worker training, maintenance, and equipment failures. The plant operated with insufficient steam pressure to maintain proper ventilation and in December 1988 was shut down again. Some observers noted that the 1988 shutdown was "unprecedented because it left highly radioactive and caustic chemical material in the process pipes and tanks. The cleanout of those materials was delayed by several equipment failures, safety problems, and environmental concerns."[115] A limited cleanout run finally began in December 1989 and concluded in March 1990.

DOE is considering another restart of PUREX to recover plutonium from spent fuel from Hanford's N-Reactor. Approximately 2,100 metric tons of spent fuel remain from reactor

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[114] For more on facilities at Hanford, see *Nuclear Weapons Databook, Volume III*, pp. 13-6 & 24-8.

[115] "Perspective" (Hanford Education Action League, Spring 1990), p. 8.

operations, which were halted in 1987. Only about 300 metric tons of the spent fuel contain weapon-grade plutonium, the remainder contains fuel-grade plutonium.

DOE had intended to build a facility, called the Special Isotope Separation plant, which would use a laser process to convert the plutonium from fuel-grade to weapon-grade. But plans for the plant, which was to be built at the Idaho National Engineering Laboratory, were cancelled in January 1990 because of the abundance of weapon-grade plutonium in the U.S. stockpile.

Prior to restart of the PUREX Plant, DOE has agreed to prepare an Environmental Impact Statement on options for addressing spent fuel stored at Hanford. The EIS is not expected to be completed until 1994, and officials estimate it will take an additional three years to prepare the plant for operations.[116]

Meanwhile, PUREX is being maintained in a shutdown mode, and Hanford officials are exploring alternative uses for the plant. Possibilities under consideration include assisting in the treatment of high-level radioactive waste, demonstrating soil decontamination processes, and a variety of other environmental management and decontamination missions.[117]

During the 1980's, parts of the Plutonium Finishing Plant were also restarted, beginning with the Plutonium Reclamation Facility in January 1984 and the Remote Mechanical C Line late in 1985. These operations were stopped several times for additional worker training and investigation of seismic concerns. PRF last operated in December 1987. The Remote Mechanical C Line has not operated since June 1989.

DOE plans to restart PFP to process the remaining inventory of plutonium scrap generated at Hanford. This scrap is currently stored in solution form, and DOE anticipates processing will take about two years.[118]

Hanford's Future

The Department has publicly announced that it is phasing out Hanford's production mission, and in its FY92 budget request, DOE transferred most of Hanford's programs to its Environmental Restoration and Waste Management account. As described in the *Reconfiguration Study*:

> The only defense production mission remaining at Hanford will be the residue recovery/metal conversion capabilities at the Plutonium Finishing Plant (PFP). While some plutonium metal satisfactory for weapons production could be produced at Hanford, none of the stockpile size options considered require it. Therefore, current planning would process residue inventories, as well as weapons-grade plutonium nitrate from PUREX, only as needed to facilitate final disposal. Hanford could then go into a terminal cleanout of

[116] Westinghouse Hanford Company, "Quarterly Briefing Book on Environmental and Waste Management Activities," WHC-SP-0434-10, March 1991, p. A-19.

[117] J.C. Fulton (Mgr., Facility Operations Programs, Westinghouse Hanford Company), letter to J.R. Hunter (Asst. Mgr., Operations and Research, DOE-Richland), January 31, 1991.

[118] "ACNFS Final Report," p. 84.

defense production facilities, finishing with terminal cleanout of the PFP itself.[119]

The *Reconfiguration Study* does not explain what is meant by "only as needed to facilitate final disposal," but the Department's proposal for Rocky Flats refers to storage of plutonium as a relatively pure oxide.

DOE's Advisory Committee on Nuclear Facility Safety has recommended an additional role for PFP:

> Rocky Flats' residue contains only low concentrations of plutonium. It is conceivable that plutonium recovery from the Rocky Flats residue will no longer be economically feasible. However, even if the Rocky Flats residue becomes waste, processing may still be needed for decontamination purposes prior to permanent disposal. If this turns out to be the case, then PFP can process Rocky Flats' residue without violating Hanford's intended mission. The Department should look into this in more detail.[120]

Despite DOE's announced intention to phase-out Hanford's production role, Hanford is being considered within the Reconfiguration PEIS to receive production operations relocated from Rocky Flats.

Savannah River Site

Plutonium processing facilities at SRS include the F-Canyon, FB-Line, New Special Recovery Facility, and HB-Line. SRS is preparing to take over processing of retired warheads from Rocky Flats and is a candidate for a new plutonium processing plant.

The Savannah River Site is located on over 300 square-miles of land about 12 miles southeast of Aiken, SC. SRS was built in the 1950's by E.I. du Pont de Nemours and Company which ran the plant until April 1, 1989. It is currently managed and operated by the Westinghouse Savannah River Company. Prior to Westinghouse assuming management, the facility was known as the Savannah River Plant (SRP).

SRS' F-Area has primary responsibility for plutonium operations. The F-Area's separations plant (called F-Canyon) and its B-Line, where plutonium nitrate solution is converted to oxide or metal, began operating in 1954. A facility for the fabrication of plutonium metal warhead components was constructed in the F-Area in the 1950's, but it never operated for that purpose, being used instead to produce reactor targets for the production of Pu-238.[121] The New Special Recovery (NSR) Facility, constructed on the roof of F-Canyon during the 1980's, was intended to significantly enhance SRS' dissolving

[119] *Reconfiguration Study*, p. 66.
[120] "ACNFS Final Report," p. 85.
[121] W.P. Bebbington, *History of Du Pont at the Savannah River Plant* (Wilmington, DE: E.I. du Pont de Nemours and Company, 1990), pp. 37 & 115. Hereafter Bebbington, 1990.

capabilities. However, startup of NSR has been delayed several times, most recently to await a redefinition of the facility's mission.

The H-Canyon, which began operations in 1955, is dedicated to tritium operations, processing uranium and neptunium, and the separation of Pu-238 for deep space missions and for the Defense Department. The HB-Line has recently been upgraded to prepare Pu-239 oxide from some feedstocks for storage or conversion to metal in the F-Area.

Recycle and Recovery Development

"For the 25 years between 1954 and 1979, the primary mission of the F-Area separations plant was the reprocessing of irradiated uranium targets for the recovery of the virgin plutonium-239."[122] While recycle and recovery operations were limited during this period, they were expanding.

From 1957 to 1959, operations in F-Canyon were halted. New dissolvers, "as large as could be fitted into the canyon cells," were installed, and a new plutonium finishing facility (then called JB-Line; now known as FB-Line) was constructed on the roof of the canyon.[123] Also, the use of sulfamic acid (as a replacement for nitric acid) was introduced for faster dissolution of relatively pure non-specification plutonium metal.[124] About 1970, dissolution capabilities were further expanded with the commencement of operations at the Special Recovery Facility,[125] which was installed in the FB-Line "as a temporary expedient to process a limited quantity of scrap."[126]

Throughout the 1970's, the United States replaced many weapons in the nuclear stockpile with newer ones. This resulted in an "increased flow of plutonium scrap" to SRS[127] and included the recycle of retired weapon components in the F-Canyon during the latter half of the decade.[128] However, existing equipment was designed to process relatively low concentrations of plutonium, and the introduction of retired components raised the possibility of a criticality accident.[129]

In fact, SRS facilities were not intended for many of their new functions. In 1982, DOE acknowledged that the Special Recovery Facility:

> ...was not designed for either the long term use that has occurred nor the higher radiation

[122] Leonard W. Gray, et al., "Plutonium Scrap Recovery At Savannah River -- Past, Present, and Vision of the Future," presented at the 12th Actinide Separations Conference (May 5, 1988), DP-MS-88-64, Rev. 2, p. 3. Hereafter "Plutonium Scrap Recovery at Savannah River."

[123] Bebbington, 1990, p. 71.

[124] Leonard W. Gray and John H. Radke, "Plutonium Scrap Recovery at the Savannah River Plant," presented at the International Symposium on Actinide Recovery, August 23-28, 1981, DP-MS-81-14 Rev., p. 5.

[125] "Plutonium Scrap Recovery at Savannah River," p. 3.

[126] DOE FY83 CBR, CPDS, p. 324.

[127] Authorization Request, E. I. du Pont de Nemours & Company, Atomic Energy Division, Savannah River Plant, Project No. S-4243, January 19, 1983, p. 2.

[128] Written response (April 25, 1991) to question submitted by ERF to DOE-SR on March 26, 1991.

[129] CRS, 1991, p. 18.

level materials that have had to be processed. Control of contamination, radiation, and maintenance scheduling requires ever increasing supervisory effort to assure safe operation. High radiation levels together with shielding that is inadequate to meet present standards limits the time personnel can perform operational and maintenance functions.[130]

Additional problems were attributed to the Special Recovery Facility's ties to the FB-Line:

> When the existing recovery facilities were installed, they were connected to JB-Line [now called FB-Line] service systems, such as solution transfer vacuum, vessel vent vacuum, cabinet ventilation, etc. These systems were designed to support the mainline process and no significant capacity modifications were made. These systems can neither adequately nor reliably support the present operations.[131]

During the 1980's, the scope of recovery operations at SRS continued to increase and included processing materials, particularly oxides, from the backlog at Rocky Flats. SRS also constructed a new plutonium recovery facility, modified some of its existing facilities, and pursued the application of processing techniques new to the site.

Two of these projects - construction of the New Special Recovery Facility and modifications to HB-Line - place SRS in a unique position to take over much of the processing previously done at RFP. Many of the other enhancements have been placed on hold pending a final decision on the proposal to permanently relocate Rocky Flats' operations.

New Special Recovery Facility

The New Special Recovery Facility was conceived as an upgrade of existing recovery operations. In 1980, DOE requested $6 million for improvements to the FB-Line's Special Recovery Facility "to dissolve off-site Pu-239 scrap and Pu-239 metal."[132] A year later, however, the "scope of work" increased, and the cost estimate jumped to $72 million to cover the design and construction of a new facility.[133]

Construction of NSR began in March 1983.[134] The plant's contractor predicted that, "The new facility will more than double present recovery capacity and will have the capability to process additional types of scrap materials."[135] Among other things, NSR was intended to help alleviate the backlog of plutonium oxide which had accumulated at Rocky Flats.

DOE anticipated completing construction in FY85.[136] Instead, during 1985 the cost

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[130] DOE FY83 CBR, CPDS, p. 324.

[131] Ibid.

[132] "Savannah River Plant, Nuclear Material Production and Defense Waste Management, Facilities Upgrading Study," DuPont, January 1980, p. VIII-45.

[133] "Savannah River Plant, Nuclear Material Production and Defense Waste Management, Facilities Upgrading Study," DuPont, February 1981, p. VIII-14.

[134] John C. Tuck, memorandum to P. N. Brush, August 15, 1990.

[135] Authorization Request, DuPont, Project No. S-4243, January 19, 1983, p. 4.

[136] DOE FY85 CBR, CPDS, p. 568.

estimate increased to $85.8 million. The additional funds were for construction of a plutonium storage facility to "provide storage space for 250 shipping containers containing plutonium bearing material....[both] incoming material and outgoing product."[137] Basic construction of NSR and the storage facility was completed in March 1989.[138] Startup had been expected in 1990, but by that time much of the oxide backlog at RFP had been processed in SRS' original Special Recovery Facility as well as in facilities at Los Alamos and Hanford.[139]

NSR's mission changed, and in 1990 DOE requested an additional $8.8 million from Congress to begin installing larger dissolvers. The larger units would allow more efficient dissolution of bulky, low-assay residues. Additionally, the money was to provide "capabilities for the recycle of plutonium parts from retired W62 [Minuteman missiles] and W68 [Poseidon missiles] weapons" at SRS rather than Rocky Flats.[140] However, work on these upgrades was stopped in 1991.[141]

Prior to stopping work on NSR, DOE stressed that the upgrades were to expand the facility's mission from scrap recovery to include warhead component recycling. The Energy Department indicated that SRS would be "the principal supplier of specification [plutonium] metal during the transition period" to Complex-21.[142] The Department also indicated that NSR would generate over five tons of transuranic waste and transuranic mixed waste, as well as one million gallons of radioactive liquid waste, per year.[143]

However, by January 1992, DOE no longer had a clear mission for the facility, and the Department decided to maintain NSR in "a shutdown condition." Startup activities will recommence "should future mission objectives require [NSR's] operation."[144] Possible future missions include processing residues from Rocky Flats and elsewhere in the complex and/or support for resumed fabrication of new warhead components.

Regardless of the mission, NSR cannot operate without the FB-Line. NSR will produce a plutonium nitrate solution; the FB-Line is necessary to convert this solution to plutonium oxide or metal. FB-Line has been shut down since January 1990, and delays in its restart are at least partly responsible for NSR not starting operations in 1991.

FB-Line

FB-Line has not operated since January 1990 when it was shut down for maintenance and planned upgrades. Several months before the shutdown, plutonium was discovered in the ventilation ducts at Rocky Flats. So, SRS officials performed an inspection of the ductwork at

137 DOE FY86 CBR, CPDS, p. 527.

138 John C. Tuck, memorandum to P. N. Brush, August 15, 1990.

139 J.G. McKibbin, interview with Brian Costner, April 8, 1992.

140 DOE FY90 Reprogramming Request, Enclosure B, p. 13, and "NEPA Documentation Recommendation for the New Special Recovery Facility," 1990, p. 2.

141 Written response (March 13, 1992) to question submitted by ERF to DOE-SR on February 28, 1992.

142 *Reconfiguration Study*, p. 159.

143 DOE-SR, "New Special Recovery Facility Waste Constituents," November 1990.

144 DOE FY93 CBR, Vol. 1, pp. 229-30.

FB-Line. The inspection "revealed significant, unanticipated accumulations" of plutonium. Steps have since been taken to remove this plutonium.[145]

Since the shutdown, other problems have been found which appear more difficult to resolve. A DOE safety review team concluded that, "In our view, substantial uncertainties exist as to whether the FB-Line can be operated at an acceptable level of safety." The reviewers noted that "some important safety systems have not been properly controlled or maintained during the 30 years of facility operation," and that the FB-Line has operated approximately ten years longer than originally expected "without formal consideration of aging effects."[146] Additional reviews are underway to better characterize problems and determine actions necessary to ensure safe operations. Related studies are not expected to be completed until 1996.[147]

However, DOE hopes to have FB-Line operating again in 1992. FB-Line will produce plutonium oxide or weapon-grade plutonium metal from feedstocks dissolved in the F-Canyon. Among the feedstocks DOE expects to process are plutonium scrap and residue generated on-site and from Rocky Flats, and components from retired nuclear warheads.[148] Absent any requirements for the material, the plutonium oxide or metal would likely be stored at SRS, possibly in the Plutonium Storage Facility described above or in other vaults.

HB-Line

HB-Line has primarily been used to oxidize neptunium-237 and Pu-238 received from the H-Canyon. The neptunium oxide was then made into target material for the SRS reactors to produce additional Pu-238. Pu-238 oxide is used as a power and heat source for some satellites and Department of Defense applications.

In 1979, DOE initiated a series of construction projects to "replace obsolete processing facilities in HB-Line."[149] These projects were designed to upgrade the facility's traditional abilities and add a new one - the processing of mixed oxide containing Pu-239 and Enriched Uranium (EU). According to DOE, HB-Line can now provide the nuclear weapons complex "with the unique capability of processing mixed oxide...to recover both the Pu-239 and the Enriched Uranium."[150]

Several DOE facilities have generated scrap material containing mixed oxide, including the Rocky Flats Plant; the Los Alamos, Lawrence Livermore, Argonne, and Brookhaven National Laboratories; and other sites.[151] Each of these facilities could ship materials to SRS for processing. In addition, DOE has requested funding to process retired weapon components

[145] "Restart Assessment of SRS FB-Line," DOE Office of Nuclear Safety, SRS-FB-91-01, August 14, 1991, p. 6.
[146] Ibid., pp. 4-6.
[147] Ibid., p. 8.
[148] DOE FY93 CBR, Vol. 1, pp. 229-30.
[149] HAC, FY83 EWDA, Pt. 4, p. 358.
[150] Written response (April 25, 1991) to question submitted by ERF to DOE-SR on March 26, 1991.
[151] Ibid.

containing Pu-239/EU.[152]

Pu-239-bearing feedstocks would be dissolved in HB-Line, and impurities removed from the resultant solution in the H-Canyon. The separated plutonium nitrate solution would then be returned to HB-Line for conversion to Pu-239 oxide. The Pu-239 oxide was to be transferred to the FB-Line for conversion to metal, possibly in late FY93 or FY94.[153] But with reduced defense requirements, the plutonium oxide will more likely be sent to F-Area for storage.[154]

Other Activities

Multipurpose Plutonium Facility

In December 1988, DOE completed its first complex-wide plan for modernizing production facilities - the "2010 Report." Westinghouse responded with its own proposal for SRS which included a Multipurpose Plutonium Facility. The facility was to be a pyrochemical and aqueous processing operation, providing support for an "economical, phased relocation of Rocky Flats."[155]

In April 1991, DOE indicated that "there is no projected or authorized project to construct this facility."[156] However, a report published in May 1991 indicates that the Multipurpose Plutonium Facility would entail "the complete renovation of a single canyon to provide a facility for permanent consolidation of all canyon processing" and projects funding for FY95.[157] The disparity between these statements appears to demonstrate that plans for the Multipurpose Plutonium Facility were progressing right up until DOE began the Reconfiguration Programmatic Environmental Impact Statement process in February 1991. It seems likely that the May report reflects information gathered prior to February.

Nonetheless, plans for consolidating canyon operations continue to garner support at SRS. Westinghouse's current manager of separations operations envisions the possibility of phasing out F-Canyon (possibly never starting up NSR) after processing some materials already on-site and cleaning out the facility's processing equipment. Materials currently awaiting processing in H-Canyon could probably be run by the mid to late 1990's. H-Canyon could then take over Pu-239 processing.[158]

Pyrochemical Development Laboratory

The Savannah River Site has no capability to use molten salt extraction, electrorefining,

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[152] DOE FY92 CBR, p. 209.

[153] Written response (May 21, 1991) to questions submitted by ERF to DOE-SR on April 25, 1991.

[154] J.G. McKibbin, interview with Brian Costner, April 8, 1992.

[155] "Defense Programs Facilities Modernization Implementation for the Savannah River Site Five Year Plan" (Westinghouse, May 1989, Predecisional Draft), p. iv.

[156] Written response (April 25, 1991) to question submitted by ERF to DOE-SR on March 26, 1991.

[157] "FY 1993 Savannah River Site Capital Assets Management Program," Deleted Version, May 1991, WSRC-RP-91-1173, Vol. I, p. 18.

[158] J.G. McKibbin, interview with Brian Costner, April 8, 1992.

or direct oxide reduction. But by 1988, SRS (then called SRP) had initiated aggressive plans to supplement its operations with pyrochemistry:

> To meet the long-term needs of plutonium scrap recovery within the DOE complex, SRP must complement its traditional aqueous-based chemistry with pyrochemical technology....The objective for pyrochemical processing techniques at Savannah River is to develop high-throughput processes for refractories and other hard-to-handle residues. The development of pyrochemical technology for scrap recovery will also put SRP in a position to accept an expanded plutonium mission.[159]

This expanded mission was to start with the installation of a Pyrochemical Development Laboratory in Building 235-F, located near H-Canyon, "to test new techniques or technology developed at LANL for possible utilization at SRS."[160] The laboratory was to have extensive capabilities for the development of production-scale applications of pyrochemistry to a wide variety of feedstocks:

> The laboratories will use full-scale equipment, allowing development work at the same scale as would be implemented in a production plant....The capabilities will include the standard pyrochemical operations of direct oxide reduction, molten salt extraction, electrorefining, and salt scrubbing, but will, more importantly, allow study of a wide range of typically unused but potentially highly beneficial pyroredox techniques....As feedstocks get leaner in plutonium content and as SRP's role in processing plutonium increases, aqueous methods will be augmented or supplanted by increasingly aggressive pyrochemical methods for recovering plutonium. Over the next ten years, a merging of aqueous and pyrochemical technology may be possible; it is anticipated that the merged system will become the preferred route for processing low-grade materials.[161]

An objective of "merging" aqueous and pyrochemical technology was to avoid the generation of a residue and salt backlog, like that which has accumulated at Rocky Flats. This would be accomplished by balancing the capacity of aqueous recovery of the residues and salts with the capacity for their generation through pyrochemical operations.

Total funding for the Pyrochemical Development Laboratory was estimated at $11 million, of which $5 million was authorized in 1989.[162] Funding continued in 1990. However, according to Westinghouse, "This proposal was terminated in March 1991 due to lack of funding, and there are no plans to reconsider this proposal."[163]

Plutonium Recovery Incinerator

A Pu-239 Recovery Incinerator was under development at SRS in the mid to late 1980's.

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[159] "Plutonium Scrap Recovery at Savannah River", pp. 7-11.

[160] Written response (April 25, 1991) to question submitted by ERF to DOE-SR on March 26, 1991.

[161] "Plutonium Scrap Recovery at Savannah River," pp. 11-13.

[162] Memo from P. W. Kaspar (Mgr., DOE-SR) to J. W. Crichton, et al (DuPont) February 2, 1989, and memo from H. A. Booth (Dir., Financial Management, DOE-SR) to M. W. Walcher (VP/GM, WSRC) August 8, 1989.

[163] Written response (April 25, 1991) to question submitted by ERF to DOE-SR on March 26, 1991.

The incinerator, to be located in FB-Line, would have burned combustible residues to "produce an ash amenable to Pu recovery" through subsequent PUREX processing.[164] DOE budget documents indicate that the incinerator was to undergo a "hot test" in FY88.[165] However these plans never materialized, and currently, according to DOE, "There are no plans to construct or operate a plutonium recovery incinerator at SRS."[166]

Remote Technology

In a 1989 report, SRS researchers discussed their ongoing efforts to develop "remote robotics technology...to support a new generation of plutonium production facilities."[167] These robotics were intended to increase processing efficiency and safety by replacing conventional glovebox handling facilities. During FY90, DOE planned to complete "demonstration of remote automation techniques" at SRS.[168]

Throughout the 1980's, DOE and both the site's prime contractors (DuPont and then Westinghouse) pursued the relocation of operations from Rocky Flats to SRS. This relocation was to have occurred through a series of planned upgrades to existing facilities, along with the construction of additional facilities as necessary. The New Special Recovery Facility, HB-Line upgrades, Multipurpose Plutonium Facility, and Pyrochemical Development Laboratory appear to be the most significant projects in this regard. Little information on these plans was made available to the public and no environmental impact statements on them were prepared.

As described in chapter one, DOE has now agreed to complete a Programmatic EIS on its plans to rebuild the nuclear weapons complex before making a final decision regarding the permanent relocation of Rocky Flats' operations. The Department anticipates that actions taken in the last decade have put SRS in the position to conduct many of RFP's functions until this decision is made and new facilities are built. However, for the short-term at least, there are no defense requirements for plutonium processing.

Other Sites

In February 1991, DOE issued an "Invitation for Site Proposals" which allowed state and local governments, and any other entity, to make an offer of at least 5,000 acres to the Department for the purpose of relocating operations from the Rocky Flats Plant. The invitation also requested offers of 10,000 acres to collocate operations from the Pantex Plant and/or the Oak Ridge Reservation along with Rocky Flats.[169] No bids were submitted.

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[164] Williams and Charlesworth, "Development of a Plutonium-239 Recovery Incinerator," Dupont-SRL, 1988.
[165] DOE FY89 CBR, Vol. 1, p. 216.
[166] Written response (April 25, 1991) to question submitted by ERF to DOE-SR on March 26, 1991.
[167] Heckendorn and Duncan, "Remote Robotic Technology Development for the new Plutonium Production Facility," Dupont-SRL, 1989.
[168] DOE FY91 CBR, Vol. 1, p. 180.
[169] "Invitation for Site Proposals," p. 1-2.

The only sites being considered are those selected by DOE. These are the Hanford Reservation and the Savannah River Site described above, as well as Pantex, Oak Ridge, and the Idaho National Engineering Laboratory. One of these sites could receive new facilities to continue operations from Rocky Flats, and possibly from Pantex and/or Oak Ridge. The purpose of collocating operations from other facilities along with Rocky Flats is to achieve maximum consolidation of the nuclear weapons complex.[170]

Past operations at Pantex, Oak Ridge, and INEL have included little or no plutonium production, processing, or fabrication. Following are very brief descriptions of these facilities.

Pantex Plant

The Pantex Plant occupies nearly 15,000 acres and is located about 17 miles northeast of Amarillo, Texas. Constructed in 1942, the plant was originally operated by the Army Ordnance Corps as a conventional ammunition shell and bomb loading facility. Today, Pantex is owned by DOE and operated by Mason and Hanger-Silas Mason Company, Inc., of Lexington, Kentucky.

Pantex fabricates high-explosive components which it assembles together with components received from elsewhere in the nuclear weapons complex into finished nuclear warheads. The plant is also responsible for maintenance, modification, and quality assurance testing of nuclear warheads already in the stockpile. Upon retirement from the stockpile, nuclear warheads are disassembled at Pantex. Plutonium components from disassembled warheads are stored on-site or sent off-site for recycling.[171] A more complete description of warhead dismantlement and plutonium storage at Pantex is contained in chapter one.

Oak Ridge Reservation

The 37,000-acre Oak Ridge Reservation is located approximately 20 miles northwest of Knoxville, Tennessee. It is managed for DOE by Martin Marietta Energy Systems. In 1942, the U.S. Army Corps of Engineers selected the area as the Manhattan Project's "Site X" for atomic bomb research and development. The reservation includes three distinct areas: X-10 (the Oak Ridge National Laboratory), K-25 (a gaseous diffusion plant), and Y-12.

X-10 is the site of the world's first plutonium production reactor. The reactor began operation in November 1943 and served as the model for reactors later built at Hanford. Early research into uranium enrichment and the separation of plutonium from irradiated reactor fuel also occurred at X-10. Plutonium operations at Oak Ridge ceased in December 1944.

The K-25 plant was built to produce highly-enriched uranium for warheads. In 1964, the plant shifted to the production of low-enriched uranium for civilian use. The K-25 plant stopped enriching uranium in 1985 and has since been used for various waste management

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[170] *Reconfiguration Study*, p. 32.

[171] *Nuclear Weapons Databook, Volume III*, pp. 76-79.

functions.

The Y-12 Plant was built in 1943. It's mission includes production of uranium components for nuclear weapons, along with fabrication of some non-nuclear parts and test devices for the weapon design laboratories, as well as other functions.[172]

Idaho National Engineering Laboratory

The Idaho National Engineering Laboratory is spread across 893 square miles and located 21 miles west of Idaho Falls. Its largest contractors are EG&G Idaho and Westinghouse Idaho Nuclear Company. INEL was established in 1949 as the National Reactor Testing Station to provide an isolated location for building and testing nuclear reactors and support facilities. Within a few years, fuel processing and nuclear waste storage began at the site. 52 reactors have been built at INEL - more than at any other location in the world. About a quarter of those still operate or are operable.

INEL's current mission includes numerous activities related to the U.S. Navy's nuclear reactor program, safety research for civilian nuclear reactors, reactor development, and nuclear waste and spent fuel management. Roughly 80 percent of INEL's budget is for defense-related projects.

The Idaho Chemical Processing Plant began operating in 1953. Its mission is to support nuclear weapons production by recovering enriched uranium from naval and other reactors for use as fuel in reactors at the Savannah River Site. However, the plant has been shut down since 1989 for noncompliance with a federal hazardous waste law - the Resource Conservation and Recovery Act. The future of the chemical processing plant is uncertain. INEL has also provided some plutonium for use in nuclear weapons research.[173]

[172] Ibid., pp. 65-75.
[173] Ibid., pp. 31-40.

CHAPTER FOUR. RECOMMENDATIONS

This chapter describes several recommendations to help ensure more responsible decision-making. These recommendations focus on the need for DOE to support an open discussion of issues related to plutonium operations and for the Department to fully absorb the significance of changes brought about by arms reductions.

The Cold War is over, and many of the basic assumptions which have justified nuclear weapons production for the last 50 years are no longer valid. DOE's plutonium operations are undergoing dramatic changes - the most significant since the nuclear weapons industry began. But the Energy Department's plans for these operations have yet to be fully reconciled with the changed assumptions of the post-Cold War world.

Before committing scarce national resources to an expensive course of action, the U.S. should develop the principles and policies that will guide its decisions. Moreover, DOE should release sufficient information on its operations to allow fully informed public involvement in decision-making, and the Department should encourage and facilitate such meaningful involvement.

Several recommendations flow from the findings of this report which, if adopted, could substantially improve the safety and cost-effectiveness of DOE's operations. Some of these recommendations can be implemented by DOE itself; others require participation by outside agencies and the public or action by Congress. These recommendations are divided into six areas: information flow, the value of plutonium, plutonium-bearing materials, international controls, facility safety, and resuming production.

Information Flow

After nearly 50 years of operating in virtual secrecy, the nuclear weapons complex should now be opened to greater outside scrutiny. There is clearly some information that should legitimately remain classified for national security reasons. But a great deal of information appears to be unnecessarily withheld without any indication that national security would be threatened by its disclosure. For example, DOE restricts public access to many of its environmental documents submitted to regulatory agencies for operating hazardous and radioactive waste facilities. Additionally, the number of warheads in the U.S. nuclear arsenal and the quantity of nuclear materials produced by DOE remains classified.

The public cannot be a full participant in decision-making processes unless it has available all of the information relevant to nuclear weapons production whose disclosure would not actually harm national security. The Department has made some progress toward releasing such information in recent years, though frequently only after repeated requests from citizen groups or legal action. If the public and policy-makers fail to comprehend the full range of reasonable alternatives, debate over the future of the complex will be distorted, and responsible, cost effective options may be missed.

To expand the release of information, congressional action will be necessary. However, regardless of congressional actions, open discussion cannot proceed without the full support and participation of DOE itself. A number of steps can be taken to facilitate an open discussion of issues affecting the nuclear weapons complex.

1) DOE should make available documents related to the need for future plutonium processing. Complete information regarding inventories and requirements for weapon-grade plutonium should be publicly available to allow a full and fair debate over the need for future plutonium operations and the construction of new facilities. DOE has often claimed that projects were essential to meet "production schedules" or to avoid "unilateral disarmament." In the 1980's, such claims were made about several plutonium-related projects, including: continued reactor production of plutonium, the Special Isotope Separation plant, and the Plutonium Recovery Modification Project. As it became clear that there was no real basis for these claims, public confidence in DOE plummeted.

   Information should be made available on the size and composition of the U.S. nuclear arsenal throughout the past fifty years, as well as its current size and composition, and future projections. DOE should also release an inventory of the number and types of nuclear weapons being retired and dismantled. Finally, DOE should make available total inventories of nuclear weapons materials contained within the arsenal, stockpiled or otherwise available for use in nuclear weapons, and contained in various materials such as scrap, oxide, and residue.

   Congress should review applicable laws and make the changes necessary to allow for open debate of the need for continued plutonium processing. Without such a debate, it is impossible to weigh the risks of plutonium operations against national security considerations or to make fully informed decisions regarding the future size and capabilities of the nuclear weapons complex. Further, as outlined below, the release of such information is essential to the success of international controls on nuclear weapons materials.

2) Congress and DOE should reevaluate current classification policies in light of the significant global changes affecting national security. DOE's labelling of documents as containing "Classified" or "Unclassified Controlled Nuclear Information" often severely limits the public's ability to understand operations throughout the nuclear weapons complex. The need to revise classification policies has been recognized for several years. Under the Reagan Administration, the President's Blue Ribbon Task Group on Nuclear Weapons Program Management concluded that:

   > One of the national security responsibilities of DOE leadership is to make available sufficient information to allow informed public debate on nuclear weapon issues. The Task Group urges that DOE review its classification procedures to ensure that criteria

are based upon current requirements rather than historical precedent.[175]

Under the current system, essentially all information on activities in the nuclear weapons complex is "born classified" and remains so until DOE affirmatively declassifies it. Rather than documents being "born classified," DOE should have to demonstrate that information contained within the documents meets specific criteria for restricted information before the material is withheld from the public. These criteria might be designed to protect information such as design drawings which would allow terrorists to gain access to critical facilities or to steal nuclear materials, as well as specific information on warhead designs. However, any exceptions should be as narrow as possible so as not to unduly hamper the public's access to information.

Additionally, DOE's Unclassified Controlled Nuclear Information (UCNI) category of controlled information should be eliminated. UCNI provisions allow DOE to restrict access to all sorts of nuclear information which is not in itself classified. The use of UCNI has resulted in excessive, unnecessary restrictions of information including environmental monitoring data, hazardous waste permit applications, and safety reports. DOE's use of this information control should be eliminated and replaced with the criteria-based approach described above.

Congress should direct and review changes made to classification policies, with DOE providing its full support and cooperation. Prior to their implementation, new classification policies should undergo public scrutiny and be revised as appropriate in response to public comments. Finally, Congress should make statutory changes as necessary to further the goal of increased public access to information.

3) <u>DOE should release all documents related to environmental, safety, and health issues associated with operations throughout the nuclear weapons complex.</u> Restricted access to information about existing and potential environmental, safety, and health impacts of DOE's operations should be eliminated. Documents describing safety issues at DOE facilities are essential to an understanding of the risks associated with operations. Further, the public deserves a full accounting of radioactive and hazardous chemical releases from DOE facilities.

DOE should devote the necessary resources to a full review of documents in its possession, as well as those in the possession of its contractors. These documents should then be made available to the public and independent researchers. As changes are made to DOE's classification system, deleted versions of documents should be reviewed again to determine if the deleted information is still considered restricted.

4) <u>DOE should provide sufficient resources to allow for the timely release of information.</u> Each of DOE's field offices, and DOE headquarters itself, handles hundreds of information requests every year. As the public becomes more aware of activities within the nuclear weapons complex, the number of such requests will increase. Currently, only

[175] "Report of the President's Blue Ribbon Task Group on Nuclear Weapons Program Management," July 1985, p. 13.

a handful of staff, operating with limited resources, are available at each site to fill these requests. Delays of months, or even years, are not uncommon; in fact, such delays are the norm. DOE should increase the number of staff available to handle information requests from the public, including the number of staff authorized to review restricted information for release, and ensure that these individuals have sufficient resources to carry out their responsibilities in a timely manner.

The Value of Plutonium

Energy Department officials have suggested that surplus plutonium be stockpiled for possible energy production or for weapons to potentially provide some return on the billions of dollars invested in plutonium production. As described in chapter one, DOE views as valuable the thousands of pounds of plutonium contained in warheads being retired from the U.S. nuclear arsenal. Additionally, DOE is preparing a policy on Plutonium Discard Limits, and it appears that the Department intends to continue recovery operations to add to the plutonium stockpile.

The principal option that could potentially provide a return on the nation's investment in plutonium is using plutonium in commercial reactor fuel. However, this option faces significant environmental and political hurdles. Moreover, the economic value of using plutonium in commercial fuel is uncertain, at best. Before the energy potential of plutonium is used to justify future plutonium processing, there should first be a clear policy established regarding the commercial use of plutonium.

Before such a policy is developed, substantially more information should be made available on the quantity of plutonium in DOE's possession, the economic, safety, and environmental implications of using plutonium in commercial reactors, and the arms control and proliferation considerations associated with this proposal. Further, the Nuclear Regulatory Commission has suggested that developing such a policy will require new rules for the safeguarding of nuclear materials at commercial facilities and a "comprehensive" Environmental Impact Statement.[176] Such an EIS should examine the use of plutonium in reactor fuel and the complete range of options available for the management of plutonium and plutonium-bearing materials. Alternatives which involve solely the storage and eventual direct disposal of plutonium as waste should be fully considered in the EIS.

The second argument for stockpiling plutonium is its potential use in future weapons production. However, the need to stockpile plutonium for this purpose is unclear. Before becoming the basis for continuing operations, there should be a national debate on the role of a weapon-grade plutonium stockpile in light of ongoing international developments. This issue is further addressed below under the heading **Resuming Production**.

Absent a national policy requiring its use, plutonium should be considered a liability. Existing plutonium inventories require extensive safeguards, monitoring, and other controls.

[176] James M. Taylor (NRC Ex. Dir., Operations), "Disposition of the Weapons Grade Nuclear Material from Decommissioned Nuclear Weapons," memo to NRC Commissioners, February 25, 1992, SECY-92-064, pp. 4-5.

Maintaining these controls for extended periods will be very costly. Ultimately plans would need to be developed for plutonium's permanent disposal.

Pending a determination about whether plutonium is an asset or a liability, plutonium and plutonium-bearing materials can be safely secured, stored, and monitored if necessary controls are in place. The storage regime should provide for compliance with existing and future international verification agreements, containment of the plutonium itself (with emphasis on preventing releases to the environment as well as theft of the material), control of oxidation, and independent oversight.

If the nation ultimately decides to proceed with a policy of stockpiling plutonium for potential use, then related operations should be funded through DOE's defense programs and/or nuclear energy program budgets - not through the Department's Environmental Restoration and Waste Management account. Scarce environmental funds should only be used for plutonium operations after a decision is made to permanently dispose of the plutonium or plutonium-bearing materials as waste.

Plutonium-Bearing Materials

Future operations at DOE's plutonium processing facilities should be principally driven by environmental, safety, and economic considerations. As described in chapter two, there are more than 100 categories and sub-categories of plutonium-bearing materials, including: scrap plutonium, laboratory equipment, filters, glovebox gloves, impure oxides, spent salts, and liquid processing residues. The quantity of plutonium contained in these materials ranges from very slight to a few kilograms. Different types of material pose differing degrees of risk and difficulty in handling, and for some materials there is no established recovery process. Management practices should be tailored to the nature of the particular scrap, oxide, or residue.

DOE should prepare Environmental Impacts Statements and other reviews before making decisions about the management of plutonium-bearing materials. Additionally, the Department should publish any proposed guidance establishing Plutonium Discard Limits for formal rule making. Further steps should also be taken to facilitate the development of a sound process for the responsible management of scrap, oxide, and residue, as well as the future operation and the decontamination and decommissioning of plutonium processing facilities.

1) <u>DOE should assess and characterize plutonium-bearing materials (scrap, oxide, and residue) throughout the nuclear weapons complex and release an unclassified report on its current and projected inventory.</u> While such an assessment has apparently begun at some DOE sites, currently it is neither comprehensive nor publicly available. A full inventory of plutonium-bearing materials (including a listing of uncertain and unknown quantities of materials) should provide the basis for identifying appropriate management alternatives, as well as increasing the public's understanding of the rationale for future activities. One additional goal of such an assessment should be to identify existing and potential environmental, safety, and health problems associated with the materials in

their current forms.

2) An advisory committee should prepare an analysis of options for the management of plutonium-bearing materials. A committee of representatives from federal, state, and tribal governments, workers at DOE facilities, and industry and public interest groups should develop a series of recommendations for the management of plutonium-bearing materials. The recommendations should be tailored to the nature of the full spectrum of scrap, oxide, and residue forms and should consider the life cycle costs of various management options. The committee should explore techniques for stabilizing and containing materials, recovering plutonium, and developing policies for the long-term disposition of plutonium. Particular attention should be given to the handling of wastes which would be generated as a by-product of proposed options.

   Recognizing that several advisory committees are being established and proposed to help address issues within the nuclear weapons complex, it may be possible that these responsibilities be given to an existing committee. Alternatively, if a new advisory committee is established for these purposes, then perhaps the committee might also take on other responsibilities. Regardless, appropriate technical and other resources should be provided to the advisory committee, and while DOE should participate in this process, the Department should not exercise any control over the conduct of the committee's work or the nature of the recommendations.

International Controls

As explained in chapter one, many of the current initiatives to reduce the size of the nuclear arsenal are unilateral and lack verification requirements. This has raised numerous concerns about the proliferation of nuclear weapons or nuclear materials from the former Soviet Union and about the ability to pursue deeper cuts in the world's nuclear arsenals. As some observers have commented:

> ...if the Reagan-Bush administrations had heeded the congressional call, beginning in 1983, for a verified fissile material production cutoff followed by verified warhead dismantlement and demilitarization of the removed fissile materials under international safeguards [then t]oday there would be hundreds of U.S. and international inspectors all over the republics of the [former Soviet Union]; Soviet plutonium production reactors would be shut down; tritium production reactors would be closed or under bilateral safeguards; fissile material components of weapons retired without replacement would be stored under bilateral safeguards; and all civil reactors, nuclear fuel cycle facilities, and civil stocks of fissile material would be under international safeguards.[177]

Despite the delay, the U.S. could still undertake several steps to ensure the verification of dismantlement and storage activities. If supported by the U.S., it appears that officials of

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[177] FAS/NRDC Report, p. iv.

the former Soviet Union would also adopt such measures. Specific recommendations include:

1) The U.S. should initiate a data exchange, including the total number of warheads of each type, the serial numbers and locations of warheads, and the total inventory by weight of plutonium and highly-enriched uranium metal in and outside of warheads.

2) The U.S. should initiate technical discussions with former Soviet officials on verification of the warhead dismantlement process itself, including procedures for tagging all warheads or their sealed containers.[178]

3) The U.S. should formally declare a moratorium on the production of nuclear weapons materials and pursue the establishment of a verified, permanent agreement banning the production of fissile materials for weapons worldwide.

Facility Safety

Substantial concerns about the safety of DOE facilities have been raised in many years. Several steps can be taken to improve conditions throughout the nuclear weapons complex.

1) DOE should develop an effective safety policy. The inadequacies of DOE's current safety policy were emphasized by the Department's Advisory Committee on Nuclear Facility Safety in its November 1991 final report:

> The DOE policy substitutes "continuous improvement" for measurable standards, pays little attention to the largely chemical nature of the risk at some Department facilities, neglects the major risk to the workers, and treats the inevitable conflict between the Department's safety and production responsibilities by simply asserting that they are "compatible." That is inadequate guidance for those who must, in the end, make practical day-to-day decisions....The alternative to a meaningful safety policy is confusion, public opposition, disarray in the establishment of safety regulations, inconsistency among organizations, undisciplined regulation, and, ultimately, disaster.[179]

The Advisory Committee did not recommend suspending operations until a meaningful safety policy could be developed. However, in light of the dramatically reduced need for nuclear weapons materials, this alternative should be given serious consideration. At a minimum, all unnecessary and deferrable operations should be suspended pending the development of a meaningful safety policy. Without such a policy in place, there is not an adequate basis for assessing the risk of operations and ensuring adequate protection for workers, the public, and the environment.

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178 Ibid., p. iii.
179 "ACNFS Final Report," p. 5.

2) DOE should update its Safety Analysis Reports. Safety Analysis Reports assess the risks of operating facilities and provide the basis for establishing operating requirements to ensure safety. Many of the Safety Analysis Reports for DOE facilities are outdated, do not comply with current requirements for such reports, and fail to consider factors associated with minimal operation of facilities or maintenance of facilities in a non-operating ("standby" or "shutdown") mode.

As plutonium requirements change, the mission of many DOE facilities is also changing. Safety considerations for a shutdown plant, with its smaller staff, are not necessarily the same as for one in full production. If precautions are not taken, corrosion, leaks, and other potentially dangerous events can occur even if a plant is not operating. Requirements of monitoring and safety systems may be different if personnel are not routinely operating plant systems. Additionally, detection and response times may be longer in a shutdown plant because of reduced staffing levels.

DOE's Office of Nuclear Safety has recognized the need for Safety Analysis Reports and their associated requirements to consider all facility operating modes, including standby and shutdown. The Office of Nuclear Safety recommended that these reports "explicitly consider the need to maintain operability of essential equipment, aging effects, and activities necessary to decontaminate and decommission" facilities.[180] Given the magnitude of changes taking place throughout the nuclear weapons complex, it is reasonable to expect that these issues should be addressed before DOE makes decisions about upgrades and long-term operations at its plutonium processing facilities.

3) DOE should involve the public in accelerated planning for the safe shut down of its facilities. The Energy Department has only begun developing plans for the shut down and eventual decontamination and decommissioning of its production facilities. Such plans are essential to the successful retirement of these facilities and will establish the basis for much of the long-term risk associated with the nuclear weapons complex.

Development of these plans should be accelerated and conducted openly, with ample opportunity for public involvement. In particular, citizens living in communities affected by DOE operations should be encouraged to become involved in this long-term planning. Such involvement might be facilitated through the use of site-specific advisory boards, as has been recommended to oversee cleanup operations.[181]

4) DOE should allow for independent licensing of new production facilities. Many of the safety problems currently plaguing the nuclear weapons complex have been attributed to the lack of independent oversight and violation of critical environmental laws and regulations. In order to best ensure the safety of any new production facilities, they should be subject to independent licensing by the Nuclear Regulatory Commission.

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[180] Office of Nuclear Safety, *Report of an Investigation into Deterioration of the Plutonium Fuel Form Fabrication Facility (PuFF) at the Savannah River Site* (Washington, DC: DOE, October 1991), p. 3.
[181] U.S. Congress, Office of Technology Assessment, *Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production* (Washington, DC: U.S. Government Printing Office, February 1991), pp. 139-41.

Resuming Production

Reducing the number of nuclear weapons in the arsenal without producing new weapons would substantially minimize the costs and consequences of operations throughout the nuclear weapons complex. This approach would allow DOE to concentrate scarce resources on cleanup activities, including the decontamination and decommissioning of production facilities.

If new weapons are to be produced, then DOE should promote maximum reliance on the reuse of intact warheads, plutonium pits, and other components. As described in chapter one, completed and ongoing research suggests that new options may be available if it is decided to resume production. The feasibility of available options should be fully and openly evaluated prior to any decision regarding the upgrade of existing production facilities or the construction of new facilities.

Additionally, Congress and the American public should openly debate the role of a nuclear arsenal in light of the dramatic global changes that have occurred. Consideration of a full range of possible stockpile sizes - from zero to a few hundred, to a few or several thousand warheads - should precede decisions about the future of plutonium operations and the entire nuclear weapons complex.