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List of Acronyms

ATR	Advanced Test Reactor
ATW	Accelerator Transmutation of Waste
CLWR	commercial light water reactor
CANDU	Canadian Deuterium Uranium
DOE	U.S. Department of Energy
EA	environmental assessment
FDPF	Fluorinel Dissolution Process Facility
FFTF	Fast Flux Test Facility
FMEF	Fuels and Materials Examination Facility
FONSI	finding of no significant impact
Hanford	Hanford Site
HFIR	High Flux Isotope Reactor
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LANL	Los Alamos National Laboratory
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NEPO	Nuclear Energy Power Optimization
NERAC	Nuclear Energy Research Advisory Committee
NERI	Nuclear Energy Research Initiative
NI PEIS	*Draft Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility*
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCAST	President's Committee of Advisors on Science and Technology
REDC	Radiochemical Engineering Development Center
RPL	Radiochemical Processing Laboratory
SRS	Savannah River Site
TRIGA	training, research, isotopes General Atomics (reactor)

Summary

S.1 PURPOSE AND NEED FOR AGENCY ACTION

Under the authority of the Atomic Energy Act of 1954, as amended, the U.S. Department of Energy (DOE) is responsible for ensuring the availability of isotopes for medical, industrial and research applications, meeting the nuclear material needs of other Federal agencies, and undertaking research and development activities related to development of nuclear power for civilian use.

To meet these responsibilities, DOE maintains nuclear infrastructure capabilities that support various missions in areas such as nuclear materials production and testing, research, and development activities related to civilian applications of nuclear power. These infrastructure capabilities include research and test facilities such as research reactors and accelerators used for steady-state neutron irradiation of materials to produce radionuclides, as well as shielded "hot cell" and glovebox facilities used to prepare materials for testing and/or to handle postirradiation materials. An additional component of this infrastructure is the highly trained workforce that specializes in performing complex tasks that have been learned and mastered over the life of these facilities.

Over the years, DOE's nuclear facility infrastructure has diminished because of the shutdown of aging facilities, recent examples being the High Flux Beam Reactor at Brookhaven National Laboratory, New York, and the Cyclotron Facility at Oak Ridge National Laboratory, Tennessee. This, in turn, has hampered DOE's ability to satisfy increasing demands in various mission areas. To continue to maintain sufficient irradiation facilities to meet its obligations under the Atomic Energy Act, DOE must assess the need for expansion of its existing nuclear infrastructure in light of its commitments to ongoing programs, its commitments to other agencies for nuclear materials support, and its role in supporting nuclear research and development programs to maintain the viability of civilian nuclear power as one of the major energy sources available to the United States. The proposed expansion of nuclear infrastructure capabilities is in response to the programmatic needs of DOE's Office of Nuclear Energy, Science and Technology and does not include programmatic needs of other program offices within DOE, including those of the Office of Science.

The Nuclear Energy Research Advisory Committee (NERAC) was established in 1998 by DOE in accordance with the Federal Advisory Committee Act to provide independent, expert advice on complex science and technical issues that arise in the planning, management, and implementation of DOE's civilian nuclear energy research programs. The chairman of NERAC has informed the Secretary of Energy that:

- "There is an urgent sense that the nation must rapidly restore an adequate investment in basic and applied research in nuclear energy if it is to sustain a viable United States capability in the 21st Century."

- "[T]he most important role for DOE [Office of Nuclear Energy, Science and Technology] in the nuclear energy area at the present time is to ensure that the education system and its facility infrastructure are in good shape."

- "Of particular need over the longer term are dependable sources of research isotopes and reactor facilities providing high volume flux irradiation for nuclear fuels and materials testing" (NERAC 2000a).

Under the guidance of NERAC, DOE has also completed an internal assessment of its existing nuclear facility infrastructure capabilities. This *Nuclear Science and Technology Infrastructure Roadmap* evaluates the existing DOE infrastructure, and identifies gaps in that infrastructure for meeting projected demands (DOE 2000a). The basic finding of this assessment also concluded that the capabilities of currently operating DOE facilities will not meet projected U.S. needs for nuclear materials production and testing, research, and development.

Consistent with these findings, DOE recognizes that adequate nuclear research reactor, accelerator, and associated support facilities must be available to implement and maintain a successful nuclear energy program. As demand continues to increase for steady-state neutron sources needed for isotope production and nuclear research and development, DOE's nuclear infrastructure capabilities to support this demand have not improved. To continue meeting its responsibilities under the Atomic Energy Act and to satisfy projected increases in the future demand for isotope products and irradiation services, DOE proposes to enhance its existing nuclear facility infrastructure to provide for: (1) production of isotopes for medical, research, and industrial uses, (2) production of plutonium-238 for use in advanced radioisotope power systems for future National Aeronautics and Space Administration (NASA) space exploration missions, and (3) support of the Nation's nuclear research and development needs for civilian application.

To evaluate the potential environmental impacts associated with this proposed enhancement, DOE has prepared the *Draft Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility* (*Nuclear Infrastructure Programmatic Environmental Impact Statement* [NI PEIS]). For purposes of analysis, the NI PEIS evaluates impacts from facility construction, modification, startup, and 35 years of operation, followed by decommissioning when applicable. The 35-year operating period is based upon the estimated length of time existing DOE irradiation facilities would continue operating if used for accommodating these missions. This timeframe also accommodates current projections that indicate the demand for radioisotopes and nuclear research and development will extend for at least the next 20 years (Wagner et al 1998; NERAC 2000b; DOE 2000a).

Medical and Industrial Isotope Production. Over the past few decades, isotopes have become vital tools for use in medicine, industry, and scientific research. Isotopes, including both radioisotopes and stable isotopes, play a particularly important role in medical diagnosis, treatment, and research. Currently, more than 12 million nuclear medicine procedures are performed each year in the United States, and approximately one-third of all patients admitted to U.S. hospitals undergo at least one medical procedure that employs the use of medical isotopes (NERAC 2000b). Medical isotopes are produced in the United States by DOE in nuclear reactors and particle accelerators. In limited cases, some medical isotopes can also be produced by extracting them from existing radioactive materials. Radioisotopes are used for both diagnosis and therapy. Diagnostic radioisotopes are used for imaging internal organs. Unlike conventional radiology, imaging with radioisotopes reveals organ function and structure, which provides additional data for a more accurate diagnosis, and assists in the early detection of abnormalities. In ongoing clinical testing, therapeutic isotopes have proven effective in treating cancer and other illnesses by cell-directed localized radiation therapy (i.e., deploying antibodies or carriers of radioactive isotopes to seek and destroy invasive cancer cells). This directed therapy can minimize adverse side effects (e.g., healthy tissue damage, nausea, hair loss), making it an effective, attractive alternative to traditional chemotherapy or radiation treatments.

For nearly 50 years, DOE has actively promoted the use of radioisotopes to improve the health and well-being of U.S. citizens. DOE's use of its unique technologies and capabilities to develop isotopes for civilian purposes has enabled the widespread application of medical and industrial isotopes seen today. DOE must provide an adequate supply of isotopes to keep pace with the growing and changing needs of the research community if it is to continue to serve this key role.

An Expert Panel convened by DOE recently reviewed several industry projections for growth in demand for medical isotopes. The Expert Panel concluded that the growth rate in medical isotope use will be significant over the next 20 years (Wagner et al. 1998). Specifically, the Expert Panel estimated that the expected growth rate of medical isotope use during the next 20 years will range between 7 to 14 percent per year for therapeutic applications, and 7 to 16 percent per year for diagnostic applications. The panel noted that these growth rates are attainable only if basic research in nuclear medicine is supported and modern, reliable isotope production facilities are available. DOE and NERAC have adopted the following findings and recommendations provided by the Expert Panel.

- Several isotopes have proven their clinical efficacy, but supply and cost concerns could dramatically affect the use of these isotopes in the practice of nuclear medicine.

- Although commercial and research applications for certain isotopes have been developed or are being developed, their limited availability and high prices are inhibiting their use in clinical applications.

- Research isotopes that have shown promise as diagnostic and therapeutic materials are not being explored because of their lack of availability or high price.

- At present, there is no domestic production facility to guarantee the continued supply of many of these isotopes.

- To meet current and future needs of the biomedical sciences community, the Expert Panel recommended:

> . . . the United States develop a capability to produce large quantities of radionuclides [radioisotopes] to maintain existing technologies and to stimulate future growth in the biomedical sciences. The successful implementation of such a program would help insure our position as an international leader in the biomedical sciences well into the twenty-first century. The panel recommends that the U.S. Government build this capability around a reactor, an accelerator, or a combination of both technologies as long as isotopes for clinical and research applications can be supplied reliably, with diversity in adequate quantity and quality.

In its recent report from the Subcommittee for Isotope Research and Production Planning, NERAC further identified that:

> It is now widely conceded that limited availability of specific radionuclides is a constraint on the progress of research. The problem is especially apparent in a number of medical research programs that have been terminated, deferred, or seriously delayed by a lack of isotope availability . . . The lack of radionuclides significantly inhibits progress in evaluating a host of promising diagnostic and therapeutic drugs in patients with debilitating and fatal diseases, examining fundamental basic science questions, studying human behavior and normal growth and development, and exploring the aging process and the products of transgene expression . . . the DOE long-term goal to have a reliable isotope supply system in place that would enable scientists to bring their creative ideas into practical use safely, quickly and efficiently is appropriate, be it basic science research, clinical medicine, or industrial endeavors. The discovery and dissemination of new knowledge should continue to be a core mission, and basic science and the application of basic science to clinical research discoveries to improve the diagnosis and treatment outcomes should be a crucial component of that mission. [DOE], in providing a federal system for the reliable supply of stable and radioactive isotopes for

research, will be an important aspect of fulfilling the federal responsibility to support biomedical research (NERAC 2000b).

Currently, approximately 50 percent of DOE's isotope production capability is being utilized. Much of the remaining isotope production capability is dispersed throughout the DOE complex. This capability supports secondary missions and cannot be effectively utilized due to the operating constraints associated with the facilities' primary missions (basic energy sciences or defense). Assuming a midpoint growth curve for future isotope demand and ensuring a diversity and redundancy of isotope supply, it is likely that DOE's isotope production facilities will be fully used within a 5- to 10-year timeframe if no enhancements to the existing nuclear facility infrastructure are implemented. This projection is made in the context of a worldwide market for radioisotopes. Although DOE's market share is a small fraction of the overall total, it is very significant for some radioisotopes and particularly important for a large number of radioisotopes that are used in relatively small quantities for research. These isotopes, which are used almost exclusively by researchers at universities and hospitals, are not purchased in quantities that would permit private industry to take over their production. However, DOE may need to significantly increase the production levels of these radioisotopes as world demand changes and promising research developments in their medical use are brought to commercialization.

Recent analyses indicate that the greatest challenge to meeting projected isotope market requirements over the next 20 years will be in the area of therapeutic medical isotopes, several of which are currently unavailable or are available only in limited quantities (Battelle 1999). For the purpose of analysis in the NI PEIS, a representative set of isotopes was selected on the basis of the recommendations of the Expert Panel, medical market forecasts (Frost & Sullivan 1997), reviews of medical literature, and more than 100 types of ongoing clinical trials that use radioisotopes for the treatment of cancer and other diseases. Currently, these medical applications primarily involve the diagnosis and treatment of three major classes of disease—cancer, vascular disease, and arthritis. Although these isotopes are a representative sample of possible isotopes that could be produced, DOE expects that the actual isotopes produced as a result of the proposed action would vary from year to year in response to the focus of clinical research and the specific market needs occurring at that time.

Industrial isotope applications fall into three broad categories: nucleonic instrumentation, irradiation and radiation processing, and technologies that use radioactive tracers. Examples of nucleonic instrumentation include gauges for measuring physical parameters, e.g., detection systems for pollutants, explosives, drugs, ores, petroleum, and natural gases; nondestructive testing by gamma radiography; and smoke detectors. Irradiation and radiation processing technologies include radiation sterilization of food and medical products and the curing of plastics. Radioactive tracer applications include studies of chemical synthesis reactions; mass transfer monitoring in industrial plants; analysis of the transport and uptake of nutrients, fertilizers, herbicides, and waste materials in plants, soils, and groundwater; and laboratory-based studies of the properties of materials.

In proposing to enhance radioisotope production missions, DOE intends to continue to complement the commercial availability of these radioisotopes. Consistent with current isotope production activities, DOE will continue to make its facilities available to the private sector to support production and sales of isotopes.

Plutonium-238 Production for Space Missions. As part of its charter under the Atomic Energy Act, DOE and its predecessor agencies have been developing and supplying radioisotope power systems (radioisotope thermoelectric generators and radioisotope heater units) to NASA for space exploration for more than 30 years. Previous NASA space missions that have used radioisotope power systems include the Apollo lunar scientific packages and the Pioneer, Viking, Voyager, Galileo, and Ulysses deep space probes. More recent missions include the Mars Pathfinder mission launched in 1996 and the Cassini mission launched in 1997. These radioisotope power systems have repeatedly demonstrated their performance, safety, and reliability in various

NASA space missions. Without these power systems, these types of space exploration missions could not be performed by NASA.

The radioisotope used in these power systems is plutonium-238. Through a Memorandum of Understanding with NASA, DOE provides these radioisotope power systems, and the plutonium-238 that fuels them, for space missions that require or would be enhanced by their use (DOE 1991). In addition, under the National Space Policy issued by the Office of Science and Technology Policy in September 1996, and consistent with DOE's charter under the Atomic Energy Act, DOE is responsible for maintaining the capability to provide the plutonium-238 needed to support these missions. The Intersector Guidelines section of the National Space Policy states that, "The Department of Energy will maintain the necessary capability to support space missions which may require the use of space nuclear power systems." Although research to identify other potential fuel sources to support these space exploration missions has been conducted, no viable alternative to using plutonium-238 has been established. Similarly, NASA has yet to identify or demonstrate technologies that can viably replace plutonium-238-fueled radioisotope power systems for use in deep space missions (NASA 1995).

Historically, the reactors and chemical processing facilities at DOE's Savannah River Site (SRS) were used to produce plutonium-238; however, downsizing of the DOE nuclear weapons complex resulted in the shutdown of the last remaining SRS operating reactor, K-Reactor, by early 1996. Also, in 1992 then-Secretary of Energy Watkins issued a decision to phase out operations at the two chemical processing facilities (F-Canyon and H-Canyon) at SRS. In accordance with that decision, the separation facilities are planned to be shut down following completion of their current missions to stabilize and prepare for disposition of Cold War legacy nuclear materials and certain spent nuclear fuel, and a determination that a new nonchemical processing technology is capable of preparing aluminum-based research reactor spent nuclear fuel for ultimate disposition.

Because the supply of plutonium-238 produced at SRS to support NASA space missions is limited, DOE signed a 5-year contract in 1992 to purchase plutonium-238 from Russia, authorizing the United States to purchase up to 40 kilograms (88.2 pounds) of plutonium-238, with the total available for purchase in any one year limited to 10 kilograms (22 pounds). Under this contract, DOE purchased approximately 9 kilograms (19.8 pounds) of plutonium-238 on an as-needed basis, an amount that also reflects the available U.S. inventory that has been reserved for space missions.[1] Larger individual quantities have not been purchased by DOE due to budget constraints. Also, purchase on an as-needed basis has avoided the costs from processing the plutonium-238 to remove the decay products that would result from storing it for an extended period of time. In 1997, DOE extended the contract for another 5 years; therefore it is set to expire in 2002. Any further extensions to the contract would need to be negotiated.

The political and economic climate in Russia creates uncertainties that could affect its reliability as a source of plutonium-238 to satisfy future NASA space mission requirements. Moreover, information is limited concerning the extent of the Russian supply, Russian plans on how they would satisfy future demand, and the nuclear safety and nonproliferation implications of the Russian production methods. The long-term viability of pursuing additional contract extensions or entering into a new contract is unclear, whereas the current inventory of plutonium-238 for space missions is expected to be depleted by approximately 2005 if currently projected missions are implemented. In 2000, NASA provided preliminary guidance to DOE to plan for the potential use of radioisotope power systems for the Pluto/Kuiper Express mission scheduled for launch in 2004, the Europa Orbiter mission scheduled for launch in 2006, and the Solar Probe mission scheduled for launch in 2007 (NASA 2000). The Pluto/Kuiper Express mission would require approximately 7.4 kilograms

[1] The environmental impacts of purchasing plutonium-238 from Russia are evaluated and documented in the *Environmental Assessment of the Import of Russian Plutonium-238* (DOE/EA-0841, June 1993), prepared by DOE's Office of Nuclear Energy.

(16.3 pounds) of plutonium-238, and the Europa Orbiter and Solar Probe missions would each require approximately 3 kilograms (6.6 pounds) of plutonium-238. DOE is also planning to provide radioisotope heater units for several NASA Mars Surveyor missions over the next decade, each of which would require approximately 0.3 kilograms (0.7 pounds) of plutonium-238. Although future space mission schedules over a long-term planning horizon of 20 to 35 years cannot be specified at this time, DOE anticipates that NASA space exploration missions conducted during this period will continue to require plutonium-238-fueled power systems. A plutonium-238 production rate of 2 to 5 kilograms (4.4 to 11 pounds) per year would be sufficient to meet these estimated long-term requirements.

Because it is not in the best interest of the United States to continue relying on foreign sources to provide an assured, uninterrupted supply of plutonium-238 to satisfy future NASA space exploration mission requirements, DOE proposes to re-establish a domestic capability for producing and processing this material. Since the SRS facilities previously used for plutonium-238 production are no longer available, DOE needs to evaluate other DOE irradiation and chemical processing facilities, as well as potential commercial light water reactors (CLWRs), for this mission. Unless an assured domestic supply of plutonium-238 is established, DOE's ability to support future NASA space exploration missions may be lost.

Nuclear Energy Research and Development for Civilian Applications. Nuclear energy is an important contributor in reducing greenhouse gas emissions in the United States, Asia and Europe. Globally, nuclear energy produces 17 percent of the world's electricity. In the United States, nuclear energy generated 20 percent of all electricity consumed in 1999. In view of these energy and environmental contributions, there is a renewed interest in nuclear power to meet an equivalent portion of the Nation's future expanding energy requirements.

In January 1997, President Clinton tasked his Committee of Advisors on Science and Technology (PCAST) to evaluate the current national energy research and development portfolio and to provide a strategy that ensures the United States has a program to address the Nation's energy and environmental needs for the next century. In its November 1997 report responding to this request, the PCAST Energy Research and Development Panel determined that restoring a viable nuclear energy option to help meet our future energy needs is important and that a properly focused research and development effort to address the potential long-term barriers to expanded use of nuclear power (e.g., nuclear waste, proliferation, safety, and economics) was appropriate. The PCAST panel further recommended that DOE reinvigorate its nuclear energy research and development activities to address these potential barriers.[2]

It is the policy of this Administration that clean, safe, reliable nuclear power has a role today and in the future for our national energy security. Recognizing this need, the Administration and the Congress have initiated two significant new nuclear energy research and development programs: the Nuclear Energy Research Initiative (NERI) and Nuclear Energy Power Optimization (NEPO). The NERI program sponsors new and innovative scientific and engineering research and development to address the potential long-term barriers identified by the PCAST Panel affecting the future use of nuclear energy. The NEPO program, a cost-shared program with industry, sponsors applied research and development to ensure that current nuclear plants can continue to deliver adequate and affordable energy supplies up to and beyond their initial 40-year license period by resolving open issues related to plant aging, and by applying new technologies to improve plant reliability, availability, and productivity.

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[2] DOE's Office of Nuclear Energy, Science and Technology has considered PCAST recommendations in the development of the NI PEIS. The NI PEIS does not evaluate programmatic needs of other program offices within DOE, including the Office of Science.

The NERAC Subcommittee on Long-Term Planning for Nuclear Energy Research has set forth a recommended 20-year research and development plan to guide DOE's nuclear energy programs in areas of materials research, nuclear fuel, and reactor technology development (NERAC 2000c). This plan stresses the need for DOE facilities to sustain the nuclear energy research mission in the years ahead. Such nuclear research and development initiatives requiring an enhanced DOE nuclear facility infrastructure fall into three basic categories: materials research, nuclear fuel research, and advanced reactor development.

Materials Research: The high radiation fields, high temperatures, and corrosive environments in nuclear reactors (terrestrial or space) and other complex nuclear systems (e.g., accelerator transmutation of waste [ATW] systems) can accelerate the degradation of pressure vessels and structural material, component materials, material interfaces and joints between materials (e.g., welds). Radiation effects in materials can cause a loss of mechanical integrity (fracture toughness and ductility) by embrittlement, dimensional changes (creep and swelling), and fatigue and cracking (irradiation-assisted stress corrosion cracking). Acquiring a fundamental understanding of radiation effects in current and future reactor materials (engineered steel alloys, ceramics, composites, and refractory metals), as well as the experimental validation of analytical models and computational methods, would require material irradiation testing over a range of neutron energies (thermal and fast flux) and doses. Material testing under simulated reactor conditions would be required to ensure the compatibility of advanced materials with the various moderators/coolants of future reactor concepts. In addition, the thermophysical properties and behaviors of liquid metal coolants being considered for advanced reactor (terrestrial or space) and ATW systems require further irradiation testing. One key area of materials research that is important to plant safety and the license renewal of existing nuclear power plants is the accelerated aging of materials to simulate radiation effects over a plant lifetime. Researchers from the United States and many foreign countries use DOE's high flux research reactors for materials testing and experimentation. These facilities have the capability to maintain a high density of neutrons in a given test volume for materials testing; shorten the time needed for such testing; tailor the neutron flux to simulate the different reactor types and conditions; and instrument the core for close monitoring of the test conditions.

Nuclear Fuel Research: Increasing demands are being placed on nuclear fuel and cladding material performance as the fuel burnup limits are extended in existing light water reactors to maximize plant performance and economic benefits. New fuel types and forms are being investigated that offer potential benefits such as enhanced proliferation resistance (uranium-thorium fuel), higher burnup, and improved waste forms for the new reactor concepts being researched and developed by DOE. In addition, plutonium-uranium mixed oxide fuels are being developed for the disposition of surplus weapons material, and high temperature, long-life fuels may be required for space reactors. Each of the various fuel and cladding types, forms, and material compositions would require research and irradiation testing under prototypical reactor conditions to fully understand fuel performance, cladding performance, cladding/fuel interaction, and cladding/coolant material compatibility. Fuel research includes a variety of thermal and fast spectrum power reactor fuel forms (ceramic, metal, hybrids such as cermet) and various fuel types (oxides, nitrides, carbides, and metallics). Irradiation experiments to characterize fuel performance would require the capability to test fuel pellets, pins, and fuel assemblies under steady-state and transient conditions in the higher temperature environments expected in future reactor designs. Reactor physics and criticality safety data for benchmarking computational codes and analytical methods used in fuel design and performance analysis would also be required.

Advanced Reactor Development: Certification and licensing of advanced reactor and complex nuclear systems will require the demonstration and validation of reactor and safety system thermal and fluid dynamic properties under steady-state and transient conditions. Typically, nonnuclear test loops are used to perform this research. However, because of the unique nature of some proposed advanced reactor concepts, test loop operation under prototypical temperature and neutron flux conditions would be necessary to adequately test and demonstrate coolant/moderator physics and thermal properties, heat transfer, fluid flow, and fuel-moderator performance.

S.2 SCOPE OF THE NI PEIS

Public Scoping Process

On October 5, 1998, DOE published in the Federal Register (63 FR 53398) a Notice of Intent to prepare an environmental impact statement on the proposed production of plutonium-238 for use in advanced radioisotope power systems for future space missions. With that announcement, DOE began preparing the *Environmental Impact Statement for the Proposed Production of Plutonium-238 for Use in Advanced Radioisotope Power Systems for Future Space Missions* (*Plutonium-238 Production EIS*). The scope of the *Plutonium-238 Production EIS* was established through a public scoping process conducted from November 4, 1998 through January 4, 1999. As part of the scoping process for that draft, DOE announced that Fast Flux Test Facility (FFTF) would not be considered a reasonable alternative for the plutonium-238 production mission unless restart of the facility was proposed for other reasons.

Since then, the Secretary of Energy announced on August 18, 1999, that DOE would prepare the NI PEIS. Because plutonium-238 production would be among the missions considered in the NI PEIS, the scope of the *Plutonium-238 Production EIS* in its entirety was incorporated within the scope of the NI PEIS, and preparation of the *Plutonium-238 Production EIS* as a separate National Environmental Policy Act (NEPA) review was terminated.

On September 15, 1999, DOE published in the Federal Register a Notice of Intent to prepare the NI PEIS (64 FR 50064). In this Notice of Intent, DOE invited the public to comment on the proposed actions during the 45-day NI PEIS scoping period that ended October 31, 1999. During this period, DOE held public scoping meetings at seven locations: Oak Ridge, Tennessee; Idaho Falls, Idaho; Richland and Seattle, Washington; Hood River and Portland, Oregon; and Washington, D.C. The written and oral comments received at these meetings and the additional comments received via U.S. mail, electronic mail, and toll-free faxes and telephone calls during the public scoping period were reviewed and considered by DOE in preparing the NI PEIS. Similarly, DOE reviewed and considered all comments and input originally received from the public during the *Plutonium-238 Production EIS* scoping period in the preparation of the NI PEIS.

For the *Plutonium-238 Production EIS*, approximately 750 scoping comments were received by DOE. At the scoping meetings on the *Plutonium-238 Production EIS*, the following general issues and concerns were raised:

- Additional irradiation service alternatives, such as CLWRs and accelerators
- Additional storage, target fabrication, and target processing alternatives, such as Argonne National Laboratory's Hot Fuels Examination Facility and the SRS H-Canyon and HB-Line
- Generation of additional waste streams
- Costs of implementing the various alternatives

In general, the people who attended the meetings in Idaho and Tennessee were supportive of DOE's proposed plans to produce plutonium-238 domestically for future space missions. However, in Richland, Washington, the meeting was attended by several stakeholder and environmental groups who voiced considerable opposition to DOE's consideration of FFTF for plutonium-238 production.

At the meeting in Richland, Washington, the main concern was that DOE should not consider restarting FFTF, that DOE has worked hard over the years to change Hanford's mission from "production" to "cleanup," and that DOE should continue to honor its commitment to cleanup. There were concerns about the generation of additional waste streams at the site and the operational safety of FFTF. There was strong opposition to restart of FFTF for any mission.

For the NI PEIS, approximately 7,000 comments were received by DOE. At the scoping meetings on the NI PEIS, the most prevalent concerns were:

- Status of and commitment to cleanup at Hanford and the impact of FFTF restart on the existing waste cleanup at Hanford
- Lack of justification for the identified missions
- Costs of implementing the various alternatives
- Need for an additional alternative calling for the permanent deactivation of FFTF coupled with the No Action alternative elements, that is, no plutonium-238 production and no additional research and development or medical isotope production beyond existing operating levels

The number of people who commented at the scoping meetings conducted in Oak Ridge, Tennessee; Idaho Falls, Idaho; and Washington, D.C., was smaller in comparison to the meetings held in the Pacific Northwest. At the scoping meeting in Oak Ridge, Tennessee, a commentor was concerned with the relationship of the NI PEIS to other DOE programs and the relative merits of accelerator and reactor performance. The commentor stated that the PEIS should include an explanation of mixed oxide fuel disposition. In addition, the commentor supported medical isotope production in Oak Ridge because it is near a transportation hub and some medical isotopes are short-lived; therefore, transportation is key.

At the scoping meeting in Idaho Falls, Idaho, most commentors supported siting the new missions at the Idaho National Engineering and Environmental Laboratory (INEEL). The commentors also stated that the socioeconomic impacts of the alternatives need to be considered in the NI PEIS. A commentor stated that decisions in regard to medical isotope production should be based on the needs of the Nation as a whole and not on perceived commercial needs. The commentor also stated that incremental DOE and commercial investments in the Advanced Test Facility (ATR) would be sufficient to enhance reactor radioisotope production needs and meet the requirements of the nuclear medicine industry.

At the meetings held in the states of Washington and Oregon, many of the comments either supported or opposed using FFTF to accomplish the proposed missions. The commentors who attended the meetings in Seattle, Washington; Portland, Oregon; and Hood River, Oregon, were strongly opposed to restart of FFTF. Many commentors stated that the Hanford cleanup mission would be jeopardized, especially when DOE has not met the Hanford cleanup milestones. Most of the comments received at the Richland, Washington, meeting supported restarting FFTF, stated that restart would not hamper Hanford's cleanup mission, and further stated that operation of FFTF could help save the lives of many people by producing isotopes to be used in new ways to treat cancer, heart disease, and other illnesses. Commentors were also concerned about the potential generation of radioactive and hazardous waste as a result of the proposed missions, as well as DOE's commitment to ongoing cleanup programs, particularly at Hanford.

At the scoping meeting in Washington, D.C., the commentors supported the need for medical isotope production. Several commentors were against the restart of FFTF and others stated that DOE needs to consider partnerships with private industry to generate necessary funds for restart. Some commentors thought a cost study should be prepared and include avoided future healthcare costs and cost savings to the national Medicare and Medicaid programs that could be realized by using nuclear isotopes in medical applications. Proliferation concerns were also raised as some commentors stated that: (1) the United States would be sending the wrong message by restarting FFTF; (2) a change in the U.S. nonproliferation policy will be required to import German mixed oxide fuel; and (3) the use of highly enriched uranium is contrary to existing U.S. nonproliferation policy. Other concerns included waste generation, Hanford cleanup, and safety at FFTF.

Comments received during the scoping periods were systematically reviewed by DOE. As a means of summarizing the issues raised during scoping, those comments with similar or related topics were grouped into categories to identify specific issues of public concern. After these issues were identified, they were further evaluated to determine whether they fell within or outside the proposed scope of the NI PEIS. In several instances, the original scope was expanded to accommodate additional issues resulting from the public scoping process.

Comments received that contributed to expansion of the scope concerned the following general areas:

- Deactivate FFTF: Alternative 5, Permanently Deactivate FFTF with no new missions at existing facilities, has been added to the scope of the NI PEIS.

- Cleanup at Hanford: Although not within the scope of the NI PEIS, information is included about the cleanup mission at Hanford and land-use planning efforts.

- Environmental contamination at Hanford: Information is included about the groundwater quality at the existing Hanford site.

- European regulatory/government issues: The import of German SNR–300 fuel is addressed, and a separate "Nuclear Infrastructure Nonproliferation Impacts Assessment" report will be completed in summer 2000 to also address export issues.

- Transition of FFTF stewardship after it is deactivated: The appropriate transition information is included.

- Restart of FFTF and budget constraints: DOE has made a commitment that implementation of the Record of Decision will not divert or reprogram budgeted funds designated for Hanford cleanup, regardless of the alternative selected.

- Tri-Party Agreement at Hanford: Information about the Tri-Party Agreement and its relationship to the NI PEIS is included.

The public comments and materials submitted during the public scoping periods for both the *Plutonium-238 Production EIS* and the NI PEIS were logged and placed in the Administrative Record for the NI PEIS. Appendix N of the NI PEIS summarizes the comments received during both public scoping periods.

Alternatives Evaluated in the NI PEIS

The NI PEIS analyzes the potential environmental impacts of using various irradiation and processing facilities to meet the following projected DOE irradiation service mission needs for 35 years: (1) production of medical and industrial isotopes, (2) production of 5 kilograms (11 pounds) per year of plutonium-238 for use in advanced radioisotope power systems for future NASA space missions, and (3) support for U.S. nuclear research and development activities. The proposed irradiation facilities include facilities that are currently operating, those that could be brought on line, or those that could be constructed and operated to meet DOE's nuclear infrastructure mission requirements. A No Action Alternative and five programmatic alternatives are listed below.

No Action Alternative
Alternative 1—Restart FFTF
Alternative 2—Use Only Existing Operational Facilities
Alternative 3—Construct New Accelerator(s)

Alternative 4—Construct New Research Reactor
Alternative 5—Permanently Deactivate FFTF (with No New Missions)

It is possible during the Record of Decision process that a combination of the alternatives could be selected, e.g., a low-energy power accelerator in combination with the existing reactors to optimize research isotope production, or in combination with FFTF to optimize research and therapeutic isotope production.

The alternatives, their associated facility options, and their relative capabilities are described in detail in Chapter 2 of the NI PEIS. As presented in **Table S–1**, the NI PEIS evaluates 26 specific technology/siting options associated with the alternatives identified above. **A preferred alternative has not yet been identified. However, in accordance with the Council on Environmental Quality regulations, DOE will identify a preferred alternative in the Final NI PEIS.**

No Action Alternative. Under the No Action Alternative (maintain status quo), FFTF would be maintained in standby status for all or a portion of the 35-year evaluation period for operations covered in the NI PEIS. For purposes of analysis in the NI PEIS, the maximum of 35 years was assumed. Ongoing operations at existing facilities, as described in Chapter 3 of the NI PEIS, would continue under this alternative. DOE would not establish a domestic plutonium-238 production capability, but could, instead, continue to purchase Russian plutonium-238 to meet the needs of future U.S. space missions. For the purposes of analysis in the NI PEIS, DOE assumed that it would continue to purchase plutonium-238 to meet the space mission needs for the 35-year evaluation period. However, DOE recognizes that any purchase beyond what is currently available to the United States through the existing contract may require additional NEPA review. DOE would continue its medical and industrial isotope production and nuclear research and development activities at the current operating levels of existing facilities. A consequence of a No Action decision would be the need to determine the future of the neptunium-237 stored at SRS. Therefore, the impacts of possible future transportation and storage of neptunium-237 are evaluated as part of the No Action Alternative.

Four options are analyzed under the No Action Alternative. If DOE decides not to establish a domestic plutonium-238 production capability in the future, the neptunium-237 would have no programmatic value and Option 1 would be selected. Conversely, if DOE decides to maintain the capability to establish a domestic plutonium-238 capability in the future, the inventory of neptunium-237 must be retained. In this case, the neptunium-237 oxide would be transported from SRS to one of three candidate DOE sites for up to 35 years of storage: Option 2, the Radiochemical Engineering Development Center (REDC) at Oak Ridge National Laboratory (ORNL); Option 3, Building CPP–651 at INEEL; or Option 4, the Fuels and Materials Examination Facility (FMEF) at Hanford.

Alternative 1—Restart FFTF. Under Alternative 1, FFTF at Hanford would be restarted and operated for the 35-year evaluation period. FFTF would be used to irradiate targets for medical and industrial isotope production, plutonium-238 production, and research and development irradiation requirements. Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue.

Targets for medical and industrial isotope production would be fabricated in one or more facilities at the Hanford Site (Hanford). Target material would typically be acquired from ORNL, where enrichment processes are conducted to produce high purity target material suitable for production of medical isotopes, and stored at Hanford. The targets would be irradiated at FFTF and then returned to the fabrication facility for postirradiation processing. From there, the isotope products would be sent directly to commercial pharmaceutical distributors.

Table S–1 NI PEIS Alternatives and Options

			Plutonium-238 Production Mission		Medical and Industrial Isotope Production and Nuclear Research and Development Mission	
	Option Number	Irradiation Facility	Storage Facility	Target Fabrication and Processing Facility	Storage Facility	Target Fabrication and Processing Facility
No Action Alternative	1	–	–	–	–	–
	2	–	REDC	–	–	–
	3	–	CPP–651	–	–	–
	4	–	FMEF	–	–	–
Alternative 1: Restart FFTF	1	FFTF[a]	REDC	REDC	RPL/306–E	RPL/306–E
	2	FFTF[a]	FDPF/CPP–651	FDPF	RPL/306–E	RPL/306–E
	3	FFTF[a]	FMEF	FMEF	FMEF	FMEF
	4	FFTF[b]	REDC	REDC	RPL/306–E	RPL/306–E
	5	FFTF[b]	FDPF/CPP–651	FDPF	RPL/306–E	RPL/306–E
	6	FFTF[b]	FMEF	FMEF	FMEF	FMEF
Alternative 2: Use Only Existing Operational Facilities	1	ATR	REDC	REDC	–	–
	2	ATR	FDPF/CPP–651	FDPF	–	–
	3	ATR	FMEF	FMEF	–	–
	4	CLWR	REDC	REDC	–	–
	5	CLWR	FDPF/CPP–651	FDPF	–	–
	6	CLWR	FMEF	FMEF	–	–
	7	HFIR and ATR	REDC	REDC	–	–
	8	HFIR and ATR	FDPF/CPP–651	FDPF	–	–
	9	HFIR and ATR	FMEF	FMEF	–	–
Alternative 3: Construct New Accelerator(s)	1	New	REDC	REDC	New[c]	New[c]
	2	New	FDPF/CPP–651	FDPF	New[c]	New[c]
	3	New	FMEF	FMEF	New[c]	New[c]
Alternative 4: Construct New Research Reactor	1	New	REDC	REDC	New[c]	New[c]
	2	New	FDPF/CPP–651	FDPF	New[c]	New[c]
	3	New	FMEF	FMEF	New[c]	New[c]
Alternative 5: Permanently Deactivate FFTF (with No New Missions)	–	–	–	–	–	–

a. Hanford FFTF would operate with mixed oxide fuel for 21 years and highly enriched uranium fuel for 14 years.
b. Hanford FFTF would operate with mixed oxide fuel for 6 years and highly enriched fuel for 29 years.
c. The new facility would not be required if a DOE site with available support capability and infrastructure is selected.

Key: 306–E, Hanford 300 Area Building 306–E; ATR, Advanced Test Reactor at INEEL; CLWR, commercial light water reactor; CPP–651, INEEL Building CPP–651 Storage Vault; FDPF, Fluorinel Dissolution Process Facility at INEEL; FMEF, Fuels and Materials Examination Facility at Hanford; HFIR, High Flux Isotope Reactor at ORNL; REDC, Radiochemical Engineering Development Center at ORNL; RPL, Radiochemical Processing Laboratory at Hanford.

Targets for plutonium-238 production would be fabricated in one of three alternative facilities at ORNL, Hanford, or INEEL. The material needed for target fabrication (neptunium-237) would be transported to the fabrication facilities, where it would be stored until fabrication. The nonirradiated targets would be transported to and irradiated at FFTF and transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would be transported to Los Alamos National Laboratory (LANL) for fabrication into heat sources for radioisotope power systems.

Under Alternative 1, raw materials, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for raw target material acquisition, material storage, target fabrication, target irradiation, and postirradiation processing and the final destination for the medical and industrial isotopes and the plutonium-238 product or for various research and development test sites.

The six options under this alternative are associated with the type of nuclear fuel to be used for FFTF operations and the specific facilities to be used for target fabrication and processing. The first three options (Options 1 through 3) would involve operating FFTF with a mixed oxide fuel core for the first 21 years and a highly enriched uranium fuel core for the remaining 14 years. The last three options (Options 4 through 6) would involve operating FFTF with a mixed oxide fuel core for the first 6 years and a highly enriched uranium fuel core for the remaining 29 years. FFTF can provide similar irradiation services with either a mixed oxide core or a highly enriched uranium core.

The U.S. nonproliferation policy (U.S. House of Representatives 1992 and White House 1993) strongly discourages the use of highly enriched uranium fuel in civilian research and test reactors. The Reduced Enrichment for Research and Test Reactors Program implements this policy by developing technical means to reduce and eventually eliminate the use of highly enriched uranium in research and test reactors throughout the world and in the United States, without decreasing their safety or significantly affecting their performance and operating costs.

To be in compliance with these policy directives, the most appropriate fuel supply for FFTF in the out years (beyond current Hanford mixed oxide and possible SNR–300 mixed oxide supplies) must be determined by a technical study with the preferred fuel source being low-enriched uranium. Highly enriched uranium fuel should only be considered if low-enriched uranium is not technically feasible, or if there are significant impacts on safety, performance, or cost associated with using fuels other than highly enriched uranium.

In the event that a decision is made to restart the reactor, and to support these policy directives, DOE's Office of Nonproliferation and National Security would undertake a study to consider the technical feasibility of low-enriched uranium fuel (under the Reduced Enrichment for Research on Test Reactors Program) for FFTF. If low-enriched uranium fuel is found infeasible, DOE would subsequently procure highly enriched uranium fuel in a manner consistent with U.S. nonproliferation policy. This study would be conducted, decisions implemented, and fuel made available during the time period between a Record of Decision indicating an FFTF restart and prior to the end of available Hanford mixed oxide and possible SNR–300 mixed oxide fuel supplies.

For the purposes of presenting a bounding analysis in the NI PEIS, DOE has analyzed the impacts of using highly enriched uranium fuel in FFTF after the available mixed oxide fuel supplies have been expended. These impacts would bound those of using a low-enriched uranium fuel form.

Alternative 2—Use Only Existing Operational Facilities. Under Alternative 2, DOE would use existing operating DOE reactors or U.S. commercial nuclear power plants to produce plutonium-238 for future space missions. The production of medical and industrial isotopes and support of nuclear research and development in DOE reactors and accelerators would continue at the No Action Alternative level. However, the currently operating DOE reactors, the High Flux Isotope Reactor (HFIR) and ATR, cannot fully meet the projected long-term need for medical isotope production and nuclear research and development, with or without the plutonium-238 production mission.

Depending on the combination of facilities used in Alternative 2, HFIR and ATR could continue their current support of the medical and industrial isotope and research and development missions, including some near-term growth, while accommodating the production of plutonium-238. Under other scenarios, some of the near-term growth in medical and industrial isotope production and nuclear research and development possible in these reactors could be limited by the addition of the plutonium-238 production. In any case, non-DOE use of these facilities would be affected by the addition of the plutonium-238 mission. If a commercial reactor were used for plutonium-238 production, the DOE facilities would be unaffected and would continue operating as discussed under the No Action Alternative.

Another component of Alternative 2 is permanent deactivation of FFTF. Permanent deactivation of FFTF (Alternative 5) could occur in conjunction with any of the options under Alternatives 2, 3, or 4. Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue under Alternative 2.

Targets for plutonium-238 production would be fabricated in one of three facilities at ORNL, INEEL, or Hanford. The material needed for target fabrication (neptunium-237) would be processed and transported from SRS to the fabrication facilities where it would be stored until fabrication. The targets would be irradiated at existing reactor facilities (HFIR, ATR, CLWR, as described in Section S.3) and would be transported back to the fabricating facilities for postirradiation processing.

Under Alternative 2, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, and postirradiation processing. In addition, the plutonium-238 product would be transported to LANL.

Nine options are proposed under this alternative. Options 1 through 3 involve the irradiation of targets in ATR at INEEL. Options 4 through 6 involve the irradiation of targets in a generic CLWR. Options 7 through 9 involve the irradiation of targets in both INEEL's ATR and ORNL's HFIR.

Alternative 3—Construction of New Accelerator(s). Under Alternative 3, one or two new accelerators would be used for target irradiation for the evaluation period of 35 years. The new accelerator(s), which would be constructed at an existing DOE site, would be used to irradiate all of the targets (i.e., for production of plutonium-238, isotopes for medical and industrial uses, and materials testing for research and development). Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue.

The targets for plutonium-238 production would be fabricated in one of the three alternative facilities at ORNL, INEEL, or Hanford. The material needed for the target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities, where it would be stored until fabrication. The targets would be irradiated at a new high-energy accelerator facility and transported back to the target fabricating facilities for postirradiation processing.

Targets for medical and industrial isotope production would be fabricated in a new support facility located at the same site as the low-energy accelerator. Target materials would be stored on site until fabrication. The targets would be irradiated in the low-energy accelerator and returned to the new support facility for postirradiation processing. Site selection for Alternative 3 is not evaluated as part of the NI PEIS. Because Alternative 3 is evaluated at a generic DOE site, no credit was taken for any support infrastructure existing at the site and it was postulated that a new support facility would be required to support operation of the low-energy accelerator and its missions and the high-energy accelerator nuclear research and development missions if both accelerators are located on the same site. While this approach bounds the environmental impact assessment for the implementation of Alternative 3, it overstates the impacts because the NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 3 or the low-energy accelerator alone is selected by the Record of Decision for subsequent consideration, follow-on NEPA assessments would evaluate potential locations for either both accelerators or one of the accelerators. It is highly unlikely that DOE would consider locating the new low-energy or high-energy accelerator on a DOE site that does not have existing infrastructure capable of supporting all or most of the proposed mission requirements.

Under Alternative 3, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, postirradiation processing, and the final destination of the plutonium-238. Alternative 3 also would include decontamination and decommissioning of the accelerator(s) and the processing facility when the missions are over, as well as deactivation of FFTF at Hanford.

Alternative 4—Construction of a New Research Reactor. Under Alternative 4, a new research reactor would be used for target irradiation for the evaluation period of 35 years. The new research reactor, to be constructed at an existing DOE site, would be used to irradiate all targets (i.e., for the production of plutonium-238, isotopes for medical and industrial uses, and materials testing for nuclear research and development). Ongoing operations at existing facilities as described in Chapter 3 of the NI PEIS would continue.

The targets for plutonium-238 production would be fabricated in one of the three facilities at ORNL, INEEL, or Hanford. The material needed for the target fabrication (neptunium-237) would be transported from SRS to the fabrication facilities where it would be stored until fabrication. The targets would be irradiated at the new research reactor facility and transported back to the target fabrication facilities for postirradiation processing.

Targets for medical and industrial isotope production would be fabricated in a new support facility located at the same site as the new research reactor. Target materials would be stored on site until fabrication. The targets would be irradiated in the new research reactor and returned to the new support facility for postirradiation processing.

Alternative 4 site selection is not evaluated as part of the NI PEIS. Because Alternative 4 is evaluated at a generic DOE site, no credit was taken for any existing support infrastructure existing at the site and it was postulated that a new support facility would be required to support operation of the new research reactor and its missions. While this approach bounds the environmental impact assessment for the implementation of Alternative 4, it overstates the impacts because the NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 4 is selected by the Record of Decision for subsequent consideration, follow-up NEPA assessments would evaluate potential locations for the new research reactor. It is highly unlikely that DOE would consider locating the new research reactor on a DOE site that does not have existing infrastructure capable of supporting all or most of the proposed medical and industrial isotope production and nuclear research and development mission requirements.

Under Alternative 4, nonirradiated targets, irradiated targets, and processed materials would be transported between the locations selected for storage, target fabrication, target irradiation, postirradiation processing, and the final destination of the plutonium-238. Alternative 4 also would include the decontamination and decommissioning of both the research reactor and the support facility when the missions are over, as well as deactivation of FFTF at Hanford.

Alternative 5—Permanently Deactivate FFTF (with No New Missions). Under Alternative 5, DOE would permanently deactivate FFTF, with no new missions. Medical and industrial isotope production and nuclear research and development missions, at the existing facilities described in Chapter 3, would continue. DOE's nuclear facilities infrastructure would not be enhanced. Plutonium-238 required to support future U.S. space missions could be purchased from Russia.

Selection of Alternatives

In the NI PEIS Record of Decision, DOE can select any alternative or combination of alternatives or elements of alternatives. For example, DOE could select Alternative 2 in combination with the new low-energy accelerator element of Alternative 3. This combination of alternative elements would provide for the requirements of the plutonium-238 production, enhanced nuclear research and development capability, and enhanced medical and industrial isotope production capability.

Alternatives Considered But Dismissed

In developing a range of reasonable alternatives, DOE examined the capabilities and available capacities of the existing and planned nuclear research facilities (accelerators, reactors, and processing [hot] cells) that potentially could be used to support one or all of the proposed isotope production and research missions (DOE 2000a). The following facilities were initially considered, but were subsequently dismissed as reasonable alternatives for meeting DOE's proposed nuclear infrastructure mission requirements.

Irradiation Facilities Dismissed. DOE evaluated the irradiation capabilities of existing government, university, and commercial irradiation facilities to determine whether they could significantly support the proposed expanded nuclear infrastructure missions. **Table S–2** presents irradiation facilities that were initially considered but dismissed from further evaluation because they lacked technical capability or available capacity. Reasons for lacking technical capability include that the facility has been permanently shut down, it does not possess the capability to produce steady-state neutrons, or that it could not maintain sufficient power levels to adequately support steady-state neutron production. Facilities were similarly dismissed if existing capacity was fully dedicated to existing missions, or if use of existing capacity to support the NI PEIS proposed action would impact existing missions. Although a number of facilities shown in Table S–2 have some available capacity, their combined available capacity is a very small percentage of the capacity needed to support the missions evaluated in the NI PEIS.

Two of these facilities, the Brookhaven LINAC Isotope Producer and the Los Alamos Neutron Science Center Linear Accelerator Isotope Production Facility, were identified in the NI PEIS Notice of Intent as existing facilities that could potentially support the proposed nuclear infrastructure missions. Although initially considered, these facilities were dismissed from further consideration because DOE determined that neither facility is capable of producing a constant, reliable source of neutrons due to dependency on the operating schedule of each facility's primary mission. In addition, existing capacity at the Brookhaven LINAC is now dedicated to other missions.

Two existing operating DOE facilities, ATR and HFIR, were evaluated as components of Alternative 2, Use Only Existing Operational Facilities. These two facilities currently provide isotope production capability, and were examined for their ability to meet the isotope production and nuclear research and development requirements of the proposed expanded missions. In addition, DOE considered whether production from ATR and HFIR could be enhanced by increasing power levels at the reactors or through other modifications to the facilities. While some growth is possible in production at these two facilities, it would only be sufficient to meet the needs for 5 to 10 years based on growth projections. Further growth could only be enabled by increasing reactor power levels. At ATR, this option is precluded by the current operating requirements for

Table S–2 Irradiation Facilities Considered But Dismissed from Further Evaluation

Facilities lacking sufficient neutron production capacity to support the NI PEIS proposed action without impacting existing missions	Neutron Radiographic Reactor Argonne National Laboratory–West
	Brookhaven Medical Research Reactor Brookhaven National Laboratory
	National Bureau of Standards Reactor National Institute of Standards and Technology
	General Atomics Training, Research, and Isotope Production Reactors
	University Small Research Reactors
	University Large Research Reactors (i.e., Massachusetts Institute of Technology and University of Missouri)
	ATLAS Heavy Ion Facility Argonne National Laboratory
	Holifield Radioactive Ion Beam Facility Oak Ridge National Laboratory
	Heavy Ion Linear Accelerator Lawrence Berkeley National Laboratory
	Alternating Gradient Synchrotron Heavy Ion Facility Brookhaven National Laboratory
	Continuous Electron Beam Accelerator Facility Thomas Jefferson National Accelerator Facility
	Electron Linear Accelerator Lawrence Livermore National Laboratory
	University Linear Accelerators
Facilities with capacity fully dedicated to existing missions	Annular Core Research Reactor Sandia National Laboratory
	Brookhaven LINAC Isotope Producer Brookhaven National Laboratory
Facilities not capable of steady-state neutron production	Sandia Pulse Reactor II and III Sandia National Laboratory
	Transient Reactor Test Facility Argonne National Laboratory–West
	Zero Power Physics Reactor Idaho National Engineering and Environmental Laboratory
	Power Burst Facility Idaho National Engineering and Environmental Laboratory
	Intense Pulsed Neutron Source Argonne National Laboratory
	Flash X-Ray Facility Lawrence Livermore National Laboratory
Facilities with insufficient power to sustain adequate steady-state neutron production	Brookhaven Medical Research Reactor Brookhaven National Laboratory
	Los Alamos Critical Assembly Facility Los Alamos National Laboratory
	General Atomics Training, Research and Isotope Production Reactors
	University Small Research Reactors
	Booster Applications Facility Brookhaven National Laboratory
	Cyclotron Facility Brookhaven National Laboratory

Table S–2 Irradiation Facilities Considered but Dismissed from Further Evaluation (Continued)

Facilities unable to produce a constant, reliable source of neutrons due to dependency on the operating schedules of their primary missions	Los Alamos Neutron Science Center Linear Accelerator Isotope Production Facility Los Alamos National Laboratory
	Brookhaven LINAC Isotope Producer Brookhaven National Laboratory
Facilities that are under construction with capacity fully dedicated to other planned missions	Dual Axis Radiographic Hydrodynamic Test Facility Los Alamos National Laboratory
	Spallation Neutron Source Oak Ridge National Laboratory
Facilities that have been permanently shut down	High Flux Beam Reactor Brookhaven National Laboratory
	Tower Shielding Facility Oak Ridge National Laboratory
	Oak Ridge Electron Linear Accelerator Oak Ridge National Laboratory
	Cyclotron Facility Oak Ridge National Laboratory

Source: DOE 2000a.

priority DOE Office of Naval Reactors missions. The power level at HFIR is already at 100 percent of Authorization Basis (85 megawatts), and modification of this Authorization Basis would be required to increase to full-design power (100 megawatts). At HFIR, this option is precluded by the extended facility outage required to implement the modifications needed to increase the authorized power level to 100 megawatts. This extended outage would have significant impacts on DOE Office of Science missions performed at this facility. Therefore, increasing power levels is not a reasonable alternative at either ATR or HFIR. DOE has not identified any other reasonable options to enhance the capabilities of these reactors.

DOE also evaluated its ability to meet increased medical and industrial isotope production and nuclear research and development needs by using existing neutron-producing accelerators. DOE concluded that using these facilities to meet the proposed action would adversely impact or replace their existing missions. Because of DOE's stated commitment not to displace current DOE missions at these facilities as a consequence of this proposed action, DOE dismissed from further consideration both the use of existing accelerators or increase in the power levels at HFIR or ATR as reasonable alternatives for the proposed missions.

Modification of CLWRs to enable online insertion and retrieval of targets for the medical and industrial isotope production missions was evaluated and dismissed as a reasonable alternative. This decision was made because the required facility modifications would be significant and would include penetrations into the reactor vessel and, potentially, the containment vessel. Additional facility modifications would be required to enable loading of the targets into a shielded cask for transport to a processing facility. Performing these facility modifications would require an extended refueling outage (with a resulting loss of power generation revenue to the CLWR owner) and could potentially extend subsequent maintenance or refueling outages to inspect, test and maintain the insertion and retrieval system, reactor vessel penetrations, and potential containment vessel penetrations. In the event that CLWRs are used for medical isotope production, the selection of isotopes to be produced would be limited to those with relatively long half-lives because there are no CLWR sites with facilities for processing irradiated targets. The targets would have to be shipped to a DOE site or to a commercial medical isotope vendor facility for processing and subsequent distribution to users. CLWRs were also considered for the proposed DOE nuclear research and development missions. CLWRs will continue to support the commercial industry research and development activities by providing a test bed for industry sponsored lead test assemblies and other related research. CLWRs cannot meet most of the requirements for supporting the

DOE nuclear research and development missions and were therefore dismissed as a reasonable alternative for supporting these missions.

Canadian Deuterium Uranium (CANDU) reactors, operating in Canada, were considered for supplying irradiation services for the plutonium-238 production mission. (Note: Canada is currently the major supplier of medical radioisotopes used in the United States.) Since use of the CANDU reactors does not meet the programmatic issue being addressed in the NI PEIS, that is the enhancement of the United States infrastructure to support the proposed missions, the CANDU reactors were considered but dismissed as a reasonable alternative. However, the environmental impacts associated with transporting the nonirradiated and irradiated neptunium-237 targets between the CANDU reactors and the target fabrication and processing facilities in the United States are bounded by the evaluations presented in the NI PEIS for the commercial light-water reactor options of Alternative 2, Use Only Existing Operational Facilities.

Some facilities listed in Table S–2 that do not have the capacity to support the proposed missions do have some existing medical or industrial isotope production or nuclear research and development missions. These facilities will continue to support their existing missions at current levels.

Processing Facilities Dismissed. Numerous existing U.S. processing hot cell facilities possess the capabilities and capacity to support the proposed missions. Given this general availability, only existing processing facilities that are collocated at DOE's candidate irradiation facility sites (i.e., ORNL, INEEL, and Hanford) were evaluated in the NI PEIS. Although multiple processing facilities exist at each of these sites, only the most suitable facilities in terms of capability, capacity, and availability were given further consideration. The processing facilities that were dismissed from consideration are listed in **Table S–3**.

Based on comments on the scope of the *Plutonium-238 Production EIS*, the H-Canyon and HB-Line facilities at SRS that previously performed the processing for the plutonium-238 production mission were reconsidered as potential processing facilities for the proposed plutonium-238 production mission even though the facilities are not collocated with a proposed irradiation facility. After reviewing the plutonium-238 production target fabrication and processing requirements, the capabilities and capacities of the facilities, and the modifications and resources required to support the plutonium-238 production mission, use of the H-Canyon and HB-Line facilities was dismissed as a reasonable alternative because:

1. DOE plans to shut down these facilities following completion of their current missions to stabilize and prepare for disposition of Cold War legacy nuclear materials and certain spent nuclear fuel, and a determination that a new nonchemical processing technology is capable of preparing aluminum-clad research reactor spent nuclear fuel for ultimate disposition.

2. The cost to extend the operating lives of these facilities to support plutonium-238 production for the proposed 35-year evaluation period would be approximately one order of magnitude higher than the costs associated with the processing facilities evaluated in the NI PEIS.

A commentor also proposed using the H-Canyon and HB-Line for a short campaign to produce all of the required plutonium-238. Based on prior production rates, it would take approximately 7 years to produce 175 kilograms (385 pounds) of plutonium-238, the total plutonium-238 production goal. The target fabrication and irradiation requirements to support this processing campaign to produce 25 kilograms (55 pounds) per year of plutonium-238 would be significant but feasible. The irradiation requirements could be supported by operating five CLWRs or operating FFTF at the 400-megawatt power level. However, a concern about the short campaign option is that the plutonium-238 would be stored a long time before use and because of natural decay may not meet the specification requirements when finally needed. This alternative was dismissed

Table S–3 Processing Facilities Considered But Dismissed from Further Consideration

Location	Facility
Argonne National Laboratory	Irradiated Materials Facility
	Alpha-Gamma Hot Cell Facility
	Building 205
Argonne National Laboratory–West	Hot Fuel Examination Facility
	Analytical Laboratory
	Fuel Conditioning Facility
Brookhaven National Laboratory	Target Processing Laboratory
	Metallurgical Evaluation Laboratory
	High Intensity Radiation Development Laboratory
Hanford Site	222-S Facility
	Postirradiation Testing Laboratory
	Shielded Material Facility
Idaho National Engineering and Environmental Laboratory	Test Area North Hot Shop and Hot Cell Facilities
	Remote Analytical Laboratory
	Fuel Processing Facility
Los Alamos National Laboratory	Chemistry and Metallurgical Research Building
	Technical Area TA–48
Oak Ridge National Laboratory	Radioactive Materials Analytical Laboratory
	Building 4501
	Irradiated Materials Examination and Testing Facility
	Radioisotope Development Laboratory
	Irradiated Fuels Examination Laboratory
Sandia National Laboratories	Hot Cell Facility
Savannah River Site	Defense Waste Processing Facility
	High-level cells
	Intermediate-level cells
	Californium shipping/receiving facility
	Californium processing facility

Source: DOE 2000a.

because of the uncertainty that, over time, the plutonium-238 produced may not meet the required specification for NASA missions.

S.3 OVERVIEW OF NUCLEAR INFRASTRUCTURE FACILITIES AND TRANSPORTATION

The following is a brief description of the facilities involved in target fabrication and postirradiation processing and target irradiation. Detailed descriptions of these facilities and the processes associated with them are provided in Appendixes A through F of the NI PEIS. Also provided is a summary of the transportation required by each alternative.

Target Fabrication and Postirradiation Processing Facilities

REDC. ORNL's REDC Building 7930 is proposed for storage of neptunium-237 in one option of the No Action Alternative. It also is proposed for storage of neptunium-237, fabrication of neptunium-237 targets, and processing of irradiated neptunium-237 targets for two irradiation options in Alternative 1 (Restart FFTF), three irradiation options in Alternative 2 (Use Only Existing Operational Facilities), and for one irradiation option in Alternative 3 (Construct New Accelerator[s]) and Alternative 4 (Construct New Research Reactor). REDC's current radiochemical missions would not be impacted by the addition of the proposed storage of neptunium-237, fabrication of neptunium-237 targets, and the processing of irradiated neptunium-237 targets activities. REDC would have no role in support of Alternative 5 (Permanently Deactivate FFTF [with No New Missions]). **Figure S–1** presents a map of the Oak Ridge Reservation (ORR) that depicts the location of REDC.

REDC is divided into four major areas: (1) a cell complex with seven cells, six shielded and one unshielded; (2) maintenance and service areas surrounding the cell complex; (3) an operating control area; and (4) an office area adjacent to, but isolated from, the operating areas. Utility services, ventilation systems, crane and manipulator systems, and liquid-waste systems also are included. The proposed plutonium-238 processing and storage activities would require equipment installation in three main areas of the second floor of REDC Building 7930. The activities required for preparing the neptunium oxide, mixing it with aluminum for ATR or HFIR targets, and preparing the mixture for either pellet fabrication or extrusion would take place in shielded gloveboxes. The mechanical operations involved in the final target fabrication may present lesser hazards that permit them to be carried out in open boxes. Cell E would contain processing equipment to purify the separated plutonium-238 product, prepare the plutonium oxide, and transfer the oxide into shipping containers. Cell E would also contain vertical storage wells for dry storage of neptunium and other actinides.

Cell D activities would include receipt of irradiated targets, as well as target dissolution, chemical separation of neptunium and plutonium from fission products, and partitioning and purification of neptunium. Cell D also contains process equipment to remove transuranic elements from the aqueous waste streams and to solidify the transuranic waste.

FDPF. The Fluorinel Dissolution Process Facility (FDPF) is in the Idaho Nuclear Technology and Engineering Center (INTEC), which is located northeast of the Central Facilities Area at INEEL and approximately 3.2 kilometers (2 miles) southeast of ATR. **Figure S–2** presents a map of the INEEL site that depicts the location of FDPF. FDPF is proposed for fabrication of neptunium-237 targets, and processing of irradiated neptunium-237 targets for 2 irradiation options in Alternative 1 (Restart FFTF), 3 irradiation options in Alternative 2 (Use Only Existing Operational Facilities), and for 1 irradiation option in Alternative 3 (Construct New Accelerator[s]) and Alternative 4 (Construct New Research Reactor).

FDPF has no current mission. Historically, INTEC reprocessed spent nuclear fuel from U.S. Government reactors to recover reusable highly enriched uranium. After DOE announced in April 1992 that it would no longer reprocess spent fuel, reprocessing operations at INTEC ended. Two buildings at INTEC are candidate storage and processing sites for plutonium-238 production: Building CPP–651, the Unirradiated Fuel Storage Facility, and Building CPP–666, FDPF.

Building CPP–651 was originally designed for the storage of special nuclear materials to support Defense Programs and is flexible in terms of the size and shape of special nuclear materials that it can receive and store. The 100 storage positions in the vault use the existing structural barriers of Building CPP–651 (earth and concrete) and provide supplemental security protection via their in-ground concrete storage silo design. Each storage position houses a rack that holds seven highly enriched uranium product cans. Racks are raised and lowered in their storage positions via an overhead 1-ton hoist.

Building CPP–666 is divided into two parts, the Fuel Storage Facility and FDPF. The Fuel Storage Facility consists of receiving and unloading areas, a fuel unloading pool, and six storage pools for storing nuclear fuel. FDPF was designed and built to process Navy fuel via three dissolver trains. When fuel reprocessing was discontinued, uranium and hazardous materials were flushed from FDPF, and the facility is currently under consideration for new missions. FDPF consists of a large hot cell and supporting areas with a total area of

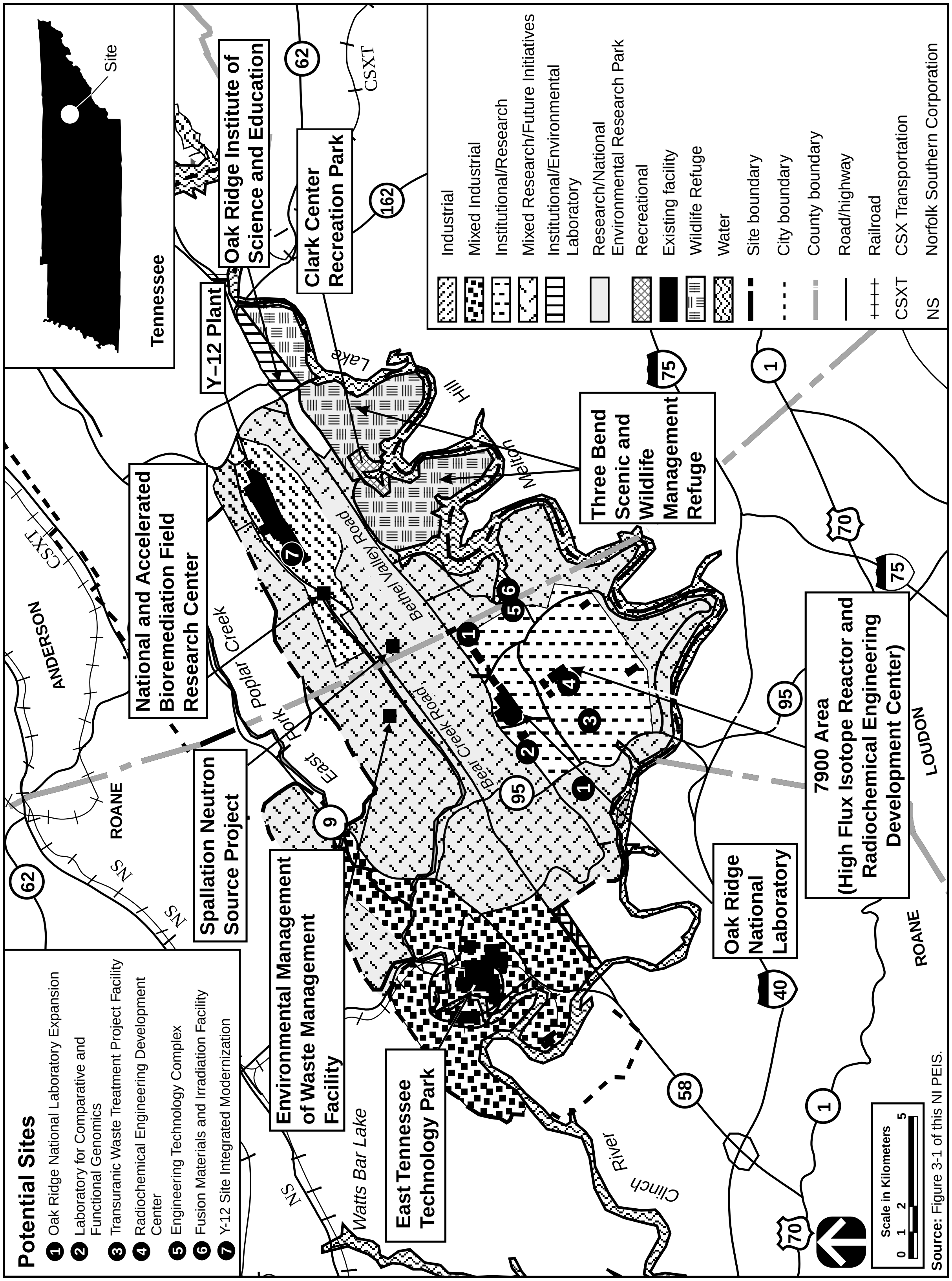

Figure S–1 Generalized Land Use at Oak Ridge Reservation and Vicinity

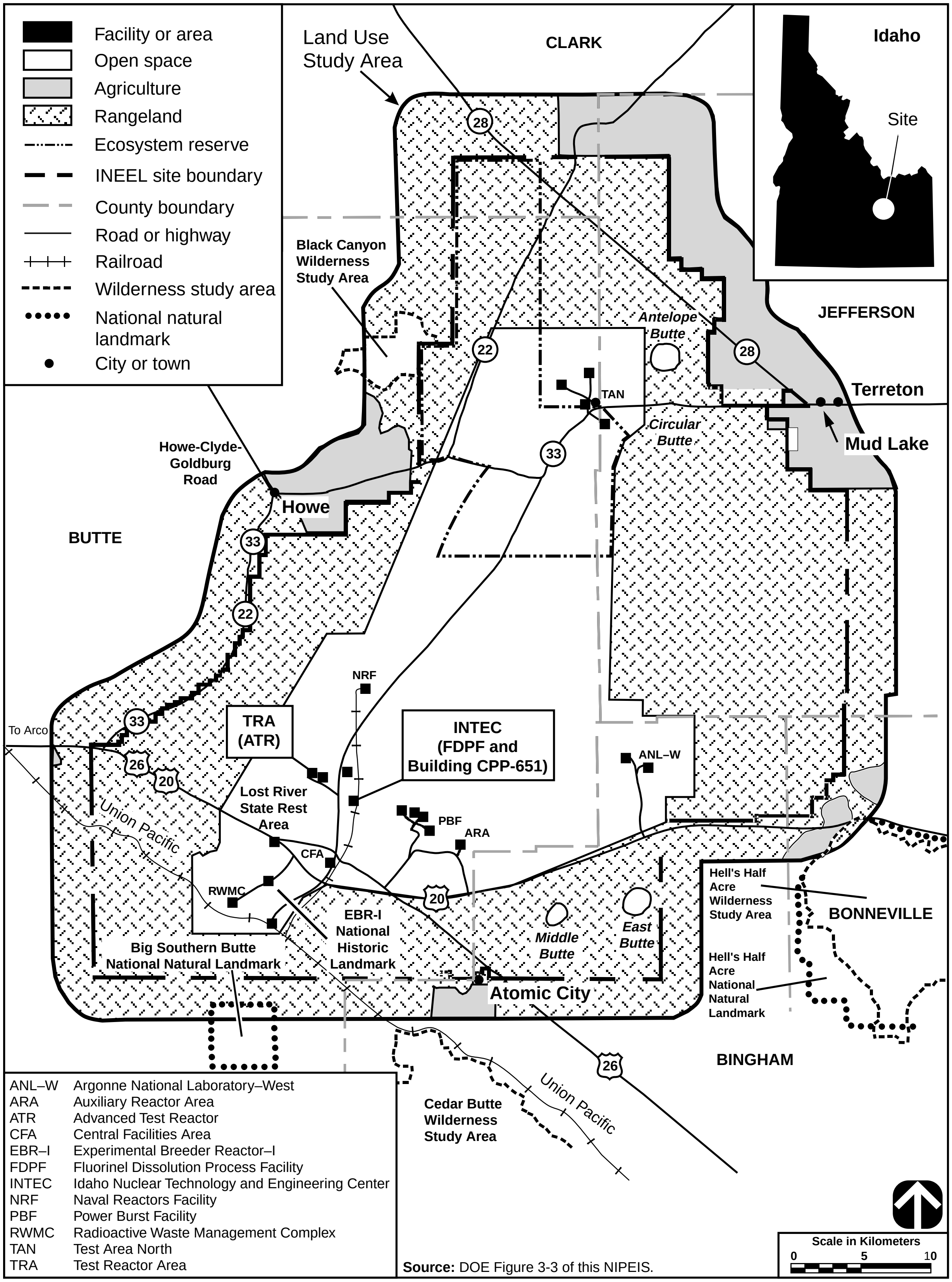

Figure S–2 Generalized Land Use at Idaho National Engineering and Environmental Laboratory and Vicinity

approximately 3,700 square meters (40,000 square feet). The facility is divided into five levels identified by their elevation relative to ground level.

The chemical separation would take place in the FDPF cell using small centrifugal contactors installed for that purpose. Storage of neptunium-237 would be performed in Building CPP–651, which is located within 100 meters (328 feet) of FDPF. There are 100 in-ground concrete-shielded storage well positions in this vault. Each storage well contains a rack that can be modified to house cans of neptunium-237.

FMEF. Use of Hanford's FMEF is proposed for storage of neptunium-237 in one option of the No Action Alternative. It is also proposed for storage of neptunium-237, fabrication of neptunium-237 targets, and processing of irradiated neptunium-237 targets for two irradiation options in Alternative 1 (Restart FFTF), three irradiation options in Alternative 2 (Use Only Existing Operational Facilities), and for one irradiation option in Alternative 3 (Construct New Accelerator[s]) and Alternative 4 (Construct New Research Reactor). In addition to the support of the plutonium-238 production mission activities in Alternative 1, FMEF would also support medical and industrial production mission and nuclear research and development mission activities at the Hanford Site. FMEF would have no role in supporting Alternative 5 (Permanently Deactivate FFTF [with No New Missions]). FMEF is adjacent to the west of FFTF in the 400 Area of Hanford. **Figure S–3** presents a map of Hanford that depicts the location of FMEF. FMEF was built during the late 1970s and early 1980s as a major addition to the breeder reactor technology development program on the Hanford Site. Although it has never been used, the facility was constructed to perform fuel fabrication, and development and postirradiation examination of breeder reactor fuels.

FMEF is currently being maintained in a condition suitable for a future mission. In 1998, FMEF was placed into a partial layup condition in order to reduce the cost of maintaining the facility. Many systems were shut down and most hazardous materials were removed from the building. However, FMEF is considered clean and uncontaminated because no nuclear materials have been introduced. Some critical systems remain in operation, e.g., the fire detection and protection systems. In order to avoid freezing of the fire protection water systems, limited heating and ventilation remains available. For example, the heating, ventilating, and air conditioning system has been modified to simplify its operation by clocking automatic dampers in appropriate configurations. Also, although the chillers have been laid up, including removal of the refrigerant, the chilled water system (containing an ethylene glycol-water mixture) remains available to help distribute heat within the building. Electrical power and lighting remain available, and the freight elevator remains in service to support routine facility walkdowns and any required maintenance. FFTF staff conducts surveillance and maintenance of FMEF.

FMEF consists of a 30-meter (98-foot) high Process Building, which has an attached Mechanical Equipment Wing on the west side and an Entry Wing on the south (front) side. The Mechanical Equipment Wing houses utility and support equipment, including water treatment equipment, air compressors, and a portion of the air conditioning equipment. The Entry Wing contains space for reactor fuel assembly (recently used as a training facility in support of the Hanford Site cleanup mission), lunchroom and change rooms, and heating and air conditioning equipment associated with the Entry Wing. Office space and administrative support areas are also housed on the second floor of the Entry Wing.

The Process Building is approximately 53.3 meters (175 feet) wide by 82.3 meters (270 feet) long, and extends from around 10.7 meters (35 feet) below grade to 29.7 meters (98 feet) above grade. Total potential operating space is approximately 17,400 square meters (188,000 square feet). The Process Building contains several large interconnected hot cells and many smaller connected hot cells. Major cranes are available, but some cranes, windows, and manipulators were not installed because construction of FMEF was halted prior to completing work on the hot cell complex. Nevertheless, the building is divided into six operating floors or levels, which are identified by their elevation relative to ground level and their primary function.

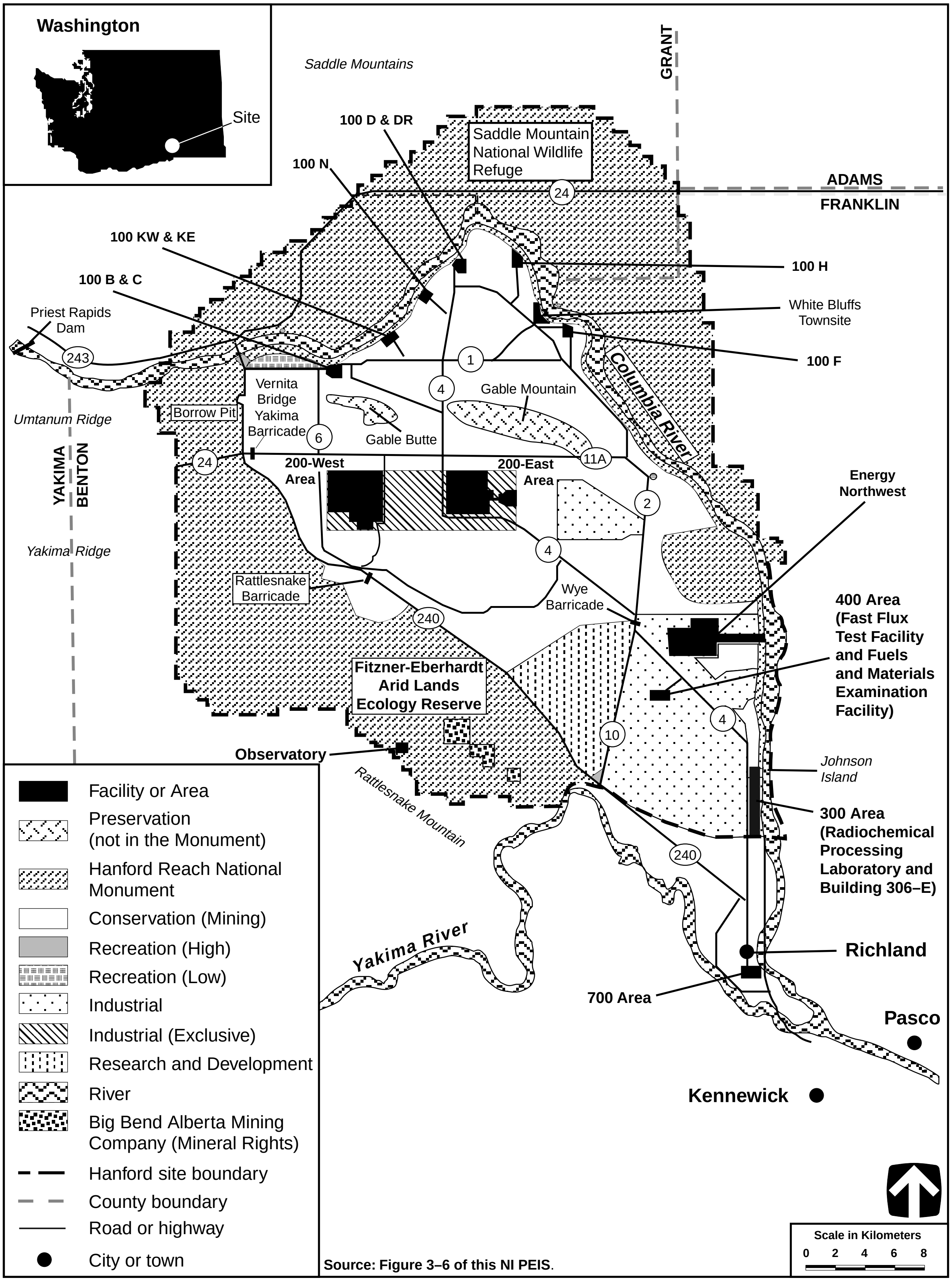

Figure S–3 Generalized Land Use at the Hanford Site and Vicinity

The use of FMEF for neptunium-237 target material storage, target fabrication, and postirradiation processing would require the construction of a new 76-meter (250-foot) stack. The neptunium dioxide (NpO_2) containers will be stored in specially designed storage vaults to provide secure, safe storage for the materials.

Hanford 300 Area Facilities (Radiochemical Processing Laboratory/Building 306–E). Two Hanford 300 Area facilities are proposed to support medical and industrial isotope target fabrication and postirradiation: the Radiochemical Processing Laboratory (RPL) and the Development Fabrication Test Laboratory (Building 306–E). The facilities support the four irradiation options in Alternative 1 (Restart FFTF) that are not supported by FMEF. RPL/306–E will be used to support medical and industrial isotope production and nuclear research and development activities. These activities will not impact current missions at the facilities. RPL/306–E have no role in support of the No Action Alternative, Alternative 2 (Use Only Existing Operational Facilities), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), and Alternative 5 (Permanently Deactivate FFTF [with No New Missions]). Figure S–3 presents a map of Hanford that depicts the location of RPL/306–E.

RPL: The research and development activities of the Radiochemical Processing Group are conducted at RPL in the 300 Area of Hanford. RPL consists of a central area that contains general purpose laboratories designed for low-level radioactive work, a front wing that contains office space and shops, and two annexes that provide shielded enclosures with remote manipulators for high-level radiochemical work. The facility also contains laboratories and specialized facilities designed for work with nonradioactive materials, microgram-to-kilogram quantities of fissionable materials, and up-to-megacurie quantities of radionuclides. RPL would be the primary site for fabricating the radioactive targets (i.e., targets containing radium-226 or recycled materials from previous irradiations).

Total space within RPL is 13,350 square meters (143,700 square feet), of which 4,140 square meters (44,500 square feet) are occupied by general chemistry laboratories. A recent space utilization survey of RPL indicated that 649 square meters (6,950 square feet), representing 15.6 percent of the facility, are presently unoccupied. All of the occupied and nearly all of the unoccupied laboratories are functional and are fully equipped with standard utilities. Several of the laboratories, especially those used for radioanalytical work, have been renovated during the past few years. Upgrading and modernization of the equipment within the chemistry laboratories has been given a high priority during the past 2 years. During the space utilization survey at RPL, an assessment was made of the number of fume hoods and shielded gloveboxes (including several small hot cells) that are available in the chemistry laboratories for additional programmatic work. Of the 79 functional fume hoods and 23 shielded gloveboxes, 50 fume hoods and 15 gloveboxes are available for additional work.

A special feature of RPL is the existence of two heavily shielded hot cell facilities located in annexes on the east and west sides of the building. These shielded facilities are the High-Level Radiochemistry Facility and the Shielded Analytical Laboratory. These two hot cell complexes are heavily used because they provide capabilities for conducting bench-scale to pilot-scale work with a wide variety of highly radioactive materials. Their capabilities include those required to conduct radiochemical separation and purification procedures, irradiated fuel or target sectioning and processing, metallography, physical properties testing of activated metals, thermal processing (including waste vitrification), and radioanalytical and preparatory chemistry operations.

The High-Level Radiochemistry Facility contains three large, interconnected hot cells designated as A-Cell, B-Cell, and C-Cell. Each of the three cells is 4.6 meters (15 feet) high and 2.1 meters (7.0 feet) deep. The A-Cell is 4.6 meters (15 feet) wide, and the B-Cell and C-Cell are each 1.8 meters (6.0 feet) wide. In-cell operations are performed using medium-duty electromechanical manipulators, and operators view their work through leaded-glass, oil-filled windows. Closed-circuit television cameras and videocassette recorders have been installed for detailed inspection work within the hot cells. The A-Cell and C-Cell also have overhead bridges that contain hoists with a 2,200-kilogram (4,840-pound) capacity. The hot cells are fully equipped with utilities and have shielded service penetrations at the front wall to allow insertion of special instruments. Each hot cell contains several process vessels located below the work deck that range in capacity from 4.0 to 320 liters (1.1 to 84.5 gallons). A large shielded door and a shielded double-door transfer port located in the rear wall of the cell provide access to each hot cell in the High-Level Radiochemistry Facility. Cask payloads weighing up to 2,200 kilograms (4,840 pounds) can be transferred into and out of the hot cells using a bridge crane located in the canyon behind the cells.

The Shielded Analytical Laboratory contains six interconnecting hot cells, each of which is 1.7 meters (5.5 feet) wide, 1.7 meters (5.5 feet) deep, and 2.9 meters (9.5 feet) high. Each hot cell is equipped with a pair of medium-duty manipulators. Turntables built into the rear walls of the hot cells provide rapid transfers of radioactive samples into and out of the cells. The Shielded Analytical Laboratory hot cells are equipped to perform a wide variety of analytical chemistry operations with highly radioactive samples.

Building 306–E: Building 306–E was constructed in 1956 as part of the nuclear material production program at Hanford, and was used to develop the col-extrusion process for N-Reactor fuel. Major upgrades and renovations were completed in the late 1960s and early 1970s to support the civilian reactor development program (Liquid Metal Reactor Program–FFTF). The building has 4,273 square meters (46,000 square feet) of floor space, with a 36.5-meter by 61-meter by 6.4-meter high (120-foot- by 200-foot- by 21-foot-high) bay containing three 10-ton, one 5-ton, and one 1-1/2-ton cranes. The facility has electron beam laser welding, certified nondestructive testing, a 3.7-meter by 3.7-meter (12-foot by 12-foot) vertical assembly and test station with 24.4-meter (80-foot) hook height, a machine shop, and an instrument development laboratory.

The building is serviced by three 1,416-cubic-meter-per-minute (50,000-cubic-feet-per-minute) supply units complete with filters, steam coils and spray chambers. Two of the units have refrigeration coils for summer time cooling. Two ceiling mounted 1,012-cubic-meter-per-minute (35,750-cubic-feet-per-minute) recirculation fans with freon compressors provide additional cooling and air movement. Fume hoods have individual exhaust fans. Chemical and acid tanks exhaust through two 340-cubic-meter-per-minute (12,000-cubic-feet-per-minute) fume scrubbers to a 12.2-meter-high 7.6-centimeter diameter (40-foot-high 3-inch diameter) stainless steel exhaust stack. Equipment exhaust collects through a grid that leads to two 566-cubic-meter-per-minute (20,000-cubic-feet-per-minute) exhaust fans. Plastic hoods and duct work are provided for highly corrosive service. Major equipment includes three industrial x-ray machines, a 6-kilowatt Hamilton Standard electron beam welder, five open face hoods, two inert gas welding chambers and one electrolytic cutoff saw.

Utilities include hot and cold water, deionized water, propane, helium, compressed air, argon, steam and sanitary of process sewers as well as a special acid drain and neutralizing tank. Normal power is provided by a 1500-kilovolts ampere transformer with 150 kilovolts ampere backup power from an adjoining building, and a 30 kilovolt ampere emergency transformer. The building is protected by redundant emergency alarm systems, fire gongs, and an evacuation siren.

New Support Facility. A new generic support facility would have the mission of preparing targets for irradiation, processing exposed targets, and housing the materials research and development activities. Siting of the generic support facility for medical and industrial isotope production would require that the facility be located in the same general vicinity (0.2 to 20 kilometers [0.07 to 12.4 miles]) as the new irradiation facility (accelerator or reactor). Collocation with the irradiation facility would be needed to process some irradiated target materials promptly after removal from the reactor/accelerator. Collocation would also minimize transportation risks because some isotopes have short half-lives. Although the facility could be located within the irradiation facility security protection area, the lack of a defense mission and the lack of a fissile material presence in the generic support facility indicates that a high level of physical protection would not be warranted.

The generic support facility mission would be accommodated by a one-story, 3,300-square-meter (36,000-square-foot) above-grade building with a 1,475-square-meter (16,000-square-foot) basement area under a portion of the footprint. The facility is designed around a center area containing the highest-risk activities and the material inventories requiring the highest level of engineered controls. Irradiated materials in casks or other shielded transport containers would enter a loading dock with a straight-line access to the primary facility hot cell. The hot sample entry area would be a high bay area with a high floor loading area between the loading dock and the hot cell access port. This configuration would allow transport cask access to the hot cell. In addition, an overhead hoist would be available to facilitate handling of materials and devices in the proximity of the hot cell.

The hot cell would accept high-radiation-level samples or those difficult to shield or manipulate (e.g., reactor core components containing samples). The hot cell would have access to a conveyor that can remotely transport samples to the hot process laboratories. In addition, samples from the hot cell could be transferred to the hot research and development laboratory gloveboxes for detailed analysis and testing. Hot cell manipulators would be located on both the operating gallery and the research and development sides of the hot cell. Adjacent to that would be the central receiving station for all other radioactive and short-exposure samples not in the reactor core components. This area, while not a hot cell, would provide personnel protection (i.e., shielding and controlled ventilation) for preliminary sample preparation and examination. It would also provide interim irradiated sample storage prior to delivery to the designated processing laboratory. When needed, samples would be transported remotely to the processing laboratories by the conveyor system.

Samples requiring a lesser degree of control would be distributed for processing throughout the remaining process laboratory wing. After processing, the radiopharmaceuticals would be either stored or packaged and shipped immediately to offsite vendors. Radioactive waste would be packaged and stored for eventual disposal. Those materials containing short-lived isotopes would be delivered to a decay/holding room so that, given appropriate decay time, they could be disposed of without a radioactive component. The process and research and development areas would be considered radiologically controlled areas, but no routinely occupied areas would require control as contaminated radiological areas. Radioactive contamination would be controlled at the hood or glovebox face. Due to this configuration, protective clothing and change rooms would be needed only for occasional maintenance activities when temporary radiological areas are established. Cold sample (nonradioactive) preparation would be accomplished in a set of three large laboratories where radiological conditions are not anticipated. Completed samples would be stored in an adjacent room along with raw sample materials (nonradioactive). Radioactive sample preparation and irradiated material recycling activities would be conducted in one of the laboratories adjacent to the conveyor. Irradiated research and development samples introduced into the hot cell could be processed or examined using manipulators within the hot cell. Samples could also enter the research and development suite of lab rooms through the hot cell port into a hot cell or glovebox. From there, they could be moved to additional research and development laboratory rooms within a controlled environment for detailed analysis and testing.

Target Irradiation Facilities

FFTF. FFTF is proposed to support the three proposed missions: 1) plutonium-238 production, 2) medical and commercial isotope production, and 3) nuclear research and development.

FFTF is a 400-megawatt thermal, liquid-cooled (sodium) nuclear test reactor that is owned by DOE and is at the Hanford Site in southeastern Washington State near Richland, Washington. Figure S–3 presents a map of Hanford that depicts the location of FFTF. Following extensive testing, FFTF was started in April 1982.

During its operation, FFTF successfully tested advanced nuclear fuels, materials, components, operating protocols, and reactor safety designs. FFTF also produced a wide variety of medical isotopes and made tritium for the U.S. fusion research program.

FFTF was originally designed and operated as a science test bed for U.S. liquid metal fast reactor programs. These programs, which were canceled in 1993, were key elements both in closed fuel cycle and actinide waste disposition technology development. In December 1993, DOE decided not to operate FFTF due to a lack of economically viable missions at that time. In accordance with the NEPA, DOE published an environmental assessment (EA) and Finding of No Significant Impact for the shutdown and deactivation of FFTF in May 1995 (DOE 1995a). The EA contained an evaluation of the environmental impacts associated with the actions necessary to place FFTF in a radiologically and industrially safe shutdown condition suitable for long-term surveillance and maintenance before final decontamination and decommissioning.

The FFTF complex includes the reactor, as well as equipment and structures for heat removal, containment, reactor safety and shutdown systems core component handling and examination, fuel off-loading and storage, utilities, and other essential services. The central structure of FFTF is the reactor containment building, an all-welded cylindrical steel structure 41 meters (135 feet) in diameter and 57 meters (187 feet) high. The reactor is located below grade in a shielded cell in the center of the containment structure. Heat is removed from the reactor by circulating liquid sodium under low pressure through three separate closed primary piping loops, which include pumps, piping, and intermediate heat exchangers. These loops are located within inerted cells (cells filled with inert gases) within the containment structure. Three secondary sodium loops transport reactor heat from the intermediate heat exchangers to the air-cooled tubes of the dump heat exchangers. From there, the heat dissipates into the atmosphere through the forced draft dump heat exchanger. [Commercial nuclear power reactors use reactor heat to create steam, which turns a turbine to produce electricity. FFTF, however, does not generate electricity.]

FFTF has demonstrated its capability to function as a nuclear science and irradiation services user facility. It has five distinct features: size, flux, test evaluation and irradiation capabilities, fuel type, and coolant type. In combination, these features provide a multipurpose facility suitable for medical and industrial isotopes production, plutonium-238 production, and nuclear research and development purposes. Although FFTF was used primarily to evaluate reactor fuels and different fuel assembly materials during its 10 years of operation, the reactor facility has also supported large and varied test programs for industry, nuclear energy (domestic and international), medical isotope applications and research, space nuclear power, and fusion research programs.

FFTF is currently defueled and is being maintained in a standby condition. Seventy-seven of the 100 systems are operational; the other 23 are in a recoverable standby state. System integrity and configuration control are being maintained. The Main Heat Transport System is being operated at approximately 200 °C (44 °F) to keep the sodium coolant in the reactor liquefied and circulating. If a decision were made to restart FFTF, several equipment upgrades are planned to return systems to operation, improve reliability, conform to current standards, improve efficiency, and minimize waste. Most of the required modifications would consist of either mechanical equipment upgrades or replacement of outdated control and computer systems.

The NI PEIS postulates that FFTF would operate at a nominal power level of 100 megawatts, one quarter of the reactor design power level, to meet the irradiation requirements of the proposed missions. Periodic increases in power level between 100 and 400 megawatts may be required to support nuclear research and development activities. Operating FFTF at a nominal 100-megawatt power level extends the reactor life and significantly reduces the generation rate of spent fuel. FFTF is currently designed to operate using mixed oxide fuel, however, it can also be operated using highly enriched uranium fuel. In the NI PEIS, DOE has not evaluated the possibility of using low-enriched uranium fuel for operation of the FFTF because it makes programmatic and economic sense to use available mixed oxide fuel supplies before using low-enriched uranium.

There are eight locations available in the FFTF reactor core that are termed Open Test Assembly positions. These positions are located under spoolpieces in the reactor head and allow the installation of 38-foot-long assemblies which extend from the reactor head down to the reactor core. Within the 82 active core locations, there are up to 20 or more additional locations that could contain a standard length (3.6-meter or 12-foot) test assembly. In addition to the test locations within the active fueled region of the core, there are 108 locations available in the surrounding reflector region where other tests could be inserted.

The FFTF core would be modified to include an array of target assemblies and rapid radioisotope retrieval systems capable of producing a number of long- and short-lived isotopes for medical and industrial applications and plutonium-238 for space power applications. In addition, reactor space would be provided for research and development test articles.

Fifteen plutonium-238 production targets would be included in the reflector region with an annual production rate of 5 kilograms. The residence time for these targets would be three 100-day cycles with five assemblies being harvested at the end of each cycle.

Long-Term Irradiation Vehicles would be used to irradiate targets to produce long-lived isotopes, installed in the reactor during normal refueling operations, and handled using standard FFTF handling equipment. The Long-Term Irradiation Vehicle would consist of a bundle of target pins installed inside a nozzle, duct, and handling socket assembly similar in appearance to an FFTF 3.6-meter (12-foot) long fuel assembly. Rapid radioisotope retrieval systems would be installed in selected Open Test Assembly positions for the production of short-lived isotopes. There would be a maximum of eight systems in the core.

ATR. ATR is a light-water-cooled and moderated reactor with a design thermal power of 250 megawatts that is owned by DOE and is in the Test Reactor Area in the southwest portion of INEEL. Figure S–2 presents a map of INEEL that depicts ATR's location. ATR would continue to operate and meet its current mission requirements including naval reactor research and development, medical and industrial isotope production, and nuclear research and development activities, at its current operating levels in the No Action Alternative, Alternative 1 (Restart FFTF), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), Alternative 5 (Permanently Deactivate FFTF [with No New Missions]), and Alternative 2 (Use Only Existing Operational Facilities) when it is not providing irradiation services in support of the plutonium-238 production mission. When ATR is supporting the plutonium-238 production mission, it would fully support its primary mission, naval reactor research and development; however, it would support the medical and industrial isotope production and nuclear research and development activities to the extent possible within its current reactor operating levels. Consideration must be given to the need to maintain appropriate levels of neutron flux to support ATR's primary mission. Neutron flux levels can be impacted by the placement of targets, such as neptunium-237 targets for production of plutonium-238, in the reactor core. The production planning assumption for ATR is from 3 kilograms (6.6 pounds) of plutonium-238 per year (if used in conjunction with HFIR) to 5 kilograms (11 pounds) of plutonium-238 per year (if ATR were used alone). Thus, ATR alone could meet the program goal of 5 kilograms (11 pounds) per year and could be used in combination with any one of the three processing facilities for the plutonium-238 production mission.

Special features of ATR include high neutron flux levels (ranging from 1×10^{15} neutrons per square centimeter per second in the flux traps to 1×10^{13} neutrons per square centimeter per second in the outer reflector positions) and the ability to vary power to fit different experiment needs in different test positions. The primary user of ATR is the U.S. Naval Nuclear Propulsion Program. A variety of other users include foreign and domestic government programs, a commercial isotope production company, industrial customers, and research and development interests. A number of support facilities are important to the operation of ATR. Among these are the Advanced Test Reactor Critical Facility, which is used to baseline experiment impacts to ATR flux profile, and the Nuclear Materials Inspection and Storage facility, which is used to receive, store and inspect reactor fuel prior to its placement in ATR.

The reactor, its primary coolant system, control room, and much of its auxiliary and experimental support equipment are in Test Reactor Area Building 670. ATR began operation in 1967 and is expected to continue operating for several decades. The reactor vessel is entirely stainless steel and the core internals are replaced every 7 to 9 years. Buildings and structures in other parts of the Test Reactor Area provide additional support functions.

ATR is a light-water-cooled and -moderated reactor with a design thermal power of 250 megawatts and typically operates at approximately 140 megawatts or less. ATR operates with highly enriched uranium fuel. Typical operating cycles are 42 days or 49 days at power followed by a 7-day outage for refueling and changeout of experiments and isotope production targets. The core is 1.2 meters (4 feet) high and is surrounded by a 1.3-meter-diameter (4.25-foot-diameter) beryllium reflector. Beryllium is an excellent neutron reflector and is used to enhance the neutron flux essential to a test reactor. ATR has nine flux traps in its core and achieves a close integration of flux traps and fuel by means of a serpentine fuel arrangement. When viewed from above, the ATR fuel region resembles a four-leaf clover. The four flux traps positioned within the four lobes of the reactor core are almost entirely surrounded by fuel, as is the center position. Four other flux trap positions between the lobes of the core have fuel on three sides. The ATR’s unique control device design permits large power shifts among the nine flux traps. Testing can be performed in test loops installed in some flux traps with individual flow and temperature control or in reflector irradiation positions with primary fluid as coolant. The curved fuel arrangement brings the fuel closer on all sides of the test loops than is possible in a rectangular grid.

Of the nine flux traps, five are configured with pressurized-water loops that allow for individual temperature, pressure, flow, and chemistry controls. The five test loops are used by the Naval Reactors program. Of the remaining four flux traps, one is dedicated to the Naval Reactors program, one is used for isotope production, one is used for low-specific-activity cobalt production, and the fourth has recently had the Irradiation Test Vehicle installed. The Irradiation Test Vehicle can be described as three small pressurized-gas test loops. The use of one of these three test loops was recently purchased by a British corporation; negotiations for use of the other two are currently under way.

In addition to the primary flux trap irradiation positions, there are some 70 irradiation positions in the beryllium reflector (and aluminum support structure) that are available for experiment irradiation and isotope production. These position diameters range from 15.9 millimeters (0.625 inch) to 127 millimeters (5.0 inches) with thermal neutron flux levels ranging from 1×10^{15} neutrons per square centimeter per second to 1×10^{13} neutrons per square centimeter per second.

INEEL has privatized the production of medical and industrial isotopes through contracting with a commercial entity, which specializes in producing isotope targets for irradiation in ATR and processing and distributing commercial-grade isotopes to its customers. Prior to commercialization, INEEL’s isotope production operations were limited in types and quantities. Since the start of commercial activities, production has expanded. Incremental investments have been identified for ATR that would make it a more versatile and capable reactor for isotope production. Commercial companies are in the discussion phase of investing in ATR to install an isotope shuttle (or rabbit) system for the production of short-lived radioisotopes. Many of these short-lived radioisotopes are expected to be in growing demand for various cancer therapies.

HFIR. HFIR is a light-water-cooled and -moderated reactor operating at a thermal power level of 85 megawatts. HFIR is owned by DOE and is in the 7900 Area in the southern portion of ORR. Figure S–1 presents a map of ORR that depicts the location of HFIR.

HFIR would continue to be operated to meet the primary mission of neutron science based research for DOE's Office of Science. In addition, medical and industrial isotope production and nuclear research and development activities would be performed on a not-to-interfere basis at the current operating level in the No Action Alternative, Alternative 1 (Restart FFTF), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), Alternative 5 (Permanently Deactivate FFTF [with No New Missions]), and Alternative 2 (Use Only Existing Operational Facilities) when HFIR is not providing irradiation services in support of the plutonium-238 production mission. When HFIR is supporting the plutonium-238 production mission, it would fully support its primary mission, but would support the medical and industrial isotope production and nuclear research and development activities to the extent possible within the current reactor operating levels. Consideration must be given to the need to maintain appropriate levels of neutron flux to support HFIR's primary mission. Neutron flux levels can be impacted by the placement of targets, such as neptunium-237 targets for the production of plutonium-238, in the reactor core. Under the planning assumptions for plutonium-238 production, HFIR could only produce from 1 to 2 kilograms (2.2 to 4.4 pounds) per year without impacting ongoing missions. As the program goal is to achieve a production rate of 5 kilograms (11 pounds) per year, production at HFIR would need to be augmented by the use of ATR to meet this goal. HFIR and ATR together could meet the program goal of 5 kilograms (11 pounds) per year, and could be used in combination with any one of the three processing facilities for the plutonium-238 production mission.

HFIR was originally designed as both an isotope production and a research reactor with a thermal flux of 3 to 5×10^{15} neutrons per square centimeter per second and a full power level of 100 megawatts-thermal (3.4×10^{8} British thermal units per hour). It is currently operating at a maximum authorized power level of 85 megawatts-thermal ($2.9\text{x}10^{8}$ British thermal units per hour) to extend the useful life of the reactor. Many experiment-irradiation facilities were provided for in the original design and several others have been added. The primary mission of HFIR is neutron science research. Isotope production is done on a not-to-interfere basis.

HFIR is light water-cooled and moderated, beryllium-reflected, and transfers its primary coolant heat load to secondary coolant through heat exchangers for dissipation to the atmosphere by an induced-draft cooling tower. The reactor uses highly enriched uranium and aluminum-clad plate fuel. The reactor vessel itself is immersed in a pool in a poured-concrete reactor building that also houses the primary coolant pumps and heat exchangers, a spent fuel pool, and experiment areas. The control and water wing of the reactor building contains the reactor control room; relay and amplifier areas; heating and ventilating equipment; pool and fire alarm equipment; instrumentation systems; and office and support rooms. A separate electrical building adjacent to the reactor building contains switchgear, diesel generators, and associated transformers that connect the facility to offsite power. The reactor building is essentially airtight and provides dynamic confinement. A special hot exhaust system exhausts air from potentially contaminated areas of the building through two absolute filters (two charcoal beds) before being released to the atmosphere through a 76-meter (250-foot) stack. The stack serves as the exhaust point for both HFIR and REDC at ORNL.

After the reactor completed 17.2 full-power years of its 20 full-power year design life in November 1986, several measures were taken to extend the useful life of the reactor, including reducing the 100 megawatts-thermal (3.4×10^{8} British thermal units per hour) rated power level to 85 megawatts-thermal (2.9×10^{8} British thermal units per hour); adjusting the primary coolant temperature and pressure; conducting periodic hydrostatic tests; establishing an irradiation embrittlement surveillance program; and installing an emergency depressurization system. Subsequent life extension programs can enable HFIR to provide support during the total 35-year evaluation period for operations.

Experiment-irradiation facilities available include (1) the hydraulic tube facility, located in the very high flux region of the flux trap, which allows for insertion and removal of irradiation samples while the reactor is operating; (2) 30 target positions in the flux trap, which normally contain transuranium production rods but which can be used for the irradiation of other experiments (two are instrumented target positions provided by a recent modification); (3) six peripheral target positions located at the outer edge of the flux trap; (4) numerous vertical irradiation facilities of various sizes located throughout the beryllium reflector; (5) two pneumatic tube facilities in the beryllium reflector, which allow for insertion and removal of irradiation samples while the reactor is operating for activation analysis; (6) four horizontal beam tubes, which originate in the beryllium reflector; and (7) four slant access facilities, called "engineering facilities," located adjacent to the outer edge of the beryllium reflector. In addition, spent fuel assemblies are used for gamma irradiation in the gamma irradiation facility in the reactor pool.

The reactor core assembly is contained in a 2.44-meter (8-foot) diameter pressure vessel located in a pool of water. The top of the pressure vessel is 5.18 meters (17 feet) below the pool surface, and the reactor horizontal midplane is 8.38 meters (27.5 feet) below the pool surface. The control plate drive mechanisms are located in a subpile room beneath the pressure vessel. These features provide the necessary shielding for working above the reactor core and greatly facilitate access to the pressure vessel, core, and reflector regions.

The neutron flux within HFIR is primarily a thermal neutron flux ranging from approximately 2×10^{15} neutrons per square centimeter per second in the flux trap to approximately 4×10^{14} neutrons per square centimeter per second in the outer regions of the beryllium reflector. Specially designed neutron beam tubes provide access to neutrons that supply intense neutron beams to various specialized instruments used for neutron scattering research.

ORNL produces a variety of medical isotopes using the HFIR for irradiation and various hot cell and glovebox facilities for target fabrication and final product purification. The nine hydraulic tube positions in the central high flux region permit the insertion and removal of targets at any time during the operating cycle (22 to 24 days) and have traditionally represented a major site for the production of medical radioisotopes. In addition to providing radioisotopes for extramural research and development and commercial applications by distribution through the DOE Isotope Production and Distribution Program, there are medical radioisotope research and development research programs at ORNL that depend on the availability of HFIR-produced radioisotopes.

CLWR. A CLWR would continue to operate and meet its primary mission requirement, providing steam for the generation of electrical power in the No Action Alternative, Alternative 1 (Restart FFTF), Alternative 3 (Construct New Accelerator[s]), Alternative 4 (Construct New Research Reactor), Alternative 5 (Permanently Deactivate FFTF [with No New Missions]), and Alternative 2 (Use Only Existing Operational Facilities) when it is not providing irradiation services in support of the plutonium-238 production mission. When the CLWR is supporting the plutonium-238 production mission, it would still fully support its primary mission. The production planning assumption for the generic CLWR is 5 kilograms (11 pounds) per year of plutonium-238 or 7.5 kilograms (16.5 pounds) per 18-month operating cycle. Thus, the CLWR alone could meet the program goal of 5 kilograms (11 pounds) per year and could be used in combination with any one of the three processing facilities for the plutonium-238 production mission and the DOE nuclear research and development mission. The use of a CLWR for the medical and industrial isotope production mission and the DOE nuclear research and development mission were not considered practical.

A typical pressurized water reactor core consists of 170 to 200 fuel assemblies arranged in the reactor vessel in an approximately cylindrical pattern. Most pressurized water reactors operating in the United States are licensed to operate at thermal power levels of 2,500 to 3,500 megawatts (8.5×10^{9} to 1.2×10^{10} British thermal units per hour) for net station electrical outputs of 800 to 1,200 megawatts electric (2.7×10^{9} to 4.1×10^{9} British thermal units per hour).

The nuclear steam supply system powered by the pressurized water reactor is generally arranged as two heat transport loops, each with two primary coolant circulating pumps and one steam generator in which the primary coolant dissipates heat generated in the reactor core to the secondary fluid in the steam generator. In addition to serving as a heat transport medium, the primary coolant also serves as a neutron moderator and reflector and as a solvent for the soluble boron used in chemical reactivity control. All nuclear steam supply system components are designed to withstand the effects of earthquakes and loss-of-coolant accidents.

The containment for a pressurized-water reactor plant consists of two structures: (1) a steel containment vessel and (2) a reinforced-concrete shield building. The containment, including all of its penetrations, is a low-leakage steel structure designed to withstand a postulated loss-of-coolant accident and to confine a postulated release of radioactive material. It houses the reactor pressure vessel, reactor coolant piping, pressurizer, pressurizer quench tank and coolers, reactor primary coolant pumps, steam generators, core flooding tanks, and letdown coolers. Safety systems directly associated with this vessel include the containment spray system, the containment air cooling system, and the containment isolation system. An annular space is provided between the wall of the containment vessel and the shield building. Overhead clearance from the dome of the shield building is also provided.

The shield building itself is a concrete structure surrounding the containment that is designed to provide biological shielding during both normal operations and hypothetical accident conditions. The shield building enables the collection and filtration of fission product leakage from the containment following a hypothetical accident by means of its emergency ventilation system. In addition, the shield building provides environmental protection for the containment from adverse atmospheric conditions and external missiles (e.g., tornado debris).

All fuel assemblies are identical in mechanical construction and are interchangeable in any core location. The basic fuel assembly is normally composed of 208 fuel rods, 16 control rod guide tubes, and one centrally located position for instrumentation, all within a 15×15 position square array. The fuel assembly is approximately 20.3×20.3 centimeters (8×8 inches) in cross section and has an overall length of 419 centimeters (165 inches).

The substitution of target rods for fuel rod positions in the center fuel assembly would only minimally impact reactor operations. The fuel rods located in the center fuel assembly position would normally not be fresh fuel (i.e., fuel inserted within the first 18-month operating cycle in the reactor); instead, they would be in their second or third operating cycle. The normal power distribution within the core and reactor coolant flow and its distribution within the core would remain within existing technical specification limits.

New Accelerator(s). One or two new accelerators would be constructed and operated in Alternative 3 (Construct New Accelerator[s]). Preconceptual designs have been developed for a low-energy accelerator and a high-energy accelerator for evaluation in the NI PEIS. The low-energy accelerator would support the medical and industrial isotope production missions and the nuclear research and development mission. This could effectively be accomplished with accelerator energies in the range of 30 to 70 million electron volts. The high-energy accelerator design would support the plutonium-238 production mission and the nuclear research and development mission. An accelerator with an energy level of 1,000 million electron volts is required to support the plutonium-238 and nuclear research and development missions.

The preconceptual design of the high-energy accelerator presented in Appendix F of the NI PEIS focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce "tuneable" neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and materials interactions.

The accelerator(s) would be constructed and operated at one or two existing DOE sites. The low-energy accelerator would be located on the same DOE site as the new support facility or at a DOE site with an existing support facility. The high-energy accelerator could be located at a different DOE site. Alternative 3 site selection is not evaluated as part of the NI PEIS.

Because Alternative 3 is evaluated at a generic DOE site, no credit was taken for any existing support infrastructure at the site, and it was postulated that a new support facility would be required to support operation of the low-energy accelerator and its missions and the high-energy accelerator nuclear research and development missions if both accelerators are located on the same site. While this approach bounds the environmental impact assessment for the implementation of Alternative 3, it overstates the impacts because the NI PEIS integrates the impacts associated with constructing new support facilities and infrastructure that may be available at the existing DOE site. In the event that Alternative 3 or the low-energy accelerator alone is selected in the Record of Decision for subsequent consideration, follow-on NEPA assessments would evaluate potential locations for either both accelerators or one of the accelerators. It is highly unlikely that DOE would consider locating the new low-energy or high-energy accelerator on a DOE site that does not have an existing infrastructure capable of supporting all or most of the proposed mission requirements.

Low Energy Accelerator: Three low-energy accelerator options would be available for the production of medical and industrial isotopes and to support nuclear energy research and development: (1) a high-current proton linear accelerator, (2) a multiparticle cyclotron, or (3) a proton-only cyclotron. The proton-only cyclotron would have distinct technical advantages over the other two options and is described further in the section that follows.

The proton-only cyclotron can be either a positive proton or negative ion type and is referred to as a proton cyclotron H^+ or proton cyclotron H^-. The alternative of a positive proton cyclotron would offer lower vacuum requirements and, with the latest technology, high-extraction efficiency can be achieved. But obtaining variable energy output would be complicated; extraction can be into only a single port and splitting the beam would require a complicated septum magnet. In comparison, the negative ion cyclotron would offer a continuous beam with high-current capacity using very simple high-efficiency extraction, a simple method to vary the particle energy, and the possibility of simultaneous irradiation of two different target arrays at different energies. The high-extraction efficiency would be achieved simply by passing the negatively charged beam through a thin foil that strips the electrons from the ion, creating a positive proton. The proton would be directly ejected from the machine by the existing magnetic field with high efficiency (greater than 98 percent). This feature would be important to minimize the activation of the cyclotron structure and thus reduce radiation exposure to the operational staff.

A high-beam current would be advantageous because more products could be prepared in a shorter time. In addition, a much higher specific-activity radioisotope could be prepared at the higher-beam current of the cyclotron. Specific activity is often a critical parameter in many nuclear medicine applications, including research and clinical use. The cyclotron can also continuously tune the beam energy, which would be an advantage for research. The ability to tune the energy with precision can also help achieve high-purity isotope production by avoiding energies where impurity isotopes would be readily co-produced. These are important advantages for flexibility in research isotope production and are within the capabilities of commercially proven technology.

A new building, with a 43-meter (140-foot) by 43-meter (140-foot) footprint, would be constructed to house the cyclotron and the four beam lines. The walls of the facility would be 4.6 meters (15 feet) thick behind the target stations to minimize the neutron flux outside the building. The walls surrounding the cyclotron itself would be 3 meters (10 feet) thick. The mazes throughout the building in general would have walls 1.5 meters (5 feet) thick, so that the total thickness surrounding the cyclotron area would be 3 meters (10 feet). The beam would be diverted to the four target stations by switching magnets located in the cyclotron vault. The beam would be directed through focusing and steering magnets to the target. In the isotope production beam line (northwest cave), the targets would be installed and removed vertically from a hot cell, which would be located on the second floor directly above the target station. The power supplies for the magnets would be housed with the power supplies for the cyclotron. The mechanical equipment for cooling water would be housed in a shielded mechanical room adjacent to the cyclotron vault. Recirculating water for cooling of the targets and systems that could contain potentially radioactive material would be separated to prevent cross-contamination. These systems would be contained in mechanical equipment rooms near the respective target station. Piping would be contained in waterproof trenches with leak detection.

High-Energy Accelerator: In accelerator production of plutonium-238, an energetic beam of protons generated by a linear accelerator would be transported to a heavy metal target where spallation neutrons would be produced and moderated in a surrounding blanket. The blanket containing neptunium-237 would capture the slowed neutrons to produce plutonium-238 through the same nuclear sequence that occurs in a reactor. The accelerator would be housed in a concrete tunnel, buried below ground to provide radiation shielding for operating personnel. A building housing radio frequency power systems and other equipment used to drive, monitor, and control the accelerator would be located above ground close to the accelerator tunnel. The target/blanket assembly would be housed inside a steel and concrete shield located within a multistory building that would contain appropriate service equipment. At the target, the small-diameter proton beam transported magnetically from the accelerator would be converted to a much larger cross section by a beam expander to reduce the power density to acceptable levels for the target cooling systems.

A source of neutrons produced by an accelerator can be used to produce plutonium-238 from neptunium-237 feedstock through the capture and decay nuclear processes. A 1,000-million-electron-volt proton beam produced by a radio frequency linear accelerator would bombard a heavy metal (uranium-238) target, with each proton producing about 40 neutrons.

A very preliminary target/blanket design has been developed for scoping purposes, based on the architecture employed in the accelerator production of tritium target/blanket design. It would use uranium-238 (cooled by heavy water [D_2O]) as the neutron-production target. The target would be surrounded by a blanket of neptunium-237 in a dilute mixture of aluminum and water coolant. Enclosing the blanket would be a beryllium reflector.

To meet the plutonium-238 production goal of 5 kilograms (11 pounds) per year, the high-energy accelerator facility would conduct three 4-month production campaigns. Each campaign would be divided into 100 days of production and 21 days for recycling the production blanket. A 90 percent plant availability during the scheduled operating periods is assumed. Based on operating experience at the Los Alamos Neutron Science Center Linear Accelerator, the 90 percent plant availability should be achievable.

The preconceptual design of the high-energy accelerator presented in Appendix F of the NI PEIS focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce "tuneable" neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and materials interactions.

New Research Reactor. A new research reactor would be constructed and operated in Alternative 4 (Construct New Research Reactor). A preconceptual design for a new research reactor was developed to meet the following DOE missions: (1) producing medical and industrial isotopes, (2) producing plutonium-238 (net annual minimum production of 5 kilograms) for use in radioisotope power systems for NASA space missions, and (3) providing irradiation services for nuclear energy research and development activities. In accordance with U.S. nuclear nonproliferation policy, a design limitation of this new research reactor is that it can only use low-enriched uranium with an enrichment of less than 20 percent uranium-235. This preconceptual design includes the basic elements of the research reactor facility, which are sufficient to support the NI PEIS, but does not include the design details (e.g., system and layout drawings, bill of materials, electrical and piping routing, etc.) commensurate with a complete preliminary reactor design.

The design of the new research reactor is based on current research reactor designs that have been approved by both the NRC and the International Atomic Energy Agency, as well as nuclear regulatory authorities of many nations. Reactor core physics calculations were performed to evaluate three different nuclear fuel designs. Based on this analysis, the desired mission for this reactor, current nuclear fuel manufacturing capabilities, and safety considerations; a training, research, isotope General Atomics (TRIGA) production reactor fuel design was selected for the new research reactor. The principal distinguishing features of the TRIGA fuel are its proven safety performance during power pulsing and its demonstrated long-term irradiation integrity.

To concurrently produce medical and industrial isotopes along with the required quantity of plutonium-238 production goal of 5 kilograms (11 pounds) per year and provide irradiation services for nuclear research and development, it was determined that a reactor core power of 50 megawatts-thermal would be necessary. The 50 megawatt-thermal power level was selected based on preliminary preconceptual designs of the reactor and targets. Subsequent to defining the baseline reactor and target designs presented in Appendix E of the NI PEIS, analyses have indicated that target design refinements and reactor design and operation refinements (e.g., increasing the operating power level to 100 megawatts-thermal) could significantly reduce the neptunium-237 target fabrication and processing requirements by increasing the neptunium-237 to plutonium-238 conversion efficiency during target irradiation by a factor of eight. At the 50-megawatts-thermal power level, the core would require an active cooling system with forced coolant flow to maintain the fuel below its material thermal limits. The new research reactor cooling system would use a tank within a pool that is connected to primary coolant circulating pumps, heat exchangers, and an ultimate heat sink consisting of two cooling towers. The pool would be housed in a reactor building that would also enclose the pumps, heat exchangers, secondary systems, and spent nuclear fuel storage pool. The spent nuclear fuel storage pool, sized to store the reactor core's discharged spent nuclear fuel for its entire 35-year evaluation period, could be hydraulically connected to the reactor core pool for refueling and emergency reflooding. The ultimate heat sink cooling towers, air exhaust stack, and emergency diesel generators would be located outside the reactor building.

The fuel for the new research reactor would be based on an extension of current licensed low-enriched uranium TRIGA fuel designs for 10- to 16-megawatts-thermal reactors. The new research reactor fuel design would be identical to current low-enriched uranium TRIGA fuel for higher power cores, except the new reactor fuel would have a larger assembly configuration array (i.e., 8 by 8 versus 4 by 4) and a longer active fuel length

(153.7 centimeters [60.5 inches] versus 55.88 centimeters [22.0 inches]). The larger array and length were selected to meet the plutonium-238 production requirements and to maintain high safety factors with respect to fuel thermal performance.

Along with the fuel rods, the core would contain a number of medical and industrial isotope and plutonium-238 production target rods. These rods would occupy positions in a fuel assembly where a fuel rod would otherwise exist. Each of these positions would have an Incoloy 800 alloy guide tube with the same dimensions as the fuel rod cladding. The target rods would be inserted into these guide tubes for their design irradiation time. In addition, some fuel rod positions in core fuel assemblies would be replaced with similar guide tubes to accommodate Incoloy 800 clad boron carbide (B_4C) control rods. Boron carbide is a widely used, proven, and accepted neutron absorber for control rods. The new research reactor core design would consist of 68 fuel assemblies, each of which would be enclosed in a square aluminum shroud for structural support and coolant flow control. The core would include eight rabbit tubes for short irradiation time production of medical or industrial isotopes and nuclear research and development. These rabbit tubes would be located outside the fuel region of the core, but still within an area with a relatively high neutron flux.

Transportation

The following is an overview of the transportation requirements for each alternative. For all alternatives, overland shipments are assumed to use trucks, either commercial vehicles or DOE safe secure trailers. Transatlantic shipments would use purpose-built ships and certain isotopes would be shipped in aircraft. The types of packaging used to transport materials is discussed in Appendix J of the NI PEIS.

Plutonium-238 purchased from Russia under all options of the No Action Alternative would be transported from St. Petersburg to a U.S. port of entry, and from there to LANL where it would be prepared for use in radioisotope power systems. The impacts of the transportation of a total of 40 kilograms (88.2 pounds) of plutonium-238 are estimated in the *Environmental Assessment of the Import of Russian Plutonium-238* (DOE 1993) and are summarized in Section 4.2 of the NI PEIS. The impacts associated with transporting 175 kilograms (385 pounds) (5 kilograms per year for the 35-year evaluation period) of plutonium-238 have been determined by extrapolation and are included in the same section. Under Options 2 through 4 of the No Action Alternative, neptunium-237 would be shipped from SRS to the designated storage facilities at ORNL, INEEL, or Hanford for long-term storage. Under Alternatives 1 through 4, the neptunium-237 would be shipped to the same facilities for storage and subsequent processing for fabrication of targets for plutonium-238 production. Medical isotopes would continue to be shipped to commercial vendors via track and air from DOE locations throughout the country.

Under Alternative 1, targets for plutonium-238 production would be fabricated in one of three alternative facilities at ORNL, INEEL, or Hanford. The targets would be irradiated at FFTF using mixed oxide fuel shipped from Europe and/or highly enriched uranium fuel from a commercial fuel fabricator in the United States. The irradiated targets would be transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would be transported to LANL for fabrication into heat sources for radioisotope power systems. Targets for medical and industrial isotope production would be fabricated in one or more facilities at Hanford. Target materials would be shipped to Hanford from other offsite facilities. The targets would be irradiated in FFTF and returned to the fabrication facilities for postirradiation processing. Medical and commercial isotopes would then be shipped to commercial vendors via truck and air.

Under Alternative 2, targets for plutonium-238 production would be fabricated in one of three facilities at ORNL, INEEL, or Hanford. The targets would be irradiated at ATR, HFIR, or a CLWR and transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would than be shipped to LANL following postirradiation processing. Medical isotopes would continue to be shipped to commercial vendors via track and air from DOE locations throughout the country.

Under Alternative 3, the targets for plutonium-238 production would be fabricated in one of three facilities at ORNL, INEEL, or Hanford. The targets would be irradiated at the new high-energy accelerator and transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would than be shipped to LANL following postirradiation processing. Targets for medical and industrial isotope production would be fabricated in a new facility at the generic DOE site. Target materials would be shipped to the new facility from offsite. The targets would be transported to the on site low-energy accelerator for irradiation and returned to the fabrication facilities for postirradiation processing. Products would then be shipped to commercial vendors via truck and air transport.

Under Alternative 4, the targets for plutonium-238 production would be fabricated in one of three facilities at ORNL, INEEL, or Hanford. The targets would be irradiated at the new reactor and transported back to the fabricating facilities for postirradiation processing. The separated plutonium-238 would then be shipped to LANL following postirradiation processing. Targets for medical and industrial isotope production would be fabricated in a new facility at the generic DOE site. Target materials would be shipped to the new facility from offsite. The targets would be transported to the new on site research reactor for irradiation and returned to the fabrication facilities for postirradiation processing. Products would then be shipped to commercial vendors via truck and air transport.

No transportation is analyzed for Alternative 5, the deactivation of FFTF, with no new missions. Medical isotopes would continue to be shipped to commercial vendors via track and air from DOE locations throughout the country.

For alternatives that include fabrication and irradiation of targets at one site, intrasite transportation between facilities is analyzed. The shipment of fuel to the irradiation facilities is also analyzed. For Alternative 4, this includes the shipment of low-enriched uranium fuel to the new reactor. For alternatives involving irradiation at FFTF, this includes the shipment of mixed oxide fuel from Europe and/or highly enriched uranium fuels from a commercial fuel fabricator in the United States.

S.4 APPROACH TO ENVIRONMENTAL IMPACT ANALYSIS

The environmental impact analysis addresses the full range of natural and human resource areas pertinent to the sites considered for the nuclear infrastructure alternatives. Impacts are assessed for land resources, noise, air quality, water resources, geology and soils, ecological resources, cultural and paleontological resources, socioeconomics, waste management, and cumulative impacts. A region of influence for each resource area is identified and analyzed for each candidate site.

Baseline conditions at the three DOE sites assessed in the NI PEIS, ORR, INEEL, and Hanford, as well as an existing CLWR, include present and reasonably foreseeable future actions at each site. Since baseline data for certain irradiation facilities were not available, sitewide data were used to quantify baseline conditions for assessment of the environmental impacts of proposed actions at each site. Sitewide data set forth in the No Action Alternative define the baseline conditions used in the analysis of action alternatives for each site and are the data upon which incremental values were added to determine overall impacts.

Impacts in all resource areas were analyzed consistently; that is, the impact values were estimated using a consistent set of input variables and computations. Moreover, efforts were made to ensure that calculations in all areas used accepted protocols and up-to-date models. The following is a brief summary of the affected resources and their impact assessment methodologies.

Land Use. Land use includes the land on and adjacent to each site, the physical features that influence current or proposed uses, pertinent land use plans and regulations, and land ownership and availability. The region of influence for land use varies due to the extent of land ownership, adjacent land use patterns and trends, and other geographic or safety considerations. The amount of land disturbed and conformity with existing land use were considered in order to evaluate impacts. Conformity with existing land use was evaluated for each alternative. Land disturbance was considered only for those alternatives involving new construction. However, because the location of one or two new accelerators or a research reactor and support facility is unknown, the acreage required is only an approximation. In order to determine the range of potential effects from new facilities, the analysis considered potential impacts from construction and operation at both a disturbed and undisturbed location at a generic DOE site.

Visual Resources. Visual resources are the natural and human-created features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture. The region of influence for visual resources includes the geographic area from which the proposed facilities may be seen. Impacts to visual resources were determined by evaluating whether or not the Bureau of Land Management Visual Resource Management classification of the site would change as a result of the proposed action. For those alternatives involving existing facilities at known DOE sites, alterations to visual features were readily evaluated and the impact on the current Visual Resource Management classification determined. For those alternatives involving construction and operation of one or two new accelerators or a research reactor at a generic DOE site, the visual characteristics of the site are unknown. Thus, to determine the range of potential visual effects, the analysis considered potential impacts from construction and operation at both a disturbed and an undisturbed location at the generic site. Impacts associated with the use of an existing CLWR are also described in a general manner because its location is not known.

Noise. Sound results from the compression and expansion of air or some other medium when an impulse is transmitted through it. Sound requires a source of energy and a medium for transmitting the sound wave. Propagation of sound is affected by various factors, including meteorology, topography, and barriers. Noise is undesirable sound that interferes or interacts negatively with the human or natural environment. The region of influence for each site includes the site and surrounding area, including transportation corridors, where proposed activities might increase noise levels. Impacts from facility modification and operation were assessed according to the types of noise sources and the locations of the proposed facilities relative to the site boundary. Potential noise impacts from traffic were based on the likely increase in traffic volume. Possible impacts to wildlife were evaluated based on the possibility of sudden loud noises occurring during facility modification and operation. Acoustic impacts from facility construction and operation at generic sites were assessed according to the types of new noise sources and characteristics identified for a generic site. The change in traffic noise levels at a generic site could not be assessed without site-specific data.

Air Quality. Air pollution refers to the introduction, directly or indirectly, of any substance into the air that could result in harmful effects of such nature as to endanger human health and harm living resources and ecosystems, as well as material property, and impair or interfere with the comfortable enjoyment of life and other legitimate uses of the environment. For the purpose of the NI PEIS, only outdoor air pollutants were addressed, which may be in the form of solid particles, liquid droplets, gases, or a combination of these forms. Air pollutants are transported, dispersed, or concentrated by meteorological and topographical conditions. Potential air quality impacts of pollutant emissions from facility modification and normal operations were evaluated for those alternatives associated with FFTF restart and the use of existing facilities. This assessment included a comparison of pollutant concentrations from each alternative with applicable Federal and state ambient air quality standards. If both Federal and state standards exist for a given pollutant and averaging period, compliance was evaluated using the more stringent standard. Air quality impacts associated with a CLWR were addressed as a contribution from the facility operation. Air quality impacts from one or two new accelerators or a new research reactor were discussed for construction and operation at a generic DOE site. Emissions of potential stratospheric ozone-depleting compounds were not evaluated, as no emissions of these pollutants were identified in engineering design reports.

Water Resources. Water resources are the surface and subsurface waters that are suitable for human consumption, aquatic or wildlife propagation, agricultural purposes, irrigation, or industrial and commercial purposes. The region of influence used for water resources encompasses those surface water and groundwater systems that could be impacted by water withdrawals, effluent discharges, and/or spills or stormwater runoff associated with construction and operation of the proposed facilities. Water use analysis involved the review of engineering estimates of expected water use and effluent discharges associated with each alternative, and the impacts on local water availability and quality, including surface water and groundwater. Impacts on water use were assessed by determining changes in the volume of current water usage and effluent discharges as a result of the proposed activities. Water quality analysis consisted of determining how effluent discharges to surface water, as well as discharges reaching groundwater, from the proposed facilities would affect current water quality. A comparison of the projected water quality with relevant regulatory standards was made. Separate analyses were conducted for surface water and groundwater impacts.

Geology and Soils. Geologic resources include consolidated and unconsolidated earth materials, including mineral assets such as ore and aggregate materials, and fossil fuels such as coal, oil, and natural gas. Geologic conditions include hazards such as earthquakes, faults, volcanoes, landslides, and land subsidence. Soil resources include the loose surface materials of the earth in which plants grow, usually consisting of mineral particles from disintegrating rock, organic matter, and soluble salts. Prime farmland includes cropland, pasture land, rangeland, and forest land. The region of influence for geology and soils includes all areas subject to disturbance by construction and operation of the proposed facilities, as applicable, and those areas beneath existing or proposed new facilities that would remain inaccessible for the life of the facilities. The geology and soils impact analysis considered the risks to the existing and proposed new facilities of large-scale geologic hazards such as faulting and earthquakes, lava extrusions and other volcanic activity, landslides, and sinkholes, (i.e., conditions that tend to affect broad expanses of land). As the exact nature of the generic DOE or CLWR sites is not known, bounding assumptions were made regarding the range of potential geologic and soils conditions that could be present, coupled with the use of highly conservative estimates of expected impacts. Once candidate sites have been identified, subsequent NEPA actions would be required.

Ecological Resources. Ecological resources include terrestrial and aquatic resources (plants and animals), wetlands, and threatened and endangered species. Terrestrial resources are defined as those plant and animal species and communities that are most closely associated with the land; for aquatic resources, a water environment. Wetlands generally include swamps, marshes, bogs, and similar areas. Endangered species are defined as those species in danger of extinction throughout all or a large portion of their range. Threatened species are defined as those species likely to become endangered within the foreseeable future. Critical habitat is defined as specific areas that contain physical and biological features essential to the conservation of species and that may require special management consideration or protection. The region of influence used for the ecological resource analysis encompassed the area potentially disturbed by construction and operation of the proposed facilities. Impacts to ecological resources may occur as a result of land disturbance, water use, air and water emissions, human activity, and noise associated with project implementation. For alternatives involving construction and operation of one or two new accelerators or a research reactor at a generic DOE site, the analysis generally considered impacts at both a disturbed and an undisturbed location at a generic DOE site. Impacts to terrestrial and aquatic ecosystems and wetlands from water use and air and water emissions were evaluated based on the results of the analysis conducted for air quality and water resources.

Cultural and Paleontological Resources. Potential impacts were assessed separately for each of the three general categories of cultural resources: prehistoric, historic, and Native American. Prehistoric resources are physical remains of human activities that predate written records. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Native American resources are sites, areas, and materials important to Native Americans for religious or heritage reasons. Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geological age. The region of influence for the cultural and paleontological resource analysis encompassed the area potentially disturbed by construction and operation of the proposed facilities. The analysis of impacts to cultural and paleontological resources addressed potential direct and indirect impacts at each site. Potential indirect impacts include those associated with reduced access to a resource site, as well as impacts associated with increased traffic and visitation to sensitive areas. Direct impacts include those resulting from groundbreaking activities associated with new construction. Because the specific location is unknown, impacts from new construction of one or two new accelerators or a research reactor, as well as operation of an existing CLWR, were addressed in a general manner. In order to determine the range of potential impacts, the analysis for new construction considered potential effects at both a disturbed and an undisturbed location at a generic DOE site.

Socioeconomics. Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics of a region. The socioeconomic environment is made up of two geographic regions, the regional economic area and region of influence. Regional economic areas are made up of regional economies and include descriptions of industrial and service sector characteristics and their linkages to the communities within a region. For each regional economic area, data were compiled on the current socioeconomic conditions, including unemployment rates, economic industrial and service sector activities, and the civilian labor force. The workforce and cost requirements of each alternative were determined in order to measure their possible effect on these socioeconomic conditions. Similarly, potential demographic impacts were assessed for the region of influence. The region of influence could represent a smaller geographic area. For each region of influence, census statistics were compiled on population, housing demand, and community services. U.S. Census Bureau population forecasts for the regions of influence were combined with overall projected workforce requirements for each of the alternatives being considered at each of the sites to determine the extent of impacts on housing demand and levels of community services. For those alternatives involving construction and operation of one or two new accelerators or a research reactor at a generic DOE site, the socioeconomic characteristics of the site are unknown. Specific impacts cannot be measured until candidate sites are identified and therefore, impacts were addressed in a general manner. Impacts associated with the use of an existing CLWR were also addressed in a general manner as the location is unknown.

Public and Occupational Health and Safety—Normal Operations. An individual may be exposed to ionizing radiation externally (from a radioactive source outside the body) or internally (from ingesting or inhaling radioactive material). For the analyses conducted in the NI PEIS, the dose from internal exposure is calculated over 50 years following the initial exposure. The three types of doses calculated are external dose, internal dose, and combined external and internal dose. The external dose can result from several different pathways, all having in common the fact that the radiation causing the exposure is external to the body. The appropriate measure of dose is called the effective dose equivalent. The internal dose results from a radiation source entering the human body through either ingestion of contaminated food or inhalation of contaminated air. The unit of measure for internal dose is the committed dose equivalent. The units used for combined external and internal dose are the rem and millirem (1/1000 of 1 rem). The corresponding unit for the collective dose to a population (the sum of the doses to members of the population, or the product of the number of exposed individuals and their average dose) is the person-rem.

The potential impacts of exposure to hazardous chemicals released to the atmosphere were also evaluated for routine operations associated with the alternatives analyzed in the NI PEIS. The receptors considered in these evaluations are the public. Impacts of exposures to hazardous chemicals for workers directly involved in the treatment process were not quantitatively evaluated because workers use personal protective equipment and engineering process controls that limit their exposure to levels within applicable limits. The health effect endpoints evaluated in this analysis include excess incidences of latent cancers for carcinogenic chemicals, and a spectrum of chemical-specific noncancer health effects such as headache, membrane irritation, neurotoxicity, immunotoxicity, liver toxicity, kidney toxicity, developmental toxicity, reproductive toxicity, and genetic toxicity for noncarcinogens.

Public and Occupational Health and Safety—Facility Accidents. The following spectrum of potential accident radiological scenarios were considered in the accident analysis assessment: 1) increase in secondary heat removal, 2) decrease in secondary heat removal, 3) decrease in reactor coolant flow rate, 4) reactivity and power distribution anomalies, 5) increase in reactor primary coolant inventory, 6) decrease in reactor primary coolant inventory, 7) radioactive releases from a subsystem or component, and 8) anticipated transients without scram (e.g., rapid shutdown using control rods and shutdown rods). For each potential accident, information is provided on accident consequences and frequencies to three types of receptors: (1) a noninvolved worker, (2) the maximally exposed offsite individual, and (3) the offsite population. For the CLWR analysis, a noninvolved worker will not be evaluated. The noninvolved worker was originally developed for large DOE sites where several different facilities are under their own control. The noninvolved worker represented an individual not under specific facility control, but also not outside the overall site boundary. At a commercial light-water reactor, however, the entire site is within the exclusion area and under the same control. Consequences to involved workers were also evaluated.

Two accidental chemical scenarios were postulated for the NI PEIS: 1) the accidental uncontrolled release of nitric acid, and 2) the accidental uncontrolled release of nitric oxide. The potential health impacts from accidental releases of hazardous chemicals were assessed by comparing estimated airborne concentrations of the chemicals to emergency response planning guidelines. The potential health impacts from the accidental release of nitric acid and nitric oxide were assessed for three types of receptors: 1) noninvolved workers, 2) offsite receptors, and 3) onsite receptors.

Public and Occupational Health and Safety—Transportation. The overland transportation of any commodity involves a risk to both transportation crew members and members of the public. This risk results directly from transportation-related accidents and indirectly from the increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive substances, can pose an additional risk due to the unique nature of the material itself. To permit a complete appraisal of the environmental impacts of the proposed action and alternatives, the human health risks associated with the overland transportation of neptunium- and plutonium-bearing material are analyzed in the NI PEIS. For each alternative, radiological risks (i.e., those risks that result from the radioactive nature of the neptunium and plutonium) are assessed for both incident-free (i.e., normal) and accident transportation conditions. The radiological risk associated with incident-free transportation conditions would result from the potential exposure of people to external radiation in the vicinity of a loaded shipment. The radiological risk from transportation accidents would come from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people. All radiological impacts are calculated in terms of committed dose and associated health effects in the exposed populations.

In addition to the radiological risks posed by overland transportation activities, vehicle-related risks are also assessed for nonradiological causes (i.e., causes related to the transport vehicles and not the radioactive cargo) for the same transportation routes. The nonradiological transportation risks, which would be incurred for similar shipments of any commodity, are assessed for both incident-free and accident conditions. The nonradiological risks during incident-free transportation conditions would be caused by potential exposure to increased vehicle exhaust emissions. The nonradiological accident risk refers to the potential occurrence of transportation accidents that directly result in fatalities unrelated to the shipment of cargo. National transportation fatality rates are used in the assessment. Nonradiological risks are presented in terms of estimated fatalities.

Environmental Justice. The NI PEIS provides an assessment of the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations from the implementation of each alternative. Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts to human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority population or low-income population is significant and exceeds the risk of exposure rate for the general population or, where available, for another appropriate comparison group. A disproportionately high environmental impact refers to an impact (or risk of an impact) in a low-income or minority community that is significant and exceeds the environmental impact on the larger community. An adverse environmental impact is an impact that is determined to be both harmful and significant. In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed or minority low-income populations are considered. Potentially affected areas examined in the NI PEIS include areas defined by an 80-kilometer (50-mile) radius centered on candidate facilities for plutonium-238 production, radioisotope production, or processing activities located at INEEL, ORR, and the Hanford Site. Potentially affected areas used in the analysis of environmental justice are the same as those used in the analysis of radiological health effects.

Waste Management. The construction and operation of the proposed facilities, as well as the permanent deactivation of FFTF and decontamination and decommissioning of one or two new accelerators, research reactor, and support facility, would generate several types of waste, depending on the alternative. Such wastes include transuranic waste, low-level radioactive waste, mixed low-level radioactive waste, hazardous waste and nonhazardous waste. The alternatives could have an impact on existing site facilities devoted to the treatment, storage, and disposal of these categories of waste. Impacts were assessed by comparing the projected waste stream volumes generated from the proposed activities at each site with that site's waste management capacities and generation rates. Only the impacts relative to the capacities of waste management facilities were considered; other environmental impacts of waste management facility operations (e.g., human health effects) are evaluated in other sections of the NI PEIS, or in other facility-specific or sitewide NEPA documents. Projected waste generation rates for the proposed activities were compared with site processing rates and capacities of those treatment, storage, and disposal facilities likely to be involved in managing the additional waste. Projected waste stream volumes could not be compared to site waste management capacities and generation rates for the alternatives involving the use of a generic DOE site or a CLWR site because a specific location was not identified.

Cumulative Impacts. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The cumulative impact analysis for the NI PEIS involved combining the impacts of the alternatives (including No Action) with the impacts of other present and reasonably foreseeable activities in the region of influence. The regions of influence for different resources can vary widely in extent. In general, cumulative impacts were calculated by adding the values for the baseline affected environment (i.e., conditions attributable to present actions by DOE and other public and private entities), the proposed action, and other future actions. This cumulative value was then weighed against the appropriate impact indicators (e.g., standards) to determine the potential for impact. For this cumulative impact assessment, it was conservatively assumed that all facilities would operate concurrently at the DOE sites. Decontamination and decommissioning of the proposed facilities was not addressed in the cumulative impact estimates. Given the uncertainty regarding the timing of decontamination and decommissioning, any impact estimate at this time would be highly speculative. A detailed evaluation of decontamination and decommissioning will be provided in follow-on NEPA documentation closer to the actual time of those actions.

S.5 COMPARISON OF ALTERNATIVES

The following sections provide a comparison of environmental impacts and risks among the alternatives. Detailed comparison tables are provided in Chapter 2 of the NI PEIS that summarize these impacts by environmental resource areas. Chapter 4 of the NI PEIS identifies construction impacts that would result from implementation of Alternatives 3 and 4, as well as operational impacts for all of the alternatives. For the purposes of summarizing the impacts, construction and operational impacts are summed in the Chapter 2 comparison tables.

In addition to a comparison among the alternatives, Chapter 2 also provides further discussion of impacts by option under each alternative. This discussion provides baseline environmental data at potential sites for reactors and their associated support facilities and summarizes the incremental environmental effects that would result from implementation of the alternatives. Baseline conditions at the three DOE sites assessed in the NI PEIS, ORR, INEEL, and Hanford, as well as an existing CLWR, include present and reasonably foreseeable future actions at each site. Since baseline data for certain irradiation facilities were not available, sitewide data were used to quantify baseline conditions for the assessment of the environmental impacts of proposed actions at each site. Baseline impacts include current operations of the existing reactors and fabrication and processing facilities that are included in the alternatives. Incremental impacts (those additional impacts that would be due to implementation of the alternatives) are added to the baseline impacts to obtain total impacts. Sitewide data set forth in the No Action Alternative define the baseline conditions used in the analysis of other action alternatives for each site and are the data upon which incremental values were added to determine overall impacts. The baseline selected for transportation impacts on human health and safety is Option 1 of the No Action Alternative (no health or safety impacts).

Numerical values were assigned to environmental impacts that include radiological and nonradiological risks to the public and workers at the candidate sites and along representative transportation routes, potential quantities of waste generated, and potential quantities of spent nuclear fuel generated. These numerical values reflect the degree to which the proposed activities would incrementally increase the environmental impacts of current activities and operations at the candidate sites. It should be noted that most of the options being considered under the various alternatives involve the use of more than one site, so the numerical values presented in Chapter 2 are the sums of the values for all of the relevant sites or transportation routes. There are two exceptions—the health risks to the maximally exposed offsite individual and the noninvolved worker. For these two exceptions, the numerical value presented is the maximum value among all relevant sites.

Comparison of Radiological Risks Among the Alternatives

For all alternatives and options, the number of incremental latent cancer fatalities would be less than one. For the purpose of analysis, incremental latent cancer fatalities were added to the baseline for expected latent cancer fatalities to obtain a total for expected latent cancer fatalities. Baseline latent cancer fatalities are discussed in Chapter 4 of the NI PEIS. Values of the baseline latent cancer fatalities are driven by cumulative radiological risks at Hanford and ORNL.

The largest radiological risks would result from accidents. Radiological risks to the public residing in potentially affected areas are driven by accident risks at the target fabrication and processing facilities. **Figure S–4** shows incremental risks to the public that would result from radiological accidents at candidate sites for irradiation facilities and for fabrication and processing facilities. The latent cancer fatalities that would be expected from radiological accidents at FMEF labeled in Figure S–4 as "FMEF (Hanford)" are those calculated for Alternative 1, Options 3 and 6. Under Options 3 and 6 of Alternative 1, FMEF would serve as the fabrication and processing facility for all targets. If FMEF were to fabricate and process neptunium-237 targets only, the radiological accident risk to the public would be reduced by approximately a factor of two as

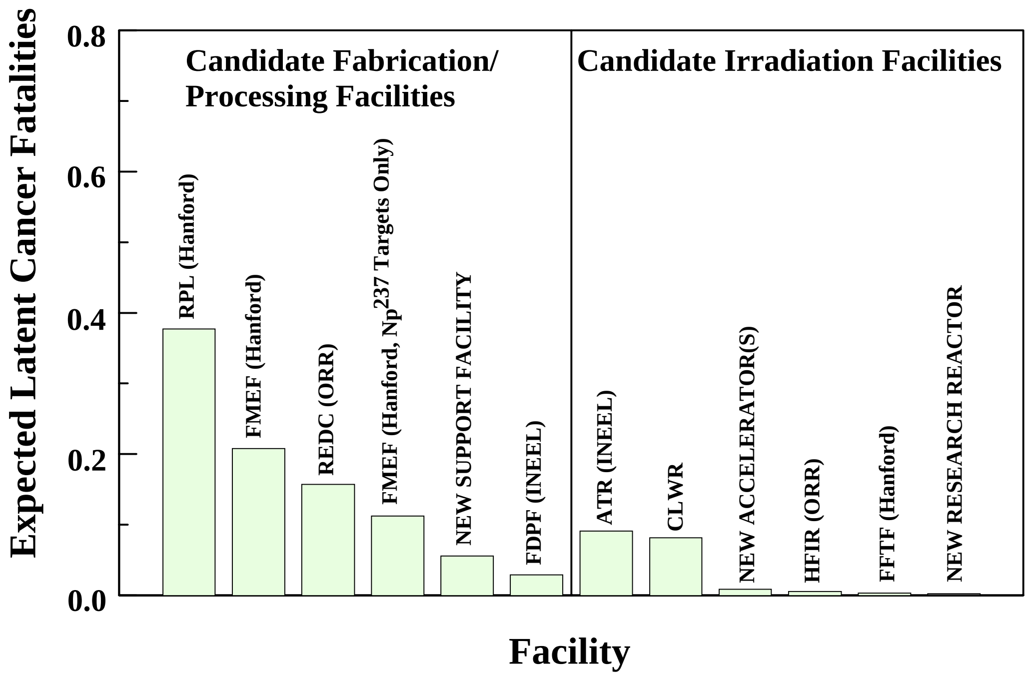

Figure S–4 Public Risks Due to Radiological Accidents at Candidate Irradiation Facilities and Candidate Fabrication and Processing Facilities

shown by the bar labeled "FMEF (Hanford, Np^{237} Targets Only)" in the figure. Candidate fabrication and processing facilities are shown to the left of the dividing line in Figure S–4, and candidate irradiation facilities are shown to the right of the dividing line. Among the fabrication and processing facilities, incremental accident risks to the public range from a low of 0.0287 latent cancer fatality at FDPF (INEEL) to 0.377 latent cancer fatality at RPL (Hanford). Prevailing weather conditions, the geographical distribution of the population at risk, and the type of target(s) processed (plutonium-238 only, other isotopes only, or both) all contribute to variations in public accident risk. Calculations of accident consequences and risks include populations residing within 80 kilometers (50 miles) of the accident site, although the consequences and risks decrease noticeably with increasing distance from the accident site. Assuming similar source terms, accidents at sites nearest a population at risk would be expected to result in the largest risk to the public. RPL (Hanford) and REDC (ORR) have the largest populations residing within 10 miles of the facility, while FDPF (INEEL) has the smallest population residing within 10 miles. Risks to the public that would be expected from radiological accidents at the candidate fabrication and processing facilities are relatively large in comparison to those for the new accelerator(s), HFIR, FFTF, and the new research reactor. A more detailed description of facility accidents is provided in Sections I.1.1, Irradiation Facilities and I.1.4, Processing and Fabrication Facilities of the NI PEIS.

Figure S–5 shows the total public risk due to accidents at the reactor and target fabrication and processing facilities for the various alternatives and options. Alternatives are listed along the horizontal axis and the total (incremental + baseline) radiological risk due to site accidents is shown on the vertical axis. The risk associated with each option under an alternative is represented by a bar whose height represents the risk calculated for that option. For the No Action Alternative and Alternative 5 (Permanently Deactivate FFTF [with No New Missions]), incremental risks are small, and the total risk nearly equals the baseline risk. Considering radiological risk to the public at the sites, Alternatives 3 (Construct New Research Accelerator[s]) and 4 (Construct New Research Reactor) are approximately equal. Implementation of Alternative 3 or 4 would also result in radiological risks approximately equal to those of Alternative 2 (Use Only Existing Operational Facilities). Incremental and total radiological accident risks shown in Figure S–5 are less than one for all alternatives and options. Alternative 1 displays the widest range of accident risks among all the alternatives due to the dependance of total public risk on the selection of fabrication and processing facilities. Normal operations at the sites would result in incremental radiological risks to the public that are typically at least three orders of magnitude less than those due to accidents at the sites.

Radiological transportation risks were found to be less than one latent cancer fatality for all alternatives and options. As indicated in **Figure S–6**, public risks due to radiological transportation accidents would be largest for Alternative 1 (Restart FFTF), Alternative 3 (Construct New Accelerator[s]), and Alternative 4 (Construct New Research Reactor). The implementation of any of these alternatives would be expected to result in over 8,000 shipments of isotopes by air transport during the 35-year evaluation period. The number of airborne shipments of isotopes under the No Action Alternative and Alternative 2 (Use Only Existing Operational Facilities) would be negligible in comparison. As a result, radiological risks to the public that would result from transportation accidents under the No Action Alternative and Alternative 2 are at least four orders of magnitude less than those under Alternatives 1, 3, and 4.

Figure S–7 shows the radiological risk to the public that would result from incident-free transportation. For all alternatives and options, the incident-free radiological risks would be less than approximately 0.2 latent cancer fatality. Radiological risks to maximally exposed offsite individuals and workers are small, and it would be unlikely that a latent cancer fatality would result among maximally exposed offsite individuals or workers.

Comparison of Nonradiological Risks Among the Alternatives

Implementation of the No Action Alternative, Alternative 1 (Restart FFTF), Alternative 2 (Use Only Existing Operational Facilities), or Alternative 5 (Permanently Deactivate FFTF [with No New Missions]) would have a small impact on visual resources, noise, water quality, geology and soils, ecological resources, cultural resources, wetlands, environmental justice, and local employment. Restart of FFTF under Alternative 1 would increase water use in the 400 Area of Hanford, with groundwater withdrawals increasing by an estimated 79 million liters (21 million gallons) per year under Option 3 or 6. There would be a substantial decrease in groundwater usage in the 400 Area of Hanford associated with the permanent deactivation of FFTF. Under these alternatives, no new facilities would be constructed and only minor modifications to existing facilities would be required.

Implementation of Alternative 3 (Construct New Accelerator[s]) or 4 (Construct New Research Reactor) would require construction at a site or sites yet to be selected. If construction were to take place on undisturbed land, the Visual Resource Management Class could change from Class II or Class III (typical of undeveloped portions of many DOE sites) to Class IV. If the location were previously developed, the Visual Resource Management Class would likely remain Class IV. Regardless of the location, criteria air pollutant concentrations during construction and operation would not be expected to exceed air quality standards for

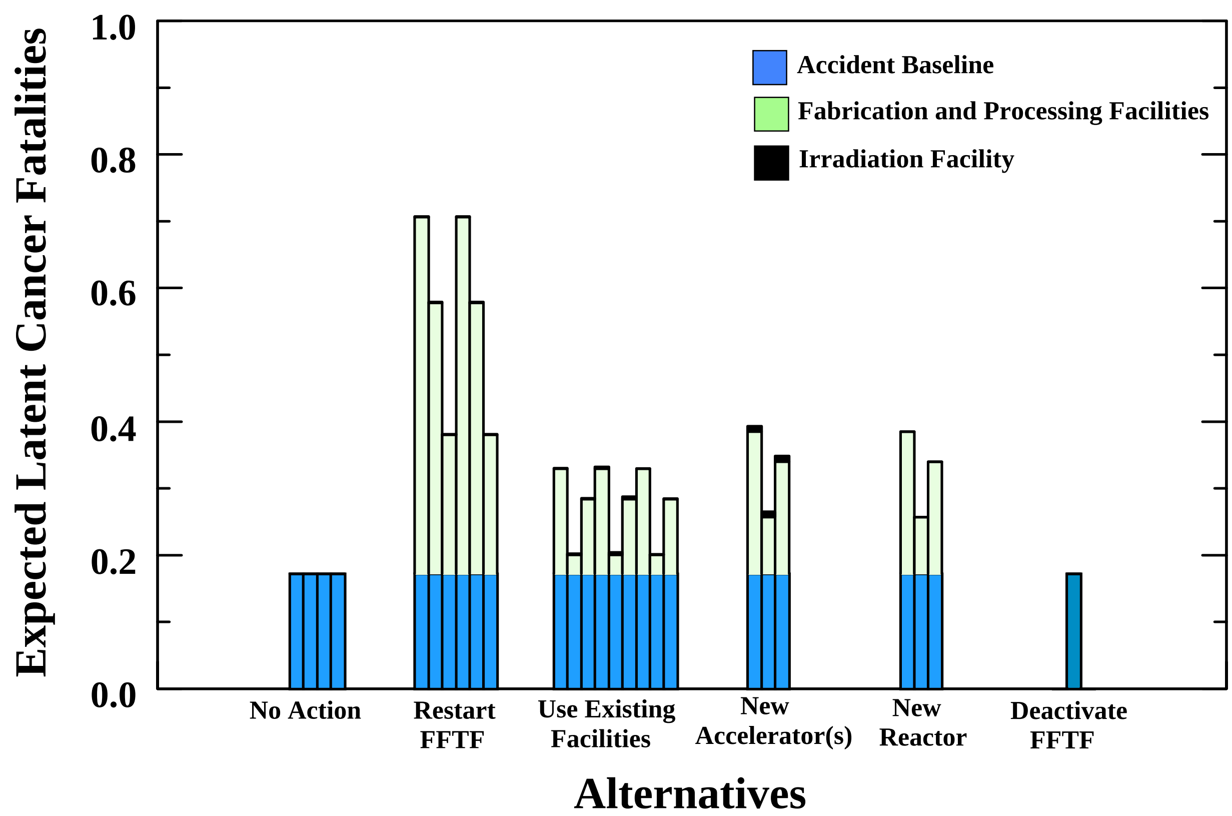

Figure S–5 Public Risks Due to Radiological Accidents at the Sites (35 Years)

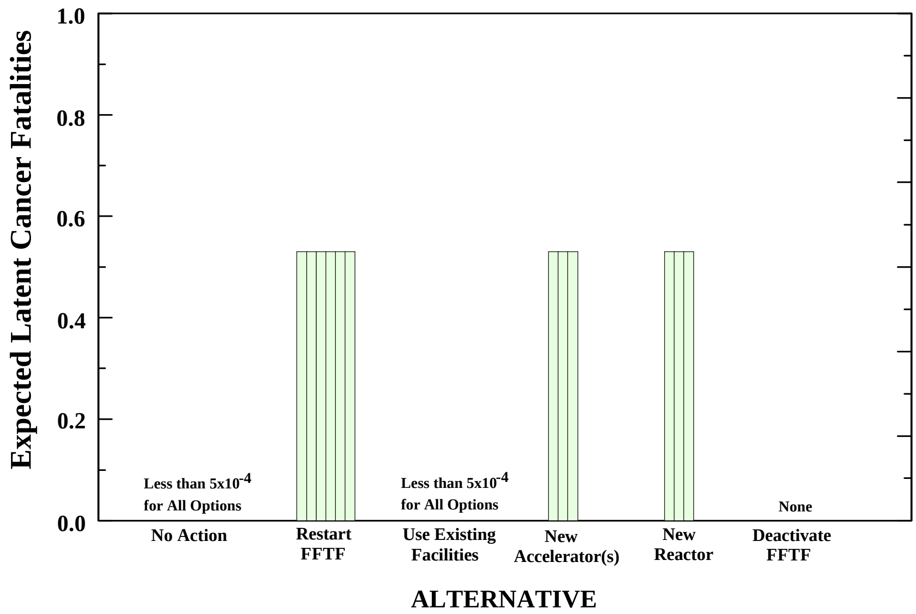

Figure S–6 Public Risks Due to Radiological Transportation Accidents (35 Years)

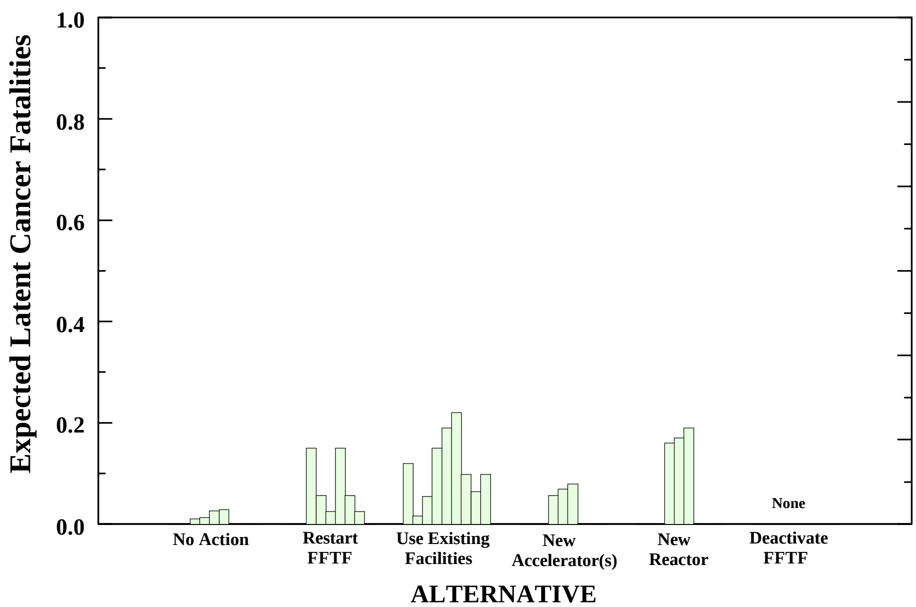

Figure S–7 Radiological Risks to the Public Due to Incident-Free Transportation (35 Years)

criteria pollutants. Typical construction activities would result in traffic and impulsive noise that could disturb wildlife near the construction site. Clearing operations would disturb approximately 20 hectares (50 acres) of land for construction of the high-energy accelerator, 4 hectares (10 acres) of land for construction of the low-energy accelerator, 4 hectares (10 acres) of land for the new research reactor, and 2.4 hectares (6 acres) for the (optional) support facility. The implementation of Alternative 3 or 4 would require the use of substantial quantities of water for operation of the proposed facilities. Operation of the new high-energy accelerator or new research reactor would account for the vast majority of the projected water use due to the high-cooling-water demands of these facilities. Specifically, operation of the high-energy accelerator would require an estimated 1,904 million liters (503 million gallons) of water per year, with operation of the research reactor requiring 807 million liters (213.1 million gallons) annually. Also included under both alternatives would be the permanent deactivation of FFTF, resulting in a reduction in water use at Hanford of approximately 197 million liters (52 million gallons) annually. This serves to somewhat mitigate the total impacts on water use at Hanford.

Construction of the facilities could result in a direct loss of wetlands, although proper site selection could mitigate the loss of wetlands. Use of undisturbed land could also impact cultural or paleontological resources. Impacts at the site(s) for new accelerator(s) or a new research reactor could also impact local employment sufficiently to affect regional economic conditions. For Alternatives 1, 2, and 5, impacts on local employment would not be expected to significantly affect regional economic conditions. However, all of these environmental areas of concern are site dependent. If Alternative 3 or 4 were selected for implementation, additional NEPA analysis addressing site-specific environmental areas of concern would be performed prior to implementation.

The analysis of air quality impacts included assessment of criteria and toxic pollutants. Implementation of any of the alternatives and options would not be expected to exceed standards and guidelines for criteria or toxic pollutant concentrations. Hazard indexes for all options under each alternative were found to be small. Cancer risks resulting from exposure to potentially carcinogenic chemicals were found to be less than 5×10^{-7} under all alternatives and options. Under Options 4, 5, and 6 of Alternative 2, target irradiation would take place in an operating CLWR yet to be selected. Since implementation of Alternative 2 would not measurably increase nonradiological air pollutant emissions, no incremental air quality impacts at the reactor site would be expected. Air quality at yet-to-be-selected accelerator or reactor sites could not be evaluated in detail. In the event that Alternative 3 or Alternative 4 were selected for implementation, site-specific air quality effects would be addressed in additional environmental documentation prior to implementation.

Waste generated from Alternatives 1 through 5 could be managed by the existing waste management infrastructure and would have a minimal influence on the existing waste generation baseline. However, transuranic waste that would be generated as a result of target fabrication and processing would be ineligible for disposal at the Waste Isolation Pilot Plant. It would be stored at the generation site pending availability of a suitable geologic repository for permanent disposal. DOE Order 435.1 requires DOE Headquarters approval of a decision to generate nondefense transuranic waste.

Figures S–8 and **S–9** show the public risk that would result from vehicular collisions (without a radiological spill) and vehicle exhaust emissions, respectively. The expected number of fatalities that would result from nonradiological traffic accidents would be less than 0.2 under all options and alternatives. The expected number of fatalities that would result from vehicular exhaust emissions would be less than 0.1 for all alternatives and options. Expected fatalities that would result from vehicular collisions (without radiological consequences) and exhaust emissions are reasonably well correlated with the distances that would be traveled under the alternatives and options (see **Figure S–10**). Traffic accident rates are dependent on the type of carrier. Both commercial trucks and DOE's SST system would be used for highway transport of isotopes.

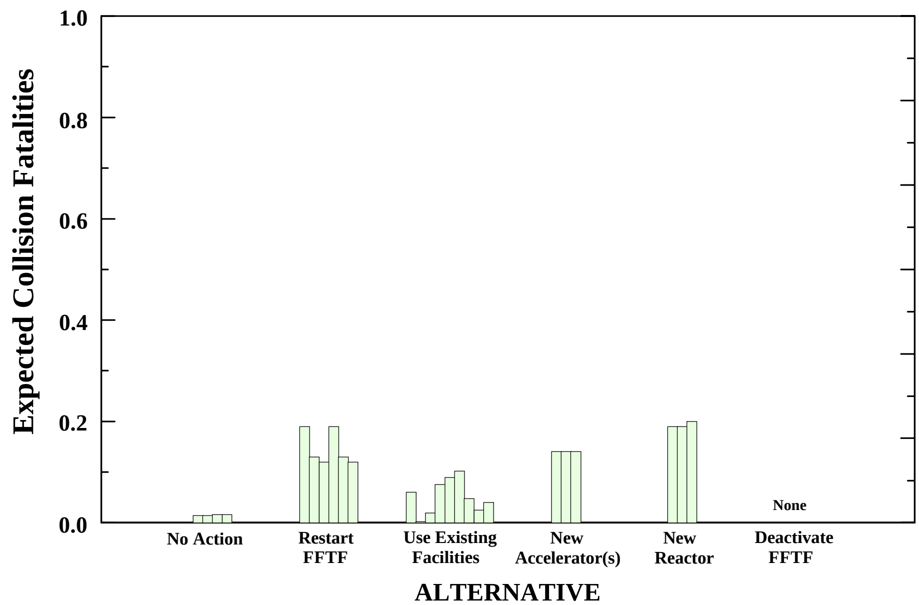

Figure S–8 Risk to the Public Due to Vehicle Collisions (Without Radiological Consequences)

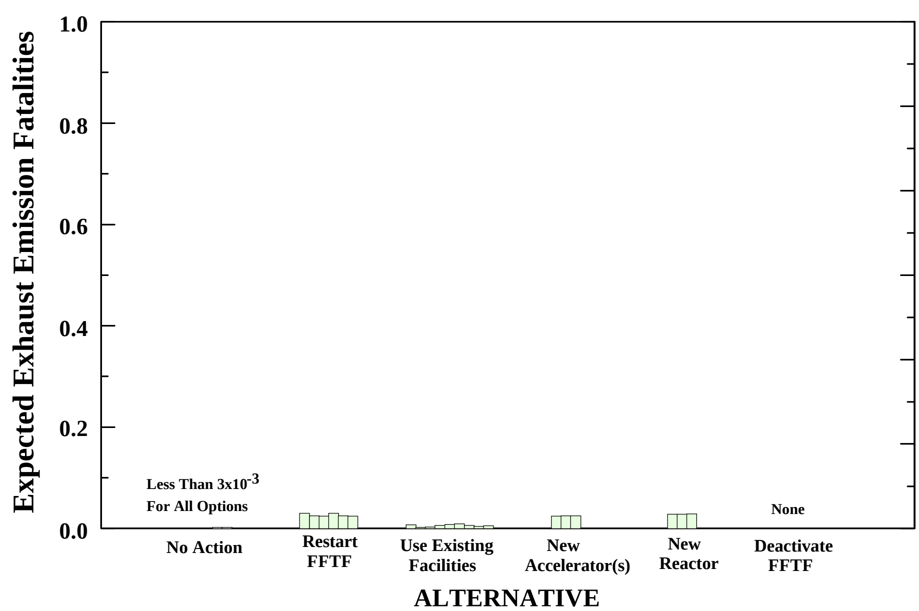

Figure S–9 Risk to the Public Due to Exhaust Emissions

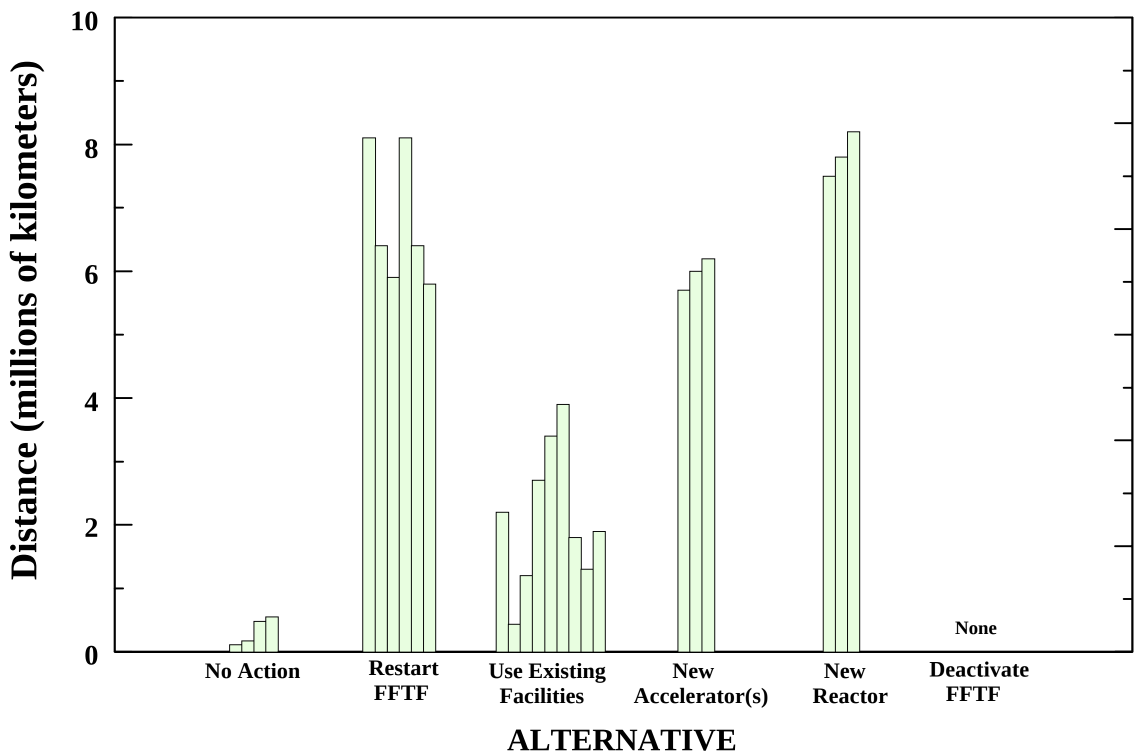

Figure S–10 Highway Distances That Would Be Traveled Under the Alternatives

Accident rates for the SST system are less than those for commercial truck, so that the expected collision fatalities for any option would increase with distance traveled, but the rate of increase would depend on the relative amounts of travel by commercial truck and the SST system.

Comparison of Mission Effectiveness Among Alternatives

This section compares the effectiveness of Alternatives 1, 2, 3, and 4 in achieving the goals of the three missions evaluated in the NI PEIS:

- Medical and industrial isotope production
- Plutonium-238 production for space mission
- Nuclear energy research and development for civilian applications

Alternative 1—Restart FFTF. FFTF would produce high-energy neutrons and a large flux level (10^{15} neutrons per square centimeter per second) that can be tailored to nearly any desired energy level. FFTF would provide the greatest flexibility for both isotope production and nuclear-based research and development among the baseline configurations for all of the proposed alternatives. Due to its large core size, flux spectrum, demonstrated testing capability, and rated power level, it would be able to concurrently support the projected plutonium-238 needs, production of medical and industrial isotopes, and nuclear research and development related to a broad range of materials, advanced reactors, advanced fuels, and waste transmutation.

Alternative 2—Use Only Existing Operational Facilities. Due to current mission commitments at the existing DOE facilities, a large portion of the reactor irradiation space is committed to existing users. The existing reactors are able to provide for the current plutonium-238 needs. However, fulfilling this requirement with these facilities would use most, if not all, excess capacity, and may require some non-federal missions to be terminated. The ability to expand the medical and industrial production would require some current missions to be postponed or terminated. If the CLWR were used for plutonium 238 production, then the existing facilities would gain additional margin for medical and industrial isotope production and limited nuclear research and development activities. These facilities have primary missions with sponsors who reserve the right to dictate to what degree and the times the facility could be used.

Alternative 3—Construct New Accelerator(s). Two accelerators, a low-energy accelerator and a high energy accelerator, are proposed for Alternative 3. The low-energy accelerator would serve as a dedicated isotope production facility. Due to the nature of this type of accelerator, it could only produce a limited number of isotopes, it has no ability to satisfy the plutonium-238 needs, and it has a limited ability to support the proposed nuclear-based research and development needs. The preconceptual design of the high-energy accelerator presented in Appendix F of the NI PEIS focused on supporting the plutonium-238 production mission. The design of the high-energy accelerator could be refined and expanded to perform additional missions such as the production of a select set of medical and industrial radioisotopes. In addition, DOE is aware of longer-term concepts that would apply high-energy accelerators to produce "tuneable" neutrons in a subcritical assembly. Such a facility could be used to address some of the missions more familiar to reactor facilities and may hold considerable promise for future science and technology research. A facility of this nature could provide unique capabilities in areas such as the testing of many different nuclear system coolant, fuel, and material interactions. The changes required to add additional capability to the high-energy accelerator could be provided, but they would increase the size of the facility, add complexity to the facility design and operation, increase the cost of construction and operation, and potentially require more time for design and construction.

Alternative 4—Construct New Research Reactor. The proposed new research reactor would provide ample neutrons for the production of plutonium-238 and for many isotopes. The thermal flux would limit the new research reactor's ability to produce a number of isotopes requiring fast or high-energy neutrons. Its lower flux levels (10^{13} neutrons per square centimeter per second) and predominantly thermal flux would limit its ability to support many of the projected nuclear-based research and development needs.

S.6 CUMULATIVE IMPACTS

The projected incremental environmental impacts of (1) constructing (as necessary) and operating the proposed facilities to store, fabricate, irradiate, and process the various targets addressed in the NI PEIS for 35 years; (2) deactivating FFTF; and (3) decommissioning the accelerator(s), research reactor, and support facility were added to the environmental impacts of other present and reasonably foreseeable future actions at or near the candidate sites to obtain cumulative site impacts. The other present and reasonably foreseeable future actions at or near the candidate sites are included in the baseline impacts presented in Chapter 3 of the NI PEIS. Cumulative transportation impacts were determined by analyzing the impacts along the various routes used to transport the materials associated with nuclear infrastructure activities over the 35-year period.

In this section, cumulative site impacts are presented only for those "resources" at a site that may reasonably be expected to be affected by the storage, fabrication, irradiation, and processing of the various targets. These include site employment, electrical consumption, water usage, air quality, waste management, and public and occupational health and safety. This section also includes the cumulative impacts associated with intersite transportation.

Activities whose impacts are contained in the cumulative site impacts include, but are not limited to, operation of the spallation neutron source facility at ORR, implementation of the advanced mixed waste treatment program at INEEL, and remediation of the high-level waste tanks at Hanford.

Details of activities that may be implemented in the foreseeable future at any of the nuclear infrastructure candidate sites and evaluated in the cumulative impact assessment, are given in the following documents:

- *Surplus Plutonium Disposition Final Environmental Impact Statement* (DOE 1999a (Record of Decision issued)
- *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a) (Record of Decision issued)
- *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement* (DOE 1996b) (Record of Decision issued)
- *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling* (DOE 1995b) (Record of Decision issued)
- *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997) (Records of Decision issued for the various waste types)
- *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995c) (Record of Decision issued)
- *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (DOE 1996c) (Record of Decision issued)
- *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (DOE 1996d) (Record of Decision issued)
- *Advanced Mixed Waste Treatment Project Final Environmental Impact Statement* (DOE 1999b) (Record of Decision issued)
- *Final Environmental Impact Statement for the Tank Waste Remediation System, Hanford Site, Richland, Washington* (DOE 1996e) (Record of Decision issued)
- *Hanford Reach of the Columbia River Comprehensive River Conservation Study and Environmental Impact Statement* (NPS 1994) (Record of Decision issued)
- *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999c)
- *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE 2000b)

- *Final Environmental Impact Statement, Construction and Operation of the Spallation Neutron Sources* (DOE 1999d) (Record of Decision issued)

- *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE 1999e) (Record of Decision issued)

- *Idaho High-Level Waste and Facilities Disposition Draft Environmental Impact Statement* (DOE 1999f)

- *Final Environmental Impact Statement for Treating Transuranic (TRU)/Alpha Low-Level Waste at the Oak Ridge National Laboratory* (DOE 2000c) (Record of Decision issued)

- *Environmental Assessment Melton Valley Storage Tanks Capacity Increase Project - Oak Ridge National Laboratory* (DOE 1995d) (Finding of No Significant Impacts [FONSI] issued)

- *Management of Spent Nuclear Fuel on the Oak Ridge Reservation* (DOE 1996f) (FONSI issued)

- *Environmental Assessment for Transportation of Low-Level Radioactive Waste from the Oak Ridge Reservation to Off-Site Treatment or Disposal Facilities* (DOE 2000d) (Draft issued)

- *Environmental Assessment for Transportation of Mixed Low-Level Radioactive Waste from the Oak Ridge Reservation to Off-Site Treatment or Disposal Facilities* (DOE, in preparation)

- *Environmental Assessment for Selection and Operation of the Proposed Field Research Centers for the Natural and Accelerated Bioremediation Research (NABIR) Program* (DOE 2000e) (FONSI issued)

The related programs included in the cumulative impact assessment for the potentially affected candidate sites are identified in **Table S–4**.

In the tables that are included in the following sections, existing site activities are combined with reasonably foreseeable activities at each site and presented under the heading “Site Activities.” Activities associated with nuclear infrastructure operations are not included under “Site Activities.” The impacts associated with the construction, (as necessary), operation, and decommissioning or deactivation (as necessary) of the proposed target fabrication, irradiation, and processing facilities are shown as “New Nuclear Infrastructure Operations.”

A bounding option was analyzed for each site. The bounding option is the option that would involve the greatest amounts of operational activities and associated environmental impacts at the candidate site. For example, the bounding option for ORR is Option 7 of Alternative 2, under which both HFIR and REDC operations would be involved in plutonium-238 production.

In addition to reasonably foreseeable site activities, other activities within the regions of the candidate sites were considered in the cumulative impact analysis for the selected resources. However, because of the distances between the candidate sites and these other existing and planned facilities, there is little opportunity for interactions among them.

Table S–4 Other Present and Reasonably Foreseeable Actions Considered in the Cumulative Impact Assessment

Activities	ORR	INEEL	Hanford
Disposition of Surplus Plutonium		X	X
Storage and Disposition of Weapons-Usable Fissile Materials	X	X	X
Disposition of Surplus Highly Enriched Uranium	X		
Waste Management PEIS	X	X	X
Spent Nuclear Fuel Management and INEL Environmental Restoration and Waste Management	X	X	X
Foreign Research Reactor Spent Nuclear Fuel Management		X	X
Stockpile Stewardship and Management	X		
Tank Waste Remediation			X
Radioactive Releases from WNP Nuclear Power Plant			X
Hanford Reach of the Columbia River Comprehensive River Conservation Study			X
Hanford Comprehensive Land Use Plan			X
Advanced Mixed Waste Treatment Project		X	
Treatment and Management of Sodium-Bonded Spent Nuclear Fuel		X	
Construction and Operation of the Spallation Neutron Source	X		
Long-Term Management and Use of Depleted Uranium Hexafluoride	X		
Treatment and Shipment of Transuranic Waste	X		
Management of Liquid Low-Level Radioactive Waste	X		
Management of Spent Nuclear Fuel	X		
Transportation of Low-Level Radioactive Waste to Off-Site Treatment or Disposal	X		
Transportation of Mixed Low-Level Radioactive Waste to Off-Site Treatment or Disposal	X		
Natural and Accelerated Bioremediation Field Research Center Assessment	X		
High-Level Waste and Facilities Disposition		X	

Source: Table 4–155 of the NI PEIS.

Cumulative Impacts at ORR

For ORR, the bounding option for the NI PEIS is Option 7 of Alternative 2. This option calls for the operation of HFIR to irradiate neptunium-237 targets and operation of REDC to fabricate and process these targets. The impacts associated with HFIR and REDC operations for other missions are included in "site activities."

Resource Requirements. Cumulative impacts on resource requirements at ORR are presented in **Table S–5**. ORR would remain within its site capacity for all major resources. If Option 7 of Alternative 2 were implemented, the proposed nuclear infrastructure facilities would require 36 percent of its available land, essentially no change in the site's use of electricity or water. There would be no additional land disturbance or development. Cumulatively, ORR would use approximately by 36 percent of its available land, 9 percent of its electrical capacity, and 36 percent of its water capacity. Site employment would increase approximately 41 workers.

Table S–5 Maximum Cumulative Resource Use and Impacts at ORR

Resource	Site Activities[a]	New Nuclear Infrastructure Operations	Cumulative Total	Total Site Capacity
Site employment	3,467	41[b]	3,508	NA
Electrical consumption (megawatt-hours per year)	1,276,380	negligible[c]	~1,276,380	13,880,000
Developed land (hectares)	4,966	0	4,966	13,794
Water usage (million liters per year)	15,802	negligible[c]	~15,802	44,348

a. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.

b. Some, or all of these worker requirements, may be filled by the reassignment of the existing site workforce.

c. Electrical consumption and water usage associated with this option would be negligible compared to that associated with other activities at ORR.

Note: To convert from hectares to acres, multiply by 2.47; to convert from liters per year to gallons per year, multiply by 0.264; to convert from megawatt-hours to British thermal units, multiply by 3.42×10^6; ~ means "approximately," and indicates that the cumulative impacts are virtually the same as those associated with "site activities" because new nuclear infrastructure operations would contribute only minimally.

Key: NA, not applicable.

Source: Table 4–156 of the NI PEIS.

Air Quality. Cumulative impacts on air quality at ORR are presented in **Table S–6**. ORR is currently in compliance with all Federal and State ambient air quality standards, and would continue to remain in compliance even if the cumulative effects of all activities are included. As shown in the table, the contributions of nuclear infrastructure operations to overall site concentrations would be very small.

Table S–6 Maximum Cumulative Air Pollutant Concentrations at ORR for Comparison with Ambient Air Quality Standards

Criteria Pollutant	Averaging Period	Most Stringent Standard[a] (micrograms per cubic meter)	Site Activities[b] (micrograms per cubic meter)	New Nuclear Infrastructure Operations (micrograms per cubic meter)	Cumulative Concentration (micrograms per cubic meter)
Carbon monoxide	8 hours	10,000	85.5	0	85.5
	1 hour	40,000	172	0	172
Nitrogen dioxide	Annual	100	20.9	1.99×10^{-4}	20.9
PM_{10}	Annual	50	12.9	0	12.9
	24 hours	150	55.4	0	55.4
Sulfur dioxide	Annual	80	50.2	0.04	50.2
	24 hours	365	271	0.31	271
	3 hours	1,300	984	0.70	985

a. The more stringent of the Federal and state standards is presented if both exist for the averaging period.

b. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.

Key: PM_{10}, particulate matter with an aerodynamic diameter less than or equal to 10 microns.

Source: Table 4–157 of the NI PEIS.

Public and Occupational Health and Safety—Normal Operations. Cumulative impacts in terms of radiation exposure to the public and workers at ORR are presented in **Table S–7**. There would be no expected increase in the number of latent cancer fatalities in the population from ORR site operations if nuclear infrastructure operations were to occur at HFIR and REDC. The dose limits for individual members of the public are given in DOE Order 5400.5. As discussed in that Order, the dose limit from airborne emissions is

Table S–7 Maximum Cumulative Radiation Exposures and Impacts at ORR

Impact	Maximally Exposed Individual		Population Dose Within 80 Kilometers (50 Miles) (Year 2020)		Total Site Workforce	
	Annual Dose (millirem per year)	Risk of a Latent Cancer Fatality[a]	Dose (person-rem)	Number of Latent Cancer Fatalities[a]	Dose (person-rem per year)	Number of Latent Cancer Fatalities[a]
Site activities[b]	3.8	6.7×10^{-5}	35.9	0.63	130	1.8
New nuclear infrastructure operations at HFIR and REDC	1.9×10^{-6}	3.3×10^{-11}	8.8×10^{-5}	1.5×10^{-6}	22	0.31
Cumulative	3.8	6.7×10^{-5}	35.9	0.63	152	2.1

a. These values are calculated based on a 35-year exposure period.
b. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities. Impacts presented in the source documents have been adjusted to reflect the Records of Decision for waste management.
Source: Table 4–158 of the NI PEIS.

10 millirem per year, as required by the Clean Air Act; the dose limit from drinking water is 4 millirem per year, as required by the Safe Drinking Water Act; and the dose limit from all pathways combined is 100 millirem per year. Therefore, as is evident in Table S–7, the dose to the maximally exposed individual would be expected to remain well within the regulatory limits. Onsite workers would be expected to see an increase of approximately 0.31 latent cancer fatality due to radiation from nuclear infrastructure operations over the 35-year operational period.

Waste Management. Cumulative amounts of wastes generated at ORR are presented in **Table S–8**. It is unlikely that there would be major impacts on waste management at ORR because sufficient capacity would exist to manage the site wastes. None of the options assessed in the NI PEIS would generate more than a small amount of additional waste at ORR.

Table S–8 Cumulative Amounts of Wastes Generated at ORR[a] (cubic meters)

Waste Type	Site Activities[b]	New Nuclear Infrastructure Operations	Cumulative Total
Transuranic	2,559	385	2,444
Low-level radioactive	341,128	2,100[c]	343,228
Mixed low-level radioactive	28,038	<175	~28,213
Hazardous (kilograms)	1,260,000	227,500	1,487,500
Nonhazardous			
Liquid	23,852,937	805	23,853,742
Solid	2,604,143	5,180	2,609,323

a. The amounts of wastes given in the table are totals for the 35-year period of nuclear infrastructure operations.
b. Wastes associated with present and reasonably foreseeable future activities do not include impacts associated with nuclear infrastructure activities.
c. Does not include the low-level radioactive waste (i.e., less than 1 cubic meter per year) expected to be generated from the operation of HFIR at ORR, nor the canisters used to transport neptunium-237 to the site which would constitute less than 10 cubic meters of low-level radioactive waste.
Note: To convert from cubic meters to cubic yards, multiply by 1.308; < means "less than"; ~ means "approximately."
Source: Table 4–159 of the NI PEIS.

Cumulative Impacts at INEEL

For INEEL, the bounding option for the NI PEIS is Option 2 of Alternative 2. This option calls for the operation of ATR to irradiate neptunium-237 targets and operation of FDPF to fabricate and process these targets. The impacts associated with ATR and FDPF operations for other missions are included in "Site Activities."

Resource Requirements. Cumulative impacts on resource requirements at INEEL are presented in **Table S–9**. INEEL would remain within its site capacity for all major resources. If Option 2 of Alternative 2 were implemented, the proposed nuclear infrastructure facilities would require essentially no change in the site's use of electricity or water. There would be no additional land disturbance or development. Cumulatively, INEEL would use approximately 2 percent of its available land, 77 percent of its electricity capacity, and 14 percent of its water capacity. Site employment would increase by approximately 24 workers.

Table S–9 Maximum Cumulative Resource Use and Impacts at INEEL

Resource	Site Activities[a]	New Nuclear Infrastructure Operations	Cumulative Total	Total Site Capacity
Site employment	7,993	24[b]	8,017	NA
Electrical consumption (megawatt-hours per year)	304,700	negligible[c]	~304,700	394,200
Developed land (hectares)	4,600	0	4,600	230,000
Water usage (million liters per year)	6,075	negligible[c]	~6,075	43,000

a. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.

b. Some, or all, of those worker requirements may be filled by the reassignment of the existing workforce.

c. Electrical consumption and water usage associated with this option would be negligible compared to that associated with other activities at INEEL.

Note: To convert from hectares to acres, multiply by 2.47; to convert from liters per year to gallons per year, multiply by 0.264; to convert from megawatt-hours to British thermal units, multiply by 3.42×10^6; ~ means "approximately," and indicates that the cumulative impacts are virtually the same as those associated with "site activities" because new nuclear infrastructure operations would contribute only minimally.

Key: NA, not applicable.

Source: Table 4–160 of the NI PEIS.

Air Quality. Cumulative impacts on air quality at INEEL are presented in **Table S–10**. INEEL is currently in compliance with all Federal and state ambient air quality standards, and would continue to remain in compliance, even with consideration of the cumulative effects of all activities. The contributions of nuclear infrastructure operations to overall site concentrations are expected to be very small.

Public and Occupational Health and Safety—Normal Operations. Cumulative impacts in terms of radiation exposure to the public and workers at INEEL are presented in **Table S–11**. There would be no expected increase in the number of latent cancer fatalities in the population from INEEL site operations if nuclear infrastructure operations were to occur at ATR and FDPF. The dose limits for individual members of the public are given in DOE Order 5400.5. As discussed in that Order, the dose limit from airborne emissions is 10 millirem per year, as required by the Clean Air Act; the dose limit from drinking water is 4 millirem per year, as required by the Safe Drinking Water Act; and the dose limit from all pathways combined is 100 millirem per year. Therefore, as is evident in Table S–11, the dose to the maximally exposed individual would be expected to remain well within the regulatory limits. Onsite workers would be expected to see an increase of approximately 0.31 latent cancer fatality due to radiation from nuclear infrastructure operations over the 35-year operational period.

Table S–10 Maximum Cumulative Air Pollutant Concentrations at INEEL for Comparison with Ambient Air Quality Standards

Criteria Pollutant	Averaging Period	Most Stringent Standard[a] (micrograms per cubic meter)	Site Activities[b] (micrograms per cubic meter)	New Nuclear Infrastructure Operations (micrograms per cubic meter)	Cumulative Concentration (micrograms per cubic meter)
Carbon monoxide	8 hours	10,000	303	0	303
	1 hour	40,000	1,330	0	1,330
Nitrogen dioxide	Annual	100	11.3	3.66×10^{-4}	11.3
PM_{10}	Annual	50	3.01	0	3.01
	24 hours	150	43.6	0	43.6
Sulfur dioxide	Annual	80	6.01	0.024	6.03
	24 hours	365	142	0.19	142
	3 hours	1,300	616	0.43	616

a. The more stringent of the Federal and state standards is presented if both exist for the averaging period.
b. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.
Key: PM_{10}, particulate matter with an aerodynamic diameter less than or equal to 10 microns.
Source: Table 4–161 of the NI PEIS.

Table S–11 Maximum Cumulative Radiation Exposures and Impacts at INEEL

Impact	Maximally Exposed Individual		Population Dose Within 80 Kilometers (50 Miles) (Year 2020)		Total Site Workforce	
	Annual Dose (millirem per year)	Risk of a Latent Cancer Fatality[a]	Dose (person-rem)	Number of Latent Cancer Fatalities[a]	Dose (person-rem per year)	Number of Latent Cancer Fatalities[a]
Site activities[b]	0.047	8.2×10^{-7}	0.35	0.0061	200	2.8
New nuclear infrastructure operations at ATR & FDPF	2.6×10^{-7}	4.6×10^{-12}	3.9×10^{-6}	6.8×10^{-8}	22	0.31
Cumulative	0.047	8.2×10^{-7}	0.35	0.0061	222	3.1

a. These values are calculated based on a 35-year exposure period.
b. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.
Source: Table 4–162 of the NI PEIS.

Waste Management. Cumulative amounts of wastes generated at INEEL are presented in **Table S–12**. It is unlikely that there would be major impacts on waste management at INEEL because sufficient capacity would exist to manage the site wastes. None of the alternatives assessed in the NI PEIS would generate more than a small amount of additional waste at INEEL.

Cumulative Impacts at Hanford

For Hanford, the bounding option for the NI PEIS depends on the parameter assessed. For example, under Public and Occupational Health and Safety, the highest radiological doses and associated latent cancer fatalities to the public would be associated with Option 1 of Alternative 1, whereas the highest doses and latent cancer fatalities to workers would be associated with Option 3 of this same alternative. Processing of targets in RPL versus processing in FMEF accounts for there being different bounding options. For each of the parameters

Table S–12 Cumulative Amounts of Wastes Generated at INEEL[a] (cubic meters)

Waste Type	Site Activities[b]	New Nuclear Infrastructure Operations	Cumulative Total
Transuranic	65,125[c]	245	65,370
Low-level radioactive	151,845	2,275[d]	154,120
Mixed low-level radioactive	16,640	<175	~16,815
Hazardous	3,637	227,500 kilograms (644 cubic meters)[e]	4,281
Nonhazardous	275,127	5,985	281,112

a. The amounts of wastes given in the table are totals for the 35-year period of plutonium-238 production.
b. Wastes associated with present and reasonably foreseeable future activities do not include impacts associated with nuclear infrastructure activities.
c. Includes 65,000 cubic meters in storage at the Radioactive Waste Management Complex.
d. Does not include the low-level radioactive waste (i.e., less than 1 cubic meter per year) expected to be generated from the operation of ATR at INEEL, nor the canisters used to transport neptunium-237 to the site which constitute less than 10 cubic meters of low-level radioactive waste.
e. Assumes for hazardous waste that 353 kilograms equals one cubic meter (22.0 pounds equals one cubic foot).
Note: To convert from cubic meters to cubic yards, multiply by 1.308; < means "less than."; ~ means "approximately".
Source: Table 4–163 of the NI PEIS.

addressed in this section, a footnote is included in each of the cumulative impact tables, as necessary, to indicate the bounding alternative/option.

Resource Requirements. Cumulative impacts on resource requirements at Hanford are presented in **Table S–13**. Hanford would remain within its site capacity for all major resources. If any of the options under Alternative 1 were implemented, the proposed nuclear infrastructure facilities would require a small increase in the site's use of electricity and water. For the bounding options identified in Table S–13, this reflects an increase of about 2 and 1 percent, respectively, over current baseline utilization for these resources. There would be no additional land disturbance or development. Cumulatively, Hanford would use approximately 6 percent of its available land, 23 percent of its electrical capacity, and 37 percent of its water capacity. Site employment would increase by approximately 130 workers.

Air Quality. Cumulative impacts on air quality at Hanford are presented in **Table S–14**. Hanford is currently in compliance with all Federal and state ambient air quality standards, and would continue to remain in compliance even with consideration of the cumulative effects of all activities. The nuclear infrastructure contributions to overall site concentrations are expected to be very small.

Public and Occupational Health and Safety—Normal Operations. Cumulative impacts in terms of radiation exposure to the public and workers at Hanford are presented in **Table S–15**. There would be no expected increase in the number of latent cancer fatalities in the population from Hanford site operations if nuclear infrastructure operations were to occur at FMEF. The dose limits for individual members of the public are given in DOE Order 5400.5. As discussed in that order, the dose limit from airborne emissions is 10 millirem per year, as required by the Clean Air Act; the dose limit from drinking water is 4 millirem per year, as required by the Safe Drinking Water Act; and the dose limit from all pathways combined is 100 millirem per year. Therefore, as is evident in Table S–15, the dose to the maximally exposed individual would be expected to remain well within the regulatory limits. Onsite workers would be expected to see an increase of approximately 0.40 latent cancer fatality due to radiation from nuclear infrastructure operations over the 35-year operational period.

Table S–13 Maximum Cumulative Resource Use and Impacts at Hanford

Resource	Site Activities[a]	New Nuclear Infrastructure Operations	Cumulative Total	Total Site Capacity
Site employment	16,005	130[b]	16,135	NA
Electrical consumption (megawatt-hours per year)	507,000	55,000[c]	562,000	2,484,336
Developed land (hectares)	8,700	0	8,700	145,000
Water usage (million liters per year)	3,006	80[c]	3,086	8,263

a. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.
b. Bounded by Option 1 of Alternative 1. Some, or all, of these worker requirements may be filled by the reassignment of the existing site workforce.
c. Electrical consumption and water usage are bounded by Option 3 or 6 of Alternative 1, with the values reflecting the increase over standby operations from restart of FFTF and associated support activities in FMEF.

Note: To convert from hectares to acres, multiply by 2.47; to convert from liters per year to gallons per year, multiply by 0.264; to convert from megawatt-hours to British thermal units, multiply by 3.42×10^6.
Key: NA, not applicable.
Source: Table 4–164 of the NI PEIS.

Table S–14 Maximum Cumulative Air Pollutant Concentrations at Hanford for Comparison with Ambient Air Quality Standards

Criteria Pollutant	Averaging Period	Most Stringent Standard or Guideline[a] (micrograms per cubic meter)	Site Activities[b] (micrograms per cubic meter)	New Nuclear Infrastructure Operations (micrograms per cubic meter)[c]	Cumulative Concentration (micrograms per cubic meter)
Carbon monoxide	8 hours	10,000	34.1	52.1	86.2
	1 hour	40,000	48.3	74.4	123
Nitrogen dioxide	Annual	100	0.25	0.0118	0.262
PM_{10}	Annual	50	0.0179	0.00084	0.0187
	24 hours	150	0.77	9.84	10.6
Sulfur dioxide	Annual	50	1.63	0.0166	1.65
	24 hours	260	8.91	9.17	18.1
	3 hours	1,300	29.6	20.6	50.2
	1 hour	660	32.9	22.9	55.8

a. The more stringent of the Federal and State standards is presented if both exist for the averaging period.
b. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.
c. Bounded by Option 3 of Alternative 1. Periodic testing of emergency diesel generators would result in higher values for certain pollutants and time periods.

Key: PM_{10}, particulate matter with an aerodynamic diameter less than or equal to 10 microns.
Source: Table 4–165 of the NI PEIS.

Table S–15 Maximum Cumulative Radiation Exposures and Impacts at Hanford

Impact	Maximally Exposed Individual: Annual Dose (millirem per year)	Maximally Exposed Individual: Risk of a Latent Cancer Fatality[a]	Population Dose Within 80 Kilometers (50 Miles) (Year 2020): Dose (person-rem)	Population Dose Within 80 Kilometers (50 Miles) (Year 2020): Number of Latent Cancer Fatalities[a]	Total Site Workforce: Dose (person-rem per year)	Total Site Workforce: Number of Latent Cancer Fatalities[a]
Site activities[b]	1.9	3.3×10^{-5}	33	0.58	841	11.8
New nuclear infrastructure operations at FFTF and FMEF or RPL[c]	0.0054	9.5×10^{-8}	0.25	0.0045	28	0.40
Cumulative	1.9	3.3×10^{-5}	33.3	0.58	869	12.2

a. These values are calculated based on a 35-year exposure period.
b. Environmental impacts associated with present and reasonably foreseeable future activities, but not including impacts associated with nuclear infrastructure activities.
c. Impacts on the public are bounded by Option 1 of Alternative 1; impacts on workers are bounded by Option 3 of Alternative 1.
Source: Table 4–166 of the NI PEIS.

Waste Management. Cumulative amounts of wastes generated at Hanford are presented in **Table S–16**. It is unlikely that there would be major impacts on waste management at Hanford because sufficient capacity would exist to manage the site wastes. None of the alternatives assessed in the NI PEIS would generate more than a relatively small amount of additional waste at Hanford. Currently, it is DOE's intent that waste generated from the restart and operation of FFTF be managed independent of the existing Hanford Site waste management infrastructure by using commercially available facilities for all waste treatment and disposal activities. DOE has developed a draft Waste Minimization and Management Plan for FFTF to incorporate pollution prevention and waste minimization practices in its consideration of the future of FFTF (DOE 2000f). If a decision were made to restart the FFTF, this plan would be used to ensure that optimum opportunities are provided for characterizing potential waste streams, identifying source reduction and recycling strategies, evaluating disposition options, developing sustainable designs, and implementing effective management strategies. This plan identifies DOE's preferred options for management, treatment and/or disposition of all waste streams related to the restart and operation of FFTF. These preferred options primarily use commercial waste handling and disposal facilities. Although it is DOE's intent to use commercial waste handling and disposal facilities, the Hanford waste management infrastructure is analyzed in the NI PEIS as a reasonable alternative for the management of wastes resulting from FFTF restart and operation in case commercial disposal is not practicable at the time of restart and operation.

Spent Fuel Management. The operation of FFTF for the proposed mission at 100 megawatts for 35 years under Alternative 1 would produce a total of about 16 metric tons of heavy metal (35,200 pounds) of spent fuel. The existing spent fuel at the Hanford site is about 2,133 metric tons of heavy metal (46,926,000 pounds), including defense and non-defense spent fuel (DOE 1995a). The environmental impacts associated with the existing inventory of spent fuel at Hanford site are minimal. The restart of the FFTF under Alternative 1 would generate 16 metric tons of heavy metal of spent fuel, which is less than 1 weight percent of the total spent fuel inventory presently at Hanford. As such, the environmental impacts associated with spent fuel management would remain minimal.

Cumulative Impacts at the Generic CLWR Site

No incremental environmental impacts at the generic site would be associated with the normal operation of a CLWR to irradiate targets. Therefore, the cumulative impacts at the generic CLWR site would not be affected by any action assessed in the NI PEIS, and are not addressed further.

Table S–16 Cumulative Amounts of Wastes Generated at Hanford[a] (cubic meters)

Waste Type	Site Activities[b]	New Nuclear Infrastructure Operations	Cumulative Total
Transuranic	9,880	385[c]	10,265
Low-level radioactive	95,666	5,005[c,d]	100,671
Mixed low-level radioactive	46,207	315[c]	46,522
Hazardous	19,600	3,100[e]	22,700
Nonhazardous			
Liquid	7,000,000	1,494,500[c]	8,494,500
Solid	1,505,000	10,500[c]	1,515,500

a. The amounts of wastes given in the table are totals for the 35-year period of nuclear infrastructure activities.
b. Wastes associated with present and reasonably foreseeable future activities, but do not include impacts associated with nuclear infrastructure activities.
c. The bounding alternative for this waste type is Alternative 1, Options 3 or 6.
d. Does not include the low-level radioactive waste expected to be generated from the canisters used to transport neptunium-237 to the site, which would constitute less than 10 cubic meters.
e. The bounding alternative for hazardous waste is Alternative 2, Option 3, 6, or 9; Alternative 3, Option 3; or Alternative 4, Option 3; which all include the deactivation of FFTF and neptunium-237 target fabrication and processing at FMEF.

Note: To convert from cubic meters to cubic yards, multiply by 1.308.
Source: Table 4–167 of the NI PEIS.

Cumulative Impacts at the New Accelerator Generic DOE Site

Cumulative impacts cannot be presented for a generic site. If Alternative 3 were selected for implementation, a subsequent site-specific analysis would be conducted for the DOE site chosen for the new accelerator(s) and support facility, and appropriate NEPA documentation would be prepared to address the cumulative impacts for that site.

Cumulative Impacts at the New Research Reactor Generic DOE Site

Cumulative impacts cannot be presented for a generic site. If Alternative 4 were selected for implementation, a subsequent site-specific analysis would be conducted for the DOE site chosen for the new research reactor and support facility, and appropriate NEPA documentation would be prepared to address the cumulative impacts for that site.

Cumulative Impacts of Transportation

Because likely transportation routes cross many states, cumulative impacts are compared on a national basis. For all alternatives assessed in the NI PEIS, occupational radiation exposure to transportation workers and exposure to the public are estimated to each represent less than 0.05 percent of the cumulative exposures from nationwide transportation over the 35-year period of nuclear infrastructure activities. No additional traffic fatality is expected; the incremental increase in traffic fatalities would be less than 0.0001 percent per year.

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