Chapter 3
Proposed Action and Alternatives

CHAPTER 3
PROPOSED ACTION AND ALTERNATIVES

This chapter describes the proposed action and alternative ways to accomplish it. It also describes considerations that are common to all alternatives, including those alternatives that were considered but not analyzed.

3.1 OVERVIEW

The alternatives analyzed in this environmental impact statement (EIS) would implement all or part of the Proposed Action. The Proposed Action is to provide an enhanced high-resolution radiographic capability to perform hydrodynamic tests and dynamic experiments in support of the historical mission of the U.S. Department of Energy (DOE) and the near-term stewardship of the Nation's nuclear weapons stockpile. Those aspects of the DOE hydrodynamic testing and dynamic experiment program that would not change regardless of the course of action selected are described in this chapter as considerations common to all alternatives. DOE considered, but did not analyze in detail, other alternatives, which are described here along with an explanation as to why they would not meet the DOE's purpose and need for enhanced testing capability. The environmental impacts of all analyzed alternatives, along with other decision factors, are summarized. The discussion in this chapter is augmented by the classified supplement for this EIS.

The No Action Alternative would not meet the DOE's purpose and need for enhanced radiographic hydrodynamic testing but is provided as a basis of comparison. The next two alternatives address various ways to meet part or all of the purpose and need. The remaining alternatives would modify the DARHT Baseline Alternative to mitigate possible environmental impacts; these mitigation measures could also be applied to the other alternatives, but they are not expressly analyzed. For example, the Single Axis Alternative could be constructed instead of the dual-axis facility under the Upgrade PHERMEX Alternative as well as the modification to the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility analyzed under the Single Axis Alternative. However, because the environmental impacts would be similar, and within the expected bounds of the alternative analyzed, this EIS does not specifically analyze that particular option.

The alternatives analyzed are:

- **No Action Alternative:** DOE would continue to use the Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility at the Los Alamos National Laboratory (LANL) and the Flash X-Ray (FXR) Facility at the Lawrence Livermore National Laboratory (LLNL) in support of its stockpile stewardship mission. Construction of the DARHT Facility would not be completed; the structure would be completed for other uses. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **DARHT Baseline Alternative:** DOE would complete and operate the DARHT Facility and phase out operations at PHERMEX. DOE may delay operation of the second axis of DARHT until the

accelerator equipment in the first axis is tested and proven. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels. This alternative was called the preferred alternative in the draft EIS.

- **Upgrade PHERMEX Alternative:** Construction of the DARHT Facility would not be completed. Major upgrades would be constructed at PHERMEX, and the high-resolution radiographic technology planned for DARHT would be installed at PHERMEX, including a second accelerator for two-axis imaging. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **Enhanced Containment Alternative:** Three options are considered under this alternative: 1) the Vessel Containment Option, 2) the Building Containment Option, and 3) the Phased Containment Option. The Phased Containment Option is the preferred alternative.

  Note: Alternatives and options examined in the draft EIS encompass and bound potential impacts from the Phased Containment Option that was added to this final EIS.

  This alternative is similar to the DARHT Baseline Alternative except that some or all tests would be conducted in a containment vessel or containment structure. All tests would be contained if a containment structure were used. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **Plutonium Exclusion Alternative:** Similar to the DARHT Baseline Alternative except that plutonium would not be used in any of the experiments at DARHT. In the future, DOE may perform some dynamic experiments with plutonium; those involving radiography would be conducted at PHERMEX and would be conducted in double-walled containment vessels.
- **Single Axis Alternative:** Similar to the DARHT Baseline Alternative except that only one accelerator hall would be completed and operated for hydrodynamic tests or dynamic experiments. The other hall would be completed for other uses. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.

This final EIS identifies the Phased Containment Option of the Enhanced Containment Alternative as the preferred alternative. However, the draft EIS described the DARHT Baseline Alternative as preferred. This change is significant both technically and as an example of the National Environmental Policy Act (NEPA) process benefitting from public participation and comments. The draft EIS discussed containment using vessels or building options that would have been committed strongly to current technology. These options were not chosen then as a preferred approach because of limitations on operations at the firing point and an inability to fully meet programmatic needs at this time. However, the public comments were strongly weighted toward containment as a method to reduce environmental consequences as much as possible. DOE recognizes the environmental benefits of containment and, therefore, has developed and identified as the preferred alternative a third option, Phased Containment, which reduces environmental consequences while providing the technologists with flexibility in how to achieve specific environmental objectives.

3.2 PROPOSED ACTION

As discussed in chapter 2, DOE needs to ensure that the U.S. nuclear weapons stockpile remains safe, secure, and reliable. The Stockpile Stewardship and Management Program is DOE's program to gain the scientific understanding needed to assess the condition of nuclear weapons and to assure their continued safety, performance, and reliability. DOE has determined that, in the absence of nuclear testing, radiographic hydrodynamic testing and dynamic experiments are necessary to provide information regarding the condition and behavior of nuclear weapons primaries. DOE has determined that enhanced diagnostic capability is needed. DOE also has determined that no other currently available technique would provide a level of information comparable to that provided by enhanced high-resolution radiographic hydrodynamic testing and dynamic experiments. As discussed in chapter 2, these conclusions have been independently verified by panels of technical experts.

In response to the specified purpose and need, DOE proposes to provide an enhanced high-resolution radiographic capability to perform hydrodynamic tests and dynamic experiments in support of its historical mission and the near-term stewardship of the Nation's nuclear weapons stockpile. DOE's preferred approach would be to complete and operate the DARHT Facility with a phased-in enhanced containment of the tests.

3.3 CONSIDERATIONS COMMON TO ALL ALTERNATIVES

Certain aspects of the DOE's hydrodynamic test and dynamic experiments program would not change, regardless of which alternative would be implemented. The actual testing program may have programmatic constraints due to a variety of reasons, such as annual testing needs, funding considerations, or to ameliorate potential environmental impacts. The type of diagnostic experiment – e.g., optical, pin shot, or weapons geometry (explained below) – would not change even though the ability to obtain diagnostic information would vary among alternatives. The complex infrastructure needed to support hydrodynamic tests and dynamic experiments would not change. The operation of the FXR at LLNL and the Radiographic Support Laboratory (RSL) at LANL would not change. Also, under all alternatives, DOE could conduct dynamic experiments involving plutonium.

3.3.1 Hydrodynamic Tests

For many years, DOE has relied upon hydrodynamic tests to obtain certain types of information about the behavior of nuclear weapons primaries during the complex interactions expected in an implosion (see figure 1-2). Hydrodynamic tests use full weapons geometry. The fissile material inside the weapon is replaced with another material. Hydrodynamic tests are used to measure material motions and compression by using pins, optics, and radiography. Hydrodynamic tests are supplemented with static, dynamic, or high-explosives experiments. The information obtained is then used to develop calculations to predict the safety, performance, or reliability of the weapons device.

Pin shot hydrodynamic tests involve replacing the fissile material of a weapons primary with another material and inserting a post, called a blast pipe, with various lengths of electrical sensors, called pins, which radiate from its end. The blast pipe is highly shielded to protect the diagnostic equipment. High explosives are placed around the outside of the inert material and pin assembly and detonated to test the mock device. The pins record the movement of the implosion. The information obtained is used to improve the understanding of how the pit surface moves during the short period of time up to a few microseconds before criticality would be achieved in an actual weapon. Personnel extrapolate the pin shot data and estimate what would happen in an actual weapon up to the point of a nuclear explosion. These estimates become less certain as the estimated point of criticality is approached. After extrapolating the pin shot information, personnel calculate estimated changes in imploding shapes and stages of reactivity. The pin assembly and blast pipe affect the geometry of implosion, so this type of test does not exactly mimic the behavior expected during an actual weapons implosion. Pin shots do not provide information about the boost gas associated with a pit. Radiography is often used as an additional diagnostic with pin shots.

Radiographic hydrodynamic tests supply additional information needed to understand the behavior of an imploding pit, and information regarding mock-ups of boost gas. Unlike a pin shot, the entire weapons primary is replicated. These tests involve replacing the fissile material of a weapon with another material, detonating the high explosives, and taking very high-speed (60 to 200 nsec) x-ray photographs of the imploding device. Radiographic images of mock-up weapons can be taken at any point during an experiment, including up to the estimated point at which a nuclear explosion would occur in an actual weapon. They provide information about density and shape changes as the pit implodes. From this information, LANL personnel modify and improve calculations and infer more detailed information about an actual nuclear explosion.

To avoid risking security, health, and safety, weapons researchers use some surrogate materials for tests and experiments. Depleted uranium is often used to mock the weapons-grade plutonium. Depleted uranium has a higher density, greater strength, and a higher melting point than weapons-grade plutonium. Tantalum is used for some hydrodynamic tests. The density of tantalum is similar to that of weapons-grade plutonium, but, like depleted uranium, it has a higher strength and higher melting point. Lead is sometimes used, primarily to look at material ejected from the pit surface and joints. The density of lead is lower than weapons-grade plutonium, and lead has lower strength and a lower melting point.

The certainty of information for radiographic hydrodynamic tests increases with the number of views that are obtained. This applies to both sequential images and images taken from different viewpoints. The amount of information obtained from radiographic hydrodynamic tests also depends on the clarity of the image. This, in turn, depends on the resolution provided by the x-ray beam spot size (a smaller beam spot size provides greater resolution) and the penetration provided by the x-ray intensity. The dense pit materials, typically represented by depleted uranium, inhibit the penetration of the x-rays and inhibit the ability to obtain images of the imploding pit. To obtain better penetration, hence better images, other surrogate materials are sometimes used, such as tantalum, which allows better x-ray penetration.

Depleted uranium is also used for related mock-up components. For example, hydrodynamic tests are sometimes used to determine the effect that a large mass, such as a weapons secondary, would have on the physics of the imploding primary. The mock-ups of the weapons secondary are often made of depleted uranium.

Optical means are sometimes used to record information for a hydrodynamic test. Under this technique, light and conventional high-speed photography are used (instead of x-rays and radiography) to record the movement of materials in the weapons mock-up. Lasers are also used for high-speed photography and interferometry to provide additional diagnostic capability.

Static radiographs are sometimes mentioned in connection with hydrodynamic tests and dynamic experiments. These static radiographs are x-ray images taken shortly before the test or experiment is fired.

Their purpose is to assure the experimenter that the device has not suffered an unacceptable or unknown change since assembly. The static radiograph thus provides a picture of the initial condition of the test or experiment.

3.3.2 Dynamic Experiments

While hydrodynamic tests examine interactions among parts of the primary, dynamic experiments explore broader issues regarding materials science. Dynamic experiments involve a variety of techniques. Depending upon the properties being examined, a variety of materials may be used. Dynamic motion is usually achieved by driving test materials with high explosives.

In the past, DOE has conducted dynamic experiments at PHERMEX using weapons-grade and other forms of plutonium metal. These experiments were conducted inside double-walled steel containment vessels. Plutonium is an extremely complex material, and DOE's understanding of its behavior is important to predict nuclear performance. In the future, DOE plans to conduct dynamic experiments to help understand the constitutive properties of plutonium, its equations-of-state (particularly under conditions involving high temperatures and pressures), and its surface behavior following shocks. Dynamic experiments may involve observing the effects that would occur on mixtures of plutonium isotopes and alloys or other adjunct materials, which would be chosen for purposes of the experiment, after being shocked by explosives-driven materials. As a matter of policy, dynamic experiments involving plutonium would always be conducted inside double-walled steel containment vessels. All experiments would be arranged and conducted in a manner such that a nuclear explosion could not result.

3.3.3 Infrastructure Requirements

Hydrodynamic testing and dynamic experiment operations require considerable infrastructure – facilities, equipment, and personnel – in support of test events. Hydrodynamic testing and dynamic experiment operations at PHERMEX take advantage of the existing infrastructure at LANL. If DARHT were to be completed and operated as proposed, those operations would take advantage of the same infrastructure. However, hydrodynamic testing and dynamic experiment operations at LANL are only a small proportion of the total workload at the LANL support facilities; these facilities support many other DOE activities at LANL such as weapons research, science, and waste management.

Hydrodynamic testing and high-explosives experiments are conducted in several phases, each requiring extensive interactions among personnel. Any given test requires direct support from several organizations, as well as additional indirect support such as security, clerical, maintenance, or monitoring personnel.

To conduct a hydrodynamic test, weapons researchers decide what kind of information is needed, and test designers and engineers determine how the information can be obtained. Special parts are designed, engineered, and fabricated for each test. The test configuration is assembled and inspected. The test assembly is transported to the firing test facility, temporarily stored until the test can be conducted, and set up at the firing site. Firing-site personnel, such as accelerator specialists and radiograph technicians, must assure that the equipment is ready to record the diagnostic information. The final test assembly is inspected, the shot is fired, and the diagnostic information recorded. The test materials are collected, recycled, or cleaned up, and the information obtained is analyzed. Computer projections are made to extrapolate the information, and the results are used to verify computational codes. Each part of the process is iterative; for example, a part manufactured for a hydrodynamic test first undergoes mechanical testing and inspection, and, if it appears inadequate, the parts designer and machinist may consult with both the weapons researchers and the test designers to develop a different part. The infrastructure requirements to support the different steps in the radiographic test experiments are summarized in table 3-1.

DOE also intends to perform dynamic experiments with plutonium under all alternatives analyzed in this EIS. The infrastructure already in place at LANL provides a strong basis for the capability to perform these experiments. The plutonium processing capability provided at TA-55 is extensive and adequate for the required operations: chemical separation, alloy preparation, foundry capability, casting, and machining. This capability exists along with the proper radiation and health protection services, security controls, and protective force controls for conduct of plutonium operations.

Transportation of plutonium parts and high explosive assemblies can be conducted onsite at LANL or over roads that may be closed to the public. All of the required manufacturing, assembly, and testing facilities are onsite. Assembly can be performed within secure facilities with protective force controls already in place.

The existing diagnostic facilities provided at TA-15, when coupled with the proposed DARHT Facility, will provide strong analysis capability that is based on the extensive testing of explosive assemblies over the last 50 years; i.e., radiography, optical, laser, microwave, and firing site controls.

Plutonium processing and high-explosive assembly facilities have been developed to support a wide range of operations. The proposed testing program that would take place under any alternative comprises only a modest part of the workload of these facilities. However, because these facilities are already available, it would not be cost effective to duplicate them at another location.

3.3.4 Flash X-Ray Facility

The FXR Facility (Building 801 at Site 300) at LLNL is included in this EIS baseline because the facility is an integral part of the DOE's capability for hydrodynamic testing. Under all alternatives analyzed in this EIS, DOE would continue to operate FXR. The continued operation of FXR would not be affected by any of the alternatives discussed in this EIS. However, the level and scope of the testing program at FXR could be affected by decisions resulting from this review.

The FXR is a key facility used by DOE to address physics issues associated with the primary stage of a nuclear weapon and other types of experiments. PHERMEX and FXR are the two DOE facilities that currently provide hydrodynamic diagnostic capability for the stockpile stewardship program. DOE anticipates maintaining and operating FXR into the next century to support LLNL's weapons stockpile stewardship mission. It is possible that, in the future, DOE could propose activities at LLNL which might affect operation of FXR, but at this time no such proposals are foreseen except those discussed below.

LLNL has operated the FXR Facility since 1983 at their Site 300, making it 20 years newer than PHERMEX. Currently, FXR represents the best hydrodynamic testing capability available to the DOE. The FXR Facility contains a linear induction accelerator with an array of diagnostic capabilities that have

TABLE 3-1.—*Infrastructure Requirements for Typical Radiographic Test Experiments*

Activity	Implementation Requirement	Infrastructure Capabilities and Resources[a]
Experiment design and engineering	Weapons computer codes	Scientists and engineers experienced in weapons work (TA-3)
	Hardware engineering specifications	Component and assembly design engineers (TA-16)
	Test design	Hydrodynamic test engineers (TA-15)
Test materials and component fabrication	Parts design	Component and assembly design engineers (TA-16)
	High-precision parts fabrication	Precision manufacturing designers and facilities Facilities and operators for depleted uranium, beryllium, tantalum, tungsten, and high explosives (TA-3)
	High-precision quality inspection	Quality inspection instruments housed in controlled environment facilities (TA-16)
	High-explosives fabrication	High-explosives fabrication facilities Experienced fabrication engineers and safety engineers (TA-16)
	High-energy detonators	High-energy detonators design, fabrication, and testing facilities Experienced detonator designers, engineers, technicians, and safety engineers (TA-22)
	Pin dome precision assembly and quality inspection	Assembly facilities near test facility Inspection instrumentation near test facility Experienced assembly designers, engineers, and technicians (TA-15)
	Special materials: plastics, glues, foams, binders, organics	Chemistry laboratories, assembly facilities, technicians (TA-9)
	Salt mock-ups	High-explosives fabrication facilities, technicians (TA-15)
Test assembly and inspection	High-explosives handling facility	High-explosives facility Experienced high-explosives operators (TA-16)
	Precision mechanical inspection	Mechanical inspection instrumentation housed in controlled environment facility (TA-16)
	Penetrating x-ray nondestructive inspection and inspection	Static radiographic testing instrumentation Experienced radiographic technicians (TA-8)

[a] Parentheses indicate LANL Technical Area where the activity or capability is located.

TABLE 3-1.—*Infrastructure Requirements for Typical Radiographic Test Experiments – Continued*

Activity	Implementation Requirement	Infrastructure Capabilities and Resources[a]
Transportation to firing site and integral storage area	Secure containment	Department of Transportation approved containers (TA-16)
	Secure transport	Department of Transportation approved vehicles; access via nonpublic roads or public road closures; safe secure transport security vehicles used with special shipping containers (TA-16)
	Secure (classified) interim storage area	Approved secure storage facility in vicinity of firing site (TA-15)
Firing-site preparation	Perimeter control	Security and safety control systems in place Engineering and administrative controls for safety Security and safety personnel (TA-15)
	Multiple diagnostic capabilities	Flash radiography instrumentation High-speed electronic recording instrumentation High-speed optical diagnostic test equipment Laser diagnostics equipment Microwave diagnostics equipment Experienced diagnostic test engineers and equipment operators Specific temperature, environmental controls for inspection and diagnostic equipment Facility, instrumentation and equipment calibration, maintenance and repair support, and technicians (TA-15)
	Facility operations support	Machine shop Electronics calibration equipment Communication system and equipment Security support systems Plant operations support personnel Fire suppression personnel (TA-15)
	Small firing-site support	Equipment, personnel for qualifying detonations and characterizing high explosives (TA-40)
	Test set-up and take-down	Onsite mobile cranes, trucks, operators (TA-15)

[a] Parentheses indicate LANL Technical Area where the activity or capability is located.

TABLE 3-1.—*Infrastructure Requirements for Typical Radiographic Test Experiments – Continued*

Activity	Implementation Requirement	Infrastructure Capabilities and Resources[a]
Uncontained testing	Materials recovery	Experienced recovery staff, equipment (TA-50)
	Materials recycle	Materials classifiers, materials characterization facility and equipment, materials storage (TA-50)
	Materials processing	Reprocessing facilities for depleted uranium, beryllium, tantalum, tungsten, and high explosives processing for reuse; technicians, transportation (TA-50)
	Waste management	Treatment, storage facilities, and staff for mixed waste, low-level radioactive waste, RCRA waste, sanitary waste Disposal facilities (offsite and onsite) (TA-54)
	Environmental monitoring	Environmental scientists, sampling and analytical technicians, chemistry laboratory facilities (TA-3)
	Worker health and safety monitoring	Health physicists, industrial hygienists, and industrial safety specialists, monitoring equipment, laboratory facilities (TA-59)
Contained experiments	Containment vessel support	Vessel design engineers Vessel test engineers, facilities Vessel cleanout Debris-handling capabilities Material recovery, reprocessing Waste treatment Vessel staging and storage (TA-15)
	Plutonium dynamic experiments	Plutonium fabrication, storage and handling Plutonium chemistry facilities Material processing and storage Specialized engineers, chemists, technicians, security, and worker safety personnel (TA-55)
Post-testing activities	Develop, digitize radiographs	Radiographic facilities and technicians (TA-15)
	Analyze images, signals	Custom computer analysis software (TA-15)
	Develop and refine analytic tools	Weapons components functional modeling capabilities, custom computer hardware and software, weapons personnel and technicians (TA-3)

[a] Parentheses indicate LANL Technical Area where the activity or capability is located.

been used to provide a detailed understanding of the behavior of the implosion systems (HPAIC 1992). FXR is a single, linear induction accelerator operating at 17 MeV to provide an x-ray dose greater than 285 rad from a spot size that is approximately the same as PHERMEX (Baker 1995; JASON 1994).

FXR is being upgraded as part of a larger revitalization project at Site 300 valued at $27.4 million (Baker 1995). The upgrades at Site 300 include a high-speed optics maintenance facility, a bunker support facility, diagnostic equipment for the bunkers, road upgrades, central control post, and a new water supply. A $5.3 million segment of the upgrade is scheduled to begin October 1995 and be completed in October 1997 (Baker 1995). This latter segment will increase the capability of FXR by allowing for two pictures to be taken along a single axis of the FXR accelerator; this is referred to as a double-pulse. However, the x-ray dose would be reduced to about 55 R per pulse. Following completion of the second upgrade, the replacement cost for FXR would be approximately $90 million.

All FXR explosive experiments are currently uncontained. In addition to the ongoing upgrades, DOE has funded studies to examine the option of using a containment facility at LLNL that would be capable of containing an explosion of up to 172 lb (80 kg) of high explosives (DOE 1992; HPAIC 1992). This potential containment facility is in the conceptual design stage. NEPA documentation for the proposed Contained Firing Facility (CFF) is in progress. During the construction period for CFF, DOE could not use FXR for hydrodynamic testing. Although the firing site is in compliance with current environmental regulations and does not adversely impact upon residential areas near Site 300, a containment facility would provide LLNL with additional flexibility to continue hydrodynamic tests and dynamic experiments, particularly in the event that future environmental regulations in California would restrict uncontained operations. Even with the planned upgrades and the inclusion of the proposed containment system, DOE has no plans to conduct experiments with plutonium at Site 300 (Multhauf 1995). DOE does not have the facility infrastructure at LLNL to support these types of experiments, and it would be unreasonably expensive (several hundred million dollars) to provide the required plutonium handling capability at LLNL. Accordingly, the FXR Facility, in current or upgraded mode or with single or dual axis capability, would not provide the enhanced capability that the DOE needs to diagnose dynamic experiments with plutonium. In the future, should DOE propose other major modifications to the FXR facility or its operations, the Department would conduct appropriate studies (including NEPA review if required) at that time.

3.3.5 Radiographic Support Laboratory

The RSL was the first part of the DARHT project at LANL. Construction started in 1988 and was completed in 1990. Under all alternatives analyzed in this EIS, DOE would continue to operate the RSL to support radiographic operations undertaken at LANL. The RSL is a 21,000-ft^2 (1,950-m^2) building located in Technical Area 15 (TA-15). The main functions of the RSL are development, calibration, testing, and repair of high-energy flash x-ray machines. The facility includes a radiographic machine room, control room, mechanical and electronics room, machine shop, and offices. In addition to supporting ongoing radiographic testing at the PHERMEX Facility, the RSL has been serving as a staging area for development of accelerator technology and the Integrated Test Stand that DOE proposes to use to achieve an enhanced radiographic hydrodynamic test capability.

Two separate panels of independent consultants convened by DOE studied the linear induction accelerator technology that DOE proposed to use, and they agreed that DOE needed to design and test the Integrated

Test Stand as the front-end of the linear induction accelerator proposed to be installed at DARHT (DFAIC 1995, DOE 1993a). The same linear induction accelerator would be used under all alternatives analyzed in this EIS except that under the No Action Alternative an enhanced accelerator capability would not be installed in PHERMEX. However, under all alternatives, including the No Action Alternative, DOE would continue to perform accelerator research in support of flash x-ray technology and use the RSL facility in the same way it is used now.

3.3.6 Site Description

All of the alternatives analyzed in this EIS refer to the PHERMEX site and/or the DARHT site (figure 3-1). These sites are located in the southeastern part of LANL TA-15 on Threemile Mesa. TA-15 is located in the center of the high-explosives research, development, and testing area, in the southwestern part of LANL, which makes up about 20 mi^2 (52 km^2), or about half of the area of LANL (LANL 1994).

The PHERMEX site and the DARHT site are about 2,000 ft (600 m) apart. These locations constitute a single site for many of the environmental impacts. For the purpose of analysis, the combined sites are considered to be Area III in TA-15, as defined by LANL for safety, security, and control of the firing sites at PHERMEX and the DARHT Facility. Area III includes the mesa top from the southeast boundary of TA-15 extending northwestward a little over 1 mi (about 2 km) to a fence line near R-183 (figure 3-2).

The PHERMEX site, shown in figure 3-1, is a small complex of buildings and structures which have been used for hydrodynamic testing and dynamic experiments at LANL. The buildings, structures, and roadways at the PHERMEX site occupy about 11 ac (4 ha). About 120 ac (48 ha) of the mesa top lie behind the safety fence for PHERMEX and within TA-15. At PHERMEX, the mesa is about 1,500 to 2,000 ft (460 to 610 m) wide, bounded on the north by Potrillo Canyon, and on the south by Water Canyon.

The DARHT site is located to the west of the PHERMEX site, also in TA-15 on Threemile Mesa. The total area for the DARHT Facility is about 8 ac (2.3 ha). This area includes about 1 ac (0.4 ha) previously disturbed under the RSL contract for the DARHT Facility access road and utilities and 7 ac (2.3 ha) disturbed by the DARHT construction. Previous DARHT construction activities through 1994 account for the clearing of 14,000 board-feet of lumber. Potential impacts related to the future construction of the DARHT site are discussed in section 5.2.2.1.1 and section 5.2.5.1.1. At this site, the mesa is about 1,600 ft (490 m) wide. It is bounded on the north by the upper reaches of Potrillo Canyon and on the south by Water Canyon. The site lies only a few hundred feet from the mesa rim for Water Canyon.

The elevation on the mesa top in Area III is about 7,180 ft (2,190 m). In the vicinity of Area III, vegetation is mainly the Ponderosa pine plant community. This plant community within the 8 ac (2.3 ha) associated with DARHT has been altered due to construction. Any reptile, amphibian, bird, and large mammal populations have been displaced by these activities. Small mammals such as rodents would have been displaced temporarily and would likely return to the disturbed area. Soils on the nearby portions of the mesa top include the Pogna fine sandy loam, rock outcrop, and Seaby loam (LANL 1993). The surface is well drained, and the main aquifer lies approximately 1,200 ft (370 m) below the surface (Broxton et al. 1994). Beneath the site, the Bandelier Tuff is likely to be more than 700 ft (215 m) thick, and the underlying Puye formation makes up the remaining interval to the water table.

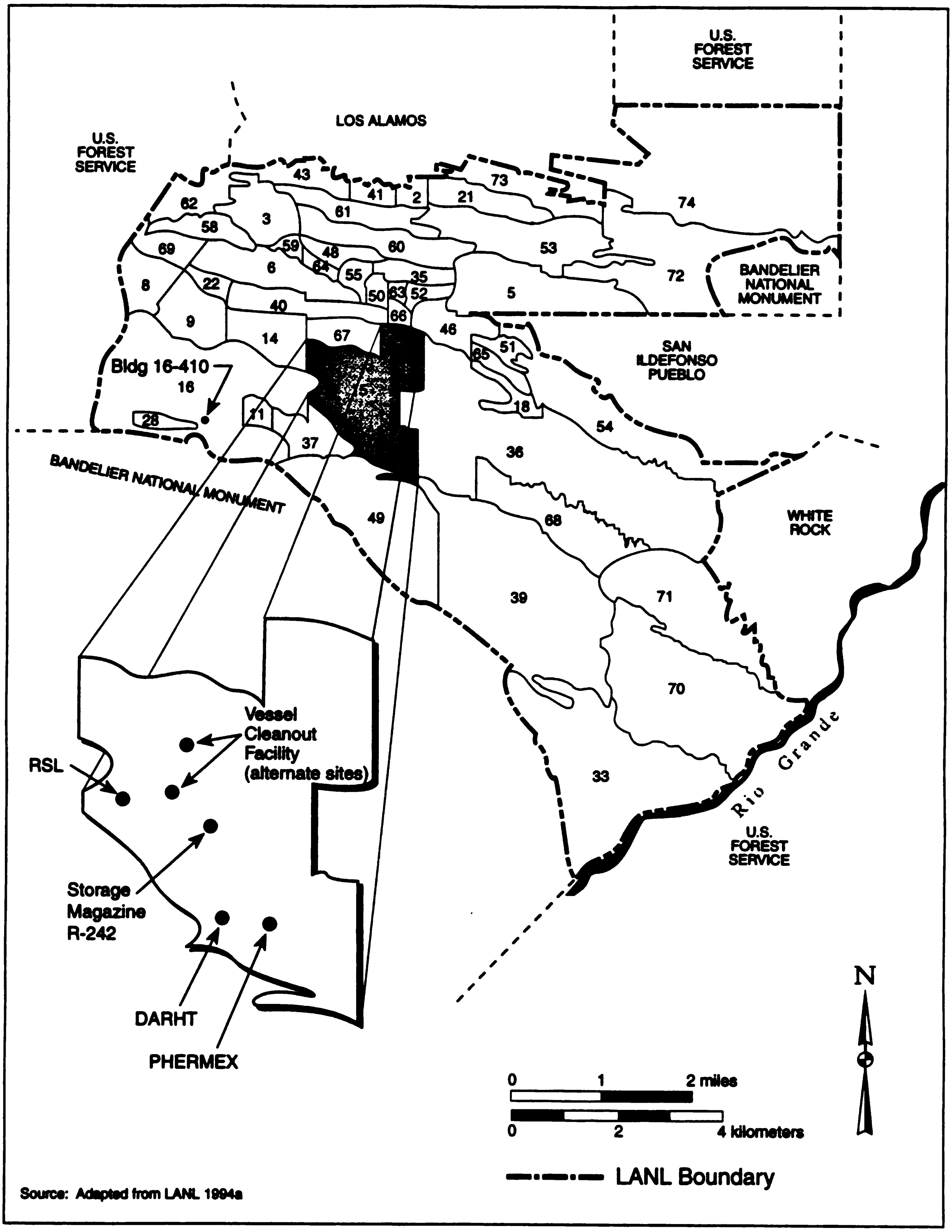


FIGURE 3-1.—*The Relationship of the LANL Technical Areas to the Location of PHERMEX and the DARHT Facilities.*

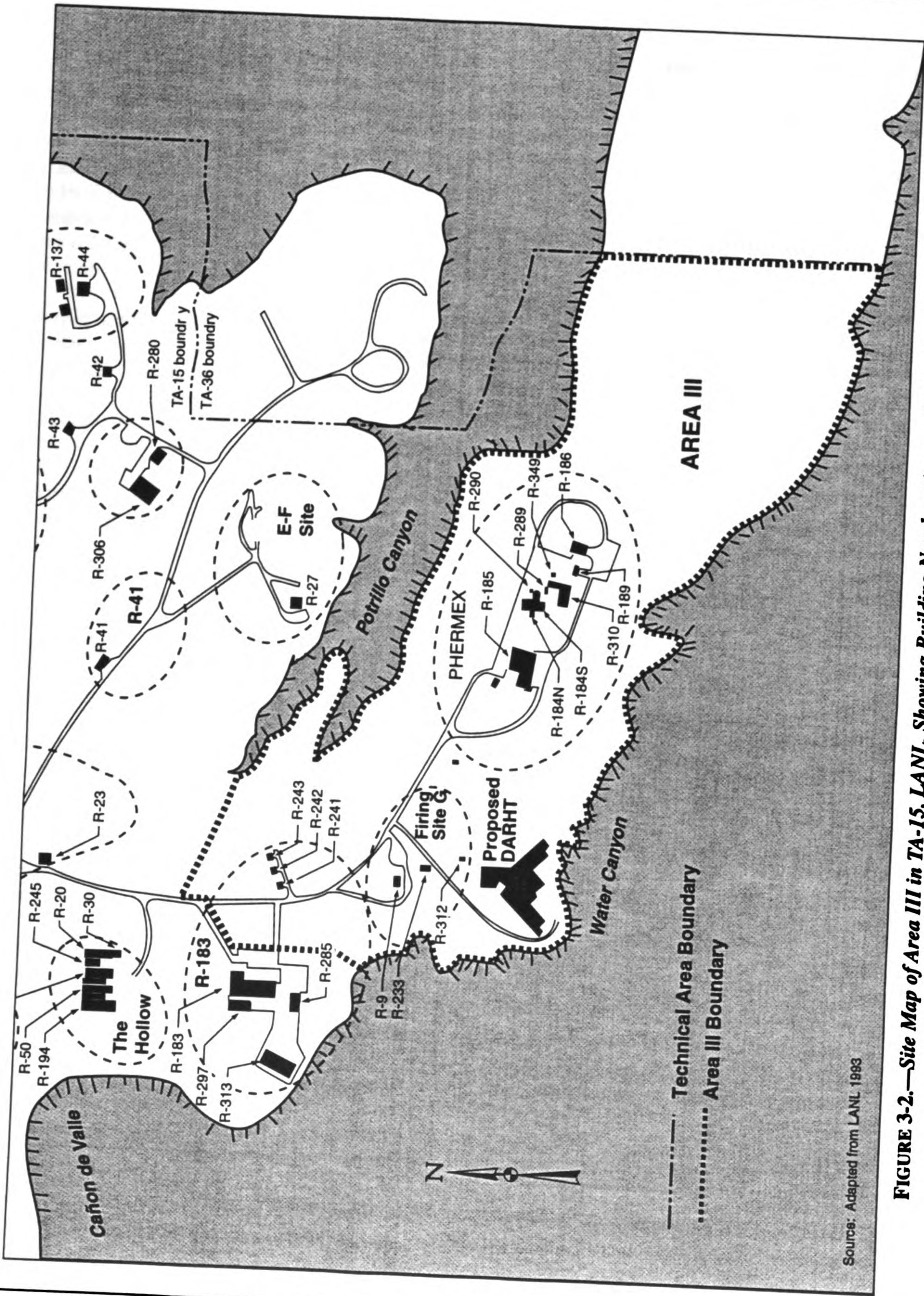


FIGURE 3-2.—*Site Map of Area III in TA-15, LANL, Showing Building Numbers (generalized schematic representation).*

3.3.7 Development of Operating Procedures

Operating procedures are already in place at PHERMEX and would be used under the No Action Alternative. Under all of the other alternatives analyzed, LANL would develop operating procedures to assist with safe, secure operation of the facility. These procedures would reflect the recent modifications resulting from the April 1995 fire at PHERMEX involving lithium hydride contaminant waste. This incident led to the modification of the Access Control Procedure that now requires a prehazard briefing for the Fire Department and clearing of all debris at the site prior to every test or experiment involving explosives.

LANL policy provides general safety guidance and requires that procedures more specific to actual operations be developed within the operating group. The operating group would also prepare a plan for emergency response. To foster a general safety awareness within the operating group, periodic meetings would be held to emphasize the aspects and consequences of safety and emergency planning. Safety considerations would take precedence over operational necessity of the operating group.

3.3.8 Waste Management

Operations for any of the alternatives would result in five categories of waste: solid waste (nonhazardous, nonradioactive), hazardous waste, mixed radioactive and hazardous waste (mixed waste), low-level radioactive waste (LLW), and transuranic (TRU) waste. The amounts of waste produced would vary according to the number and types of tests performed each year. Chapter 5 contains estimates of the amounts of waste expected to be produced from these operations.

Solid waste would be disposed at the LANL Area J landfill in TA-54 or sent to an approved disposal facility. Hazardous waste would be taken to TA-54 for temporary storage awaiting treatment and disposal. Mixed waste would be treated and disposed according to the site treatment plan. Low-level radioactive waste would be disposed at the LANL low level waste disposal site in TA-54. Transuranic waste would be stored at LANL Area G in TA-54 awaiting packaging and certification for shipment to the Waste Isolation Pilot Plant (WIPP).

A single-walled vessel would be used in support of hydrodynamic tests for both the Phased Containment Option and the Vessel Containment Option. This vessel would be decontaminated and reused until the structural integrity of the vessel would dictate retirement of the vessel. The vessels would not require disposal as LLW; following decontamination, the vessels would be categorized as scrap metal. The generation of LLW would reduce waste from 12,500 ft^3/yr (350 m^3/yr), as proposed under the DARHT Baseline Alternative, to 3,600 ft^3/yr (101 m^3/yr) with 75 percent containment as achieved under the final stage of the Phased Containment Option of the Enhanced Containment Alternative. This constitutes a reduction from 4 to 2 percent of the total LANL LLW disposal at Area G.

A double-walled vessel that would be used in support of a dynamic experiment containing plutonium would be transported to the LANL Plutonium Handling Facility at TA-55 for decontamination procedures. Previous experience has indicated that the vessels would be categorized as TRU waste following decontamination. It is anticipated that the vessels would be cut into pieces to reduce their volume prior to certification for disposal at WIPP. DOE estimates that two vessels per year would be used in dynamic experiments. This would yield approximately 26,000 lbs (11,820 kg) of steel that could be TRU contaminated and thus require disposal as TRU waste. Material contaminated by alpha-emitting radionuclides, which are heavier than uranium, with half lives greater than 20 years and in concentrations greater than 100 nCi/g of material are categorized as TRU waste.

3.3.9 Decontamination and Decommissioning

Under all alternatives analyzed in this EIS, eventually DOE would no longer need PHERMEX or the DARHT Facility and would decontaminate and decommission (D&D) the structures. The structures would eventually be demolished as well.

The only difference among alternatives would be the timing of the eventual D&D. For example, under the No Action Alternative, Plutonium Exclusion Alternative, and Upgrade PHERMEX Alternative, DOE would continue to operate PHERMEX indefinitely, while under the DARHT Baseline Alternative, DOE would phase out operations at PHERMEX over a four-year transition period. DOE would then proceed with D&D and demolition of the structure when it is no longer needed. DOE estimates that the DARHT Facility has a 30-year design life, regardless of whether the structure is used for hydrodynamic tests and dynamic experiments, as under the DARHT Baseline Alternative, or for other uses, as under the No Action Alternative.

At the end of the useful life of either PHERMEX or DARHT, DOE would evaluate options for disposal of the facility. At that time DOE would perform engineering evaluation, environmental studies, and a NEPA review to assess the consequences of different potential courses of action.

D&D activities would result in the generation of mixed waste, radiological waste, and solid waste. Demolition would result in solid waste in the form of construction rubble and possibly other types of waste. These wastes would be treated and disposed.

DOE anticipates that alternatives for disposition of the two facilities would include:

- D&D and demolish the structures and release the site for unrestricted use
- D&D and demolish the structures and restrict use of the site
- Partial D&D and retain structures for unrestricted use
- Partial D&D and retain structures for modified or restricted use
- No D&D and retain structures for similar or modified use

DOE cannot anticipate which options may be considered reasonable in the future and so cannot assess these alternatives in this EIS.

3.4 NO ACTION ALTERNATIVE

The No Action Alternative describes the continuation of the current situation (status quo) that would be expected in the future if DOE did not implement the DARHT Baseline Alternative or any other alternative analyzed in this EIS. The No Action Alternative serves as a basis of comparison for all other alternatives analyzed. For this EIS, the No Action Alternative would be to continue to operate PHERMEX at LANL and FXR at LLNL and not acquire an enhanced radiographic hydrodynamic testing capability. However, the No Action Alternative is not static. DOE would use these facilities to support its science-based stockpile stewardship and management program to the greatest extent possible. Accordingly, the type and number of hydrodynamic tests and dynamic experiments could vary from the type and number used in the past, as program needs change.

Under the No Action Alternative, the following would occur:

- PHERMEX and FXR would continue to provide hydrodynamic test capability
- PHERMEX would undergo occasional maintenance and operational upgrades, but the facility could not be upgraded to achieve the enhanced radiographic capability proposed for DARHT.
- The partially constructed DARHT Facility would be mothballed, and construction would not resume until another use for the structure could be determined (e.g., office space or accelerator applications), and appropriate reviews, including design and NEPA review as appropriate, were completed
- The RSL would continue to support radiography technology and operations at LANL
- Three-dimensional or time-dependent information would be partially obtained at PHERMEX by conducting sequential tests of nominally the same design
- DOE would perform some dynamic experiments; those using plutonium would be conducted in double-walled containment vessels

Under this alternative, DOE would continue to operate PHERMEX well into the next century. As discussed in chapter 2, over time, maintenance of the facility would be increasingly difficult in the event that replacement parts become unavailable to maintain and operate the vintage accelerator.

Under this alternative, DOE would determine another use for the partially constructed DARHT Facility, and would complete the structure following redesign and other appropriate reviews. This may require additional NEPA review. For the purposes of this EIS, in order to serve as a basis of comparison for other alternatives, DOE has assumed that completing the structure would involve completing a concrete shell similar to the DARHT Facility; DOE recognizes that other types of uses may require modification to the structure and different construction materials or techniques, compatible with other requirements for structures within TA-15 or the larger explosives testing area.

3.4.1 Facility

PHERMEX was constructed in the 1960s and first operated in 1963; the north and south amplifier rooms were added in 1980 and the R-310 Multidiagnostics Operations Center in 1988. The PHERMEX Facility includes three major buildings and several other support buildings and structures (see figure 3-2).

Table 3-2 lists some of the PHERMEX buildings and their functions. PHERMEX uses a radio-frequency accelerator (instead of a linear induction accelerator, like that at FXR) that was designed and built at LANL specifically for radiography. The accelerator is unique in that it was designed for a maximum charge per pulse by using a very low frequency (50 Mhz) to provide maximum stored energy per pulse.

TABLE 3-2.—*PHERMEX Buildings and Their Functions*

Building	Function
R-185	Power Control Building for PHERMEX (two-story). Contains equipment for regular site power and heating, ventilation, and air conditioning (HVAC), and special equipment to generate and control high voltages, store electrical energy, generate and control radio-frequency energy, and control PHERMEX functions during a test shot. One of only two buildings at the facility that personnel are allowed to occupy during a test shot.
R-184	Houses the linear accelerator, PHERMEX, and its ancillary equipment that produce the x-rays for imaging a test shot. Accelerator's 25 to 30 MeV electron beam impinges on a tungsten target which then emits the x-ray beam. Has high voltage power supplies and radio-frequency equipment. Personnel are not allowed in the building when the accelerator is operating.
R-310	Multidiagnostics Operations Center, built in 1988. Has a control room for firing explosive tests independently or in conjunction with PHERMEX radiography. Houses diagnostic equipment associated with firing control and data collection from test shots. Second of the two buildings that may be occupied during a test shot.
Firing Area and R-349	Contains detonator firing equipment. Firing site can handle 150 lb[a] (68 kg) of explosives on the pad in front of the Building R-184 bullnose which protects the x-ray converter. Larger explosive charges, up to about 1,000 lb (454 kg), can be accommodated by moving the firing point up to a distance of 160 ft (48 m) to the east away from Building R-184.

[a] Throughout this EIS, quantities of explosives are mentioned. Although different explosive compounds may be used, quantities are always given as an equivalent amount of TNT, which serves as a standard reference.

Although PHERMEX is able to obtain several hundred amperes peak beam current, the voltage quickly drops, resulting in a beam energy spread that limits beam spot size (DFAIC 1995).

No new construction or site modification at PHERMEX is included in the No Action Alternative, with the exception of DOE's proposal to relocate the Ector machine. In 1991, DOE proposed moving Ector from Site R-306, TA-15, to the PHERMEX site. Site preparations to receive the Ector machine have been ongoing since 1992 and have consisted of installing a concrete pad and an above-ground oil tank. Ector is an existing 30-year-old x-ray diagnostic machine that is scheduled to be moved to the PHERMEX site in 1995 or 1996 for experiments in which a wide-field-of-view, medium-resolution radiograph of an entire assembly being tested is needed simultaneously with a high-resolution radiograph of the same test. Ector could be used to image the large-scale motion of the lower-density region of an experiment while PHERMEX images a smaller high-density region of the same test. Ector would not require a separate building. DOE has completed NEPA review of certain site preparation activities that could be used for Ector and will complete all required NEPA review before the proposed relocation of Ector to the PHERMEX site is done. Use of Ector at PHERMEX would eventually be phased out.

Under the No Action Alternative, a double-walled steel containment vessel would be used at the firing-site facility to contain emissions and debris from selected dynamic experiments, particularly those involving plutonium.

3.4.2 Operations

The historic operational baseline for PHERMEX is described in appendix B. The PHERMEX Facility can detonate high-explosive charges up to 150 lb (70 kg) located at the principal firing point. If larger high-explosive charges are necessary, such charges up to about 1,000 lb (454 kg) would be located at firing points to the east along the accelerator axis. For such experiments, a temporary expendable blast shield would be constructed as necessary to mitigate blast effects. Both uncontained and contained shots are fired at PHERMEX.

Typical requirements to conduct a radiographic test are listed in table 3-1. Operations specific to PHERMEX can be divided into six steps: planning, assembly, placement, diagnostic verifications, firing, and post firing. Typically, the need and the initial planning for a test shot involve several LANL organizations (see section 3.3.3). Experts within the division that operates PHERMEX often participate in the planning aspects related to mechanical support, placement, and diagnostics. Completed assemblies are usually prepared elsewhere and delivered to the firing site. The Access Control Office (ACO) monitors transportation activities within the PHERMEX controlled area. A limited number of assembly operations, such as electrical connections at the firing point, may be performed at the TA-15 site.

Before a shot is fired, the firing supervisor clears the firing point of personnel and makes the final connections to the high-explosive assembly. The firing supervisor contacts the ACO for a list of personnel in the PHERMEX area and accounts for each one. No one is allowed to enter or exit the area until the shot is fired. Clearance patrolmen make a sweep from the PHERMEX site out to the designated control point and set up a roadblock. The roadblock remains in place until the shot is fired and the area is declared safe by the firing supervisor. The firing supervisor, clearance patrolmen, and the ACO maintain radio contact during the firing procedure. Fire suppression personnel and equipment remain in standby at the designated control point during the firing procedures.

Activation of the detonators occurs just before the PHERMEX x-ray machine is pulsed and is controlled by the facility safety system. Operation of the PHERMEX radiographic beam is controlled by physical interlocks and a machine visual disconnect terminal. The system includes an explosives visual disconnect terminal. For pin test assemblies, the pins are connected to their power supply just prior to firing and comprise the pin diagnostic network. The pin diagnostic network connections are protected in a manner similar to connections for the detonator circuit.

Prior to use, all simulated weapons assemblies are monitored for the presence of fissile material according to pit verification procedures. This monitoring is performed and verified by the firing supervisor and a member of the firing crew.

After the shot has been fired and the site declared safe, the clearance patrolmen remove the roadblocks and firemen on standby enter the area to control fires. The operating crew enters the firing area, collects any diagnostic data, and moves the film cassette to another building for dismantling. Film cassettes are heavily armored containers that protect the x-ray film from the explosive blast. Other detectors, using scintillators and recording cameras (generically known as "gamma-ray cameras"), could also be used and would be protected in similar cassettes. Post-firing activities include cleaning up the firing site and collecting firing-site debris. Cleanup and debris removal are often scheduled only after a sequence of shots. If a containment vessel has been used, the vessel is moved by truck to another LANL facility for opening, cleaning, and refurbishing.

Personnel who are engaged in recovery or cleanup activities typically are required to wear protective clothing as deemed necessary by the LANL Environment, Safety, and Health radiation control technician. Contamination of the firing point by undetonated explosives is highly unlikely, but remotely possible. If such contamination occurs, cleanup under a Special Work Permit is required before the firing point may be used again.

The PHERMEX operating crew includes personnel to field an experiment and support personnel to maintain the PHERMEX accelerator and all of the site's ancillary equipment. The number of workers with radiation safety training and available to be assigned to tasks at or near the PHERMEX firing area currently ranges from 67 to 77. Only nine radiation workers are required at one time. Some of the support personnel for a test typically include two electronics technicians for the diagnostic chamber, two or more PHERMEX operators, two staff members to provide physics support, one or more mechanical technicians for maintenance and upgrades, two clearance personnel, a firing crew of three technicians, a photographic technician to handle and process the x-ray films, and additional personnel depending on the diagnostics fielded for a test shot. Most of these people also support other programmatic efforts unrelated to PHERMEX.

3.5 DARHT BASELINE ALTERNATIVE

Under the DARHT Baseline Alternative, DOE would complete construction and operate both axes of the DARHT Facility. An artists' conception of the DARHT Facility is shown in figure 1-1. If the DARHT Facility becomes operational, DOE would phase out operation of PHERMEX over approximately four years. The DARHT Baseline Alternative is not expected to affect future operations of the RSL at LANL, the FXR at LLNL, or other smaller explosive test facilities at LANL and LLNL. Under the DARHT Baseline Alternative, a steel containment vessel could be used at the firing site facility to contain emissions and debris from selected dynamic experiments; experiments involving plutonium would be conducted inside a double-walled steel vessel.

The DARHT Facility responds to DOE's need to obtain enhanced hydrodynamic testing capability. Through its weapons research and design expertise at LANL, DOE developed DARHT to provide enhanced diagnostic capability to study the behavior of nuclear weapons. DARHT was designed specifically to provide three-dimensional information and to obtain deeply penetrating, high-resolution radiographic images.

DARHT would be used to study the three-dimensional implosion of mock nuclear weapons primaries. DARHT would enable imaging through very thick, dense materials; take multiple, very brief snapshots from two different lines of sight; and provide images of very high resolution. Completion and operation of the first axis of DARHT would produce radiographic images with significantly higher spatial resolution and penetration than is now possible at either PHERMEX or FXR. With completion and operation of the second axis, DOE would be able to obtain three-dimensional data as well as time-sequenced images taken within millionths of a second or at arbitrary times.

Compared to the present capability at PHERMEX and FXR, the DARHT Facility would:

- Provide higher resolution of the entire imploded primary area

- Provide more information content in each radiographic image because of the reduction in beam size proposed for DARHT and the corresponding increase in resolution
- Provide two independent views, taken at right angles to each other, of the systems being tested; this capability could be used to provide either three-dimensional data or provide information at two slightly different times, whichever would be more important in observing a particular system
- Provide this increased information content over the full field of view of the machine, which would encompass a full-scale mockup of the system to be tested
- Provide up to a seven-fold increase in x-ray strength, compared to PHERMEX

DARHT was first proposed in the early 1980s as a diagnostic facility to be used as part of LANL's ongoing weapons research and development mission. DARHT was intended, then as now, to assist in evaluating the safety, performance, and reliability of existing weapons. In addition, at that time hydrodynamic testing at DARHT, in conjunction with underground nuclear testing, was intended to assist in designing new nuclear weapons and replacement parts.

The DARHT Facility would provide a flash radiographic capability for the testing of high explosives systems and components. Other types of electronic, optical, and photographic diagnostics would also be available at the site. Timing options would allow triggering of the two x-ray beams either simultaneously or with slight delays. Simultaneous images from the two axes would provide for three-dimensional data while sequential images would aid in studying the time history of a test assembly.

DOE may install, test, and prove the linear induction accelerator equipment in the first axis (the southeast accelerator hall) before purchasing, assembling, and installing the accelerator equipment in the second axis. This would be to ensure that the accelerator technology will perform as anticipated before incurring the expense of equipment for the second axis. Accordingly, DOE has split the expenditure for the second axis equipment into a separate budget line item for the remainder of the project. This is in keeping with the recommendations of independent panels of consultants convened by DOE to review technology plans (HPAIC 1992; DFAIC 1995; DOE 1993a). Although the two 1992 reports suggested delaying construction of the second axis until the first axis was tested and proven, in 1992 DOE approved funding for construction of accelerator halls for both axes. DOE allowed for site preparation and construction for both accelerator halls to proceed at the same time to avoid undue disruption to operation of the first axis while the second accelerator hall was constructed. The accelerator halls and associated diagnostic areas were modified to accommodate the recommendations of the various panels and to ensure that the DARHT Facility could provide diagnostics used by LLNL, and thereby function as a shared user facility (DOE 1993a).

Hydrodynamic and explosives operations proposed for the DARHT firing-site facility are similar to those currently undertaken at the PHERMEX facility, which is located approximately 2,000 ft (600 m) to the east of the DARHT site. The DARHT Facility would provide increased information and improved radiographic diagnostic capability over PHERMEX because of the increased temporal and spatial resolution and two lines of sight. Although the DARHT Facility is designed to provide more and better data for each shot, the total number of shots per year would remain about the same as for the No Action Alternative.

Hydrodynamic testing at the DARHT Facility would consist of observations of explosive systems in combination with surrogate materials, such as depleted uranium or tantalum, which simulate the behavior of weapons materials but are physically incapable of producing energy from nuclear reactions during testing. In addition, the facility could be used for testing systems such as high-velocity impacts and explosive forming of metals.

3.5.1 Facility

The DARHT Facility would consist of a new accelerator building, with two accelerator halls, firing point, and the associated support and diagnostic facilities at the DARHT site (see figure 3-3). The proposed firing point would be at the juncture of x-ray beams produced by two electron beam accelerators oriented at right angles to each other to provide dual-axis, line-of-sight radiographs. The accelerators would be housed in halls about 225 ft (70 m) long by 50 ft (15 m) wide. The existing RSL, which supports all radiographic machines at TA-15, would be used to support the DARHT Facility.

Construction of the DARHT Hydrotest Firing Site (HFS) began in May 1994, and construction was halted on January 27, 1995, by preliminary injunction from the U.S. District Court, Albuquerque, New Mexico. At that time, approximately 34 percent of the construction of the HFS was complete. The completed construction includes installation of an earthen berm on the northern side of the DARHT site as a radiation protection measure. It is estimated that construction, installation, and testing activities for the first axis would take an additional 38 months, and 66 months for both axes, if this alternative were to be implemented.

3.5.2 Operations

The steps necessary to conduct a radiographic test are shown in table 3-1. The DARHT Facility would be able, by design, to detonate high explosives charges up to 150 lb (70 kg) located at the dual axis firing point. If larger high explosives charges were necessary, charges up to 500 lb (230 kg) would be located at a firing point to the northwest along the axis of the southeast accelerator to provide sufficient distance between the firing site and the building. For such experiments, a temporary expendable blast shield would be constructed to mitigate blast effects.

All LANL firing sites have an established exclusion zone that is a safety feature to provide protection to personnel and structures while testing takes place. During a test, the exclusion zone is the area that is cleared of any personnel before each shot. There are limitations on the types and design of structures that can be built within exclusion zones. The high-explosive testing area at LANL comprises 20 mi^2 (52 km) and includes several high-explosive test facilities (see section 3.3.6). Each test facility has a defined exclusion zone. The radius of each zone is based on the amount of high explosive for which the facility is designed. The proposed DARHT Facility would have an exclusion zone of 2,500 ft (950 m).

The operations to be performed at the proposed facility would be similar to those currently performed at, and proposed for, the PHERMEX facility. Some differences arise because there would be two x-ray machines to coordinate with a test detonation, and the DARHT x-ray machines would not be identical in their operating parameters to the PHERMEX machine. The operational tasks include design; assembly and placement of the test assembly at the firing point; setting up and checking out the diagnostic apparatus;

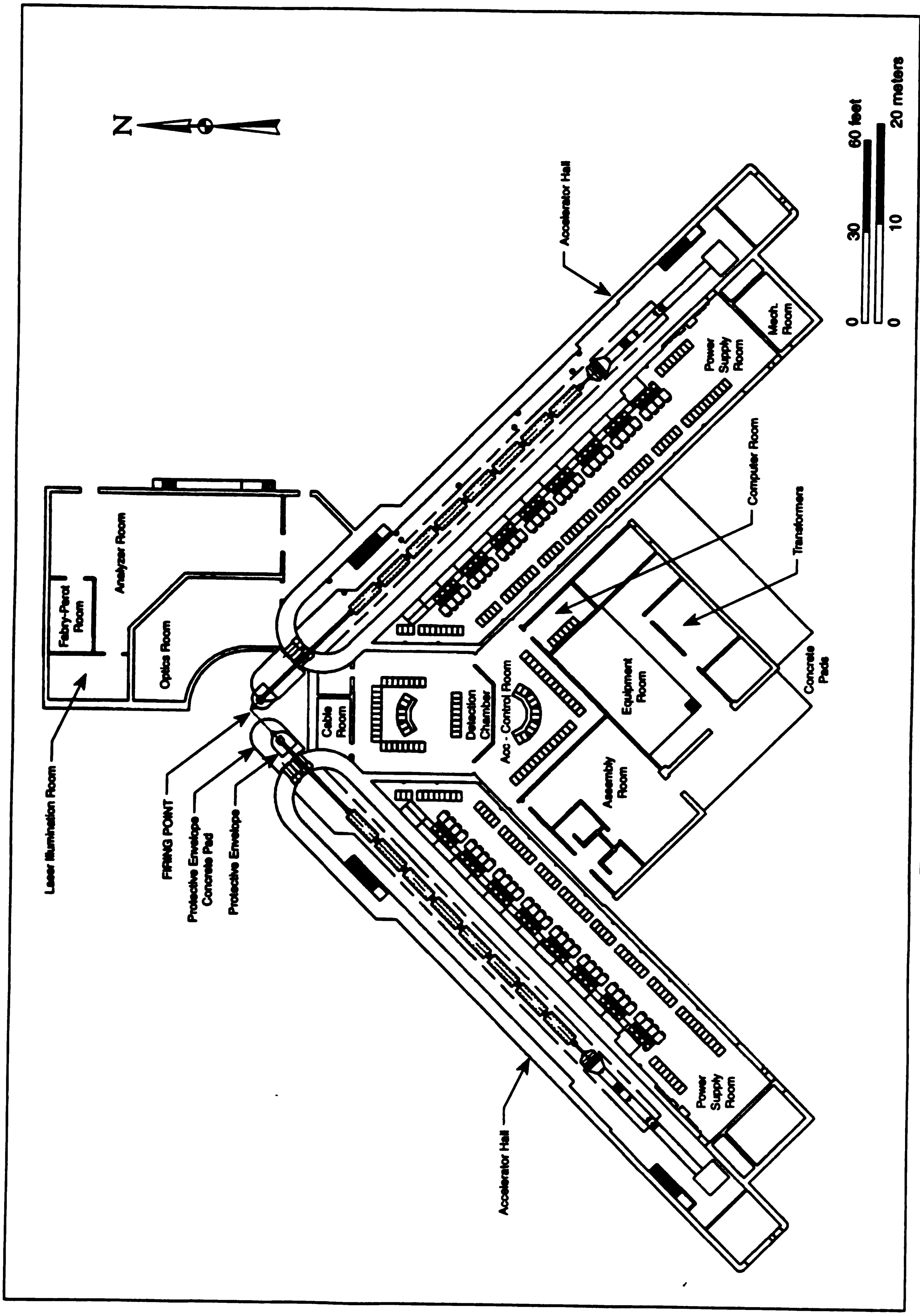


FIGURE 3-3.—*Proposed DARHT Facility Plan.*

executing the experiment from a remote control room; and completing post-firing tasks associated with securing the firing pad and cleanup. Preliminary data reduction is usually done onsite to determine the success of the experiment.

One of the few differences between operations at the DARHT and existing PHERMEX Facilities would be the operation of two accelerators from the remote control room in the two-axis mode of operation. Since there would be two buildings containing accelerators, only minor upgrades to most existing operating procedures and administrative controls would be needed. Multiple x-ray pulses generated by a single axis could also be achievable. However, the new technology of DARHT would result in changes to electronic operation and control of the facility.

Accelerators at the DARHT Facility would produce a sharply focused x-ray beam that would be much faster than that of PHERMEX (approximately 60 nsec pulse width) and with a much higher x-ray dose. The electron beam would be converted into an intense x-ray beam emanating from a spot size that is approximately one-third that of PHERMEX. Figure 3-4 presents a comparison of spot size for PHERMEX, FXR, and DARHT.

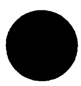
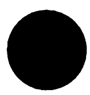
Smaller spot size increases ability to perceive detail	PHERMEX	FXR	DARHT
Spot Size (mm) (Resolution)	3	3.4	1.2
Relative Spot Size			
Actual Spot Size			

FIGURE 3-4.—***Comparison of Penetration and Resolution for PHERMEX, FXR, and DARHT (data from JASON 1994).***

Since publication of the draft EIS, DOE has decided to propose incorporating upgraded accelerator and x-ray diagnostic equipment within the proposed DARHT facility. This proposal would apply to all alternatives that include DARHT accelerators. By simply extending the accelerators to increase the minimum electron-beam energy 25 percent to a nominal 20-MeV and by enhancing existing equipment to generate a higher-current beam, DOE proposes to increase the output x-ray dose to 550 to 1650 R (depending upon the final accelerator operating point that would be determined upon commissioning the facility) while maintaining the small x-ray spot size. The existing DARHT facility design supports this option, so no increase in facility footprint or services would be required, although capital costs would increase as shown in section 5. The performance history of electron accelerators for flash radiography shows that machine performance improves considerable in a few years from the original startup. This type of improvement is expected for DARHT as appropriate technology becomes available and such capabilities as a dose stretch of 2000 R or more, increased beam energy up to approximately 30 MeV, and the generation of multiple pulses are possible while remaining within the bounds of this EIS.

The accelerator could also be operated in a second mode without the production of x-ray beams. In this mode of operation, the electron beam would be stopped within a graphite target (beam stop) placed within the building near the exit of the accelerator. Tantalum shielding would be used to enclose x-ray production in the beam stop. This mode would be used during testing and beam-tuning operations in preparation for beam production for an actual test. Operational procedures in this mode would be essentially the same as in the x-ray production mode.

Explosives would not be stored, handled, or processed inside any DARHT building. Explosives operations would be performed in accordance with approved procedures and at other locations on the site. Conventional high explosives consisting of bare charges and clad devices would be positioned outside the DARHT structure and detonated at the firing point. Several kinds of test and x-ray preparation activities, identical to those conducted at PHERMEX, would be conducted at the firing point prior to detonation. These include positioning and mechanical alignment of the test assembly relative to the x-ray beam, establishing and verifying the cabling for diagnostics, and resistance measurement testing of the detonators to be used in the hydrodynamic test.

During preparations for a test, repetitively pulsing the accelerators would be necessary to focus and adjust the electron and/or x-ray beams. Tuning of the accelerator components, without high-explosive operations, is expected to account for a very large fraction of the operation of the accelerator.

The proposed facility would use lasers both for lining up radiographic tests and for diagnostic purposes in optical tests. Operation of both the helium-neon laser and the solid state lasers (Neodymium: yttrium aluminum garnet with harmonic generator) to be employed in the accelerator rooms at the DARHT Facility would be performed in accordance with standard industrial safety practices. Further administrative and engineering controls in accordance with LANL procedures would be used for laser operation. Only operators who have been trained and certified in laser operation would be allowed to operate the lasers when used for alignment and checkout. When used as a diagnostic in an experiment, the lasers would be operated from the control room.

When containment would be used for a test shot, the blast products would remain in the containment vessel that would be taken to another LANL facility for cleaning and refurbishing. The contained blast debris would be taken to appropriate processing or disposal facilities according to the nature of the debris.

In 1988, a U.S. Environmental Protection Agency (EPA) radiological air emissions approval to construct the DARHT Facility under 40 CFR Part 61, the National Emission Standards for Hazardous Air Pollutants regulations, was obtained for the DARHT Baseline Alternative. This approval limits the annual expenditure of uranium to 440 lb (200 kg). This limit was based on the amount of depleted uranium used at PHERMEX during the mid-1980s. However, since that time, underground nuclear testing has ceased, programmatic objectives have changed, and a limit of 1,540 lb (700 kg) would be required to meet all objectives under this alternative. For example, safety tests of full-scale systems involving accident scenarios with stockpiled systems in sympathetic detonation would expend more depleted uranium per test than a single system test of the type envisioned at the time the permit was obtained. During a hydrodynamic test, ascertaining the proper function of certain stockpiled components that contain tritium could also be needed. These tests would be expected to release a small amount of tritium, and the maximum annual release would be less than 0.06 in^3 (1 mL, 3 Ci) of tritium. A new EPA approval would be needed for DARHT to operate at these new limits, and until it is obtained, operations at the DARHT Facility would be bounded by the current approval.

Sanitary wastes from the DARHT Facility would be handled by a septic system at the facility. Water for cooling accelerator components would pass through a cooling tower that has an average blowdown of 2,000 gal/d (7,600 L/d).

3.6 UPGRADE PHERMEX ALTERNATIVE

Under the Upgrade PHERMEX Alternative, DOE would upgrade PHERMEX with the new high-resolution radiographic technology developed for DARHT (see figure 3-5). (The existing PHERMEX x-ray machine is not technically capable of meeting DOE's need for enhanced high-resolution radiography.) PHERMEX would be remodeled and enlarged to accept the new equipment. Under this alternative, DOE would obtain improved high-resolution capability, as compared to the present capability at PHERMEX and FXR, and would construct a second accelerator hall to provide the capability to obtain three-dimensional and time-sequence data. As in the DARHT Baseline Alternative, the accelerator equipment for the second axis may be procured and installed after the equipment in the first axis was installed, tested, and proven. As in the DARHT Baseline Alternative, a steel containment vessel could be used at this firing site facility to contain emissions and debris from selected dynamic experiments; experiments involving plutonium would be conducted inside a double-walled steel vessel.

As discussed earlier in this chapter, some of the potential measures discussed for the DARHT Baseline Alternative could be applied to this alternative; however, they are not expressly analyzed. For example, DOE could decide to enlarge the existing single axis at PHERMEX and equip it with the enhanced radiographic capability originally planned for the DARHT Facility. Although this would not meet all of the DOE's programmatic objectives, the environmental impacts of such an approach would be within the range of impacts expected from the alternatives analyzed in this EIS.

The DARHT Facility would not be completed, but the partially constructed concrete shell of the firing site facility would be put to other uses, as described in the No Action Alternative. The Upgrade PHERMEX Alternative is not expected to affect future operations of the RSL at LANL, the FXR at LLNL, or other smaller explosive test facilities at LANL and LLNL. During the upgrade construction, expected to last a little over four years, DOE would suspend its hydrodynamic testing program at LANL. During this time, DOE would be limited in its ability to use radiographic techniques in assessing problems that might arise in the stockpile.

3.6.1 Facility

Under the Upgrade PHERMEX Alternative, DOE would install the proposed enhanced hydrodynamic capabilities at the present PHERMEX Facility site. The PHERMEX structures and equipment would be used to the extent possible, but extensive replacements of and modifications to the present PHERMEX Facility would be required. Because only the enhanced radiographic technology developed for DARHT is currently available to provide the capability needed, and because the linear induction accelerator planned for DARHT is the only currently available technology to provide the needed capability, the radio-frequency accelerator now at PHERMEX would be removed and replaced with a linear induction accelerator. The new accelerator is physically larger than the existing accelerator, and would not fit in the existing accelerator hall. The existing hall would have to be extensively remodeled.

Under the conceptual design for this upgrade, the two accelerator halls and other buildings for the firing site would be sized and laid out similarly to the plans for the DARHT Facility. Orientation of the complex would be consistent with the existing accelerator hall at the PHERMEX site, with the first upgraded accelerator hall being an extension of the existing hall and the second hall constructed at a right

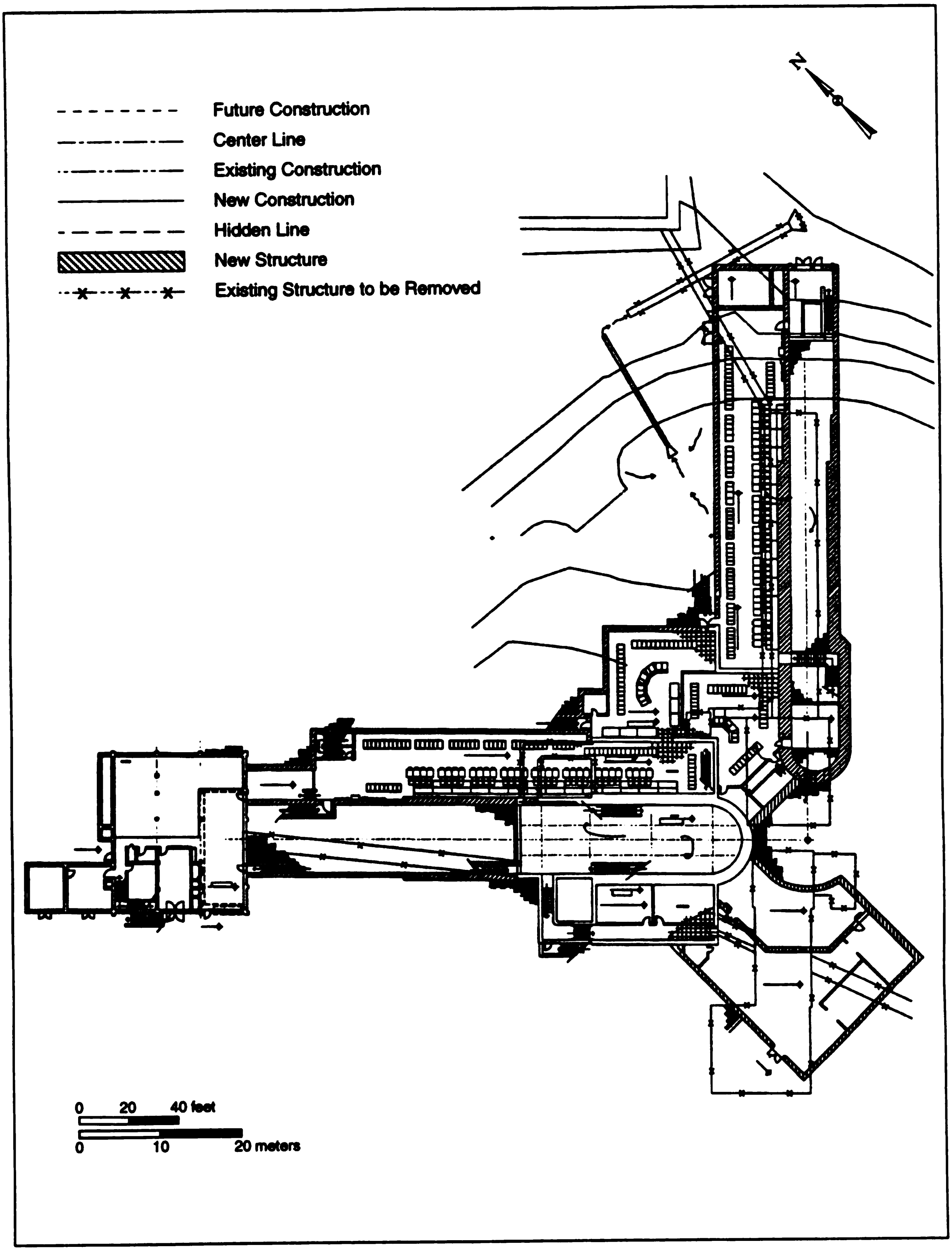


FIGURE 3-5.—*Conceptual Design of the PHERMEX Upgrade Facility.*

angle to the first. The demolition of several existing structures and cleanup of existing debris would be necessary before construction could begin on facilities under the Upgrade PHERMEX Alternative.

The existing PHERMEX building would be used under the Upgrade PHERMEX Alternative, but the structure would require substantial modification. The current PHERMEX diagnostic buildings are not appropriately configured for the Upgrade PHERMEX Alternative and would be demolished and replaced. The underground tunnels, which interconnect buildings, would be removed where necessary and abandoned in place if no longer needed. The mechanical and electrical systems at PHERMEX are inappropriate for DARHT technology and would be replaced. Cleanup, demolition, construction, installation, and testing activities associated with the Upgrade PHERMEX Alternative would require approximately 51 months to complete.

No new transmission lines would be required for the upgraded PHERMEX Facility; however, new water, fire protection, and gas lines would be installed to meet the requirements of the upgraded facility. A new sanitary sewer would also be required.

3.6.2 Operations

The operations to be performed at the upgraded PHERMEX Facility would be identical to those planned for the DARHT Facility. These operational tasks are described in section 3.5.2.

3.7 ENHANCED CONTAINMENT ALTERNATIVE

The Enhanced Containment Alternative differs from the DARHT Baseline Alternative in that it assumes the addition of a means (i.e., containment) to prevent the release of most or all airborne emissions, metal fragments, and other debris resulting from firing-site operations. The containment could be either portable steel vessels or a permanent building.

The DARHT draft EIS analyzed both a Vessel Containment Option and a Building Containment Option. These options pose hypothetical "bounding" situations; however from a programmatic standpoint either option would have serious design or operating limitations. Therefore, DOE has developed a third option, called the Phased Containment Option, to take advantage of the environmental mitigation effect of enhanced vessel containment while still allowing the DARHT Facility to be completed quickly to meet the need for enhanced radiographic capability as soon as possible. The Phased Containment Option has replaced the DARHT Baseline Alternative as DOE's preferred alternative.

Under the Building Containment Option, the concrete containment structure would have to be very large in comparison to the firing site to contain the overpressure from an explosive test; DOE would forego the capability for experiments or tests using larger amounts of high explosives or some other specific types of large tests because of the structural limitations of the building. Also, this option would place limits on DOE's ability to conduct dynamic experiments with plutonium because of the difficulty in moving the large, double-walled steel containment vessels needed for plutonium experiments in and out of the containment building.

Under the Vessel Containment Option, the EIS analysis assumes that the DARHT Facility would operate from the first with a certain percentage of tests and experiments conducted inside modular single-walled steel containment vessels. However, the number of tests that could be conducted early in the operating life of the facility would be significantly reduced if this limitation were imposed. Although some conceptual work has been done, DOE has not yet designed the vessels. DOE would have to perfect a prototype vessel before fabricating all the vessels intended. Also, the Vessel Containment Option depends on construction of a vessel cleanout facility; the design for this building could not be finalized until after the prototype vessels were perfected to determine the specific details of cleanout equipment and techniques. DOE estimates that it would take approximately 10 years beyond the availability date for the DARHT Facility to complete these activities and be able to conduct a full schedule of contained tests. However, by phasing in the vessel prototyping program, within about 10 years DOE could achieve the same environmental protection results as could be obtained under the Vessel Containment Option without adversely affecting the program. For the first 10 years, environmental mitigation would be less than would occur under the DARHT Baseline Alternative but greater than would occur under the Vessel Containment Option; thus the Phased Containment Option is "bounded" by the other two situations.

Under either the Vessel Containment Option or the Phased Containment Option (once fully implemented), DOE would conduct most hydrodynamic tests and dynamic experiments using containment vessels. On a case-by-case basis, DOE might opt to conduct certain types of tests as uncontained, such as those using a very large explosives charge (larger than the containment vessel rating for the active phase); those requiring complex diagnostics (such as certain optics or laser tests) that cannot be achieved using a containment vessel; those requiring measurement of material movement beyond the confines of the vessel; or those using a very small explosives charge or small amounts of hazardous materials where use of the vessel would not be practical, cost-effective, or environmentally significant. For the purpose of this EIS analysis, DOE estimates that up to about 25 percent of all tests might need to be uncontained under either the Vessel Containment Option or the fully implemented Phased Containment Option. Under the Building Containment Option, all hydrodynamic tests and dynamic experiments would be contained. Dynamic experiments involving plutonium would always be conducted in a double-walled steel containment vessel under any approach.

Under the Vessel Containment Option or the fully implemented Phased Containment Option, DOE would expect to immediately use a sufficient number of vessels and their related infrastructure for containment of 75 percent of the experiments with materials made from beryllium, depleted uranium, or Resource Conservation and Recovery Act characteristic metals. For the contained experiments, at least 99 percent by mass of these materials would be retained as a result of using a single-walled containment vessel. Although DOE expects that any such vessel system would be designed to be highly effective, for the purpose of this EIS, DOE has made a conservative assumption that the single-walled containment vessel system might fail and allow a release of some material to the outside environment up to 5 percent of the time. Such a failure would be expected to release gaseous by-products of the detonation and possibly small fragments. Experiments using plutonium would always be done within double-walled vessels that have been demonstrated to fully contain these types of tests and would not lead to environmental release.

Use of either the portable steel containment vessels or the addition of a permanent containment building to the DARHT structure would require construction of a separate cleanout facility, in addition to the construction for the DARHT Baseline Alternative. Under either the Vessel Containment Option or the Phased Containment Option (preferred alternative), this would be a separate vessel cleanout facility for cleaning out the portable steel vessels and recycling materials as appropriate. Two alternative sites that are being considered for this facility are shown in figure 3-6 (Larson 1995). An existing firebreak road would be improved and paved to provide access to either site.

Under the Building Containment Option, a separate cleanout facility would be constructed near the containment building at the DARHT Facility to assist in periodic cleanout of the containment building and recycling materials as appropriate. Other than slight modifications to the DARHT Facility parking lot, no additional access road would be required for the cleanout facility. Compared to the DARHT Baseline Alternative, DOE would have to immediately acquire several additional portable single-walled containment vessel systems under the Vessel Containment Option. For the Phased Containment Option (preferred alternative), the first phase would include the fabrication of a prototype vessel system and local, portable recycling capability. The second phase would require construction of five additional vessels and a separate vessel cleanout facility.

Under this alternative, DOE would obtain greatly improved high-resolution capability, as compared to the present capability at PHERMEX and FXR, but would forego some degree of image resolution due to scattering and loss of x-ray penetration caused by the containment vessel or structure. Under the preferred alternative, DOE may perform a limited number of selected experiments unconfined (no vessel) when the best possible resolution would be a critical need.

3.7.1 Facility

This section describes the facility that would be constructed at the DARHT site to implement the Enhanced Containment Alternative. Under this alternative, if single-wall steel vessels were used, a separate vessel cleanout facility, about 12,000 ft^2 (1,115 m^2) would be built near the DARHT site to recycle the vessels and experimental material after each use. Double-wall vessels would be handled the same as under the No Action Alternative, and would not be treated at this facility. The vessel cleanout facility would include a vessel and debris cleanout area and handling equipment to minimize secondary waste generation and personnel exposure during cleanout operations. Any secondary waste would then be transferred to a LANL disposal area. Under this approach, several new containment vessels would be purchased or fabricated. If a permanent building for containment were added to the current DARHT plans, the separate vessel cleanout facility for shot debris would still be needed.

A containment structure would add about 13,000 ft^2 (1,200 m^2) to the DARHT building, but all of this additional area would be within the original DARHT Facility area. Portions of the earthen berm around the northern side of the site would have to be removed to build the containment structure and provide access to the building, but the berm would no longer be needed for its original purpose, which was to provide radiation shielding. Under the Building Containment Option, a cleanout facility for shot debris would still be needed.

3.7.1.1 Containment Vessels

LANL has experience in using containment vessels for explosives tests up to 44 lb (20 kg) of high explosives and is presently developing a new design of reusable, transportable vessels for use with higher explosive loadings which would have a full suite of diagnostic capabilities. A prototype containment vessel for a 110-lb (50-kg) high explosive load is in the design stage (see figure 3-7). This single-walled

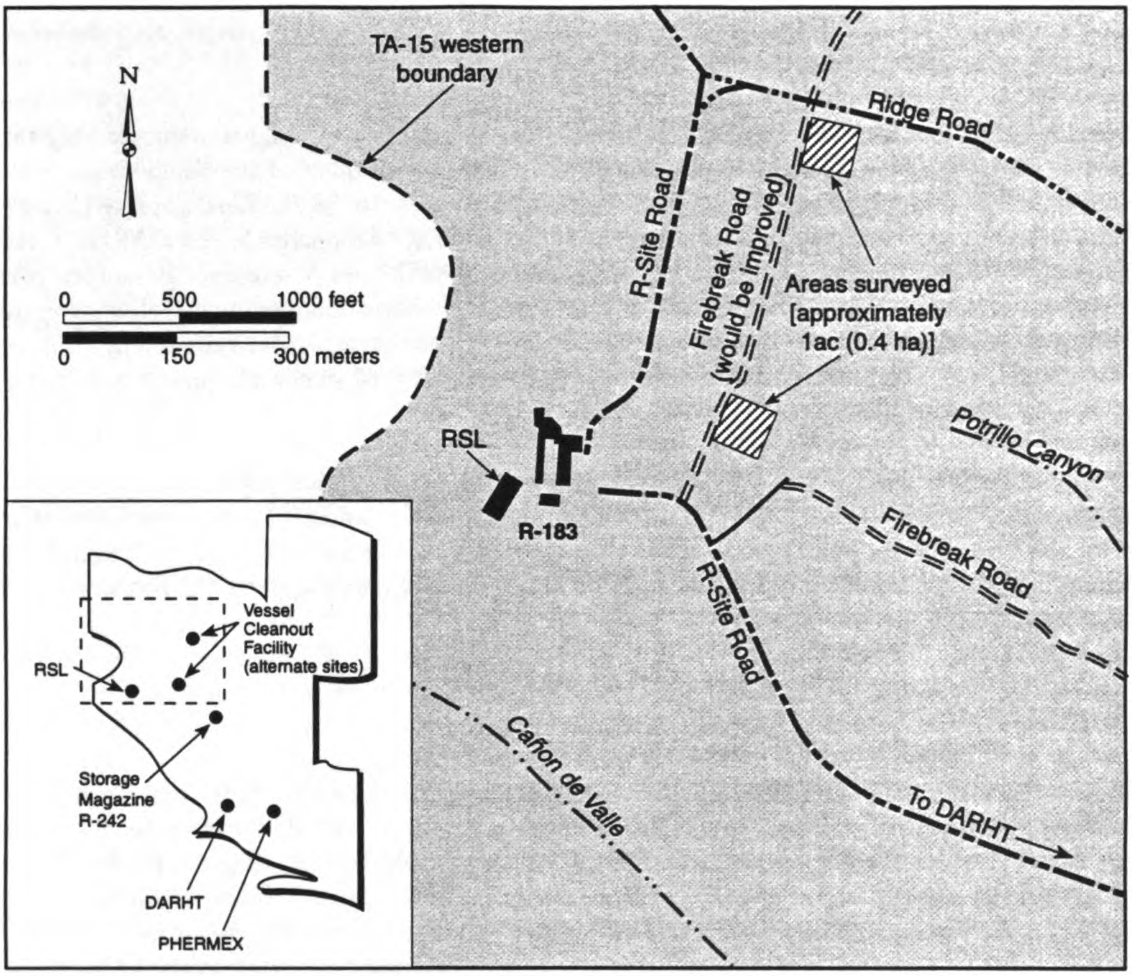


FIGURE 3-6.—*Potential Locations for the Proposed Vessel Cleanout Facility.*

vessel would be modular in design to allow users to modify the vessel geometry to accommodate different experiments and shot configurations. The vessel would consist of a 14-ft (4.3 m) diameter cylindrical shell with four ports for extension modules and a removable hemispherical top shell. The extension modules would be 6 ft (2 m) in diameter, 8 ft (2.5 m) long, and could be specifically configured to accommodate a particular experiment or diagnostic. Each extension module would have five ports: one on top for placing diagnostic equipment in the module and two ports on each side that can accommodate optical windows. The vessels would be fabricated from a state-of-the-art military steel so that field repairs and modifications would be possible. A support and alignment system would provide adjustments to align experiments for radiography or other diagnostics. This type of vessel would not be used for dynamic experiments with plutonium; these experiments would be conducted in double-walled vessels of a different design (see section 3.3.2).

DOE has considered proposing a Contained Explosives Test Complex, which would expand DOE's current capabilities for contained experiments. The Test Complex would provide for 15-ft (5-m) diameter vessels for firing capability up to 440 lb (200 kg) in addition to the 110-lb (50-kg) vessels described above and the support complex for containment vessels.

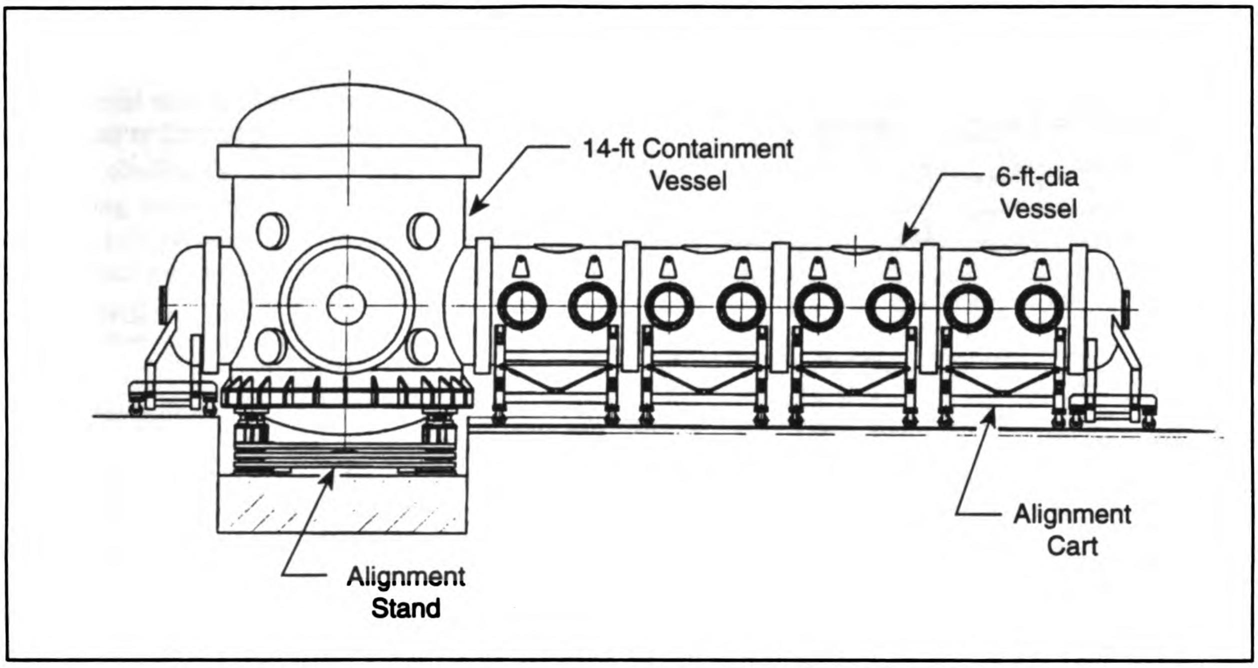


FIGURE 3-7.—*Conceptual Design of a 110-lb (50-kg) Containment Vessel.*

3.7.1.2 Containment Building

A containment building would be attached to the planned DARHT structure at its north end; it would enclose the firing point and extend to the northwest aligned with the axis of the southeast accelerator hall. This addition would extend to approximately the center line of the existing earthen berm. A concept for such a building, designed to contain a 185-lb (85-kg) test explosion at the DARHT firing point is shown in figure 3-8 (LANL 1995). A 625-lb (285-kg) test explosion could be accommodated in this building at the firing point shown about 40 ft (12 m) northwest of the dual-axis firing point, but only one accelerator could be used for imaging a test there. Preconceptual design is used to assist general layout and analyses of tradeoffs between chamber volume and resulting maximums for internal temperatures and pressures.

The walls, floor, and roof of the chamber that would contain a test explosion would be reinforced concrete 5 to 6 ft (1.5 to 1.8 m) thick. The roof would also have 6 ft (2 m) of gravel above the concrete to prestress the roof against explosive pressure. Replaceable fragment shielding would protect the inside surfaces of the chamber. In the design shown, the containment area within the building would be about 10,400 ft^2 (970 m^2), and its volume would be about 260,000 ft^3 (7,360 m^3) as fixed by the maximum charge of 625 lb (285 kg). If a maximum of only 185 lb (85 kg) of high explosives is to be fired, the building could be sized down by shortening its length in the northwest direction. The need to cool and vent the resultant hot atmosphere, up to 650°F (343°C), would require a large robust mechanical cleanup system. A support area within the containment building would also be necessary to provide decontamination for personnel and other services during cleanup and shot preparation. Construction of the containment building would add, at a minimum, about one year to the DARHT construction schedule (LANL 1995).

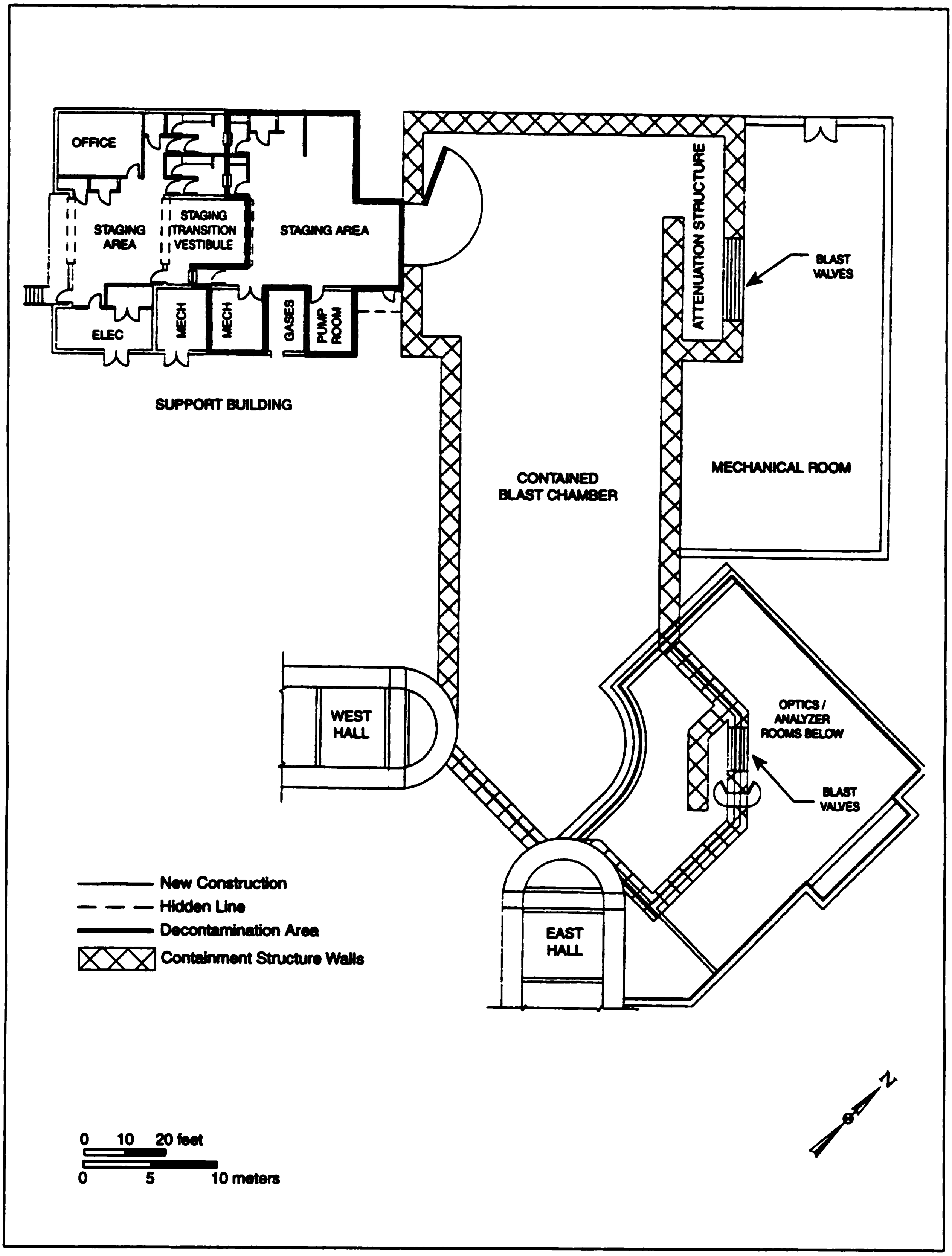


FIGURE 3-8.—*Conceptual Design of the Containment Building.*

3.7.1.3 Vessel Cleanout Facility

A conceptual sketch of the proposed vessel cleanout facility is shown in figure 3-9. The facility would be constructed at TA-15 if portable single-wall steel vessels were used for containment, or a similar facility would be constructed near the containment building if such a building were used. The approximate size of the building would be 12,000 ft^2 (1,115 m^2). The main components of this facility would be two large bays, a debris processing room, and an analytical laboratory. Under the preferred alternative, the vessel cleanout facility would be constructed under Phase 1 and put on-line during Phase 2 of the implementation of this option.

3.7.2 Operations

Under the Enhanced Containment Alternative, operations at the DARHT Facility would be the same as for the DARHT Baseline Alternative for the accelerators and their ancillary equipment. However, differences in operations would arise for setting up a test assembly and for post-shot operations to clean up the test shot products. Three operational options would be possible depending on whether the approach to containment would be to use portable steel vessels, a containment building, or a phased development and implementation of portable steel vessels. With steel vessels or a containment building, there would be an exclusion area as for uncontained shots, but it would be reduced appropriately.

3.7.2.1 Vessel Containment Option

To set up a shot, a new or refurbished single-wall steel vessel would be delivered to the firing area by a heavy-duty tractor-trailer unit. The facility set-up crew would transfer the vessel to the firing point using a crane. The crew would also attach tested extension modules (figure 3-7) to the vessel if needed to accommodate the test assembly for a particular test. The main vessel and its attached extension modules would then constitute the containment vessel. Removing the hemispherical top to the vessel would provide access so the test assembly could be placed or assembled in the vessel. The containment vessel would have an electrical pass-through and optical ports for the test assembly and diagnostics.

Following a shot, the containment vessel would pass through several steps to render it safe, remove internal debris, and prepare it for subsequent reuse. First, the vessel's post-shot atmosphere would be vented and pumped out through high-efficiency particulate (HEPA) filters. A crane would be used to place the vessel on a trailer, and the vessel would be transported away from the DARHT Facility to adjacent vessel cleanout and test refurbishment facilities. The vessel would remain on the trailer during the cleanout and preparation process by using a mechanism to rotate the vessel-trailer assembly 90 degrees to facilitate cleanout.

Operations at the vessel cleanout facility would include single-wall vessel cleanout, debris recovery/ decontamination, vessel decontamination, recovery of process fluids for reuse, and solidification of nonrecoverable materials from the process for disposal. Debris would be emptied from the vessel and separated by size. Large pieces of debris would be decontaminated in a cleaning tray using a polymeric extractant solution that binds and solubilizes radioactive and toxic metals. The cleaned debris would be stored for recycling. Fine debris not suitable for recovery would be transferred into a reaction tank where it would be agitated with the polymer extractant, and the resulting slurry would subsequently be filtered to

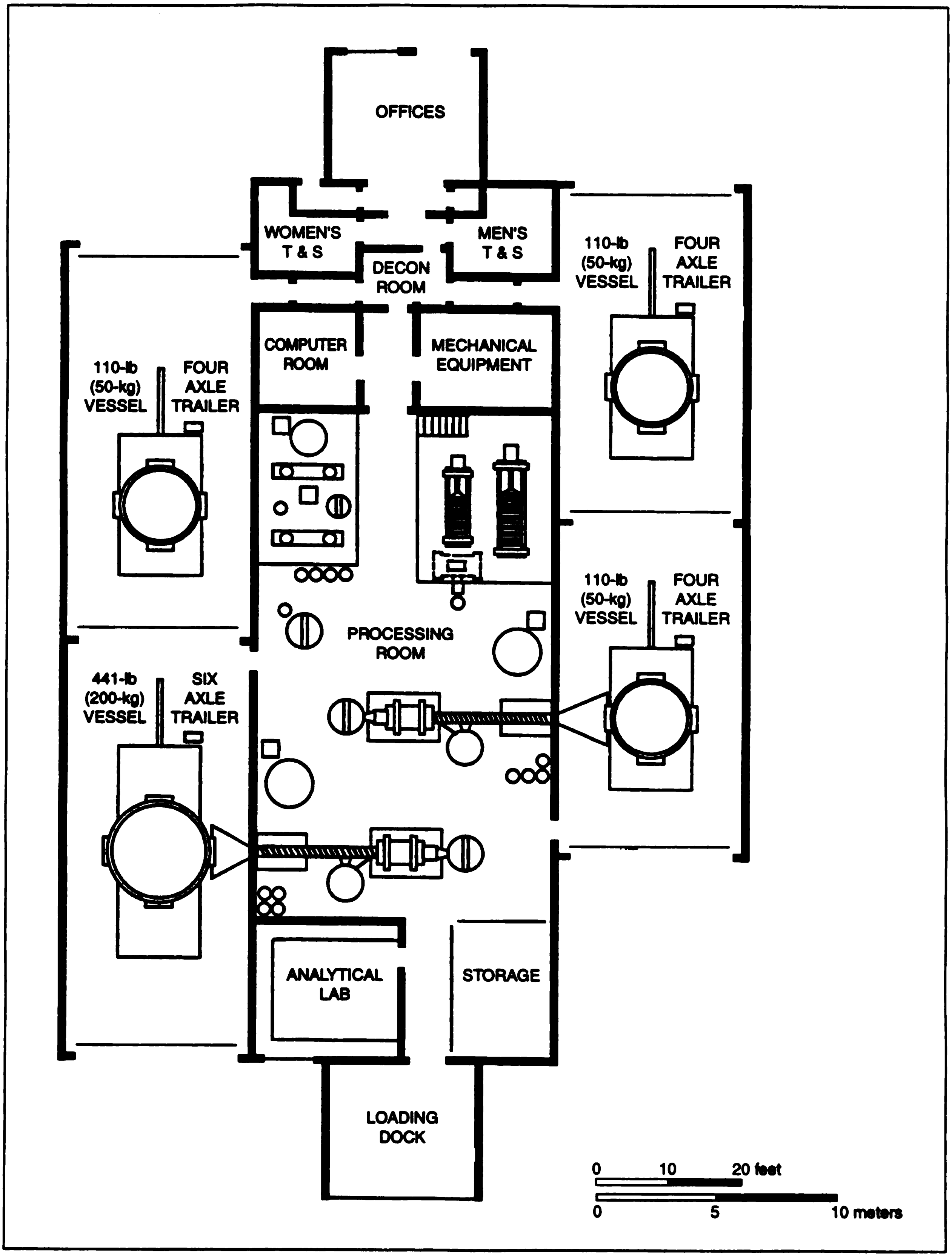


FIGURE 3-9.—*Conceptual Design of the Vessel Cleanout Facility.*

collect the solids. Following cleanout, the emptied vessel would be moved to secondary containment in the wet bay, sprayed for further decontamination using polymeric extractant, and finally rinsed. Metal-loaded polymer from the extraction and wash processes would be collected in a tank for extraction of the metal and regeneration of the polymer.

Cleaned vessels would be moved on their trailers to an existing building (R-285) for refurbishing. The refurbishing operations might include detection and repair of damaged areas, painting the interior, installation of shot supporting fixtures and diagnostics, and pressure tests.

3.7.2.2 Building Containment Option

The blast chamber in the containment building would be approximately 48 ft (15 m) wide by 160 ft (49 m) long (see figure 3-8); walls would be no closer than 17 ft (5.1 m) to the dual-axis firing point; and the chamber would have a 25-ft (8-m) floor-to-ceiling interval. However, access to the chamber, proximity of the inner surfaces, and the need for portable lighting affect the efficiency of experiment setup compared to uncontained testing.

Before a shot, the firing crew would verify that no personnel were in any portion of the containment building and that the mechanical systems affecting containment were functional. Following the detonation of a maximum charge, gases and aerosols would fill the blast chamber; the pressure and temperature would not exceed 20 psi (14,060 kg/m^2) and 650° F (343° C), respectively. This pressure would bleed off through blast valves into the treatment area where the gases would be mixed with sufficient ambient air to allow filtration through HEPA filters. The process of venting and purging gases would take about two hours. Following purging, an automated wash system using three ceiling-mounted, retractable water cannons would spray the walls and ceiling with water or other solutions. Wash-down water or solutions would be collected in floor drains connected to a collection tank, filtered, and stored for reprocessing. Following the wash down, a decontamination team wearing protective clothing would enter and clean the chamber to make it safe for minimally protected personnel to enter. Venting, purging, cleanup, and testing of the chamber are estimated to take approximately two days using four workers. In addition, replacement of damaged fragment shielding would be an ongoing activity.

The processes for recovering debris from the containment building would be similar to those described for the portable steel vessels. The vessel cleanout facility would be sited near the containment building. Debris resulting from detonations within the blast chamber would be segregated and reclaimed. Polymer extractant solutions would be used for decontaminating chamber surfaces.

3.7.2.3 Phased Containment Option (Preferred Alternative)

Under the preferred alternative, containment for tests and experiments at DARHT would be provided according to an incremental, phased plan. This approach has the advantage of allowing the lessons learned in each phase to be incorporated in the next phase and provides for a lower overall cost (capital plus operating costs) as well as a lower initial expenditure for design and capital cost.

The Phased Containment Option has been added to the containment options presented in the draft EIS to meet two objectives: 1) to improve the long-term average containment of materials used in the tests and experiments, and 2) to allow the DARHT Facility to meet programmatic goals as soon as possible while developing improved containment technology. To mitigate potential adverse environmental impacts, this option establishes materials release goals that would be met by using the containment vessels and augmented cleanup of debris from shots that necessarily must be uncontained. The environmental impacts would also decrease over time because vessels with larger capacity would be developed that would allow larger tests to be conducted with containment instead of as uncontained tests. Under this option, less material would be released to the environment compared to the DARHT Baseline Alternative.

Containment will be phased into DOE's long-term hydrodynamic testing program according to the following plan.

- **Phase 1 – Demonstration:** A prototype vessel system and portable cleanout unit would be used to contain 5 percent of the material over a 5-year period. During this period, a permanent vessel cleanout facility would be constructed and an additional vessel system specified and fabricated, incorporating experience gained during this phase.
- **Phase 2 – Containment:** A five-vessel containment system and a permanent vessel cleanout building would contain 40 percent of the material over the second 5-year period.
- **Phase 3 – Enhanced Containment:** Based on experience, vessels would be improved for use with 75 percent or more of the material over the next 20-year period.
- **Phase 4 – 440-lb (200-kg) Containment Option:** If justified by the development effort and operating experience, a 440-lb (200-kg) vessel may be developed to contain a greater percentage of material.

Figure 3-10 shows a step function plot that represents the phased implementation of the preferred alternative. The resulting average containment would reach the environmental release reduction goals proposed in the Enhanced Containment Alternative over a period of 10 years with a smaller impact on operations and lower initial capital expenditures.

Phase I would be a demonstration phase of this option because this type of vessel has not previously been used at DOE and, thus, the operation of the system is not well established. If technological problems were to be encountered using this vessel, then the percentage reduction of materials released to the environment, as described by the different phases of this option, would be obtained by the following methods: altering the number of experiments or tests, using nonhazardous materials where possible, or picking up materials near the firing point beyond those which are normally retrieved.

The DARHT Baseline Alternative (section 3.5) serves as the baseline for the phased containment discussion. The DARHT Baseline Alternative analysis shows that open-air hydrodynamic testing would result in releases that were less than one percent of the total regulatory limits for most release pathways and only a few percent of the limit for the remainder. The use of containment is not driven by a regulatory concern. Rather, the benefit of reducing the amounts of materials released is directly related to environmental stewardship and a desire to mitigate or eliminate required cleanup activities at the end of the facility lifetime. Therefore, the optimum environmental benefit is derived from concentrating resources on tracking and control of a few important constituent materials: depleted uranium, lithium hydride, beryllium, lead, and tritium.

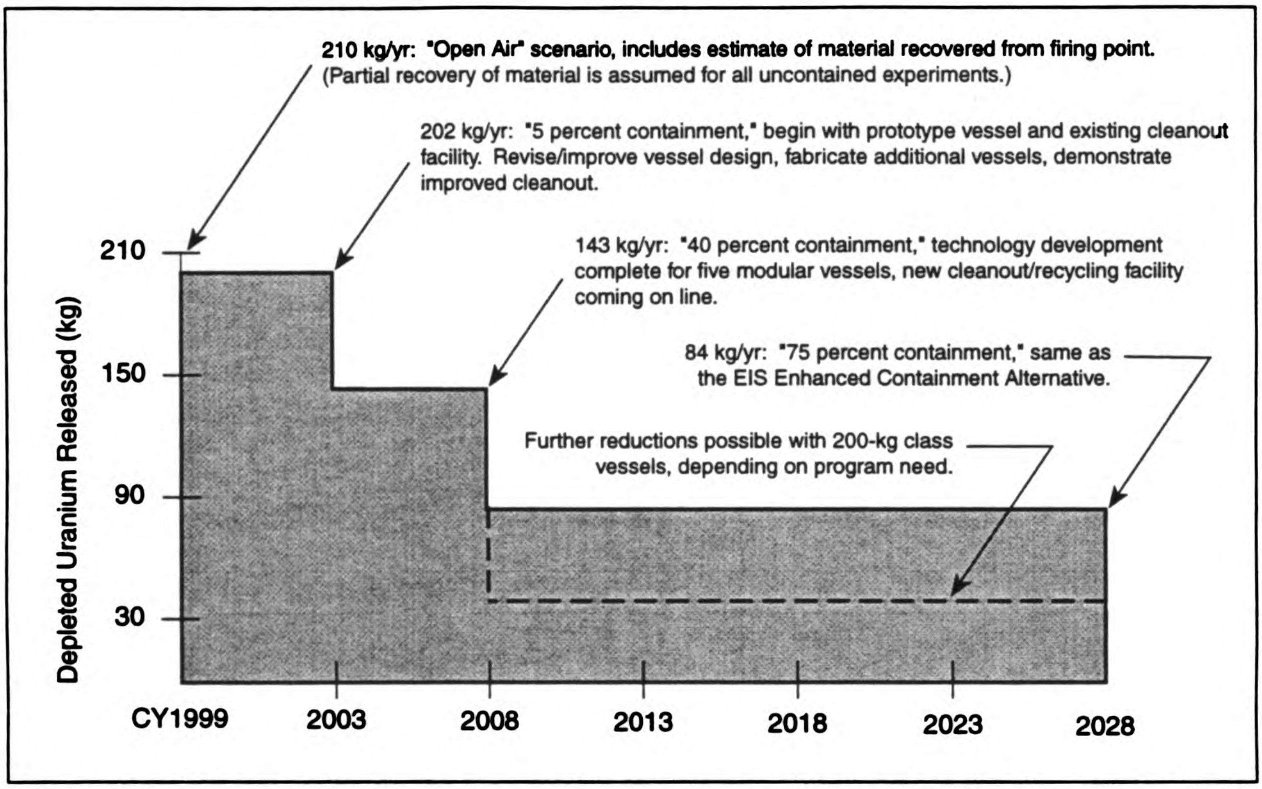


FIGURE 3-10.—*Schematic Representation of the Implementation Plan for the Phased Containment Option.*

In addition to containment, three other methods for limiting the annual releases of the experimental materials of concern would be used: material replacement, improved post-shot recovery techniques, and a programmatic strategy for experiment planning and scheduling. Soil remediation technology and surrogate material replacement techniques would be developed and the advantages of these techniques would be compared with containment methods. The most effective combination of these methods would then be installed at the firing site so that the reduced release goals for phased containment would be realized. Finally a programmatic planning strategy for experiments would provide assurance that the total releases over any 5-year period would not be above the goals set for the Phased Containment Option. The combined reduction from all these methods would be used to meet the relatively stringent requirements placed on the operation by the Phased Containment Option (preferred alternative). A brief outline of the steps in the preferred alternative is given in the following subsections.

3.7.2.3.1 Phase 1 – Demonstration (5 Years)

Concurrently with the commissioning of the DARHT Facility, a prototype containment vessel system would be fabricated and used to contain up to 5 percent of the experimental material at DARHT. A portable cleanout unit would also be developed, manufactured, and stored in the vicinity of the DARHT Facility. Cleanout would consist of the use of the same techniques for material separation and scavenging with polymer extractant as described in section 3.7.2.1. However, the processing would be performed using open-air manipulation of the vessel segments, coupled with the use of portable tanks and trucks for holding and transporting both the polymer solutions and the recycled material. Any resulting solid and liquid waste streams would be transferred to the appropriate LANL group. Post-shot recovery methodologies would also be enhanced and implemented as appropriate during this phase of operation. Construction would begin on a permanent vessel cleanout facility.

3.7.2.3.2 Phase 2 – Containment (5 Years)

Based on the experience gained during Phase 1, a permanent vessel cleanout facility would be put into operation. Five vessels and additional vessel segments would be fabricated as justified by operational experience. Up to 40 percent of the experimental material would be contained during this phase. Containment goals would be met or exceeded through the use of a combination of techniques: containment, material replacement, post-shot recovery, and program management.

3.7.2.3.3 Phase 3 – Enhanced Containment (Remainder of Facility Lifetime)

Experience gained during Phase 1 and Phase 2 would allow the final containment techniques to be developed that could result in containment of up to 75 percent of the experimental material. The DOE would meet the release reduction goals of this phase through the use of the combination of techniques discussed above. The desirability of using containment versus soil remediation would be reevaluated carefully at the time of the implementation of this phase. The decision to develop a vessel capable of containing a 440-lb (200-kg) charge would also be made at the time of the implementation of this phase.

3.8 PLUTONIUM EXCLUSION ALTERNATIVE

Under the Plutonium Exclusion Alternative (referred to in the Notice of Intent as the "Institutional Control Alternative"), DOE would complete and operate DARHT as described in the DARHT Baseline Alternative but would limit use of the facility to exclude any applications involving experiments with plutonium. There are two programmatic impacts associated with the Plutonium Exclusion Alternative: 1) DOE would not obtain the higher resolution information for dynamic experiments with plutonium; and 2) DOE would continue to maintain and operate PHERMEX in addition to DARHT. This alternative is analyzed to provide a basis of comparison between the environmental impacts expected to occur if the DARHT Facility were used to conduct contained dynamic experiments with plutonium (the DARHT Baseline Alternative) or not used for contained dynamic experiments with plutonium. DOE would conduct dynamic experiments with plutonium at PHERMEX or other facilities. This alternative would not be expected to affect future operations at the RSL at LANL, the FXR at LLNL, or other smaller explosive test facilities.

3.8.1 Facility

The facilities required under the Plutonium Exclusion Alternative are identical to those described for the DARHT Baseline Alternative at the DARHT site.

3.8.2 Operations

Operations at the DARHT Facility under the Plutonium Exclusion Alternative would be the same as those described for the DARHT Baseline Alternative except that DOE would not incorporate plutonium into any of the experiments at DARHT. The DARHT Baseline Alternative specifies containment for experiments that incorporate plutonium. Under the Plutonium Exclusion Alternative, containment vessels would be used for selected experiments involving hazardous materials. There would be no differences in facility operations for uncontained tests and no differences in the explosion products that might be deposited on the firing site or the surrounding area.

3.9 SINGLE AXIS ALTERNATIVE

Under the Single Axis Alternative, DOE would complete construction of the DARHT Facility with one accelerator hall and would operate only a single axis of DARHT with one accelerator. The second hall (second axis) would not be completed as an accelerator hall for DARHT but could be put to other uses such as office space. Under this alternative, DOE would obtain greatly improved high-resolution capability, as compared to the present capability at PHERMEX and FXR, but would forego the capability to obtain three-dimensional, rapid-time-sequenced data.

Under the Single Axis Alternative, operation of PHERMEX would be phased out. This alternative is not expected to affect future operations of the RSL at LANL, the FXR at LLNL, or other smaller explosive test facilities at LANL and LLNL.

3.9.1 Facility

The facility for the Single Axis Alternative would be identical to that for the DARHT Baseline Alternative at the DARHT site except that DOE would not install an accelerator and its ancillary equipment in the southwest accelerator hall. Figure 3-3 shows the layout of the DARHT Facility. The southeast accelerator hall would be completed as planned to provide the single-axis, x-ray radiographic capability. The DARHT firing site, associated support and diagnostic facilities, and the RSL would all be considered part of the single-axis facility.

Construction at the DARHT site would be nearly the same for the Single Axis Alternative as for the DARHT Baseline Alternative. The entire firing-site complex would be completed under this alternative, but only the basic structure of the southwest accelerator hall would be finished as planned. The interior finish would depend on how that space might best be used, and that determination would be made at a later date. Possible uses for the southwest wing include storage, office space, or laboratory space for research efforts.

3.9.2 Operations

Operations under the Single Axis Alternative would be similar to those under the DARHT Baseline Alternative, but they would be somewhat simplified by the need to coordinate only one x-ray machine with the test assembly detonation. Operation of the single x-ray machine would be the same as its operation as part of a dual x-ray system. Under the Single Axis Alternative, some tasks might be reduced in number or scope, but all of the activities described as part of the DARHT Baseline Alternative would remain. The high-explosive testing program would be modified to single-axis capabilities and would be similar to that for the No Action Alternative.

More emphasis would be placed on studying the late stages of hydrodynamic phenomena under the Single Axis Alternative, resulting in less use of blast-protected, electronic-position-indicating diagnostics compared to the No Action Alternative. However, more total shots would be required to synthesize three-dimensional and time-sequence data and to address reproducibility among shots. Therefore, the cost and yearly progress of the testing program would be similar to the No Action Alternative.

For this alternative, use of heavy equipment inside the accelerator hall, such as overhead cranes, would be about half of that needed for the DARHT Baseline Alternative. On the other hand, use of heavy equipment on the firing point would be the same as for the DARHT Baseline Alternative.

3.10 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

A NEPA review specifies the purpose and need for an agency to take action, describes the action that the agency proposes to meet that purpose and need, and identifies reasonable alternatives to meet part or all of the purpose and need. A potential alternative may be dismissed from a NEPA review as unreasonable if it would not meet part or all of the agency's purpose and need to take action, or for such reasons as taking too long to implement, being prohibitively expensive, or being too speculative in nature. An agency does not need to analyze an alternative that would not be responsive to the specified purpose and need.

The DOE considered, but did not analyze in detail, several alternatives in addition to those discussed above. None of the following would meet DOE's need for enhanced radiographic hydrodynamic test capability. These include:

- Alternative sites
- Alternative location at LANL
- Alternative facilities
- Consolidation
- Use of FXR
- Alternative types of tests
- Relinquishing reliability of the nuclear stockpile
- Weapons design
- No hydrodynamic testing
- Other programmatic alternatives
- Other mission alternatives

3.10.1 Alternative Sites

As an alternative to constructing and operating the DARHT Facility at LANL, construct and operate the facility at an alternative site.

DOE considered, but dismissed as unreasonable, the alternative of locating, constructing, and operating the DARHT Facility at a site other than LANL. DOE's need for hydrodynamic test facilities for weapons work is limited to those needed to support testing programs for LANL and LLNL. DOE has no need to construct hydrodynamic test facilities at non-DOE sites.

As discussed in section 3.3.3, LANL already has infrastructure in place to support its dynamic experiments and hydrodynamic testing program. This infrastructure supports operations at the PHERMEX Facility and other smaller LANL firing sites. The same infrastructure would be needed to support hydrodynamic testing and dynamic experiments at the DARHT Facility. Although other DOE sites have some of this infrastructure in place, no other DOE site currently has all the infrastructure in place to support all aspects of hydrodynamic tests and dynamic experiments being done at PHERMEX or proposed to be done at DARHT. DOE considers that this would represent an unreasonably expensive option to replicate some or all the infrastructure at another DOE site to support a facility with the same capability as the proposed DARHT Facility. It would not be cost-effective for DOE to replicate support facilities solely to support hydrodynamic testing or dynamic experiments.

In the future, DOE may choose to change facilities or operations at LANL or other DOE sites for other reasons. However, any such changes would be the result of separate DOE proposals in response to a different Departmental need and would be subject to appropriate reviews, including a NEPA review.

DOE considered two alternative means of conducting LANL's hydrodynamic testing at a site other than LANL:

- **Single Site:** Locate and construct the proposed radiographic hydrodynamic test facility at another site, make use of existing infrastructure at that site, and construct the remaining infrastructure at that site
- **Multi-Site:** Locate and construct the proposed radiographic hydrodynamic test facility at another site and make use of existing infrastructure at that site, supplemented by existing infrastructure at LANL or other sites

Neither alternative was considered to be reasonable for reasons described in the following sections.

3.10.1.1 Single Site

Replicating all the infrastructure needed to support a hydrodynamic test program or dynamic experiments at a single site other than LANL would be unreasonably expensive. Although theoretically all of the support facilities could be constructed and operated at another site, depending on the infrastructure already in place at the site, this could increase the cost of the DARHT Facility several times.

Depending on the location of the alternative site, DOE could incur extensive travel costs because LANL personnel would have to oversee the LANL testing program at another site, which would involve travel of several people at least once a week. If the other site had a hydrodynamic test or dynamic experiment program of its own (as does LLNL), the number of shots that could be scheduled to support both programs could be limited; this could be detrimental to both. In the event that the radiographic hydrodynamic test or dynamic experiment capability were to be located elsewhere, DOE would have to continue to operate and maintain PHERMEX to support smaller tests or dynamic experiments at LANL that would not be cost-effective to transport to the other site. DOE would therefore have to invest substantial capital to repair the facility to keep it viable over the long term, in addition to constructing and maintaining the enhanced radiographic test facility. This would not meet the need to replace PHERMEX.

Besides LANL, LLNL, the Nevada Test Site (NTS), and Pantex have some hydrodynamic testing infrastructure in place. However, they are considered to be unreasonable alternatives to LANL for siting a testing facility to support the proposed action because they would require expensive additional specialized infrastructure to support the hydrodynamic tests and dynamic experiments under the Proposed Action. In addition, as discussed above, DOE would need to continue to operate and maintain PHERMEX, which does not meet the need to replace the existing PHERMEX radiographic capability.

- **LLNL:** LLNL is the only DOE site, besides LANL, which has the capability currently in place to support hydrodynamic tests. However, LLNL is considered unreasonable to support a LANL hydrodynamic testing facility for two reasons. First, the type, size, and number of shots that LANL would require in addition to the number of shots that LLNL already conducts could unduly burden the support infrastructure that currently exists at LLNL, unless personnel and equipment were replicated. This would be considerably more costly than the proposed DARHT Facility. Second, without a major additional investment, LLNL could not provide the material recovery/recycle capability and waste treatment, storage, and disposal to support LANL's program in addition to its own. In addition, DOE does not conduct dynamic experiments with plutonium at LLNL. It would be unreasonably expensive to replicate the required infrastructure needs at LLNL for the sole purpose of supporting a facility as small as the proposed DARHT Facility.
- **NTS:** NTS has supported a testing program with experiments similar to hydrodynamic tests. However, NTS is considered unreasonable to support a radiographic hydrodynamic testing facility in the near term because NTS does not now have the required material recovery/recycle capability. It would be unreasonably expensive to replicate the required infrastructure needs at NTS for the sole purpose of supporting a facility as small as the proposed DARHT Facility.
- **Pantex:** Pantex has supported high explosives testing. However, Pantex is considered unreasonable to support a radiographic hydrodynamic testing facility in the near term because Pantex does not currently have any of the required infrastructure other than instrumented firing sites. In addition, currently the site could not support dynamic experiments with plutonium. It would be unreasonably expensive to replicate the required infrastructure needs at Pantex for the sole purpose of supporting a facility as small as the proposed DARHT Facility.

3.10.1.2 Multi-Site

Making use of multiple sites presents logistical problems that would be unreasonably inefficient and expensive to overcome. DOE believes that the quality of the hydrodynamic testing program would be degraded by splitting among multiple sites the testing functions for the improved capability needed. Collocated personnel achieve a certain synergism and efficiency in their interactions; this would be lost if personnel involved in different stages of a test event were located at different sites. Depending on the split, the ability to fix in-process mistakes or to iterate a design feature could be slowed to the point that test schedules could not reliably be met. Splitting the mission responsibility among sites would dilute the focus achieved by consolidating at a single institution, and would also blur lines of funding and responsibility. DOE would incur significant costs for transporting equipment, materials, and personnel among multiple sites and LANL. As described for a single site, travel costs would increase, the number of shots could be limited, and LANL would have to continue to operate and maintain PHERMEX, which does not meet the need to replace the existing PHERMEX radiographic capability.

DOE has considered whether each of the different steps of the hydrodynamic testing process could take place at a location other than LANL. Although some aspects could take place at various DOE sites, transportation, firing-site support, and materials management (materials reprocessing and recycling, and waste treatment and disposal) are limiting factors. Sites with some infrastructure in place include LLNL, at Livermore, California; NTS, near Las Vegas, Nevada; and the Pantex Plant, near Amarillo, Texas.

- **Transportation of test assemblies:** Shipping assembled hydrodynamic test assemblies is difficult. An assembled pin shot cannot be transported for more than a short distance because the diagnostic sensors must be very precisely located and are very susceptible to dislocation when moved. If transported, they must be moved only under controlled conditions (secure transport, very stable shipping container, very slow speeds). If public roads were used, either the road would have to be closed to the public (as is now the case at LANL), or safe, secure, transport vehicles would have to be used.

- **Firing site:** High explosive testing areas require a large buffer zone for safety reasons and perimeter-limited access for security and safety reasons. Several DOE sites are large enough to provide adequate secure buffer zones for a hydrodynamic test or dynamic experiment firing site. However, to operate a radiographic hydrodynamic test or dynamic experiment facility would require that several collocated support functions be available at the firing site. This would be a limiting factor for an alternative site because it would be difficult and expensive to replicate all the support facilities that would have to be located in the vicinity of the firing site. The site would have to have appropriate permits and licenses to allow for high explosives work. Other than LANL, LLNL is the only DOE site with in-place, firing-site support capability sufficient to support radiographic hydrodynamic tests or dynamic experiments. LLNL facilities are sized and scheduled to handle their own testing program, and the additional shots sufficient to support LANL's testing program could unreasonably burden the existing LLNL facilities. The NTS has firing sites and is currently qualifying a firing site to conduct radiographic hydrodynamic tests, which would use large charges of high explosives. Pantex has instrumented firing sites used to test high explosives, but these firing sites are not currently configured to support the required radiographic hydrodynamic testing and dynamic experiments, and to do so, besides being very expensive, would conflict with the current use of these sites.

- **Materials Management:** Materials management includes materials reprocessing and recycling, waste treatment, and disposal. Waste processing and disposal are limiting factors. Cleanup and recycling operations for hydrodynamic tests and dynamic experiments require specialized handling techniques. An alternative site would have to have the means to treat and dispose of debris and other waste hardware after a test is complete, and to collect, process, and recycle reusable materials. This would include the ability to clean out and, if necessary, dispose of large containment vessels. LANL is the only site with the requisite facilities in place. Although LLNL has waste processing, disposal, and recycling facilities in place that are sufficient to handle their own hydrodynamic testing program, it does not have facilities in place to handle containment vessels or sufficient capability to handle LANL's waste stream in addition to its own. NTS has a waste disposal capacity that is used by other DOE sites, but does not have in place the specialized facilities required to support the Proposed Action.

3.10.2 Alternative Location at LANL

As an alternative to constructing DARHT at the proposed sites, construct DARHT at an alternative site at LANL.

In the 1980s, DOE considered different locations at LANL for the DARHT Facility, and determined that the proposed site was preferable. The proposed site is within the explosives testing area and makes use of existing infrastructure such as access roads and utilities. Replicating the proposed facility at another location at LANL would result in duplicating infrastructure and related construction that has already occurred, with no programmatic gain or increase in onsite safety.

3.10.3 Alternative Types of Facilities

As an alternative to constructing a hydrodynamic testing facility, use an alternative type of facility to conduct diagnostic experiments.

The DARHT Facility responds to DOE's need for enhanced capability for hydrodynamic testing and dynamic experiments. No other type of facility provides hydrodynamic testing capability other than a hydrodynamic testing facility. An alternative type of hydrodynamic testing facility that could produce the needed capability in the near-term would be essentially a replication of the DARHT Facility. DOE and LANL have spent more than 10 years optimizing the design of DARHT; DOE does not consider it reasonable to spend additional time and expense to develop additional design studies for alternative facilities that would not meet the specified need nor add programmatic value.

DOE proposes to install a linear induction accelerator as the basis for the radiography equipment at the DARHT Facility. Other types of accelerators are available, such as radio-frequency, pulsed-power, or inductive-voltage-adder accelerators, and theoretically they could be used to power a radiography machine. However, these have not yet been demonstrated to provide the necessary radiographic performance to meet DOE's stated proposal and need. DOE may choose to incorporate modified or improved technology over the life of the project as it becomes available, particularly to provide cost, performance, and schedule benefits. The equipment proposed to be installed in DARHT, if the facility is completed and operated, was designed to improve on the technology and equipment used at FXR (which is also a linear induction accelerator). The technology proposed for the DARHT Facility has been reviewed by two independent technical panels, DARHT Feasibility Assessment Independent Consultants (DFAIC) and Independent Consultants Reviewing Integrated Test Stands (ITS); both have concurred with the technology proposed (DFAIC 1992; DOE 1993a). DOE does not consider it reasonable to revisit the technical evaluation of the currently available technology for the enhanced capability proposed, or to await possible development of future technologies that are now considered either speculative or inferior to the proposed technology for the intended use.

DOE has conceptualized a multi-axis, multi-time Advanced Hydrotest Facility (AHF) for the next generation of advanced hydrotesting capability. If proposed, this facility could provide up to eight radiographic views of the primary's implosion. In the longer term, this facility may help assure weapons reliability and safety without nuclear testing. The AHF would be based on new and emerging technology. This conceptualized facility has not yet reached the stage of a firm Departmental proposal. Both facility requirements and candidate or potential technologies require development and validation. The DARHT Facility would provide information useful for the design of the AHF, and experience gained from its operation would be important in optimizing the operations of this advanced facility (JASON 1994). AHF is not considered to be a reasonable alternative to the DARHT Facility for the following reasons: it is still only a concept, the technology to support AHF is not yet developed or proven, and the conceptual design and development of the technology for AHF would take several years to complete, as would the process of siting studies, construction design, and appropriate NEPA review. The conceptual AHF is one of the facilities under consideration in the *Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (PEIS).

3.10.4 Consolidation

As an alternative to operating more than one hydrodynamic test facility, consolidate hydrodynamic testing capability at one site.

The DOE has historically maintained hydrodynamic testing capability at both LANL and LLNL; it would not be advantageous to fulfilling the mission of the DOE to maintain hydrodynamic testing facilities at only one site. DOE has proposed DARHT to be a shared user facility but has not proposed shutting down hydrodynamic testing capability at either LLNL or LANL. Consolidating LANL's testing program with LLNL's at LLNL is discussed section 3.10.1.3., and is dismissed as unreasonable. DOE has not identified any need to consolidate LLNL's testing program with LANL's at LANL. Consolidation at one site is therefore not considered as a reasonable alternative to the DARHT Baseline Alternative.

3.10.5 FXR

As an alternative to operating DARHT, modify and upgrade the FXR facility at LLNL to provide the capabilities proposed for DARHT.

DOE is in the process of upgrading the FXR Facility under a separate proposal. Under this type of alternative, in addition to the already proposed upgrades, FXR would be remodeled and enlarged to construct a second accelerator hall to accept the new technology developed for DARHT, and PHERMEX would continue to operate at LANL. This is considered unreasonable as an alternative for the Proposed Action because DOE does not conduct dynamic experiments with plutonium at LLNL and it would require several hundred million dollars to duplicate the required plutonium handling capability. In the future, should DOE propose to provide three-dimensional capability at LLNL, a separate NEPA review would be prepared at that time if required.

3.10.6 Alternative Types of Tests

As an alternative to operating DARHT, use an alternative type of test to conduct diagnostic experiments.

Although hydrodynamic testing is used in conjunction with other types of testing capability, such as computer modeling or nuclear testing, no other type of experimental facility will produce the diagnostic results of a hydrodynamic testing facility. The President, Congress, and the Secretaries of Energy and Defense have determined that the Nation needs to maintain and improve its hydrodynamic test capabilities that reside with DOE. The purpose of the Proposed Action is to provide improved hydrodynamic test capability. Other types of tests would not meet the Agency and National need for the type of information that can only be obtained from hydrodynamic tests. DOE will continue to use other diagnostic tools, such as computer modeling, in conjunction with hydrodynamic testing, as has been done for more than 30 years.

3.10.7 Relinquishing Reliability of the Nuclear Stockpile

As an alternative to operating DARHT, relinquishing the goal of maintaining the reliability of nuclear weapons would mean that hydrodynamic testing (hence the DARHT Facility) would not be needed.

The alternative of not maintaining the integrity of the nuclear weapons stockpile does not meet the direction from the President and Congress to maintain a safe, secure, and reliable nuclear deterrent as a cornerstone of National defense. Thus, this alternative is not considered to be reasonable.

3.10.8 Weapons Design

As an alternative to operating DARHT to ensure weapons safety and reliability, operate DARHT to design prototype weapons, and study impacts on the Nation's nonproliferation objectives and the impact of fabricating prototype weapons.

As discussed in section 3.5, in the 1980s, DOE proposed to operate DARHT to provide enhanced hydrodynamic testing capability in support of the Nation's nuclear weapons design program, as well as in support of ensuring safety and reliability of stockpiled nuclear weapons. As stated in section 2.3.4, in the event that this Nation decides as a matter of policy that new nuclear weapons should again be developed, we would use all appropriate means at our disposal to accomplish this. Hydrodynamic testing, along with many other tools, could be used to assist in weapons development. However, in 1991, the President stated that the United States would not design new nuclear weapons in the foreseeable future; any decision to reverse this policy would come from the President and Congress. Accordingly, DOE does not at this time need to propose, design, or construct new facilities to assist with new weapons design. In any event, the environmental impacts of hydrodynamic tests at the DARHT Facility, the existing hydrodynamic testing facilities, or other alternatives analyzed in this EIS would vary by the number of test shots, size of explosive charge, materials used, and the design of the facility, not the intended application of test results.

3.10.9 No Hydrodynamic Testing Alternative

As an alternative to operating DARHT, do not construct or operate any hydrodynamic testing facility, and do not conduct hydrodynamic tests.

As discussed in chapter 2, the President and Congress have directed DOE to ensure the safety, performance, and reliability of the weapons stockpile, and to maintain and enhance its hydrodynamic testing capability in order to perform this task. A proposal not to conduct hydrodynamic testing would not meet this purpose.

3.10.10 Other Programmatic Alternatives

As an alternative to operating DARHT, use alternative means to conduct the Nation's stockpile stewardship program.

As discussed in chapter 2, the PEIS will analyze alternative means to conduct the Nation's stockpile stewardship program. The relationship of the DARHT EIS to that PEIS is discussed in that chapter. The President and Congress have determined that, as one aspect of conducting stockpile stewardship, the Nation needs to maintain and improve its hydrodynamic test capabilities that reside with DOE. The DARHT Facility responds to that purpose and need.

3.10.11 Other Mission Alternatives

As an alternative to operating DARHT as part of the DOE weapons program, consider an alternative nonweapons mission for DOE or LANL.

The nuclear weapons mission of DOE is established by law. Alternative missions for LANL do not respond to the purpose and need specified in this EIS. Accordingly, nonweapons missions are not considered to be reasonable alternatives to the DARHT Baseline Alternative.

DOE anticipates that the *LANL Sitewide EIS* discussed in chapter 2 will examine the cumulative impacts of facility operations in support of the mission assignments at LANL and that the PEIS discussed in chapter 2 will examine the impacts of alternative ways to perform the Stockpile Stewardship and Management Program. If, in the future, DOE would eliminate weapons research at LANL, including hydrodynamic testing, the Department would examine the need for additional NEPA review. This review would be used to determine the disposition of existing weapons research facilities at LANL, including any hydrodynamic test facilities existing at that time. DOE currently has no plans to withdraw weapons research work from LANL.

3.11 COMPARISON OF ALTERNATIVES

The following tables comparatively summarize the alternatives analyzed in this EIS in terms of their expected environmental impacts and other possible decision factors. Table 3-3 compares the environmental impacts of the alternatives as discussed in detail in chapter 5; for the most part, environmental impacts would be expected to be similar among the alternatives analyzed.

Table 3-4 summarizes facility construction and operations factors. The entries in this table are self-explanatory for the most part. However, the material releases information needs explanation. These entries represent estimated annual material releases to the environment immediately after high-explosive tests conducted at PHERMEX or the DARHT Facility. Subsequent cleanups are not considered in the estimated amounts. As discussed in section 3.7, under the Enhanced Containment Alternative, for the Vessel Containment and the Phased Containment options, this EIS conservatively assumes that the vessels would be used for most, but not all, tests, and that the single-wall containment vessels may have a leak rate of 1 percent and a maximum failure rate of 5 percent. The gaseous products from the detonation of high explosives (90 percent) would not be contained, and the remaining products would consist of carbon soot. In general, the impacts from accidents with single-walled containment vessels are higher than for uncontained tests, because the releases are more concentrated and are closer to the ground. For all alternatives, any future dynamic experiments using plutonium would be conducted within double-walled vessels that have been demonstrated to fully contain the tests and yield no measurable releases. Table 3-5 compares the hydrodynamic testing capabilities that would be expected under the alternatives analyzed.

COMPARISON OF PREFERRED ALTERNATIVE, DRAFT AND FINAL EIS

Since the publication of the draft DARHT EIS, DOE has changed its preferred alternative to the Phased Containment Option of the Enhanced Containment Alternative. The preferred alternative identified in the draft EIS is now called the DARHT Baseline Alternative. Environmental impacts associated with the final EIS preferred alternative as compared to the draft EIS preferred alternative are shown below:

- The concentration of uranium in water, as a percent of the drinking water standard, would be lower by about a factor of 10
- Soil contamination would be lower by about 40 percent
- Regional employment, labor income, and goods and services would be increased by about 25 percent
- The amount of low-level waste generated would be reduced by more than 50 percent over the life of the project
- Population dose from routine operations would be lowered by over 40 percent, although doses would be low in either case and no latent cancer fatalities (LCFs) would be expected
- Air quality would degrade by about factor of four from operational releases of metals, but would still be less than 0.05 percent of applicable standards in all cases
- Estimated radiation doses to workers from routine operations would be low and no LCFs would be expected, although exposure to depleted uranium in the vessel cleanout facility would result in radiation doses about five times higher
- Potential radiation doses to the public and noninvolved workers due to hypothetical accidents would be low and no LCFs would be expected, although under these accident scenarios exposure to depleted uranium would result in radiation doses about 10 to 20 times higher due to the more concentrated nature of the dispersal plume ejecting from the containment vessel
- Irreversible commitment of concrete and diesel fuel during construction and natural gas and electricity during operations would be 10 to 20 percent higher

Other potential impacts, including impacts from routine operations and accidents involving plutonium, would be essentially the same between the two alternatives.

TABLE 3-3.—*Summary of the Potential Environmental Impacts of the Alternatives*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Land Resources								
Acreage committed								
PHERMEX (ac)	11	11	11	11	11	11	11	11
DARHT (including RSL) (ac)	8	8	8	9[a]	8	9[a]	8	8
Air Quality								
Construction								
Maximum percent of standard[b]								
NO_2	1.6	3.3	3.3	3.3	3.3	3.3	3.3	3.3
PM_{10}	5	11	11	11	11	11	11	11
SO_2	1	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Operations								
Maximum percent of standard[b]								
NO_2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
PM_{10}	2.2	2.2	2.2	2.2	0.2	2.2	2.2	2.2
SO_2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Be	0.00005	0.00005	0.00005	0.0002	0.0002	0.0002	0.00005	0.00005
Heavy Metal	0.005	0.005	0.005	0.02	0.02	0.02	0.005	0.005
Lead	0.001	0.001	0.001	0.007	0.007	0.007	0.001	0.001
Noise (qualitative)	Possible nuisance	Possible nuisance	Possible nuisance	75% reduction	Nuisance unlikely	Possible nuisance, phasing to 75% reduction	Possible nuisance	Possible nuisance
Water Resources								
Depleted uranium contamination, % drinking water standard (after millennia)	<1	<1	<1	<0.1	<0.1	<0.1	<1	<1

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.
[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.
[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).
[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.
[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.
[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE 3-3.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Soils								
Depleted uranium contamination area (ac)	15	15	15	15	15	15	15	15
Max. concentration (approx.) (ppm)	9,000	5,000	9,000	2,000	1,000	3,000	5,000	5,000
Biotic Resources								
Habitat reduction[c] (ac)	None	None	None	1	1	1	None	None
Threatened, endangered and sensitive species	None	When mitigated, none	None	When mitigated, none	None	When mitigated, none	When mitigated, none	When mitigated, none
Disturbance by noise	Some	Some	Some	75% reduction	Near zero	Some, phasing to 75% reduction	Some	Some
Cultural Resources (qualitative)	None	When mitigated, none	None	When mitigated, none	None	When mitigated, none	When mitigated, none	When mitigated, none
Socioeconomics								
(Annual impacts, 1996 to 2002)								
Employment (FTE)	—[d]	191	199	321	238	253	273	104
Regional labor income (millions)	—[d]	$ 4.1	$ 4.3	$ 6.8	$ 5.1	$ 5.4	$ 4.9	$ 2.2
Regional goods & services (millions)	—[d]	$ 6.8	$ 6.9	$ 12.0	$ 8.4	$ 9.0	$ 8.6	$ 3.8

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.
[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.
[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).
[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.
[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.
[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE 3-3.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative: Vessel	Building	Phased	Plutonium Exclusion Alternative	Single Axis Alternative
Human Health								
Depleted Uranium								
Public, 30-yr life of project								
MEI dose (rem)	7×10^{-4}	7×10^{-4}	7×10^{-4}	5×10^{-4}	5×10^{-4}	6×10^{-4}	7×10^{-4}	7×10^{-4}
Population dose (person-rem)	30	30	30	13	8	17	30	30
Latent cancer fatalities	None	None	None	None	None	None	None	None
Workers, 30-yr life of project								
Average dose (rem)	0.3	0.3	0.3	0.6	0.6	0.6	0.3	0.3
Collective dose (person-rem)	9	9	9	60	60	60	9	9
Latent cancer fatalities	None	None	None	None	None	None	None	None
Plutonium								
Public, 30-yr life of project	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}
MEI dose (rem)	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Population dose (person-rem)	None	None	None	None	None	None	None	None
Latent cancer fatalities								
Noninvolved Workers, 30-yr life								
of project	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}
Collective dose (person-rem)	None	None	None	None	None	None	None	None
Latent cancer fatalities	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Workers								

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.
[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.
[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 6 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).
[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.
[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.
[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE 3-3.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Facility Accidents								
Involved workers, worst case explosion related fatalities	15	15	15	15	15	15	15	15
Depleted Uranium								
Public								
MEI dose (rem)	6×10^{-4}	6×10^{-4}	6×10^{-4}	1×10^{-2}	1×10^{-3}	1×10^{-2}	6×10^{-4}	6×10^{-4}
Population dose (person-rem)	1.9	1.9	1.9	17	1.7	17	1.9	1.9
Latent cancer fatalities	None	None	None	None	None	None	None	None
Noninvolved worker dose (rem)	7×10^{-4}	7×10^{-4}	7×10^{-4}	5×10^{-2}	5×10^{-3}	5×10^{-2}	7×10^{-4}	7×10^{-4}
Plutonium								
Public (95th percentile meteorology)								
MEI dose (rem)	76	76	76	76	76	76	76	76
Population dose (person-rem)	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Latent cancer fatalities	12	12	12	12	12	12	12	12
Noninvolved worker dose (rem)	160	160	160	160	160	160	160	160
Transportation								
Workers, 30-yr life of project								
Dose (rem)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Public, 30-yr life of project								
Population dose, (person-rem)	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}
Latent cancer fatalities	None	None	None	None	None	None	None	None

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.

[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.

[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).

[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.

[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.

[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.

[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE 3-3.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Waste Generated, Annual								
Solid Sanitary Waste (ft^3) (non-hazardous, non-radioactive)	9,400	9,400	9,400	9,400	9,400	9,400	9,400	9,400
Hazardous (lb)								
Solid	310	310	310	310	310	310	310	310
Liquid	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Mixed Waste (55-gal drums)	1	1	1	1	1	1	1	1
Low-Level Waste (ft^3)	12,500	12,500	12,500	3,600	360	5,700[e, f]	12,500	12,500
TRU Waste (tons) (steel vessels)	2	2	2	2	2	2	2	2
Unavoidable Adverse Impacts	See soils	See soils	See soils	See soils	See soils	See soils	See soils	See soils
Irreversible and/or Irretrievable Commitment of Resources								
Construction								
Concrete (yd^3)	15,000	15,000	28,000	16,000	22,000	16,000	15,000	15,000
Diesel fuel (gal)	9,500	11,500	17,000	12,500	18,200	12,500	11,500	11,500
Electricity (MWh)	365	365	750	365	450	365	365	365
Operations								
Depleted uranium (lb/yr)	1,540	1,540	1,540	1,540	1,540	1,540	1,540	1,540
Natural gas (ft^3/yr)	8,700	10,400	13,000	13,300	14,800	12,600[e, g]	10,400	10,400
Electricity (MWh/yr)	550	2,250	2,500	2,600	2,900	2,500[e, g]	2,250	1,350
Long-term Productivity (qualitative)	None	None	None	None	None	None	None	None

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.

[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.

[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).

[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.

[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.

[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.

[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE 3-4.—*Summary Comparison of the Alternatives*

Factor	No Action[a] Alternative	DARHT Baseline Alternative	Upgrade PHERMEX[b] Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessels[c]	Building[d]	Phased[e]		
CONSTRUCTION								
Facility Footprint (ft^2)	36,000	36,000	45,600	49,300	72,500	49,300	36,000	36,000
Laydown Area (ac)	2.5	2.5	2.5	3.5	3.5	3.5	2.5	2.5
Added Roadway (ft)	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Construction Materials								
Concrete (yd^3)	15,000	15,000	28,000	16,000	22,000	16,000	15,000	15,000
Cement (lb)	9,800,000	9,800,000	18,100,000	10,300,000	14,300,000	10,300,000	9,800,000	9,800,000
Steel (tons)	640	950	1,500	1,000	1,300	1,000	950	900
Copper (tons)	15	85	100	90	100	90	60	60
Stainless Steel (tons)	15	100	105	105	110	105	100	60
Aluminum (tons)	2	15	15	15	15	15	15	8
Glycol (gal)	0	3,800	3,800	3,800	3,800	3,800	3,800	1,900
Non-PCB Mineral Oil (gal)	0	30,000	30,000	30,000	30,000	30,000	30,000	15,000
Excavation (yd^3)	25,000	25,000[f]	40,000	25,000	30,000	25,000	25,000	25,000
Backfill (yd^3)	25,000	25,000	40,000	25,000	28,000	25,000	25,000	25,000
Rebar (tons)	600	600	1,000	600	900	600	600	600
Fuel								
Diesel (gal)	9,500	11,500	17,000	12,500	18,500	12,500	11,500	11,500
Gasoline (gal)	9,500	11,500	17,000	12,500	18,500	12,500	11,500	11,500
Propane (lb)	9,500	11,500	17,000	12,500	18,500	12,500	11,500	11,500
Electricity (kWh)	365,000	365,000	750,000	365,000	450,000	365,000	365,000	365,000

[a] No construction at PHERMEX; however, construction at proposed DARHT site to complete building for nonhydrodynamictesting purposes.
[b] New construction at PHERMEX plus DARHT construction to complete building for nonhydrodynamictesting purposes.
[c] DARHT Facility plus vessel cleanout facility.
[d] DARHT Facility plus vessel cleanout facility and containment building.
[e] For operations, represents the annual average over the 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct pases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Excavation for DARHT is complete.
[g] Sulfur hexafluoride is used as an insulator at PHERMEX.
[h] When vessel is used for containment.
[i] For all alternatives, the annual materials used in this group are the same as the table entries for No Action.

TABLE 3-4.—*Summary Comparison of the Alternatives – Continued*

Factor	No Action[a] Alternative	DARHT Baseline Alternative	Upgrade PHERMEX[b] Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single-Axis Alternative
				Vessels[c]	Building[d]	Phased[e]		
CONSTRUCTION (continued)								
Work Force	365,000	365,000	750,000	365,000	450,000	365,000	365,000	365,000
Craft (hr)	100,000	118,000	248,000	148,000	278,000	148,000	118,000	118,000
Noncraft (hr)	25,000	28,000	58,000	36,000	52,000	36,000	28,000	28,000
Project Management (people)	max. 15/day	max. 15/day	max. 15/day	max. 15/day	max. 15/day	max. 15/day	max. 15/day	max. 15/day
Noise Levels Generated (dBA)	93	93	93	93	93	93	93	93
Waste Disposal Costs ($ thousands)	14.5	14.5	41.5	14.5	30.0	14.5	14.5	14.5
TOTAL CAPITAL COSTS ($ millions, construction and equipment)	49	145	167	176	181	187	145	97
OPERATIONS								
Materials Used (annual)								
Water (gal)	40,000	70,000	70,000	110,000	110,000	100,000	100,000	60,000
Helium (ft^3)	6,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Sulfur Hexafluoride (ft^3)[g]	3,100	0	0	0	0	0	0	0
Acetone (gal)	3	3	3	3	3	3	3	2
Ethanol (gal)	6	6	6	6	6	6	6	3
Polymer (lb)	0	0	0	50	50	40	0	0
Energy (annual)								
Natural Gas (ft^3)	8,700	10,400	13,000	13,300	14,700	12,600	10,400	10,400
Electricity (kWh)	550,000	2,250,000	2,500,000	2,600,000	2,900,000	2,520,000	2,250,000	1,350,000

[a] No construction at PHERMEX; however, construction at proposed DARHT site to complete building for nonhydrodynamictesting purposes.
[b] New construction at PHERMEX plus DARHT construction to complete building for nonhydrodynamictesting purposes.
[c] DARHT Facility plus vessel cleanout facility.
[d] DARHT Facility plus vessel cleanout facility and containment building.
[e] For operations, represents the annual average over the 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct pases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Excavation for DARHT is complete.
[g] Sulfur hexafluoride is used as an insulator at PHERMEX.
[h] When vessel is used for containment.
[i] For all alternatives, the annual materials used in this group are the same as the table entries for No Action.

TABLE 3-4.—*Summary Comparison of the Alternatives – Continued*

Factor	No Action[a] Alternative	DARHT Baseline Alternative	Upgrade PHERMEX[b] Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single-Axis Alternative
				Vessels[c]	Building[d]	Phased[e]		
OPERATIONS (continued)								
Work Force								
Radiation-Trained Workers	9	15	15	24	24	24	20	13
Support Staff	5	5	5	5	5	5	5	5
Noise Levels Generated (dBA), at nearest community by 150-lb explosion	65	65	65	65/not audible[h]	not audible	65/not audible[h]	65	65
Operating Costs per Year ($ millions)	4.2	6.5	6.5	10.4	10.4	9.8[e]	6.5	5.4
Material Releases[i]								
Depleted Uranium (lb)	1,540	1,540	1,540	450	90	720	1,540	1,540
Beryllium (lb)	20	20	20	6	2	9	20	20
Lead (lb)	30	30	30	9	2	14	30	30
Copper (lb)	220	220	220	65	13	100	220	220
Other Metals (lb)	440	440	440	130	25	210	440	440
High Explosive (lb)	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300
Tritium (Ci)	3	3	3	3	3	3	3	3
Lithium Hydride (lb)	220	220	220	65	13	100	220	220

[a] No construction at PHERMEX; however, construction at proposed DARHT site to complete building for nonhydrodynamictesting purposes.
[b] New construction at PHERMEX plus DARHT construction to complete building for nonhydrodynamictesting purposes.
[c] DARHT Facility plus vessel cleanout facility.
[d] DARHT Facility plus vessel cleanout facility and containment building.
[e] For operations, represents the annual average over the 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct pases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Excavation for DARHT is complete.
[g] Sulfur hexafluoride is used as an insulator at PHERMEX.
[h] When vessel is used for containment.
[i] For all alternatives, the annual materials used in this group are the same as the table entries for No Action.

TABLE 3-5.—*Comparison of Facility Attributes*

Attribute	No Action Alternative (Baseline)	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessels	Building	Phased		
Image Quality	Baseline for comparison, does not meet needs	Best resolution, penetration meets needs	Best resolution, penetration meets needs	Better resolution, penetration meets most needs	Better resolution, penetration meets most needs	Better resolution, penetration meets most needs	Best resolution, penetration meets needs	Best resolution, penetration meets needs
3-D Capability	Only with multiple shots that introduce inconsistency and increase costs	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Only with multiple shots that introduce inconsistency and increase costs
Time-sequence Capability	Only with multiple shots that introduce inconsistency and increase costs	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Better quality and available with single shot	Only with multiple shots that introduce inconsistency and increase costs
Testing Efficiency	Baseline for comparison	Best, fewer tests and lower cost to obtain same data	Best, fewer tests and lower cost to obtain same data	Worst, more time to cycle tests	Worst, more time to cycle tests	Near Best[a] Intermediate[b] Worst[c]	Best, fewer tests and lower cost to obtain same data	Best, fewer tests and lower cost to obtain same data
Firing Point Materials Released	Baseline for comparison	Reduced 15 percent	Reduced 15 percent	Reduced 75 percent	Reduced 95 percent	Reduced 50 percent	Reduced 15 percent	Reduced 15 percent
Time Frame for Operation	Currently available	Single Axis ready 38 months after ROD, dual Axis in 66 months	Dual Axis ready 71 months after ROD	Single Axis ready 38 months after ROD, dual axis in 66 months	Dual Axis ready 77 months after ROD	Single Axis ready 38 months after ROD, dual axis in 66 months	Single Axis ready 38 months after ROD, dual axis in 66 months	Single Axis ready 38 months after ROD
Miscellaneous	High-power R tubes may become unavailable		No testing at LANL for 51 months	New vessel cleanout center, costs may discourage small experiments, no overhead diagnostics	New vessel cleanout center, costs may discourage small experiments, no overhead diagnostics	New vessel cleanout center, costs may discourage small experiments, no overhead diagnostics	Maintaining DARHT and PHERMEX increases cost	One accelerator hall available for a secondary use

[a] Phase 1, the first five years of operation
[b] Phase 2, the second five years of operation
[c] Phase 3 the final 20 years of operation