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**Idaho
National
Engineering
Laboratory**

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Department
of Energy*

**Environmental Resource Document for the
Idaho National Engineering Laboratory**

Volume 1

**John S. Irving
Principal Investigator**

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Environmental Resource Document for the Idaho National Engineering Laboratory

Volume 1

**John S. Irving
Principal Investigator**

Published July 1993

**Idaho National Engineering Laboratory
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415**

**Prepared for the
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ABSTRACT

This document contains information related to the environmental characterization of the Idaho National Engineering Laboratory (INEL). The INEL is a major U.S. Department of Energy facility in southeastern Idaho dedicated to nuclear research, waste management, environmental restoration, and other activities related to the development of technology. Environmental information covered in this document includes land, air, water, and ecological resources; socioeconomic characteristics and land use; and cultural, aesthetic, and scenic resources.

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FOREWORD

Introduction

This environmental resource document (ERD) provides an overview of important hydrologic, geologic, atmospheric, ecological, socioeconomic, and cultural information about the Idaho National Engineering Laboratory (INEL). Even though this ERD does not discuss environmental impacts, it was designed to help INEL managers understand current conditions at the INEL and evaluate the impact that future actions will have on the environment.

This document is a combination of the *INEL Environmental Characterization Report* (1985) and the original draft of the *Environmental Resource Document* (1991). It may be used by INEL contractor and subcontractor personnel as a basis for the "Existing Environment" section of environmental impact statements or for the "Site Description" section of environmental assessments. However, individuals must make correct interpretations of the data when characterizing environmental resources. Simply copying sections from this document for use in other environmental documents is not the proper use of this ERD. Additional information for site-specific analysis will likely be needed for National Environmental Policy Act documents. Individuals who prepare documents are encouraged to gather complete and accurate information by seeking experts in each pertinent field.

To reference this ERD in another document, use the following:

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National Environmental Policy Act Documentation

On January 1, 1970, President Nixon signed the National Environmental Policy Act (NEPA) into law. In the ensuing years, NEPA has become the basic policy-setting Federal law relating to protection of the environment. It has provided the initiative for passage of other Federal and state environmental statutes (e.g., The Archaeological and Historic Preservation Act, The Fish and Wildlife Coordination Act). All potential projects involving any Federal agency must undergo a review in accordance with NEPA to identify and evaluate potential environmental impacts. To meet the requirements of NEPA and DOE Order 5440.1D, DOE NEPA Regulations (10 CFR 1021), DOE NEPA Guidelines, Secretary of Energy Notice 15-90, and appropriate DOE-ID orders, environmental documentation must be prepared or existing documents reviewed for the following:

- Facility modification
- General plant projects
- Proposed line item construction projects
- Major changes in continuing programs
- New programs or research and development projects.

Section 102(2)(C) of NEPA requires that an environmental impact statement shall be "included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment" (NEPA, PL 91-19, 42 USC 4321-4347). As defined in the Council on Environmental Quality regulations, "major Federal action" includes actions with effects that may be major and which are potentially subject to Federal control and responsibility. "Major" reinforces but does not have a meaning independent of "significantly" (40 CFR 1508.27). Actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by Federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals. A "major Federal action" can be adoption of policies that will alter or result in agency programs; adoption of formal plans that are the basis of future agency actions; adoption of programs that prescribe allocation of agency resources; or approval of specific projects such as construction or management activities.

Determination of "significant impact" of a proposed action requires examination of both the *context* and *intensity* of the impact. The significance of the impact of an INEL activity would usually be considered in the *context* of the local site effects. Both short- and long-term effects and cumulative impacts must be examined. *Intensity* refers to the severity of the impact, and the following criteria should be considered in evaluating the intensity of an impact:

1. Both beneficial and adverse aspects
2. The degree to which the proposed action affects public health or safety

3. Unique characteristics of the geographic area (historic or cultural resources, wetlands, endangered species, etc.)
4. The degree to which the effects on the quality of the human environment are likely to be highly controversial
5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks
6. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration
7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts
8. The degree to which the action may adversely affect designated or potential historic places or may cause loss or destruction of significant scientific, cultural, or historical resources
9. The degree to which the action may adversely affect an endangered or threatened species or its habitat
10. Whether the action is a violation of Federal, state, or local environmental protection laws or requirements.

Major Federal actions with significant impacts require an environmental impact statement, and those with potentially significant impacts require at least an environmental assessment. This ERD provides information to help INEL personnel comply with NEPA and other related Federal and state laws. For direction on the need for NEPA documentation, see the *Environmental Compliance Planning Manual*, Vols. I, II, and III, April 1991, DOE/ID-10166, Rev. 3.

Volume 1 of this ERD contains a general description of INEL resources. Volume 2, Appendices A through H, contains more specific information on each resource. In addition, an annotated bibliography of important references and guidance documents is included for most resource areas. Appendix G discusses the environmental databases compiled within EG&G Idaho, describes the Geographic Information System used at the INEL, and provides a list of coverages. Also, Appendix H discusses data deficiencies in several resource areas at the INEL.

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1. DESCRIPTION OF THE INEL

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ACRONYMS

A1W	Large Ship Reactor
ANL-W	Argonne National Laboratory-West
ARA	Auxiliary Reactor Area
B&W	Babcock & Wilcox Idaho, Inc.
BAPL	Bettis Atomic Power Laboratory
CFA	Central Facilities Area
DOE	U.S. Department of Energy
DOE-CH	U.S. Department Of Energy, Chicago Operations Office
DOE-ID	U.S. Department Of Energy, Idaho Operations Office
DOE-PNR	U.S. Department Of Energy, Pittsburgh Naval Reactors Office
ECF	Expended Core Facility
ICPP	Idaho Chemical Processing Plant
INEL	The Idaho National Engineering Laboratory
MK-Ferguson	Morrison-Knudsen-Ferguson Company
NERP	National Environmental Research Park
NRF	Naval Reactors Facility
PBF	Power Burst Facility
PTI	Protection Technology Idaho, Inc.
RWMC	Radioactive Waste Management Complex
S5G	Natural Circulation Reactor
SPERT	Special Power Excursion Reactor Tests
TAN	Test Area North
TRA	Test Reactor Area
TRU	Transuranic
WEC	Westinghouse Electric Corporation
WINCO	Westinghouse Idaho Nuclear Company

1. DESCRIPTION OF THE INEL

1.1 Introduction

The Idaho National Engineering Laboratory (INEL) is a U.S. Department of Energy (DOE) facility devoted to nuclear energy research and related activities. The INEL was established in 1949 as the National Reactor Testing Station. Since its inception, the INEL has been involved in defense and nondefense related activities. Testing at the INEL proved that nuclear power could be safely used for generating electricity and for other peaceful uses. More nuclear reactors and a wider variety of reactor types have been built at the INEL than at any other single location in the world. Currently, 14 of the 52 INEL reactors are operable. The remaining reactors were phased out as their missions were completed.

The INEL has also engaged in alternate energy process research and development, nuclear waste management, and chemical and geological sciences. Besides nuclear reactor and fuel cycle technology, current activities include industrial conservation, environmental research, and other nonnuclear energy development.

1.2 INEL Missions

1.2.1 Mission Statement

As a DOE multiprogram laboratory, the INEL conducts research, development, and engineering principally in support of the DOE's national mission. It also provides services, unique facilities, and an environment for use by additional government agencies, educational institutions, and industry. The INEL focuses its engineering and technological efforts on the following:

- Defense-related nuclear material production centered largely on receipt, storage development, and processing of spent fuels, and management of resulting wastes
- Development of defense-related reactor technology
- Irradiation operations and associated programs in materials testing, isotope production, and irradiation services
- Development of liquid metal reactor technology
- Training of Nuclear Navy personnel.

The INEL also provides waste management and waste technology development for the low-level and transuranic (TRU) waste programs; spent fuel transportation/equipment for the Office of Civilian Radioactive Waste Management, and support to the Nuclear Regulatory Commission, the Department of Defense, and other Federal agencies.

Description of the INEL ♦ 1-2

Implicit in the INEL's mission is the development and enhancement of those critical engineering and science capabilities necessary to support primary mission thrusts. Accomplishing this requires careful selection of projects, including those offering significant technological challenges in the research, development, testing, and evaluation of advanced electronic, computer, and mechanical systems.

The INEL accomplishes its mission through applying advanced engineering ideas to a broad range of research, development, demonstration, testing, and evaluation programs. Implementation of the mission is accomplished through DOE Idaho Operations Office (DOE-ID) management of the following:

- Contractor operations, both onsite and offsite
- Active participation with other national laboratories and academic institutions
- Contracts assistance programs with the private sector that promote the transfer of engineering and applied science in the enhancement of U.S. industrial competitiveness.

1.2.2 Mission Areas of Primary Interest

The INEL strives to accomplish its mission by means of a systems approach. Systems within the target technology are recognized and defined; following this, critical technological barriers or gaps are identified. Scientific and engineering tasks are performed by a combination of INEL, industrial, and academic partners in an integrated effort to design, develop, and ultimately validate (through testing) critical subsystems or components. INEL's mission statement emphasizes several areas called Thrust Areas. These include the following:

- Energy Efficiency and Renewable Energy
- Competitive Industrial Processing
- National Security and Defense
- Nuclear Technology
- Waste Management and Minimization
- Advanced Technology and Methods
- Environmental Engineering and Restoration.

1.3 Organization and Administration

The INEL is operated by seven contractors: EG&G Idaho, Inc., Westinghouse Idaho Nuclear Company (WINCO), Babcock & Wilcox Idaho, Inc. (B&W), Protection Technology Idaho, Inc. (PTI), Morrison-Knudsen-Ferguson Company (MK-Ferguson), Westinghouse Electric Corp. (WEC), and Argonne National Laboratory-West (ANL-W). These contractors conduct various programs at the INEL under the administration of three DOE operations offices: DOE-ID, Pittsburgh Naval Reactors Office (DOE-PNR), and Chicago Operations Office (DOE-CH).

DOE-ID is responsible for common INEL Site services, safety, and emergency planning and compliance with environmental regulations. DOE-ID provides some of these services directly and provides the rest through its prime contractor, EG&G Idaho, furnishes general support services for the INEL Site. EG&G Idaho manages the reactor-safety experimental program for the DOE and Nuclear Regulatory Commission by investigating reactor technology, waste management, and irradiation operations. EG&G Idaho also develops waste technology and carries out other energy and research programs.

WINCO operates the Idaho Chemical Processing Plant (ICPP) for fuel storage, fuel processing, and waste management. B&W manages and operates the Special Manufacturing Capability program; PTI provides physical security protection for all EG&G Idaho, WINCO, and B&W facilities. MK-Ferguson is the INEL construction contractor. The programs and activities of these contractors and the Site support functions are administered by DOE-ID.

WEC manages the Naval Reactors Facility under the administration of DOE-PNR. Activities include testing advanced design equipment, prototyping new systems for current naval nuclear propulsion plants, and obtaining data for future design. Additionally, there is a facility for training naval personnel on comprehensive nuclear plant operations.

ANL-W is operated for the DOE by the University of Chicago. Under the administration of DOE-CH, ANL-W operates four major facilities at the INEL that are fully dedicated to Liquid Metal Reactor and Breeder Reactor programs.

1.4 Location

The INEL is located in the southeastern portion of Idaho, southwest of Yellowstone National Park. Regionally, the INEL is nearest to the cities of Idaho Falls and Pocatello and to U.S. Interstate Highways I-15 and I-86 north. The INEL occupies 2,300 km² (890 mi²) on the northwestern edge of the Snake River Plain in southeastern Idaho (Figure 1-1).

The INEL lies in five southeast Idaho counties: Butte, Bingham, Bonneville, Jefferson, and Clark. Most of the INEL is located in Butte County. Mountain ranges bordering the INEL on the north and west are the Lost River Range, the Lemhi Range, and the Centennial Range. The topography of the INEL is flat to gently rolling with predominant relief manifested as volcanic buttes or unevenly surfaced basalt flows. Approximately 95% of the INEL has been withdrawn from the public domain. The remaining 5% includes public highways (U.S. 20 and 26; Idaho 22, 28, and 33) and the Experimental Breeder Reactor I, a historic landmark.

Major facilities at the INEL are widely separated and occupy approximately 0.5% of the total land area (Figure 1-1). Besides activities related to nuclear energy, the INEL has been designated as a National Environmental Research Park (NERP). As a NERP, the INEL provides an area for research on the environmental impacts of human activities on a largely undisturbed ecosystem. Much of the NERP research has dealt with migration and movement of radionuclides through the physical and biological environment.

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Figure 1-1. Location of major facilities at the Idaho National Engineering Laboratory in southeastern Idaho.

1.5 INEL Facilities

1.5.1 Overview

For operational efficiency, the INEL Site has been divided into nine distinct and geographically separate functional areas (Figure 1-1). Each area carries out a particular type of program (e.g., large systems, reactors, laboratories) or support (e.g., office, crafts, warehouses) activities. Major INEL facility areas are the following:

- Argonne National Laboratory-West
- Auxiliary Reactor Area
- Central Facilities Area
- Idaho Chemical Processing Plant
- Naval Reactors Facility
- Power Burst Facility
- Radioactive Waste Management Complex
- Test Reactor Area
- Test Area North.

Besides these major facilities, office buildings, a computer center, and two major laboratories are located in Idaho Falls. A significant portion of INEL-related technical, analytical, and administrative support capability occurs in Idaho Falls. Site-wide and facility "master plans" are illustrated in the Site Development Plan (EG&G Idaho 1990). This plan provides the following information on each major facility at the INEL:

- Mission
- Assumption used to develop planning analysis
- Goals
- Future needs
- Evaluation
- Master plan development
- Analysis of alternatives
- Changes in direction
- Detailed maps of facility.

1.5.2 Facility Operations

1.5.2.1 Argonne National Laboratory-West (ANL-W). ANL-W is located 32 km (20 mi) east of CFA. The site is the most advanced in the nation for the development of liquid-metal-cooled fast breeder reactors. The six major facilities at ANL-W play a major role in the nation's liquid metal breeder reactor program. These include the following:

- Experimental Breeder Reactor II
- Fuel Cycle Facility

Description of the INEL ♦ 1-6

- Fuel Manufacturing Facility
- Hot Fuel Examination Facility
- Zero Power Physics Reactor
- Transient Reactor Test Facility.

The Integral Fast Reactor program focuses the mission of ANL-W operations: to develop and prove the performance, safety, and economics of the Integral Fast Reactor concept.

Support facilities such as analytical chemistry and nondestructive analysis laboratories are also operated at the ANL-W site. Research activities are widely varied, and many different types of projects are available: electrochemical transport, radiochemistry, materials research (including new waste forms), reactor safety and analysis, operation problem-solving, criticality safety, shielding calculations, in-cell equipment design, waste characterization, robotics, fuel cycle process development, fuel performance analysis, actinide burning experiments, computer control support systems, and reactor physics. For more detailed information regarding the activities and mission at the ANL-W site, refer to the Argonne National Laboratory Institutional Plan (FY 1992–1997) (ANL 1992).

1.5.2.2 Auxiliary Reactor Area (ARA). The ARA is located 12.9 km (8 mi) east of CFA (see Figure 1-1). It consists of four parts: ARA-1, ARA-II, ARA-III, and the Reactive Storage and Treatment Area. The ARA, previously known as the Army Reactor Area, was established as a working area to develop a compact power reactor that can be moved with a small amount of time between shutdown and startup. In 1965, the Army Reactor Program was phased out. Since then, all reactors have been removed or dismantled. The support buildings are now vacant. Since 1966, work at ARA has included a variety of technical support services for INEL research and development programs that use the metallurgy laboratory, the instrument development laboratory, and the hot cell facility.

1.5.2.3 Central Facilities Area (CFA). CFA is located approximately 80.5 km (50 mi) from Idaho Falls and Pocatello (see Figure 1-1). Original facilities at CFA were built in the 1940s and 1950s. The facilities were initially used to house Naval Gunnery Range personnel and later, National Reactor Testing Station personnel. The facilities have been modified over the years to fit the changing needs of the INEL. They now provide four major types of functional space: craft, office, services, and laboratory.

The construction of a multicraft complex and two office buildings has allowed consolidation of personnel into these facilities. This has resulted in the elimination or conversion of 17 older buildings. Construction of the Security Headquarters Facility consolidated the security administrative and training functions. The mission of CFA is to provide efficient, centralized support services for programmatic and nonprogrammatic efforts of all INEL contractors and the DOE.

1.5.2.4 Idaho Chemical Processing Plant (ICPP). The ICPP is currently operated for the DOE by WINCO. The ICPP began operations in 1953 as the principal INEL facility for

receipt, interim storage, and reprocessing of nuclear materials such as irradiated nuclear fuel from test, defense, and research reactors in the United States and other countries. The ICPP also has management of the attendant wastes generated from these operations.

With the changes in world events in recent years, the demand for reprocessing spent nuclear fuels to recover fissile uranium has changed. In April 1992, DOE announced that the reprocessing part of the ICPP mission would be phased out. However, the need to properly manage these fuels and wastes remains a high priority.

Spent fuel from reactors is transported by truck to the ICPP, where it is unloaded and placed in underwater or dry storage. Formerly, the fuel was transferred to a vessel to be dissolved into a liquid. The dissolved fuel went through a solvent extraction process to separate the uranium from radioactive wastes and other impurities.

Underground tanks temporarily store liquid waste from reprocessing and other sources. The liquid waste is then put through a calcination process and converted to solid, dry, sand-like particles. The resulting solid waste, known as calcine, is stored in large stainless steel bins designed for a 500-year life. This waste product will eventually be transformed into a glass or glass-ceramic log and stored at a permanent federal repository. Additional information on the ICPP is contained in Idaho Chemical Processing Plant Technical Site Information (Ferguson and Hatfield 1992).

The mission of the ICPP is the following:

- Develop and implement technologies for the disposal of spent fuel and high-level waste
- Receive, store, and process Navy and other DOE-assigned fuels for disposition
- Develop and apply technologies to minimize waste generation and manage radioactive and hazardous wastes
- Identify and conduct site remediation work and facility decontamination and decommissioning activities.

1.5.2.5 Naval Reactors Facility (NRF). NRF is a training center for Navy personnel who will staff nuclear powered surface ships and submarines. NRF also performs developmental testing of nuclear power systems for naval applications. The NRF is part of the joint DOE-Naval Nuclear Propulsion Program under the jurisdiction of DOE-PNR and operated by WEC (BAPL 1991). NRF was established in 1949 and is located in the west-central portion of the INEL, approximately 11.2 km (7 mi) from CFA. Three operating facilities comprise the NRF:

- The Natural Circulation Reactor (S5G)
- Large Ship Reactor (A1W)

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- Expended Core Facility (ECF).

Additionally, the deactivated Submarine Thermal Reactor (S1W) is located at NRF.

S5G started up in 1965 and is a pressurized water reactor having the capability to operate in either a forced circulation or a natural circulation flow mode in which cooling-flow through the reactor is caused by thermal circulation rather than by pumps. Natural circulation improves plant safety, simplifies plant design, increases reliability, and reduces the plant noise level. The A1W is a prototype facility consisting of a dual pressurized water reactor plant within a portion of a steel hull, built to prototype the aircraft carrier Enterprise. All components withstand seagoing use. Started up in 1958, this is the first nuclear plant to have two reactors powering one ship propeller shaft. S1W is the prototype for the USS Nautilus (the first nuclear powered submarine) and started operations in 1953. S1W was inactivated in 1989 following 36 years of operations (BAPL 1991).

The ECF receives, examines, and prepares naval expended cores for shipment to the ICPP for recovery of the enriched uranium in the spent fuel. Another ECF activity is to handle and examine irradiation tests (small-scale representations of current or future core designs) in the INEL's Advanced Test Reactor, providing test information for design personnel at the Bettis and Knolls Atomic Power laboratories. Part of the building contains deep, water-filled pits for safe underwater disassembly, examination, and preparation for analysis of radioactive components and irradiation tests. Portions of the disassembled components are sent to hot cells within the building for further examination and testing (BAPL 1991).

1.5.2.6 Power Burst Facility (PBF). PBF was initially constructed for the testing of four reactors for reactor transient behavior and for safety studies on light-water-moderate enriched-fuel systems. The Special Power Excursion Reactor Tests (SPERT) began in the late 1950s. At that time, the area consisted of the Control Area and the Reactor Area, the latter including the reactors. The PBF Control Area served as the control center for all SPERT and PBF operations. PBF is located 9.3 km (5.8 mi) northeast of CFA on Jefferson Boulevard (see Figure 1-1). PBF is divided into four sections:

- PBF Control Area
- Waste Engineering Development Facility
- Waste Experimental Reduction Facility
- Radioactive Mixed Waste Storage Facility.

The PBF mission is to provide efficient facility support for programmatic and nonprogrammatic efforts for the present and future needs at the INEL. Pursuit of a new program to use the PBF Reactor and Control areas is currently underway, and continued support will be provided for waste processing, development, and storage at the Waste Engineering Development Facility, the Waste Experimental Reduction Facility, and the Radioactive Mixed Waste Storage Facility.

1.5.2.7 Radioactive Waste Management Complex (RWMC). Located 11.3 km (7 mi) southwest of CFA, the RWMC is a restricted area on the INEL (see Figure 1-1). The RWMC provides waste management for TRU contaminated, solid, and low-level radioactive waste. The facility also supports research and development projects on shallow land-burial technology. Currently, 58.2 hectares (144 acres) at the RWMC are used for the actual disposal and storage of waste.

The mission of the RWMC is to provide waste management for the present and future needs of the INEL and assigned DOE offsite generators of low-level and TRU waste. The RWMC also retrieves, examines, and certifies stored TRU waste for ultimate shipment to the DOE Waste Isolation Pilot Plant in New Mexico. In addition, the RWMC is used to initiate and support research, development, and demonstration projects that will better enable the RWMC to manage waste in a way that is cost-effective, safe for personnel, and safe for the environment. For more detailed information, consult the most recent Site Development Plan.

1.5.2.8 Test Reactor Area (TRA). TRA is located in the southwestern portion of the INEL, 7.9 km (4.9 mi) northwest of CFA (see Figure 1-1). The area was originally established in the early 1950s with the development of the Material Test Reactor. Two other major reactors followed: the Engineering Test Reactor and the Advanced Test Reactor. The Engineering Test Reactor has been inactive since December 1981. The Material Test Reactor was shut down in 1970 and the building is now used for offices, storage, and test areas for the ICPP.

In the past 30 years, 73 buildings and 56 structures have been constructed at TRA. Currently, these facilities provide four major types of functional space: reactor, laboratory, office, and craft-support for maintenance. The major program at TRA is the Advanced Test Reactor.

The mission of TRA is to provide facilities, utilities, and support capabilities to enable government and private agencies to conduct experiments associated with the development, testing, and analysis of materials used in nuclear and reactor applications. For more detail, refer to the Site Development Plan.

1.5.2.9 Test Area North (TAN). TAN is located on the INEL site at the north end approximately 43.4 km (27 mi) northeast from CFA (see Figure 1-1). The area was originally established in the 1950s to support the U.S. Air Force and Atomic Energy Commission Aircraft Nuclear Propulsion Program. The program was canceled before a nuclear powered aircraft could be built. TAN is broken down into four areas:

- Initial Engine Test Facility
- Contaminated Test Facility, previously the Loss-of-Fluid Test Facility
- Technical Support Facility
- Water Reactor Research Test Facility.

The mission of TAN is to provide for specific programs located in the north area of the Site. There is no specific mission of the Initial Engine Test Facility since it is presently inactive. The

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specific mission of Contaminated Test Facility is to conduct loss-of-coolant experiments that simulate loss-of-coolant accidents as part of the nation's power water reactor program. The specific mission of the Technical Support Facility is to provide unique facilities for the support of energy research and defense programs, and to maintain specialized facilities for technical engineering and remote radioactive materials handling programs and other INEL programs. Refer to the Site Development Plan for more detailed information.

1.5.2.10 Idaho Falls. DOE-ID is located in Idaho Falls, a community of approximately 44,000 people. DOE-ID serves as the base of operations for DOE's management of research and testing contracts carried out at the INEL, and other sites in New York, Pennsylvania, Colorado, and Montana. The DOE owns or leases buildings throughout the Idaho Falls business district for approximately 2,400 DOE and contractor personnel who administer and support work at the INEL. Detailed information on size of work force, activities, and location of each building complex is found in the Site Development Plan.

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2. LAND RESOURCES

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ACRONYMS

AVZ	axial volcanic zone
B&R	basin and range
ESRP	Eastern Snake River Plain
INEL	Idaho National Engineering Laboratory
M	magnitude (earthquakes)
SRP	Snake River Plain
VRZ	volcanic rift zone

2. LAND RESOURCES

This section covers the land resources of the Idaho National Engineering Laboratory (INEL) and the regional area that influences the INEL. In this section, regional refers to the 320-km (199-mi) radius of the INEL and local is the Eastern Snake River Plain (ESRP).

2.1 Geology, Seismology, and Volcanism

2.1.1 Regional Geologic Setting

A knowledge of the regional geologic setting is necessary in order to understand the geologic history, subsurface stratigraphy, seismic hazards, and volcanic hazards of the INEL.

2.1.1.1 Physiographic and Geologic Provinces (ESRP and Basin-and-Range). The INEL is located on the ESRP near its northwestern boundary where it adjoins the northern Basin-and-Range (B&R) province (Figure 2-1). The ESRP is the eastern part of the Snake River Plain (SRP) physiographic province. The SRP is a broad, low-relief basin floored with basaltic lava flows and terrestrial sediments. It is about 100 km (62 mi) wide and over 600 km (373 mi) long. It extends in a broad arc from the Idaho-Oregon border on the west to the Yellowstone Plateau on the east. It transects and sharply contrasts with the mountainous country of the northern B&R province and the Idaho Batholith (Figure 2-2). Surface elevations on the SRP decrease continually and gradually from about 2,000 m (6,562 ft) near Yellowstone to about 650 m (2,133 ft) near the Idaho-Oregon border. Summits of mountains surrounding the Plain range up to 3,700 m (12,139 ft) in elevation, producing a maximum elevation contrast of about 2,300 m (7,546 ft).

The northern B&R province is comprised of north- to northwest-trending mountain ranges [with peaks up to 3,700 m (12,139 ft) high] separated by intervening basins [1,400 to 1,600 m (4,593 to 5,249 ft) in elevation] filled with terrestrial sediments and volcanic rocks. Individual mountain ranges in the vicinity of the SRP are up to 200 km (124 mi) long and 30 km (19 mi) wide. They are sharply separated from the intervening basins by late Tertiary to Quaternary normal faults (see seismicity and seismic hazards in Section 2.1.3). The basins are 5 to 20 km (3 to 12 mi) wide and grade onto the plain.

The Yellowstone Plateau is a high volcanic plateau underlain by Pleistocene (less than 2 million years old) rhyolitic volcanic rocks (Figures 2-2 and 2-3). Its elevation of about 2,100 to 2,600 m (6,890 to 8,530 ft) is significantly higher than that of the ESRP but not as high as the mountain summits of the northern B&R province. The Plateau is characterized by extremely high heat flow from the surface; extremely high temperatures at shallow depths; abundant hot-spring, fumarolic, and geyser activity; and landforms controlled by thick rhyolitic lava flows. These characteristics reflect the recency of volcanic activity in the area (2 million years ago to several tens of thousands of years ago).

Figure 2-1. Location of the INEL within the regional context of the northeastern B&R province, the SRP, and the Yellowstone Plateau.

Figure 2-2. Topographic character of the ESRP in contrast to that of the B&R province.

Figure 2-3. Decreasing elevation of the ground surface from Yellowstone to the southwest along the ESRP (Brott et al. 1981).

The central part of Idaho, adjoining the northern margin of the central SRP, is characterized by a large area of irregular mountainous terrain with peaks ranging in elevation from 2,400 to 3,700 m (7,874 to 12,139 ft). Streams dissecting the area usually have dendritic drainage patterns reflecting the homogeneous nature of the underlying granitic rocks that comprise the Idaho Batholith (Figures 2-1 and 2-2).

2.1.1.2 Paleozoic, Mesozoic, and Early Cenozoic History. During the Paleozoic and Mesozoic Eras, deposition of continental shelf carbonates (limestones and dolomites) occurred in a north-trending belt, which included southeastern Idaho, along the western margin of the North American continent (Oldow et al. 1989). Thrust faulting accompanied the deposition of these sediments in Paleozoic time (Antler orogeny), during the Paleozoic/Mesozoic transition (Sonoma orogeny), and again in Mesozoic/Cenozoic time (Sevier/Laramide orogenies). This thrust faulting produced the Idaho/Wyoming thrust belt (the Overthrust Belt) that extends through eastern Idaho (Figure 2-4). In early Cenozoic time, eastward-directed thrust faults and belts of deformation probably continued uninterrupted through southeastern Idaho.

Large volumes of granitic rock were emplaced by igneous intrusion into the upper crust during Mesozoic and early Cenozoic thrusting to produce the Idaho Batholith in central Idaho (Figure 2-4). Subduction of the Pacific plate beneath the North American plate caused large-scale melting of lithospheric rocks all through the western Cordillera. In addition to the Idaho Batholith, the Sierra Nevada Batholith and other large granitic intrusive bodies were formed during this time.

In the early Cenozoic, northwest-southeast-directed extension produced the northeast-trending Trans-Challis fault zone and the associated Custer and Panther Creek grabens (Figure 2-5). Accompanying volcanism caused caldera subsidence along the trend of the grabens. Volcanic rocks of the Challis volcanic field, which covers much of south-central Idaho adjacent to the northwestern margin of the ESRP, were erupted from sources along the Trans-Challis fault zone and elsewhere in south-central Idaho.

2.1.1.3 Late Cenozoic and Quaternary History of the ESRP.

Yellowstone Hotspot—The processes that caused development of the SRP began about 17 million years ago. A rising plume of anomalously hot rocks in the earth's mantle (the Yellowstone Hotspot) first impinged on the base of the lithosphere at that time. Since the mantle plume is rooted deep in the earth, probably at the mantle-core boundary, it has remained relatively stationary while the lithosphere and crust (North American plate) have shifted across it due to plate tectonic processes. At 17 million years ago, the North American plate was positioned so that the area now located in north-central Nevada was directly above the hotspot. As plate tectonic activity has moved the plate southwestward at about 3.5 cm/year, the hotspot has left its distinctive effects strung out in a band extending from its present position at Yellowstone National Park to north-central Nevada.

Figure 2-4. Sevier (Mesozoic to Early Cenozoic) overthrust belt (Oldow et al. 1989).

Figure 2-5. Challis volcanic field and early Cenozoic tectonic features (Moye et al. 1988).

The effects of the hotspot on the lithosphere and crust have been profound. Two types of large-scale melting have occurred (Leeman 1982):

1. Melting of the hot mantle material in the rising plume generated basaltic melts (magmas) that migrated to mid-crustal levels [about 20 km (12 mi) deep]. This melting was due to decrease in pressure on high-temperature mantle material as it moved from great depth.
2. Melting of mid-crustal rocks produced granitic melts that migrated upward to near-surface reservoirs and caused widespread explosive and effusive rhyolitic volcanism typical of that at Yellowstone National Park. This melting was due to heating of mid-crustal rocks by the much hotter basaltic magmas that rose from the mantle plume.

The effects of the hotspot that can be observed at the surface of the earth today include widespread, large-volume sheets of rhyolitic tuffs emplaced by explosive processes, large-volume rhyolitic lava flows, calderas from which the rhyolitic volcanic rocks erupted, elevated topography in the area directly over the hotspot due to buoyant effects of the hotspot, and the basin of the ESRP caused by subsidence as plate motion moved volcanic highlands southwestward away from the hotspot.

Calderas from which the rhyolitic volcanic rocks erupted are typically 30 to 70 km (19 to 43 mi) across and resulted from foundering of the roof of shallow magma chambers as voluminous explosive eruptions occurred (Morgan 1988). As the roofs foundered into the evacuated magma chambers, the resulting depressions were filled with thick sequences of rhyolitic volcanic rocks. As the North American plate has migrated to the southwest across the Yellowstone hotspot, a string of calderas and volcanic fields has been formed in the wake of the hotspot (Figure 2-6). The subsidence of the surface due to crustal cooling along this string of volcanic fields has led to the formation of the ESRP.

Another way to view the progression of hotspot-related rhyolitic volcanism is in a plot of the age of volcanic rocks versus distance from Yellowstone along the ESRP (Figure 2-7). This diagram shows that the beginning of rhyolitic volcanism becomes younger towards Yellowstone and that basaltic volcanism has covered most of the rhyolitic volcanic fields in the ESRP.

Modifications to Crustal Structure Resulting from Hotspot Processes—In addition to large-scale melting and volcanism described in previous sections, the crust beneath the ESRP was modified significantly by the melting processes associated with the hotspot (Sparlin et al. 1982). The crystallization of large volumes of basaltic magma in the mid-crust produced a roughly 10-km (6-mi) thick lens of anomalously dense rock that transmits seismic waves faster than the material above or below (Figure 2-8). The added weight of this material to the crust, along with the contraction due to cooling after passing over the hotspot, has caused the ESRP to subside in elevation by about 2 km (1.2 mi) during the past 4 million years.

Basalt Volcanism and Sedimentation in the Subsiding ESRP Basin—The subsidence of the ESRP has produced an elongate northeast-trending basin in the wake of the

Figure 2-6. Track of the Yellowstone Hotspot and positions and ages of associated silicic volcanic fields (Pierce and Morgan, 1990; 1992).

Figure 2-7. Younging age at inception of rhyolitic volcanism from southwest to northeast along the ESRP (Armstrong et al 1975; Hackett and Morgan 1988).

Figure 2-8. ESRP topography, gravity, and crustal structure (Sparlin et al. 1982).

hotspot during the past 4 million years. Two types of materials have accumulated to a total thickness of 1 to 2 km (0.6 to 1.2 mi): (a) basalt lava flows that were generated by residual heat in the upper mantle beneath the ESRP and that rose to the surface to erupt into the subsiding basin, and (b) deposits of sedimentary material that have formed interbeds between lava flows. The sediments are composed of fine-grained silts that were deposited by wind action, silts, sand, and gravels deposited by streams such as the Big Lost River, and by clays, silts, and sands deposited in lakes such as Mud Lake and its much larger ice-age predecessor, Lake Terreton.

The accumulation of these two types of rocks in the ESRP has resulted in the observed sequence of interlayered basalt lava flows and sedimentary interbeds. Volcanism is a sporadic process. During the long periods of quiescence between volcanic periods, sediments accumulated to thicknesses varying from less than 1 m (3.3 ft) to more than 60 m (197 ft). During short periods of volcanic activity, numerous lava flows commonly accumulated to thicknesses reaching several tens of meters.

Basin-and-Range Tectonic Activity—The B&R province of the western United States is a region of extending crust, high elevations, high heat flow, and extensive Cenozoic volcanism (Eaton 1982). The north-to-northwest trends of normal faults and mountain ranges in the B&R province and of in situ stress determinations (Zoback and Zoback 1980; 1991) show that the area is undergoing east-west- to northeast-southwest-directed extension. In the northern B&R province, which is transacted by the ESRP, the extension produces north-trending normal faults and mountain ranges on the southern side of the ESRP and northwest trending ones on the northern side. The mountain ranges are caused by a process called block faulting. As extension stretches the area, the brittle upper crust [upper 10 to 16 km (6 to 10 mi)] can respond only by breaking into blocks that rotate slightly along the faults to produce long, narrow mountain ranges with intervening basins (valleys) (Stewart 1978).

The rugged topography and high elevations characteristic of these mountain ranges die out at the margins of the ESRP and give way to the relatively flat and low-lying topography characteristic of the Plain. The activity on the normal faults that bound the ranges must also die out near the Plain margins, or else the mountain ranges would continue across (Hackett and Smith 1992).

Extension on the ESRP is accommodated by intrusion of basalt dikes along northwest-trending volcanic rift zones (see Sections 2.1.3.5 and 2.1.4) instead of normal faulting (Smith et al. 1989; Rodgers et al. 1990; Hackett and Smith 1992). The occurrence of Holocene and historic (1983) normal faulting earthquakes in the northeastern B&R province and Holocene dike injection events in the ESRP suggest that both regions are still actively extending.

2.1.1.4 Mineral Resources of the INEL Area. Mineral resources in the INEL area include sand and gravel, pumice, phosphate, and base- and precious metals (Strowd et al. 1981; Mitchell et al. 1981). Within the INEL boundaries, the only resources found or produced to date are sand, gravel, and pumice. This includes material for construction aggregate, for decorative stone, and for burial of waste at the Radioactive Waste Management Complex (Minkin 1992).

Large phosphate deposits occur and are mined in the mountains to the south of the ESRP in the Pocatello and Blackfoot areas (Strowd et al. 1981). In the southern portions of the Pioneer, Lost River, Lemhi, and Beaverhead ranges to the west, northwest, and north of the INEL, numerous prospect pits and small mining operations have been developed. These were developed to search for and produce small quantities of copper, lead, zinc, tungsten, silver, gold (Strowd et al. 1981; Mitchell et al. 1981).

2.1.2 Subsurface Stratigraphy at the INEL

2.1.2.1. Interlayered Basalt and Sediment Underlain by Silicic Volcanic Rocks. The interlayered sequence of basalt and sedimentary interbed material beneath the INEL is documented by hundreds of drill holes located throughout the INEL and surrounding regions (Anderson and Lewis 1989; Anderson 1991). Only four drill holes deeper than 610 m (2,000 ft) have been drilled on the INEL (Figure 2-9). Two of these, INEL-1 and WO-2, document the presence of rhyolitic volcanic rocks beneath the basalt-sediment sequence. The drillhole information coupled with geophysical data show that the upper 1 to 2 km (0.6 to 1.2 m) of the crust beneath the INEL is composed of interlayered basalt and sediment. Rhyolitic volcanic rocks of unknown thickness lie beneath the basalt-sediment sequence. Absolute ages of the oldest basalts at the bottom of the sequence have not been determined because of lack of sample material and because of alteration of the basalts at that depth. However, we know that the entire sequence has accumulated since the passage of the Yellowstone hotspot about 4.3 million years ago. This correlates well with the identification of a thin layer of Kilgore rhyolite tuff, known to be 4.3 million years old, near the bottom of corehole 2-2A (Figure 2-9). The youngest basalts known on the ESRP are the 2,100-year-old flows from the Great Rift at Craters of the Moon and Wapi/Kings Bowl lava fields. This brackets the age of the basalt-sediment sequence between about 4.3 million years and 2,100 years (Kuntz et al. 1986). The rhyolitic volcanic rocks beneath the basalt were erupted between 6.5 and 4.3 million years ago, when the Yellowstone hotspot was beneath this part of the ESRP (Pierce and Morgan 1990; 1992).

The interlayering of unconsolidated sediments within the basalts (Figures 2-9 and 2-10) is important to INEL facilities for several reasons:

1. Because of the extreme difference in the velocity of seismic waves as they pass through the basalt and unconsolidated sediments, seismic energy is scattered between alternating rock and sediment layers, causing greater attenuation than in more typical, near-surface rocks. This means that INEL facilities founded in bedrock experience lower-damaging ground motions due to possible earthquakes than they would if unconsolidated sedimentary interbeds did not exist beneath the ESRP (Woodward-Clyde Consultants 1990). Thicker sediment layers are more effective attenuators of seismic energy than are thin ones.
2. The interbedded sediments are composed mostly of fine-grained materials (silts and clays), which have very low permeability and high absorption capabilities. Therefore, they impede the downward migration of water and contaminants to the water table.

Figure 2-9. Stratigraphy of INEL based on lithologic logs and ages of rocks in four deep holes (Doherty et al. 1979; Doherty 1979a,b; Hackett and Smith 1992).

EXPLANATION

- B** BASALT — Basalt-flow group composed of one or more related flows. Letter, B, indicates sequence of group from top to bottom of section. Locally includes cinders and thin layers of sediment
- CLAY, SILT, SAND, AND GRAVEL** — Major sedimentary interbed between basalt-flow groups. Locally includes cinders and basalt rubble
- GEOLOGIC CONTACT** — Queried where uncertain
- WELL** — Entry, 66, is local well identifier. Dashed line indicates measured or estimated water level in aquifer in 1990. Lower arrow indicates measured water level in aquifer in 1989 or 1990. Upper arrow indicates measured water level of perched ground water in 1989 or 1990. Number, 676, at bottom of well is total depth of well in feet below land surface

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Figure 2-10. Geologic section A-A' in the Test Reactors Area and the Idaho Chemical Processing Plant area (Anderson and Lewis 1989).

3. The low permeability of the sedimentary interbeds commonly causes localized perched water zones beneath some INEL infiltration ponds and beneath natural infiltration/recharge zones such as the Big Lost River channel and sinks at flood stage.
4. The sedimentary interbeds can confine portions of the aquifer, causing them to be somewhat isolated from other parts of the aquifer.

2.1.2.2 Characteristics of Basalt Lavas. An idealized section showing the characteristics of ESRP basalt lava flows is shown in Figure 2-11. From bottom to top, basalt lava flows typically are composed of a basal rubble zone, a lower vesicular zone, a massive columnar jointed zone, an upper vesicular and fissured zone, and a cap of platy jointed crust.

Near-vent lava flows are typified by thin, vesicular, platy flows (shelly pahoehoe). Also, pyroclastic ejecta layers are commonly interleaved within the thin flow layers. With distance from the vent, the shelly pahoehoe grades rapidly into the structures described above (Figure 2-11). Deflation pits, in which solidified crust has subsided over areas where lava has drained away, are common throughout the flow but more numerous near the terminus.

2.1.2.3. Sediment facies. Sediments of diverse origins cover and are interbedded with basalts of the ESRP. Surface lava flows throughout INEL and surrounding regions are covered by varying thicknesses of windblown silt (loess). Alluvial sands and gravels are common along the Big Lost River channel through the INEL, and lacustrine clays deposited in Pleistocene Lake Terretion are common in the northern and northeastern part of the site (Figure 2-12) (Kuntz et al 1990). Since the sedimentary depositional processes operating in the geologic past are similar to those operating today, these same types of sediments make up the interbeds in the subsurface.

2.1.3 Summary of Seismicity And Seismic Hazards

Continuing investigations of seismicity and seismic hazards for INEL are briefly summarized in this section. For additional information on all subjects in this section, see Section A.2 in Appendix A.

2.1.3.1 Historic and Instrumental Seismicity Within the ESRP. Instrumental seismicity since 1970 shows that the ESRP has experienced only microearthquakes [with an earthquake magnitude (M) < 1.5] and that the numbers of microearthquakes are very small compared to the numbers of earthquakes outside the ESRP (Jackson et al. 1991; 1993). In fact, since 1972, only 19 microearthquakes ($M < 1.5$) have been recorded within the ESRP, while thousands of earthquakes ($M > 2$) have been recorded in areas surrounding the ESRP. No historic earthquakes ($M > 2.5$) have occurred on the ESRP (Engdahl and Rinehart 1988, 1991; Woodward-Clyde Consultants 1992a) (see Figure A-1 in Appendix A). In the central SRP, near Shoshone, an earthquake is postulated to have occurred in 1905 (Stover et al. 1986). Recent analysis of historic records shows that the 1905 earthquake most likely had an epicenter near the town of Snowville in northwestern Utah and a magnitude of 5.5 (Oaks et al. 1992; Oaks 1992) (see Appendix A, Task 9).

Figure 2-11. Idealized longitudinal section of a typical ESRP basalt lava flow.

Figure 2-12. Generalized geologic map of the INEL (adapted from Kuntz et al. 1990; Scott 1982).

2.1.3.2 Parabolic Distribution of Seismicity Around the ESRP and Yellowstone.

Historical seismicity in the region surrounding the ESRP occurs in a parabolic zone that centers on Yellowstone (Figure 2-13) (Anders et al. 1989). One arm of the parabola extends westward from Yellowstone across that part of the B&R north of the ESRP, and the other extends southwestward from Yellowstone into north-central Utah. Each arm is close to the ESRP near Yellowstone but sweeps increasingly farther from the ESRP with distance southwest from Yellowstone (Figure 2-13). The parabolic distribution of historical seismicity corresponds to the distribution of Holocene displacements on normal faults of the B&R province north and south of the plain (Pierce and Morgan 1990; 1992). The parabolic distribution of seismicity and young faulting is suggested by Anders et al. (1989) and Pierce and Morgan (1990; 1992) to be related to the tectonic and thermal effects of the Yellowstone hotspot as it is overridden by the lithosphere and crust of the North American plate.

2.1.3.3 Relationship to the Intermountain Seismic Belt and the Centennial Tectonic Belt. The seismicity of the INEL and ESRP area can also be viewed in the context of regional seismicity of the western United States. The parabolic distribution of seismicity around the ESRP is part of a regional zone of seismicity (the Intermountain Seismic Belt) that has been recognized for many years (Smith and Arabasz 1991; Smith and Sbar 1974). The Intermountain Seismic Belt extends northward from Arizona and southern Nevada, through central Utah along the Wasatch Front, and includes the southern limb of the parabola as it sweeps from northern Utah to the Yellowstone Plateau (Figure 2-14). The limb of the parabola that extends westward into Idaho has been called the Idaho seismic zone (Smith and Sbar 1974) and recently referred to as the Centennial Tectonic Belt (Stickney and Bartholomew 1987). Smith and Arabasz considered this limb to be a projection of the Intermountain Seismic Belt into central Idaho (Figure 2-14).

2.1.3.4 Historic and Instrumental Seismicity Within and Around the ESRP. Several earthquakes of magnitude greater than 6 have occurred in the parabolic zone of seismicity since 1884 (Engdahl and Rinehart 1988). The closest large earthquakes to the INEL are the 1959 Hebgen Lake earthquake (M 7.5) and the 1983 Borah Peak earthquake (M 7.3) (Figure 2-15). Both were felt at the INEL, but neither caused damage to INEL facilities (Gorman and Guenzler 1983). The 1983 Borah Peak earthquake was a typical B&R-style, normal-faulting earthquake involving simple rupture of the Thousand Springs segment of the Lost River fault (Doser and Smith 1985; Crone et al. 1987; Crone and Haller 1991) (Figure 2-15). The 1959 Hebgen Lake earthquake was a complex earthquake with multiple shocks over a few seconds of time (Doser 1985). Surface rupture associated with the earthquake affected three faults of diverse orientation. Its high magnitude and complex nature probably result from its proximity to the Yellowstone Plateau and from the effects of vertical movements associated with the hotspot in combination with horizontal extension associated with B&R tectonism.

2.1.3.5 Earthquake Sources Contributing to INEL Seismic Hazards. Earthquake sources that contribute to INEL seismic hazards consist of regional sources and fault sources. Regional sources include that part of the B&R province lying near the ESRP, the ESRP itself, the Idaho Batholith, and the Yellowstone Plateau (Figure 2-1). Fault sources include specific faults in the regions surrounding the ESRP (Figures 2-15, 2-21, and 2-22). In this section,

Figure 2-13. Parabolic zone of seismicity about the ESRP and centered on the Yellowstone plateau (Anders et al 1989; Hackett and Morgan 1988).

Figure 2-14. Location of the Intermountain Seismic Belt and Centennial Tectonic Belt with respect to the SRP.

Figure 2-15. Locations of the 1983 Borah Peak and 1959 Hebgen Lake earthquakes.

information about the most important of the faults and regions is summarized. Detailed discussions of all regions and faults is presented in Section A.2 of Appendix A.

Basin-and-Range Faults—B&R normal faults have the capability of generating large magnitude earthquakes ($M > 7$), which will affect INEL facilities. For this reason, the three closest B&R faults to the INEL (the Lemhi, Lost River, and Beaverhead faults) have been identified as potential earthquake sources and have been singled out for detailed investigations (Figure 2-16). In addition, the Rexburg fault has been recognized as a B&R fault that may extend for significant distance into the ESRP, making it also worthy of further investigation.

Lemhi Fault—Detailed paleoseismic and structural investigations have been performed on the southern Lemhi fault (Woodward-Clyde Consultants 1992b; Bruhn et al. 1992). Results are the following:

1. Segmentation of the southern Lemhi fault is redefined based on timing of paleoseismic events and on detailed mapping of the structure of the fault in bedrock and surficial deposits (Figure 2-17). Solid, dashed, dash-dot, and dotted lines represent different rupture lengths possible in each scenario.
2. The most recent earthquake events on the various segments ranges from 15,000 to 25,000 years ago (Figure 2-18).
3. There is evidence for temporal clustering of earthquake events (i.e., clusters of several events over a few thousand years separated by long intervals (10s of thousands of years) of quiescence.
4. Maximum magnitude of earthquakes in the southern part of the fault is about a magnitude of 7 (Woodward Clyde Consultants 1992b).
5. Bedrock structural features of the southern part of the fault suggest that Quaternary displacement dies out at the south end of the Lemhi Range near the ESRP boundary and that significant seismogenic fault movements do not extend onto the ESRP (Figure 2-19). However, reflection seismic surveys conducted in 1984 and 1991 suggest that faults exist at depth for some distance out from the ends of both the Lemhi and Lost River Ranges.

Lost River Fault—From a seismic hazard point of view, this fault is about equal to the Lemhi. It is slightly farther away from most INEL facilities (hence Lemhi was studied first), but its threat is similar. Current studies are underway to develop information on its earthquake history.

Beaverhead Fault—Although considerably farther from INEL than the Lemhi and Lost River faults, earthquakes from this fault will contribute significantly to the probabilistic hazard assessment.

Figure 2-16. B&R faults important to INEL seismic hazards assessment.

A = Preferred scenario based on most reasonable interpretation of paleoseismic data.

B = Less-preferred scenario, which allows for rupture from just south of the Coyote Springs trench to the southern end of the range.

C = Least-preferred scenario, which allows for the slight possibility of rupture of the entire lengths of both the Fallert Springs and Howe segments.

Figure 2-17. Possible rupture scenarios for the southern Lemhi fault (Woodward-Clyde Consultants 1992b).

PALEOSEISMIC RESULTS: SOUTHERN LEMHI FAULT

Summary of earthquake events deduced from 4 trenches logged in 1990 and 1991. The data suggest that proposed segment boundaries (solid arrowheads) do not terminate earthquake ruptures. Instead, single events (E2, etc) may extend from Coyote Springs south to the end of the range (open arrowheads). Resulting rupture lengths of 34-35 km and corresponding $M_w=6.9$ establish the MCE for the southern Lemhi fault.

Figure 2-18. Summary diagram of earthquake chronology for the southern Lemhi fault.

Figure 2-19. Structural mapping suggests that Quaternary faulting terminates at cross fault A or at the cross faults at Howe Point (Bruhn et al. 1992).

Rexburg Fault—This fault will also contribute to the probabilistic hazard and, importantly, an understanding of the reasons for its apparent extension onto the ESRP should be developed. This understanding may help determine the southern extent of earthquake activity on faults closer to the INEL.

Volcanic Rift Zones—Volcanic vents on the ESRP are concentrated in NW-trending and NE-trending linear belts (Figure 2-20). For information on sites 1 through 4 in Figure 2-20, see Section 2.1.4.2.3. The NW-trending belts have associated ground deformation features and are referred to as volcanic rift zones (VRZs) (Figure 2-21). The ground deformation features are fissures, faults, grabens, and monoclines that form due to dilational stresses above the tops of basalt dikes as magma moves from depth to the surface. Three VRZs occur in the INEL region of the ESRP, the Great Rift VRZ (which extends southeastward from Craters of the Moon National Monument), the Arco VRZ (which extends southeast from Arco across the southwestern corner of the INEL), and the Lava Ridge-Hells Half Acre VRZ (which extends from the south end of the Lemhi Range to the Hells Half Acre lava field) (Figure 2-22).

From analogy with active VRZs in other parts of the world (Iceland and Hawaii), we know that during periods of volcanic activity, the VRZs are sources of seismic hazard (Karpin and Thurber 1987; Einarsson 1991). Even though the magnitude of VRZ earthquakes is smaller than that of the B&R faults, the closer proximity of VRZs to INEL facilities indicates that they can be significant contributors to both deterministic and probabilistic seismic hazards (Woodward-Clyde Consultants 1992a,b; Hackett et al. 1993; Einarsson and Brandsdottir 1979; Karpin and Thurber 1987).

The VRZs and the axial volcanic zone (AVZ) (discussed below) have remained as highlands throughout much of the development of the ESRP and thus do not receive as much sediment as the basins between them (Figures 2-23 and 2-24). This results in large-scale heterogeneities in seismic energy transmission and in aquifer properties.

Axial Volcanic Zone—Volcanic vents on the ESRP are also concentrated in a northeast-trending zone along the axis of the ESRP (Figures 2-20, 2-21, and 2-22). This is called the AVZ to distinguish it from VRZs. It is important to make this distinction because the AVZ does not contain northeast-trending ground deformation features that would qualify it to be a VRZ. The few ground deformation features that do occur in the AVZ are northwest-trending fissures. This indicates that the volcanic vents in the AVZ are fed by northwest-trending dikes and that, even though it is not a VRZ, seismicity is associated with volcanism there. Thus, it also plays an important role in deterministic and probabilistic seismic hazards assessment (Woodward-Clyde Consultants 1992b).

Boundary of the ESRP—The northwest boundary of the ESRP has been considered as a possible seismic source because an active normal fault was suspected to occur there (EG&G Idaho 1985). While it is true that a northeast-trending fault or faults may exist at depth (Pankratz and Ackermann 1982), the only evidence for active faulting consists of the presence of a small

Figure 2-20. Distribution of volcanic vents on and near the INEL (USGS 1991; Kuntz et al. 1990).

Figure 2-21. Volcanic rift zones and axial volcanic zone near the INEL (Kuntz et al. 1990; Golder Associates 1992b).

Figure 2-22. Volcanic rift zones of the ESRP (Kuntz et al. 1992).

Figure 2-23. Modified "plains-style" volcanism on the ESRP near the INEL.

Figure 2-24. Percentage of sediments in basalt section for holes drilled into the aquifer.

northeast-trending topographic scarp on an alluvial fan on the southeast side of the Arco Hills (Scott 1982). That scarp was trenched in 1989 by the Idaho Geological Survey (Breckenridge and Othberg 1991). Resulting trench logging showed that no faulting occurs there and that the scarp is due to surficial processes—perhaps an eolian modification of a fire scar.

Random Earthquake—Current Nuclear Regulatory Commission guidelines indicate that for an area as large as the ESRP with no major faults present, a random or floating earthquake should be considered. This is defined as the largest earthquake that could conceivably occur in the area without leaving evidence for its occurrence on the surface (i.e., without surface rupture). A good case can be made that the dike injection process operating in the ESRP relieves differential stresses to the point that only volcanic-related earthquakes ($M \leq 5.5$) can occur here (Parsons and Thompson 1991; Hackett and Smith 1992; Woodward-Clyde Consultants 1992b). The 1905 Shoshone earthquake, also magnitude 5.5, may have occurred within the SRP.

Nontectonic Lineaments On and Near the INEL—The surface of the ESRP contains many lineaments that can be observed from the air, on aerial photographs, and on satellite images. Most of them are nontectonic in origin (Golder Associates 1992a). One of the most pronounced of these lineaments, called the Principal Lineament, was studied extensively for the 1985 Environmental Characterization Report and was subsequently shown to be caused by eolian modifications to a large fire scar (EG&G Idaho 1985; Morin-Jansen 1986). This process produces many lineaments and perhaps even small topographic scarps on the ESRP. Other lineaments are caused by unmodified fire scars, linear stream drainages, alignments of vegetative or soil contrast with unknown causes, fluvial deposits (stream, river), palcoslood deposits, and eolian deposits (dunes).

Effects of Stratigraphy on Transmission of Seismic Energy—The interlayering of basalt lava flows and unconsolidated sediments beneath the INEL produces a seismic velocity structure that attenuates seismic energy to a greater extent than is typical of most near-surface rock sequences. This is because the velocity of seismic waves in the basalts is much greater than that in the sediments. Therefore, in an area where several thick interbeds exist in the subsurface, the reflection and damping of seismic energy is significant. Studies to model ground motion at INEL facilities have shown the importance of this factor (Woodward-Clyde Consultants 1992b).

Deterministic and Probabilistic Seismic Hazards Assessments—A deterministic ground motion assessment for the New Production Reactor at the INEL, which considers all seismic sources (B&R faults, VRZs, AVZ, random) has just been completed (Woodward-Clyde Consultants 1992b). A deterministic ground motion assessment for other INEL facilities was completed (Woodward-Clyde Consultants 1990), but it considers only the Lemhi fault as the seismic source because the south end of the Lemhi Fault is the closest active fault to most INEL facilities. A probabilistic seismic hazard assessment was done for the New Production Reactor (Woodward-Clyde Consultants 1992b) and one is in progress for other INEL facilities (Woodward-Clyde Federal Services 1993). These are summarized in Section A.2 of Appendix A.

2.1.4 Volcanism and Volcanic Hazards

2.1.4.1 Introduction. The regional-tectonic framework of ESRP volcanism has previously been introduced in Sections 2.1.1 and 2.1.2. Basaltic and rhyolitic volcanism has affected the ESRP for about the past 10 million years and has continued into geologically recent time. No historical eruptions have occurred on the ESRP, but lava has flowed as recently as 2,100 years ago from the Great Rift, about 25 km (15.5 mi) southwest of the INEL. Other Holocene basaltic lava fields near the southern INEL boundary are nearly as young, and range from about 5,000 and 13,000 years in age (Kuntz et al. 1986). Many basaltic vents and three rhyolitic vents located within the present INEL boundary erupted between about 200,000 and 1.2 million years ago (Kuntz et al. 1990). For these reasons, an assessment of volcanic hazards at the INEL is warranted, and such an evaluation is based on the record of past volcanism in the region.

In the present section, information on the timing, distribution, and eruptive character of volcanism that could affect the INEL is summarized. Potential volcanic hazards are grouped into two categories: those related to volcanic sources within the INEL area, and those related to distant, non-ESRP sources. For near-field volcanism, the volcanic history of the ESRP and the INEL area (Figures 2-6, 2-12, and 2-22) dictates that three varieties of volcanism be evaluated: (a) the formation of future silicic calderas and associate eruptions of voluminous ash and pumice, as occurred in the INEL area between about 6.5 and 4.3 million years, during passage of the Yellowstone mantle plume (Pierce and Morgan 1992) (Figure 2-6); (b) the growth of new silicic lava domes near the INEL, as occurred at Big Southern Butte (0.3 million years), East Butte (0.6 million years), and elsewhere along the AVZ near the southern part of the INEL (Figure 2-25) (Kuntz et al. 1990); (c) phenomena related to Quaternary ESRP basaltic volcanism, largely involving the effusion of lava flows and magma-induced ground fissuring across the INEL area (Figures 2-20 and 2-25).

Potential impacts from distant volcanic sources include (a) Pyroclastic flows or tephra fall from explosive-silicic eruptions of the Yellowstone Plateau, 100 to 200 km (62 to 124 mi) northeast of the INEL, and (b) tephra fall from the Cascade volcanoes and other explosive volcanic centers in the western United States.

Up-to-date references on general aspects of volcanism and associate volcanic hazards include Wohletz and Heiken (1992), Blong (1984), and Latter (1989). Data and analysis specific to INEL volcanic hazards have been compiled by Volcanism Working Group (1990). Subsequent, related publications address ESRP regional tectonics (Rodgers et al. 1990; Malde 1991; Parsons and Thompson 1991; Pierce and Morgan 1992; Hackett and Smith 1992) and ESRP volcanism (Kuntz 1992; Kuntz et al. 1992; Morgan 1992). In addition, detailed geologic mapping (Kuntz et al. 1990; Golder Associates 1992b) has led to improved knowledge of basaltic-vent and fissure locations in the INEL area.

2.1.4.2 Potential Volcanic Hazards of the INEL Area. Table 2-1 summarizes the important characteristics of volcanism in the INEL area. The nature and timing of volcanism is reconstructed from interpretation of ESRP volcanic deposits, and from the results of K-Ar dating

Figure 2-25. Basaltic volcanism and dike intrusion along volcanic rift zones (a) and rhyolite dome eruption along the axial volcanic zone (b).

Table 2-1. Characteristics of volcanism in the INEL area (see Figure 2-22 for map distribution of volcanic zones and related features).

	CALDERA FORMATION	RIFT-ZONE VOLCANISM	AXIAL-ZONE VOLCANISM	AREAS BETWEEN VOLCANIC ZONES
MAGMA TYPES	rhyolite (viscous and gas-rich)	basalt (fluid and gas-poor)	basalt and subordinate rhyolite	basalt (and minor rhyolite?)
VOLCANIC STYLE AND PRODUCTS	highly explosive; voluminous pumice and fine ash	mild & effusive; erupt mainly lava flows from fissures, low shield volcanoes and small tephra cones	as per rift zones, but also local rhyolite domes & intrusions (Big Southern, Middle, East Buttes) with local explosive phenomena	as per volcanic rift zones and axial volcanic zone
STRATIGRAPHY	filled with thick (up to several km), welded, silicic ash-flow tuffs, lava flows and sediments [Heise Volcanics]	piles of 1- to 30-m thick basalt lava flows & minor interbedded sediment; total lava thickness 0 to >1 km [Snake River Group]	basaltic lava flows and dispersed small tephra cones; isolated rhyolite domes and intrusions [Snake River Group]	fine clastic sediment of fluvial, lacustrine and eolian origins; fewer lava flows than near VRZs [Snake River Group]
TECTONICS AND PHYSICAL CONFIGURATION	collapse: broad, oval depressions, 10s to 100 km wide and 1-2 km deep, ringed by inward-dipping fractures	extensional: NW-trending, linear belts of open fissures, monoclines, small normal faults and basaltic vents	extensional, but magma-induced fissures or faults are rare; a diffuse, NE-trending, volcanic highland along the ESRP axis	subsidence(?): broad, low topographic basins between extensional and constructional volcanic highlands; seldom disturbed by magma intrusion
GEOLOGIC AGE IN INEL AREA	6.5 Ma to 4.3 Ma in INEL area, now covered by younger basaltic lava. [2 Ma to 0.6 Ma on Yellowstone Plateau]	Surficial INEL basalts: 1.2 Ma to 0.05 Ma; most are 0.7 Ma to 0.1 Ma. Inception of major ESRP basaltic volcanism began about 4 Ma.	basalt: >1 Ma (Middle Butte) to 5.2 Ka (Hells Half Acre). rhyolite: >1 Ma (near East Butte) to 300 Ka (Big Southern Butte)	as per VRZs
QUATERNARY ERUPTION FREQUENCY	zero in INEL area; Quaternary calderas closest to INEL occur on Yellowstone Plateau	low; one eruption per 10,000 to 100,000 yrs (see Table 2-3)	low: one basaltic eruption per 10,000 years (see Table 2-3); one rhyolitic intrusion or dome every 200,000 yrs or longer	very low; by definition less frequent than along VRZs (one eruption per 100,000 yrs or more)

of volcanic rocks. Observations of historical volcanic phenomena are also useful toward understanding prehistoric INEL volcanism, particularly the basaltic-rift-zone eruptions of Iceland and Hawaii, and the growth of silicic-lava domes at various volcanic centers along the Pacific Rim.

2.1.4.2.1 Formation of ESRP Silicic Calderas and Related Volcanism—Explosive, voluminous eruptions of silicic pumice and ash, and associated caldera collapse occurred on the ESRP during passage of the Yellowstone hotspot between about 6.5 and 4.3 million years (Malde 1991; Pierce and Morgan 1992) (Figure 2-6). Tephra-fall and pyroclastic-flow deposits from these eruptions were dispersed over tens of thousands of square kilometers in southern Idaho and adjoining states, and are known as the Heise Volcanics (Morgan 1992).

The risk of explosive-silicic volcanism and caldera formation in the INEL area is considered negligible for a number of reasons:

- The mantle plume (Yellowstone hotspot), which has been the apparent energy source of voluminous, caldera-forming, silicic volcanism on the ESRP, has now moved under the Yellowstone Plateau, 100 to 200 km (62 to 124 mi) northeast of the INEL, and accounts for the Quaternary silicic volcanism and ongoing hydrothermal activity of that area (Malde 1991; Pierce and Morgan 1992).
- Thermal modeling (Blackwell 1989) and geophysical studies of the ESRP crustal structure (Sparlin et al. 1982) show that the silicic magma chambers inferred to have existed in the shallow crust of the ESRP during late Tertiary time are now entirely solidified and are therefore incapable of erupting.
- The recurrence intervals (quiescent periods) between major caldera eruptions on the ESRP and the Yellowstone Plateau were 0.5 to 1.7 million years long. Two-and-one-half to eight recurrence intervals (4.3 million years since latest such ESRP eruption) have therefore elapsed in the INEL area, suggesting that caldera-related silicic volcanism has ceased.
- The time-transgressive pattern of the ESRP: Yellowstone silicic volcanism suggests that explosive silicic volcanism expires after basaltic lava flows have filled the calderas. On the ESRP, the late-Tertiary-silicic calderas are buried by up to several kilometers of late-Tertiary-to-Quaternary basalt and sediment.

2.1.4.2.2 Growth of Rhyolitic Domes, Intrusions, and Related Phenomena—Volcanic domes are steep-sided mounds of lava, commonly of silicic (rhyolitic) composition, for which the magma is too viscous to flow more than a few kilometers from the vent (Figure 2-25). The growth of domes is predominately an effusive process, and blocks of the surrounding terrain can be uplifted and tilted as the viscous magma approaches the surface (Spear and King 1982). Growing domes are steep-sided and rubbly, gravitatively unstable, and are therefore prone to slope failure. In addition, dome lavas commonly contain sufficient amounts of dissolved gas to generate small explosions. As a result, small-volume tephra-fall deposits and

blocky pyroclastic flows are frequently associated with dome growth (Fink 1990; Wohletz and Heiken 1992).

Several small ($<7 \text{ km}^3$) rhyolite domes were emplaced in the INEL area during the past 1.2 million years, located along the AVZ (Table 2-1 and Figure 2-12): Big Southern Butte (0.3 million years) (Spear and King 1982; Fishel 1993), Cedar Butte (0.4 million years) (Hayden 1992), East Butte (0.6 million years), Middle Butte (inferred as uplifted by a shallow silicic intrusion; uplifted basalt dated at 1.1 million years), and an unnamed butte (1.2 million years). The estimated recurrence interval for ESRP silicic-dome effusion in the INEL area is 200,000 years ($5 \times 10^{-6}/\text{yr}$), based on five domes (those cited above), emplaced within a 1-million-year period (1.2 to 0.3 million years).

The Quaternary rhyolitic domes postdate the earlier caldera-related silicic volcanism by about 3 million years, and they are compositionally dissimilar to the caldera rhyolites (Leeman 1982), suggesting that they are volcanologically distinct phenomena. Although tephra falls and small-volume pyroclastic flows are commonly associated with silicic-dome growth, no such deposits have been identified in the INEL area, probably owing to coverage by younger basaltic lava and sediment. Several centimeters of tephra could accumulate 10 km or more downwind of growing volcanic domes. Given the flat terrain of the ESRP and the major effects of dome effusion, intrusion, and uplift, pyroclastic volcanism and corrosive gases would likely be restricted to about 5 km from a growing volcanic dome. Any fumes and tephra associated with dome growth along the AVZ would probably be carried northeastward along the southern INEL boundary, and eventually offsite, by prevailing southwesterly winds.

Based on the apparent 200,000-year recurrence interval ($5 \times 10^{-6}/\text{yr}$) and the likely restriction of hazardous phenomena to near-vent areas, the probability of a silicic dome affecting the central and northern INEL is judged to be very small ($<10^{-6}/\text{yr}$). The most likely area of future silicic-dome emplacement is along the AVZ; hence, the probabilistic risk of impact on southern-INEL facilities would be somewhat higher, but still $<10^{-6}/\text{yr}$.

2.1.4.2.3 Basaltic Volcanism and Related Phenomena—With the exception of localized and infrequent silicic-dome volcanism, and as shown on Figure 2-12 and Table 2-1, Quaternary volcanism of the INEL area has been predominately basaltic. Potassium-argon (K-Ar) dating of lava flows (Kuntz et al. 1990) demonstrates that the ages of basaltic vents on the INEL range from greater than 1 million years on the northern INEL to about 200,000 years on the southern INEL near the AVZ. Although their vents are not situated on the INEL, four Holocene basalt lava fields erupted along the AVZ between about 13,000 and 5,000 years ago (Kuntz et al. 1986). In one case, the 13,400-year-old Cerro Grande lava field crossed what is now the southern INEL boundary. Quaternary basaltic volcanism on the ESRP has largely involved mild, effusive outpourings of fluid lava flows from eruptive fissures and small, low-lying shield volcanoes (Greeley 1982; Kuntz et al. 1992).

Volcanic-Rift Zones—Basaltic vents are not randomly disseminated across the INEL area, but tend to concentrate in northwest-trending, linear belts (Kuntz 1992; Kuntz et al. 1992),

known as VRZs. These belts are marked by basaltic vents as well as open fissures, monoclines, and small normal faults—structures that were produced during propagation of vertical dikes (0 to 4 km deep) that fed the surface eruptions (Figure 2-25) (Rubin and Pollard 1988; Smith et al. 1989; Hackett and Smith 1992). ESRP VRZs are inferred to be underlain by basaltic-dike swarms, based on their surface-deformation features and their equivocal correspondence with positive aeromagnetic and gravity anomalies (Josten et al. 1993). ESRP VRZs are polygenetic features (i.e., they were apparently active through numerous cycles of volcanism). The Great Rift has well-developed volcanic- and surface-deformation features that formed during eight cycles of Holocene volcanism (Kuntz et al. 1988) (Figure 2-22). Others such as the Arco VRZ are more diffuse and diachronous, with fissures and vents dispersed across an 8-km (5-mi) wide belt (see #4 in Figure 2-20), formed by multiple cycles of volcanism between 600,000 and 10,000 years ago. The Lava Ridge–Hells Half Acre volcanic-rift zone is a strongly diachronous feature; its northern portion is occupied by lavas more than 1 million years old, and its southern terminus is marked by the 5,200-year-old Hells Half Acre lava field and dike-induced fissures (#3 in Figure 2-20). Its central region is poorly developed and is marked by a single monocline that was likely induced by dike intrusion (#2 in Figure 2-20). The Howe–East Butte VRZ (Kuntz 1978) is poorly expressed surficially and is largely covered by fluvial and lacustrine sediment on the central INEL; five vents and several isolated fissures (#1 in Figure 2-20) are associated with a positive, northwest-trending aeromagnetic anomaly (Josten et al. 1993).

Axial Volcanic Zone—The most voluminous and recent volcanism in the INEL area occurred during the past 1.2 million years along the AVZ, which is a broad, northeast-trending constructional-volcanic highland consisting of coalesced basaltic shield volcanoes, tephra cones, and isolated silicic domes. The AVZ forms a topographic divide along the ESRP axis. It differs from VRZs because northwest-trending fissure swarms that typify VRZs are rare, and its overall topographic orientation is perpendicular to the regional stress field. Basaltic-dike-intrusion processes along the AVZ are probably similar to those of volcanic-rift zones, but increased magma supply along the ESRP axis and the predominance of large shield volcanoes has apparently covered most of the dike-induced surface deformation along the AVZ.

Hazards of INEL-Area Volcanism—Table 2-2 lists hazards associated with ESRP basaltic volcanism, based on interpretation of the ESRP eruption products, and by analogy with historical observations of rift-zone volcanism in Hawaii and Iceland (seismicity related to basaltic-dike intrusion along VRZs is discussed in Section A.2 of Appendix A). The most significant hazard is inundation or burning of facilities by lava flows. Such flows vary greatly in volume and may cover a few square kilometers to 400 km² or more (Kuntz et al. 1992). On gentle terrain such as the ESRP, lava flows would generally move downslope at a few meters per minute. Large lava flows on the ESRP seldom exceed 30 km (18.6 mi) in length, and most are less than 12 km (7.5 mi) long. Borehole investigations and outcrop studies indicate that most ESRP basaltic lava flows are less than 10 m (33 ft) thick and taper to several-meter thickness at flow edges. They are therefore unlikely to surmount major topographic or manmade obstacles. The general topography and vent locations of the INEL area (Figure 2-20) suggest that future lavas will most likely erupt from vents along the AVZ or at the intersections of that zone with the VRZs, from which they could flow toward the central INEL.

Table 2-2. Hazards associated with basaltic volcanism on the ESRP. Entries are listed from highest to lowest relative hazard.

PHENOMENON	RELATIVE FREQUENCY	SIZE OR AREA OF INFLUENCE	COMMENTS
lava flow	common	3 km ² to 400 km ² area of coverage, based on sizes of ESRP lava fields of the past 15 Ka	significant hazard; typical basaltic phenomenon; lava from fissures or shield volcanoes may inundate large areas downslope of vents
ground deformation: fissuring, faulting and uplift	common; associated with virtually all shallow magma intrusion, and eruption	fissuring could affect areas of 2 x 20 km; minor tilting & broad uplift in areas to 5 x 20 km	significant hazard; due to shallow dike intrusion; "dry" intrusion may occur without lava flows
volcanic earthquakes	common; associated with magma intrusion before and during eruption	maximum M = 5.5 and most events M < 4; ground vibration may affect facilities within 25 km	moderate hazard; swarms of shallow earthquakes (<4 km focal depth) occur as dikes propagate underground
gas release	common; associated with fissuring and lava effusion	may affect few km ²	low hazard; local plume of corrosive vapor, downwind from eruptive vent or fissure
tephra fall	rare	restricted to near-vent areas; may affect several km ² downwind	low hazard; basaltic eruptions are inherently nonexplosive and may form small tephra cones but little fine ash to be carried downwind
base surge (ground-hugging blast of steam and tephra)	rare	effects limited to radius of several km from vent; < 10 km ² area	low hazard; steam explosions due to interaction between ascending magma and shallow groundwater; water table too deep under most of INEL
tephra flow (ground-hugging flow of hot, pyroclastic material)	extremely rare	near vent; may affect area < 1 km ²	very low hazard; as per tephra fall but affecting even smaller areas

2.1.4.3 Volcanic Recurrence and Probabilistic Risk for INEL-Area Volcanism.

Although volcanic hazards can be qualitatively identified on the basis of the geologic record, risk is more difficult to assess because risk is usually expressed quantitatively and in probabilistic terms. Volcanic hazards may exist, but there can be no risk unless life or property is threatened. Risk can be thought of as the product or interplay of some hazardous phenomenon "x" and its potential impact on life or property at a given location. Quantitative risk assessment requires not only detailed knowledge of the timing and nature of past volcanism, but also the conditional probability of its impact on human life or property. Conditional probabilities take into account not only volcanic-recurrence intervals, but also nonvolcanic parameters such as distance from vents, local-terrain configuration, and prevailing-wind directions.

Table 2-3 gives estimated volcanic-recurrence intervals for INEL volcanic zones and borehole sites, estimated by summation of individual vents and fissures in the respective volcanic zones, and dividing that sum by the total time period of volcanism within each zone. This approach gives minimum-recurrence estimates and is very conservative because it is assumed that every vent or fissure (sometimes a set of fissures, when they could be confidently grouped as cogenetic) represents a single eruptive episode. It is more likely that each eruptive episode involved eruptions from several vents and the opening of multiple fissures, based on the record of Holocene volcanism and on analysis of ESRP magma generation, rise, and storage (Kuntz 1992; Hackett and Smith 1992).

In general terms, Table 2-3 and Figures 2-12 and 2-22 suggest that the shortest recurrence intervals (8,000 to 15,000 years), the most recent volcanism (Holocene lava fields), and hence the most probable areas of future basaltic volcanism and ground deformation are the AVZ and the Arco VRZ. Within this context, Volcanism Working Group (1990) estimated the conditional probability of basaltic volcanism to affect a south-central INEL site as being less than 10^{-5} /yr. This value can generally be applied to sites across the southern INEL, where the risk due to AVZ basaltic (and rhyolitic) volcanism is greatest. On the northern INEL, far from the AVZ, and where both silicic and basaltic volcanism are older and less frequent, the probability of ESRP volcanic impacts to facilities is estimated to be less than 10^{-6} /yr.

2.1.4.4 Potential Volcanic Hazards from Distant Sources. The locations and general characteristics of potentially hazardous volcanoes in the western United States are summarized by Bailey et al. (1983) and by Wright and Pierson (1992), and potential impacts to the INEL from eruptions of those volcanoes are addressed by Volcanism Working Group (1990). The selective analysis given below supports the general conclusion that significant impacts to the INEL from distant volcanic eruptions are highly improbable.

Yellowstone—Geologic and geophysical investigations (Smith and Christiansen 1980) indicate that the mantle plume that has left its 15-million-year track across southern Idaho and formed the SRP now resides beneath the Yellowstone Plateau, explaining the crustal structure, high heat flow, geothermal features, and explosive silicic volcanism of that area. The Yellowstone Plateau volcanic field has produced more than 6,000 km³ of silicic tephra, in three cycles of explosive, caldera-related volcanism during the past 2.1 million years, largely in the form of

Table 2-3. Estimated volcanic-recurrence intervals (and eruption probabilities) for volcanic zones and borehole sites in the INEL area.

VOLCANIC ZONE OR BOREHOLE	DATA SOURCES	TIME INTERVAL OF VOLCANISM [years b.p.]	NUMBER OF VENTS OR GROUPS OF VENTS/FLOWS/FISSURES	COMMENTS	ESTIMATED RECURRENCE INTERVAL (1)	ESTIMATED RECURRENCE INTERVAL (2)
Great Rift (25 km southwest of INEL)	Kuntz and others, 1986, 1988	2,100 - 15,000 yrs (radiocarbon dating)	> 85 total vents & lava flows; 8 fissure groups; 8 Holocene eruptive periods (each lasting a few centuries, and each including multiple flows and cones)	no impact on INEL; most recently and frequently active of all ESRP rift zones; thus provides minimum-recurrence for entire ESRP; most probable area of future ESRP volcanism	176 yrs (5.7×10^{-3} / yr)	1,800 yrs (5.3×10^{-4} / yr)
Axial Volcanic Zone (southern INEL)	Kuntz and others, 1986, 1990	5,000 - 730,000 yrs (K-Ar dating; radiocarbon; paleomagnetic data)	65 mapped vents; 4 Holocene lava fields, 3 of them shared by volcanic rift zones. 20 vent/flow/fissure groups	could affect much of southern INEL; most recently and frequently active of all volcanic zones that could impact INEL	8,000 yrs (1.2×10^{-4} / yr)	36,500 yrs (2.7×10^{-5} / yr)
Arco Volcanic Rift Zone (southwestern INEL)	Kuntz, 1978; Smith and others, 1989; Kuntz and others, 1990	10,000 - 600,000 yrs (radiocarbon, K-Ar and TL dating; paleomagnetic data)	50 vents and fissure sets; 2 Holocene lava fields. 15 vent/flow/fissure groups	volcanism could affect southwestern INEL	12,000 yrs (8.3×10^{-5} / yr)	33,300 yrs (3×10^{-5} / yr)
Lava Ridge-Hells Half Acre Volcanic Rift Zone (north & east INEL)	Kuntz and others, 1986, 1990	5,000 - 1,200,000 yrs (K-Ar dating; radiocarbon; paleomagnetic data)	35 mapped vents, fissures and monoclinal; 1 Holocene lava field: Hells Half Acre. 10 vent/flow/fissure groups	could affect northern & eastern INEL; extremely long eruptive history; includes oldest and youngest basalts in the INEL area	50,000 yrs (2×10^{-5} / yr)	120,000 yrs (8.3×10^{-6} / yr)
Howe-East Butte Volcanic Rift Zone (central INEL)	Kuntz, 1978; Golder Associates, 1992	230,000 - 730,000 yrs (K-Ar dating; paleomagnetic data)	5 - 7 mapped vents and fissures. 4 vent/flow/fissure groups	old, poorly exposed and sediment-covered; identified in part by subsurface geophysical anomalies	100,000 yrs (1×10^{-5} / yr)	125,000 yrs (8.0×10^{-6} / yr)
Borehole NPR SITE E (south-central INEL)	Champion and others, 1988	230,000 - 640,000 yrs (K-Ar dating; paleomagnetic data)	9 lava-flow groups (each group contains multiple flows, erupted over a short time)	dates from 600-foot interval of subsurface lavas give recurrence estimate consistent with surficial geology of the area	(not applicable; total number of lava flows unknown)	45,500 yrs (2.2×10^{-5} / yr)
Borehole RWMC 77-1 (southwestern INEL)	Kuntz, 1978; Anderson & Lewis, 1989	100,000 - 565,000 yrs (K-Ar and TL dating; paleomagnetic data)	11 lava-flow groups (each group contains multiple flows, erupted over a short time)	dates from 600-foot interval of subsurface lavas give similar recurrence interval as nearby Arco & Axial zones, reflecting general correspondence of subsurface flow groups and surface vent groups.	(not applicable; total number of lava flows unknown)	42,000 yrs (2.4×10^{-5} / yr)

Estimated volcanic-recurrence intervals (with corresponding annual probabilities of occurrence given in parentheses), for volcanic zones and borehole sites in the INEL area.

Recurrence intervals (1) are based on counting of individual vents and fissures, an extremely conservative procedure that yields bounding values of minimum recurrence (shortest intervals). Recurrence intervals (2) are based on grouping of vents and fissures into geologically reasonable sets according to (a) the assumption that vent / fissure groups each cover a 2 x 5-km geographic area (based on observed areas of vent / fissure sets that were products of discrete ESRP fissure eruptions), (b) consistency with map relations and (c) other factors such as NW-alignment of vent / fissure groups and professional judgement concerning the spatial relationships of vents and fissures within the context of magmatic processes.

tephra-fall and pyroclastic-flow deposits (Christiansen 1984). Ash layers from Yellowstone have been identified in the Quaternary stratigraphic record across much of western North America (Izett and Wilcox 1982). Eruptions of this magnitude are rare in the worldwide geologic record, and the three climactic Yellowstone eruptions occurred at 2.1, 1.3, and 0.6 million years (Christiansen 1984), for an average recurrence interval of 700,000 years.

Hazards on the INEL from potential Yellowstone eruptions include blanketing by pyroclastic flows or volcanic ash. The INEL lies 160 km (99 mi) from the Yellowstone caldera rim, and more than 200 km (124 mi) from the Hot Springs Basin area of northeastern Yellowstone, a likely site of future eruptions. For comparison, maximum-runout distances of large-volume pyroclastic flows (ignimbrites) from Yellowstone, the ESRP, and elsewhere, traveling on relatively flat terrain, generally range from 100 to 150 km (62 to 93 mi). Hence, the likelihood of pyroclastic flows from even the largest Yellowstone eruptions reaching the INEL is essentially nonexistent because of the great distance and intervening topographic barriers.

Although no direct relationship exists between ashfall thickness and damage parameters (Blong 1984), the historical eruptions of Mt. St. Helens demonstrate that about 8 cm (3 in.) of ash can generally be accommodated by the infrastructure of a technologically advanced nation, without serious long-term consequences (Warrick et al. 1981). Ash-fall thickness from Yellowstone could exceed 8 cm (3 in.) if there were a large eruption ($>40 \text{ km}^3$), and if wind conditions were to disperse the ash cloud directly over the INEL. Such conditions are conceivable in light of past Yellowstone volcanism, but are highly improbable because prevailing winds would not likely direct ash toward the INEL and because the recurrence intervals of such events are extremely long (0.5 to 1 million years). It is worth noting that less than 5 cm (2 in.) of Yellowstone ash have been found on the ESRP at INEL-equivalent distances (Izett and Wilcox 1982).

Cascade Volcanoes and Other Western United States Centers—The Cascade volcanoes of Northern California, Oregon, and Washington have produced many Quaternary tephra layers, some of them widely dispersed across the western United States (Izett 1981). These centers lie 700 to 800 km west of the INEL, at distances and prevailing-wind directions that prevent all but the largest ashfall eruptions from impacting the INEL area. The Mazama ash is a voluminous (ca. 40 km^3) and widespread ash layer that erupted from what is now Crater Lake, Oregon, and is a product of the largest-known Cascade eruption. In the INEL area, the Mazama ash is from 0.5 to 2 cm (0.2 to 0.8 in.) thick.^a Theoretical considerations and field measurements indicate that less than 6 cm (2.4 in.) of Mazama ash would have fallen on the INEL if the dispersal axis of the cloud were directly overhead. This effectively eliminates all Cascade volcanoes as sources of significant [$>8 \text{ cm}$ (3.3 in.)] ashfall at the INEL.

A similar conclusion is reached for other western United States volcanoes, such as the Long Valley caldera, which erupted about 600,000 years ago and produced the 600-km^3 Bishop Tuff.

a. Private communication with S. J. Miller and A. J. Crone, 1990.

Long Valley is more than 800 km (497 mi) southwest of the INEL. As per the Yellowstone analysis given above, significant [>8 cm (3.3 in.)] ash fall could be expected only for improbable conditions and at extremely long recurrence intervals.

2.1.4.5 Conclusions. Hazards associated with INEL-area volcanism as well as distant volcanic sources are evaluated. The most significant hazards and risks to INEL facilities are associated with basaltic volcanism and related phenomena from ESRP vents.

For volcanic areas such as the ESRP, with no historical volcanism and an incomplete chronologic record of prehistoric volcanism, assessments of potential volcanic hazards and volcanic risk are based on interpretation of the long-term geologic record, and on the documented effects of historical eruptions in analog regions such as Iceland and Hawaii. Volcanic hazards to the INEL are related to future basaltic and rhyolitic eruptions along VRZs and the AVZ. The most significant volcanic hazard to INEL is the inundation or burning of facilities by basaltic lava flows from VRZs. A significant, related hazard is disruption of facilities due to ground deformation accompanying magma intrusion along VRZs; opening of fissures, normal faulting, broad-region tilting, and uplift within several km of vents (see Surface Faulting discussion in Section A.2 of Appendix A). Other, less significant basaltic hazards include volcanic-gas emission and disruption of groundwater.

Available geologic-map data and geochronometry of INEL basalt lava flows suggest minimum (most conservative) volcanic-recurrence intervals of 10^{-4} to 10^{-5} per year, for the AVZ and for the Arco and Lava Ridge-Hells Half Acre VRZs. The probabilistic risk of basalt-lava inundation or intrusion-related ground disturbance is therefore estimated to be less than 10^{-5} /yr for adjacent sites on the southern INEL. Risk from these phenomena at northern-INEL sites is still lower because volcanism there has been less frequent and less recent. The probability of significant impact from all other volcanic phenomena, such as growth of new rhyolite domes on the ESRP or thicker than 8-cm (3.3-in.) tephra fall from non-ESRP vents, is estimated to be $<10^{-5}$ /yr, due to the combined effects of great distance, infrequency, low volume, and topographic or atmospheric barriers to the dispersal of tephra on the INEL.

2.2 Soils

With the exception of a few prominent buttes, the landscape of the INEL is dominated by fairly low-relief lava flows of various ages, which produce irregular topography. The flows range in slope from nearly flat (0–2%) to fairly steep (up to 30%) in areas of pressure ridges. The lava is primarily a highly porous and fractured basalt of Pleistocene and Holocene age. It is capped by wind-blown sediments from several episodes and sources (see Section 2.2.1). A general soil map of the INEL is presented in Figure 2-26.

The Big Lost River and Birch Creek influence soils of the western half and the northern part of the INEL (Section 2.2.2). North of the Big Lost River are sediments from ancestral Lake Terretton, which are generally very deep, fine-grained (clay loams and clays), and alkaline (see Section 2.2.3). Soils formed in colluvium along the foothills of the western edge of the INEL are

Figure 2-26. Soils at the INEL.

discussed in Section 2.2.4. A more comprehensive discussion of these soil types may also be found in Olson and Jeppesen (1993).

2.2.1 Eolian Sediments Over Lava

The majority of landforms at the INEL are dominated by lava flows. Most of the lava within soil profiles is either fractured rocks or basaltic grus (decomposed basalt), although there has been evidence that some of the lava has weathered to sand- and silt-sized particles. The contribution of the weathered material to the sola is geographically variable due to the complex interaction of parent material, erosion, and decomposition (weathering). Overlying the lava flows are eolian materials, which vary in thickness, origin, and properties.

Eolian sediments are either loess or eolian sand, ranging in depth from a thin veneer to over 2.3 m (6 ft). Most eolian deposits on the INEL are around 1.2 to 1.9 m (3 to 5 ft) deep, and almost all are less than 3.8 m (10 ft). Loess is fine-grained sediment, generally originating from the glacial flour left behind by retreating glaciers during the Pleistocene. Eolian sands are coarser-grained sediments, believed to have originated from the Big Lost and Snake Rivers, and the shorelines of ancestral Lake Terreton.

There are believed to be at least two distinct episodes of loess accumulation represented on the INEL (Forman 1993). Age dating using thermoluminescence and radiocarbon methods indicate that the youngest loess (Loess A) was deposited between 40,000 and 10,000 years ago. The older deposit at the INEL, Loess B, was deposited between 80,000 and 60,000 years ago (Forman 1993). The soil developed in Loess A contains a calcic horizon in the subsurface, typical of a desert soil. The Loess B deposit contains a paleosol with an argillic horizon underlain by a C horizon. The Bt (argillic) horizon in Loess B contains clay cutans and has a clay maxima of 32 to 36% (Forman et al. 1993). A stratigraphically older loess unit (tentatively Loess C) is present at limited exposures on the INEL (Forman et al. 1993).

The source of the loess has not been conclusively identified. Forman et al. (1993) suggest that the origin of the Pleistocene loess on the SRP may be the aggraded valleys, alluvial fans, and pluvial lake margins that existed during glaciation. Nace et al. (1975) indicate that the loess is not locally derived and was seemingly originated by deflation from "distant" areas.

Not all eolian deposits are silty loess. Eolian sands are predominant along the eastern margins of the Big Lost River and in the northern half of the INEL (Figure 2-26). Eolian sands on the INEL likely originated from the Big Lost or Snake Rivers or from the beaches of the ancestral Lake Terreton. INEL eolian sand deposits examined by Bright and Davis (1982) contain diatoms and sponge spicules, suggesting that the original source for the loess was lake and stream beds of the region, and that the remains of aquatic organisms can be moved from their source by wind.

Unlike silt- and clay-sized particles, which are transported in a suspended load, sand grains are transported by bouncing or being knocked into the air by another grain. The jumping sand

grains never get far off the ground, rarely exceeding 0.9 m (3 ft) in a strong desert wind (Flint and Skinner 1974). Being always close to the ground, sand is easily stopped by obstacles and heaped into dunes. This discontinuous distribution of sand differs from that of the blankets of loess, largely because of the nature of the transport processes involved. It is not possible to capture the microdistribution of sands on a general soils map.

Elongated dunes are conspicuous in the northeastern part of the INEL. They are stretched across the top of clayey sediments from the ancestral Lake Terreton.

2.2.2 Alluvial Deposits

The Big Lost River, Birch Creek, and the Little Lost River enter the INEL and terminate in four playas in the north-central part of the INEL. The Big Lost River drains approximately 3,650 km². It enters the INEL on the west side of the Site, flows northward, and terminates in a relatively dramatic setting called the Big Lost River Sinks. There are three recognized terraces of the Big Lost River on the INEL. Around the Test Reactor Area, older deposits are capped with desert pavement and have moderately developed calcic horizons at a depth from 25.4 to 30.5 cm (10 to 12 in.). Typically, the soils are gravelly sands to gravelly loams or loamy sands, with low water holding capacity and high permeability. There are also several earth mounds in this area. Deposits closer to the most recent channel of the river, i.e., the younger deposits, generally show little sign of calcic horizon formation, and most are not capped with desert pavement. These soils are classified as young soils that occur on recent erosional surfaces or floodplains.

The textural classes change along the course of the river, but where these changes occur is not well understood or mapped. There is a dramatic change in textural class from the floodplain at the southern end of the Site to the Sinks area to the north, but whether there is a gradual or sudden change related to the gradational settling of sediments is yet undetermined. Depth to gravel from the deposit is highly variable, as seen in some of the gravel pits in the alluvium around the Test Reactor Area and the Central Facilities Area.

Birch Creek originates from springs below Gilmore Summit in the Beaverhead Mountains and terminates on the INEL in an area called the Birch Creek playa. The Birch Creek alluvial deposits on the INEL are generally gravelly loams. The playa deposit, in contrast, is deep, calcareous, alkaline, silty clay loam or silty clay. This deposit, which occupies the lowest elevation on the INEL, overlies the ancestral Lake Terreton deposit.

Soils in the Birch Creek alluvium exhibit considerable variability, but generally the profiles consist of a loamy surface soil over an alluvial gravel subsurface. Bartholomay and Knobel (1989) analyzed the mineralogy of surficial sediments from Birch Creek drainage, and reported dominantly quartz and calcite, with lesser amounts of feldspar and other minerals.

2.2.3 Lacustrine Deposits, Playas, and Sand Dunes

Ancestral Lake Terreton occupies much of the northern part of the INEL, and is overlain in many areas by sand dunes or elongated sand "trains." This lake was probably originally fed by both the Big Lost River and Birch Creek, and the high stage of the lake is estimated to be at an altitude of about 1,463 m (4,800 ft) above mean sea level (Nace et al. 1975). Bright and Davis (1982) indicate that Lake Terreton was a shallow (8-m) lake that once covered about 150 km² of land, and filled its basin as recently as 700 years ago. The lacustrine deposit generally consists of clayey, alkaline surface soils over stratified subsoils. Some of the soils in the ancestral lake bed are sodic, i.e., high in exchangeable sodium. The sandy deposits over the lacustrine deposits consist of eolian sand, presumably from the Big Lost or Snake Rivers or the Lake Terreton shoreline.

Bars, spits, and hooks from Lake Terreton are well preserved on the modern landscape. On top of some of the Lake Terreton deposits are deposits of the Birch Creek playa, at the terminus of the Birch Creek and the Big Lost River Dry Channel (Nace et al. 1975). Interestingly, these features are also clayey at the surface. One of the shorelines from Lake Terreton is clearly visible in the Test Area North area. The playa deposits contain an abundance of free carbonates, as evidenced by their strong reaction (effervescence) to dilute hydrochloric acid. Salt-tolerant plant species occupy the playa, indicating the presence of salinity in the soil (but no data are available to verify this).

Patches of sand are found throughout the old Lake Terreton area. The origin of the sand is believed to be from the beaches of ancestral Lake Terreton or the Big Lost or Snake Rivers. These sands are characteristically very well sorted, with little silt and practically no clay (Nace et al. 1975). They exhibit little soil development. Most likely, the dunes are still shifting or have only recently become stabilized. Soils in the sands lack a calcic horizon and support plant communities that are distinct from surrounding areas. Unlike loamy sites, which support Wyoming big sagebrush and blue bunch wheatgrass, these sandy sites typically support basin big sagebrush and Indian ricegrass. These sandy soils are situated on top of clayey lake bottom sediments, which are remnants of Lake Terreton and the Birch Creek playa.

Relatively large playas are located at the terminus of the Big Lost and Little Lost Rivers in the Big Lost River Sinks, and at the terminus of the Birch Creek in the Birch Creek playa. The Big Lost River Sinks area contains the largest expanse of wetlands on the INEL. Areas within the Sinks at one time supported cattails and similar wetland plant species, and shells are widespread in the Sinks. Soils in the area (characterized as Blackfoot soil series) are deep, moist, and rich in organic matter. The Birch Creek playa contains deep, clayey, alkaline soils overlying stratified deposits of the ancestral Lake Terreton.

Small playas are located throughout the lava flows and within Lake Terreton deposits. These features are too small to delineate on a general soils map, but consist of fine-grained soils, which may be sodic.

The Birch Creek playa is the lowest elevation on the INEL. Birch Creek playa surface soils are generally fine-grained, alkaline silty clay loams and clays (with as much as 40% clay), have high cation exchange capacity, and relatively high amounts of calcium, magnesium, and sodium.

The soils generally have low permeability and support salt-tolerant plant species. Surface soils in the fine-textured Birch Creek deposits develop surface cracks, which occur on bare surfaces between vegetation.

Ryegrass Flats is located at the entrance of the INEL on Highway 20, and an unnamed playa is located south of Power Burst Facility. These have been delineated on the soils map (Figure 2-26) because of their distinctive appearance and features, even though they are smaller than other mapping units.

Both of these playas contain very deep, fine-grained soils and support grasses. Small playas and slickspots are inclusions in other mapping units and have not been delineated.

2.2.4 Colluvial Deposits

Colluvial deposits are prevalent along the mountainous slopes on the west side of the INEL and surrounding East and Middle Buttes. In some areas, the transition from colluvium to alluvium is gradual, and the boundaries of map units designed around these concepts are somewhat arbitrary. The deposits grade from colluvial deposits along the foothills to outwash and terrace deposits on lower slopes. Generally, the soils in these deposits are gravelly.

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3. AIR RESOURCES

Patrick R. Leonard

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ACRONYMS

ANL-W	Argonne National Laboratory-West
CFA	Central Facilities Area
CO	carbon monoxide
dBA	decibels
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EPA	Environmental Protection Agency
ESRP	Eastern Snake River Plain
INEL	Idaho National Engineering Laboratory
LOFT	Loss of Fluid Test
NO _x	nitrogen oxides
NPR	New Production Reactor
OSHA	Occupational Safety and Health Administration
SO ₂	sulfur dioxide
TAN	Test Area North
TSP	total suspended particulate
VMT	vehicle miles traveled

3. AIR RESOURCES

Air resources at the Idaho National Engineering Laboratory (INEL) are those parameters that are normally associated with and influenced by atmospheric conditions. For additional information on air resources, see Clawson et al. (1989), which summarizes the climate of the INEL, and Department of Energy (DOE) (1992), which contains annual air monitoring information for regulatory purposes. Noise levels at the INEL are measured for regulatory purposes by the responsible industrial hygienist and for environmental impacts.

3.1 INEL Climatic Conditions

The climatological database of the INEL consists of several types of measurements. The wind regime on and around the INEL has been monitored in detail for many years. These data comprise the largest portion of the INEL climatological database. Air temperature has also been monitored in detail for many years, and the data comprise the second largest portion of the database. Wind speed and direction and air temperatures are currently monitored at many locations on-Site and off-Site. Precipitation and atmospheric moisture content also comprise part of the climatological database. These parameters are currently being measured at a few sites on the INEL (Clawson et al. 1989).

Other parameters that have been measured in the past, but for which observations have been stopped, include soil temperature, solar and terrestrial radiation, atmospheric pressure, and the state or condition of the ground. Other special atmospheric phenomena have been observed and are found in the climatological database. Descriptions and summaries of each of these types of data are found in Clawson et al. (1989) and in the similar reports that preceded it.

3.1.1 INEL Meteorological Observation Network

There were 30 meteorological observation stations in operation at and surrounding the INEL as of January 1993. Table 3-1 gives the type of data being collected, the period of record, and the location code for each station. The physical location of each on-Site and off-Site active observation station is shown in Figures 3-1 and 3-2.

All the monitoring stations currently measure wind speed and direction, normally at 15 m (50 ft) above ground level. Air temperature is also recorded at some of these stations, normally at the 1.5-m (5-ft) level. The Loss of Fluid Test (LOFT) facility, Argonne National Laboratory-West (ANL-W), and Grid 3 serve as primary observation stations. These stations are heavily instrumented. Tall towers at these stations measure wind velocity and air temperatures at multiple levels up to 76 m (250 ft). Atmospheric humidity is also currently recorded at Central Facilities Area (CFA) and ANL-W, while precipitation is monitored at CFA. These data are continuously being added to the INEL climatological database.

Meteorological data have been collected at more than 45 locations on and near the INEL. The weather station at the CFA, established in 1949, was the first meteorological observation

Table 3-1. Active INEL meteorological monitoring stations as of January 1993.

LOCATION	Period of Record			
	CODE	WIND SPEED & DIRECTION	AIR	PRECIPITATION
			TEMPERATURE	
ONSITE STATIONS				
Argonne National Lab-West ^{a,b}	ANL ^b	1964-present ^c	1964 present ^c	none
Base of Howe Peak	BAS	1992	1992	none
Central Facilities ^a	CFA	1950-present	1949-present	1950-present
Deadman Canyon	DEA	1992	1992	none
Grid 3	GRI	1957-present ^{c,e}	1979-present ^c	none
Loss of Fluid Test	LOF ^d	1953-present ^{c,e}	1987-present ^c	none
Naval Reactor Facility	NRF	1956-present	none	none
Power Burst Facility	PBF	1964-present	none	none
Radioactive Waste Management Complex	RWM	1977-present	none	none
Rover	ROV	1972-present	none	none
Sand Dunes	SAN	1956-present	none	none
Test Reactor Area	TRA	1971-present	none	none
OFFSITE STATIONS				
Aberdeen	ABE	1968-present	none	none
Arco	ARC	1968-present	none	none
Big Southern Butte	BIG	1968-present	none	none
Blackfoot	BLA	1968-present	1971-present	none
Blue Dome	BLU	1968-present ^c	1954-present ^c	1954-1955
Craters of the Moon	CRA	1992	1992	none
Dubois	DUB	1968-present	1971-present	none
Hamer	HAM	1971-present	none	none
Howe	HOW	1950-present ^e	1971-present	none
Idaho Falls	IDA	1968-present	none	none
Kettle Butte	KET	1968-present	none	none
Minidoka	MIN	1968-present	1972-present	none
Montevieu	MON	1955-present ^c	1955-present ^c	1955-1963
Richfield	RIC	1968-present	1972-present	none
Roberts	ROB	1968-present	none	none
Sugar City	SUG	1968-present	1972-present	none
Taber	TAB	1968-present	none	none
Terreton	TER ^c	1950-Present ^c	1958-1961	1958-1961

- a. Instrumentation includes dew point temperature (period of record is from 1978 for CFA and 1978 for ANL-W).
- b. Station code is also referred to as Experimental Breeder Reactor (EBR)-II.
- c. Meteorological variable is measured at multiple levels.
- d. Station code is frequently identified as TAN.
- e. Station was not operational for the entire period of record.

Figure 3-1. Location of the on-Site active INEL meteorological monitoring stations.

Figure 3-2. Location of the off-Site active INEL meteorological monitoring stations.

station established solely in support of the INEL. It is also the only on-Site station with over 35 years of record for air temperature and precipitation. The National Climatic Data Center contains data from this station under the designation "Idaho Falls 46 W." Data from the Test Area North (TAN) station were included in National Climatic Data Center records under the designation "Idaho Falls 42 NW." Some early monitoring stations, established in 1950 and 1951, were originally identified as follows:

- R (or A) = Arco
- WBO = CFA
- P = East Perimeter
- H = Howe
- M = Midway
- T = Terreton.

The Midway and East Perimeter stations, however, are no longer being used. The Arco, CFA, Terreton, and Howe stations are still operational and are currently designated ARC, CFA, TER, and HOW, respectively. Additional details about these stations are more completely discussed in Clawson et al. (1989).

Some confusion may arise when using climatological data from old or discontinued stations. Many old stations have been known by more than one name, which was usually a one-letter location designation as given above. For example, instrumentation at TAN has, at different times, been known as Idaho Falls 42 NW, ANP, WXA-2, LOFT, and Initial Engine Test. Currently, the LOFT station is known as LOF. The location of a few stations has also changed. For example, the current Terreton site (TER) is not at the original Terreton (T) site. Furthermore, several monitoring stations have been combined into one station; for example, STRs 1, 2, 3, and 4 have been combined as the Naval Reactors Facility. Therefore, one must exercise care when working with older data.

3.1.2 INEL General Weather Pattern

3.1.2.1 Wind Patterns. Since 1950, many monitoring stations have continuously measured wind speed and direction (always recorded as the direction from which the wind is blowing). The network of wind stations supporting operational requirements at the INEL has been expanded considerably since the installation of the original six stations. These original stations were upgraded and new sites established during the 1964–1970 period to form an expanded observational network using 15-m (50-ft) towers. The original strip chart recording system was replaced during 1969–1970 with radiotelemetry equipment. Knowledge of the general wind flow patterns on the INEL is based on these data records.

Wind patterns over the INEL can be quite complex. The orientations of the surrounding mountain ranges and the Eastern Snake River Plain (ESRP) play an important part in determining the wind regime. The INEL is in the belt of prevailing westerly winds, which are channeled within the ESRP to produce a west-southwest or southwest wind. Local mountain and

valley features exhibit a strong influence on the wind flow under other meteorological conditions as well. At the mouth of Birch Creek, the northwest to southeast orientation of this valley channels strong north-northwest winds into the TAN weather station area.

3.1.2.1.1 INEL Near-surface Wind Flow Patterns—The characteristics of the near-surface wind regime at the INEL can best be described using a graphical display called a wind rose. Wind roses are graphs that display the frequency (in percent) of the occurrence of winds from various direction sectors for selected speed classes and calm periods. This is an effective method of showing joint wind speed and direction frequency distributions at a glance. They easily illustrate the differences between stations, seasons, sensor levels, stability classes, etc. Wind roses for several stations are shown on pages 15 through 26 in Clawson et al. (1989).

3.1.2.1.2 Winds Aloft—An extensive record of upper air observations, taken from routine pibal (pilot balloon) observations, exists from 1950 through 1965. A pibal was released every morning at CFA during those years between 8:00 and 10:00 to obtain the wind speed and direction at selected levels above the surface. These balloons were tracked up to heights of 4,270 m (14,010 ft) mean sea level. The primary purposes of these soundings was to provide information for short-term forecasts in support of INEL operations. A detailed wind rose analysis of the compiled data set, however, is helpful in understanding the INEL wind regime.

Wind roses for the winter, spring, summer, and fall seasons, and combined winds from all seasons illustrate several features of the wind speed and direction variation with height above the INEL [see pages 40–44 in Clawson et al. (1989)].

3.1.2.1.3 INEL Wind Speeds—Monthly average wind speeds, corresponding directions at the 6- and 76-m (20- and 250-ft) levels, the highest hourly average wind speeds, and corresponding directions for a given month at CFA are shown on page 28 of Clawson et al. (1989). The same type of information for the 6- and 46-m (20- and 150-ft) levels at TAN is listed on page 29 of the same reference. April has the highest 20-ft average wind speed at both CFA (9.3 mph) and TAN (9.5 mph). December has the lowest average wind speed at 20 ft for both CFA (5.1 mph) and TAN (4.6 mph).

3.1.2.1.4 INEL Atmospheric Stability Classes and Associated Conditions—Atmospheric stability class data starting about 1980 are available for most of the on-Site stations. Some of these data are summarized by wind roses shown on pages 38 and 39 of Clawson et al. (1989). Other stability data are available in tabular form as joint frequency distributions. Some of these joint frequency distributions are included in the attachments to the Engineering Design Files (EG&G Idaho 1991; EG&G Idaho 1992). A joint frequency distribution is a compilation of the number of hours the wind blows in each of the 16 compass directions, for each wind speed class, and for each stability class.

In the past, stability classes were defined by a Nuclear Regulatory Commission method using vertical temperature gradients. Currently, an Environmental Protection Agency (EPA) method assigns hours to the six (A–F) stability classes. This EPA method uses a σ_θ approach based on

the standard deviation of the horizontal wind direction, the wind speed at 10 m (10 ft), and information on daytime versus nighttime data.

3.1.2.2 INEL Temperature Patterns. The location of the INEL, including its altitude above sea level, its latitude, and its intermountain setting, affects the climate of the Site. Annual rainfall at the INEL is light and the region is classified as arid to semi-arid. The INEL's dry air and infrequent low clouds allow intense solar heating of the surface during the day and rapid cooling at night. These factors combine to give a large diurnal range of temperature near the ground. Due to the moderating influence of the Pacific Ocean, most of the air masses flowing over this area are usually warmer during winter and cooler in summer. The average daily air temperature for a 39-year period at two points on the INEL varied from a low of -12.2 to 10.6°C (10 to 13°F) in January, to a high of 21°C (70°F) in July. The average daily air temperature range is 3.3°C (38°F) in summer and -5°C (23°F) in winter. The Centennial and Bitterroot Mountain Ranges keep most of the shallow but intensely cold winter air masses from entering the ESRP when they move southward from Canada. Occasionally, however, the cold air can spill over the mountains. When this happens, cold air is held in the ESRP by the surrounding mountains, and the INEL experiences low temperatures for periods lasting a week or longer. Clawson et al. (1989), pages 47-70, contain INEL air temperature data and discusses the data and its implications.

Solar radiation is the source of the energy for most air movement in the atmosphere. It is measured in terms of global, direct, diffuse, and net radiation. It can also be converted to percent possible sunshine, percent sky cover, and day length. Data on these parameters are available in Clawson et al. (1989), pages 94-97.

3.1.2.3 INEL Moisture Patterns. Precipitation and atmospheric moisture data are detailed in Clawson et al. (1989), pages 76-93. The frequencies of occurrence, probabilities, and duration of precipitation periods are discussed and data presented in tables. Snowfall amounts and accumulations are recorded. Also discussed are parameters such as humidity, dew point temperature, mixing ratio, and pan evaporation rate. For example, the following data can be found in Clawson et al. (1989): The average annual total precipitation is between 8 and 9 in. The average mid-day relative humidity is about 55% in the winter. The average mid-day relative humidity in the summer is about 18%. These two values represent the highest and lowest average values over the year.

3.1.3 Weather Hazards

Several types of meteorological phenomena that occur at the INEL can be considered hazards. Among these are thunderstorms, lightning, blowing snow, dust devils, and tornadoes. Weather hazards are used for design and accident scenario considerations under the National Environmental Policy Act. These weather hazards are discussed in Clawson et al. (1989), pages 100-103. The subject of high winds is discussed on pages 28-30.

3.2 Air Quality

Air quality at the INEL is monitored for reasons related to worker and public health, regulatory compliance, and because the INEL is a National Environmental Research Park.

3.2.1 Regulatory Overview

The INEL is regulated for radioactive emissions, particulate emissions, and toxic air pollutants. Radioactive emissions that do not fall under the State of Idaho's particulate emissions rule are regulated by Region 10 of the EPA under National Emission Standards for Hazardous Air Pollutants. The majority of INEL air emissions are subject to State of Idaho rules as either particulate or toxic air pollutants.

The Idaho air quality standards are specified in Rules and Regulations for the Control of Air Pollution in Idaho, Idaho Administrative Procedures Act 16.01. These standards are identical to the National Ambient Air Quality Standards for certain criteria pollutants (Table 3-2). Although the total suspended particulate (TSP) standard was revised by EPA in 1987 to include only PM-10 (particles with an aerodynamic diameter less than or equal to a nominal 10 μm), Idaho currently maintains an interim standard for both TSP and PM-10.

The State of Idaho is also concerned with numerous toxic air pollutants, as specified in the Idaho Air Quality Bureau's *Draft New Source Review Methods for Toxic Air Pollutants*. The ambient standards for noncarcinogenic toxic air pollutants are 8-hour average ambient concentrations not to exceed 1/1000 of the occupational exposure level, which is the time-weighted average threshold limit value used by the Occupational Safety and Health Administration (OSHA) or the American Council of Governmental Industrial Hygienists. For stack emissions, the limit is 1/15 of the occupational exposure level measured at the stack.

Because "ambient air" is defined by the Idaho Air Quality Bureau as any air that the public has access to, the ambient standards for both criteria and toxic air pollutants apply at public highways that traverse the INEL, in addition to the INEL boundary. In the southern half of the INEL, this includes U.S. Highway 20/26.

3.2.2 INEL Ambient Air Quality

Effluent released to the air are monitored at potentially significant release points, INEL routine monitoring sites, and off-Site background locations [Department of Energy (DOE) 1989]. Effluent monitoring is summarized annually in DOE (1992). The Radioactive Waste Management Information System reports the results of the radioactive effluent monitoring by month, facility, and radionuclide. The Industrial Waste Management Information System reports the results of the nonradioactive effluent monitoring by month, facility, and toxic air pollutant. These two computer-based systems make it possible to extract the data and report them in a variety of formats, depending on the information needed.

Table 3-2. Ambient air quality standards and maximum concentrations applicable to releases of air contaminants at the INEL.

Pollutant	Averaging Time	Ambient Concentration ($\mu\text{g}/\text{m}^3$)	Idaho Ambient Air Quality Standard ($\mu\text{g}/\text{m}^3$) ^a	
			Primary	Secondary
SO ₂ ^b	3-h	14.0	none	1,300
	24-h	8.0	365	none
	Annual	0.2	80	none
NO ₂ ^b	Annual	4.7	100	100
CO	1-h	— ^c	40,000	40,000
	8-h	— ^c	10,000	10,000
TSP ^d	24-h	88.0	260	150
	Annual	40.0	75	60
PM-10 ^e	24-h	32.0	150	150
	Annual	14.0	50	50

a. Source: Rules and Regulations for the Control of Air Pollution in Idaho, IDAPA 16.01.1101.01.

b. Source: "INEL Site Environmental Surveillance Data for the Fourth Quarter, 1989," April 1990.

c. Data not available.

d. Source: Average of the 1989 monitoring data from TSP sampler at Central Facilities Area (R. G. Mitchell, personal communication).

e. Estimated using a PM-10/TSP ratio of 0.36 for fugitive dust.

3.2.3 Nonradioactive Airborne Effluent Monitoring

Nonradioactive airborne effluent originate from five primary sources at the INEL: calcination of high level radioactive liquid waste at the New Waste Calcining Facility, combustion of coal for steam generation at the Coal-Fired Steam-Generating Facility, combustion of fuel oil for heating at all INEL facilities, motor vehicle exhausts, and fugitive dusts from waste burial and construction activities.

Nitrogen oxide (NO_x) emissions are routinely monitored at the New Waste Calcining Facility. Sulfur dioxide (SO₂), NO_x, and carbon oxides are monitored at the Coal-Fired Steam-Generating Facility. Emissions of sulfur dioxide from heating oils are calculated from sulfur content and the

amount of fuel used. Emissions of NO_x and SO_2 from fuel are calculated using emission factors developed by the EPA and the amount and type of fuel burned at each facility as reported by the Industrial Waste Management Information System. Motor vehicle emissions and fugitive dusts are not monitored at their sources. Major nonradioactive airborne effluent for 1991 are given on page B-23 of DOE (1992).

3.2.3.1 Nonradioactive Background Concentrations at the INEL. Environmental pollutant monitoring at the INEL has been conducted for NO_x , SO_2 , and TSP (Table 3-2). Two NO_x samplers were activated in 1988 at the INEL, one located at the intersection of Van Buren Boulevard and Highway 20/26 and the other at the Experimental Field Station. An SO_2 monitoring station was placed into service at the Van Buren and Highway 20/26 intersection on October 6, 1989. The NO_x and the SO_2 analyzers are designated as equivalent methods by EPA. The maximum ambient concentrations for SO_2 and NO_2 (Table 3-2) were taken from fourth quarter 1989 instrument measurements. The annual TSP background concentration was estimated from an average of 35 24-hour samples in 1989 ($40 \mu\text{g}/\text{m}^3$). The maximum TSP 24-hour concentration was estimated from the highest 24-hour sample collected during 1989 ($88 \mu\text{g}/\text{m}^3$). No monitoring data were available for carbon monoxide (CO) or PM-10 at the INEL. PM-10 background was estimated using a PM-10/TSP ratio of 0.36 for fugitive dust (EPA 1985, Section 11.2.1-3). Ambient concentration for CO was not estimated but is believed to be extremely low due to the low density of traffic on and near the INEL.

3.2.3.2 Existing Nonradiological Air Source Emissions Inventory. To assess the total impact on ambient air quality as a result of the proposed New Production Reactor (NPR) sources, the baseline emissions of NPR pollutants emitted from existing INEL sources was assessed (DOE 1990). The NPR baseline represents the most current accumulation of INEL air sources because a summary prevention of significant deterioration does not exist for the INEL.

3.2.3.2.1 INEL Stationary Sources—The existing emissions of criteria pollutants at the INEL prior to NPR operations were estimated for a baseline year of 1995. At the time of the analysis (March 1991), a Site-wide emissions inventory assessing the emissions from nine major facility areas (approximately 800 sources) at the INEL was being developed. This inventory is yet unpublished. In the interim, estimates of existing stationary source emissions for four criteria pollutants were obtained from the *INEL Draft Air Emissions Inventory to the Idaho Air Quality Bureau* and from analysis of the fuel processing restoration permit to construct and prevention of significant deterioration. These emissions include a planned 90% reduction in the main Idaho Chemical Processing Plant stack NO_x emissions, and the addition of fuel processing restoration emissions. Based on the available information, four criteria pollutants were inventoried: TSP, CO, NO_x as NO_2 , and SO_2 (Table 3-3).

3.2.3.2.2 INEL Mobile Sources—Mobile sources are all types of vehicular traffic and portable type generators. Mobile sources include INEL buses, locomotives, air traffic, and temporary construction sources.

Table 3-3. Inventory of existing sources of emissions for criteria pollutants for an estimated 1995 baseline.

Area	TSP		CO		NO _x		SO ₂	
	TPY ^a	lb/h	TPY	lb/h	TPY	lb/h	TPY	lb/h
CPP	83.14	22.00	90.67	22.16	813.53	230.33	1029.60	292.40
HRF	36.73	10.08	18.37	5.04	202.02	55.44	607.39	166.68
TRA	12.75	3.30	6.38	1.65	70.13	18.15	210.32	54.43
TAN	4.48	2.41	14.93	6.18	151.56	65.40	51.14	23.48
ANL	5.89	1.38	14.71	3.46	58.85	13.82	126.77	29.77
CFA	2.56	1.01	6.43	2.55	25.76	10.24	43.78	17.14
PBF	0.16	0.05	4.47	1.48	5.44	0.97	7.90	2.56
ARA	0.18	0.06	0.45	0.14	1.80	0.55	3.10	0.94
RWMC	<u>0.11</u>	<u>0.03</u>	<u>0.26</u>	<u>0.08</u>	<u>1.05</u>	<u>0.32</u>	<u>1.80</u>	<u>0.55</u>
TOTAL:	145.99	40.32	156.66	42.74	1330.10	395.22	2081.80	587.95

a. Tons per year.

3.2.3.2.3 Emission Factors—Baseline emissions for mobile sources were based on the estimated 1995 baseline data to the extent possible. It is assumed that vehicular traffic from 1988 to 1995 will remain at relatively constant levels. Vehicular emissions for the primary pollutants associated with vehicle exhaust can be calculated using emission factors based on vehicle type [which includes an assumption of fuel used (gas or diesel)], vehicle model (car or truck), and year of manufacture. The exhaust emissions evaluated are PM-10, SO₂, CO, NO_x, lead (Pb), and nonmethane hydrocarbons. The PM-10 emission factor includes exhaust and tire wear. Emission factors were provided by ANL-W.

The factors for hydrocarbons, CO, and NO_x were computed for 1995 using MOBILE4, assuming an average vehicle speed of 72 kph (45 mph); vehicle operating mode distribution consisting of 10% cold starts, 5% hot starts, and 85% stabilized operation; monthly temperature statistics for Idaho; and high altitude operation. Factors for PM-10 and Pb are based on computations by Energy and Environmental Analysis, Inc., Arlington, Virginia, in August 1985, using a program to calculate size-specific particulate emissions for mobile sources for the calendar year 1990 and a vehicle speed of 40 kph (25 mph). Emission factors for SO₂ were derived from the Compilation of Air Pollutant Emission Factors, Volume 2, Mobile Sources (EPA 1985) for the calendar year 1995, adjusting for improvements in fuel efficiency. Table 3-4 presents the emission factors used for mobile sources.

3.2.3.2.4 Vehicle Miles Traveled—DOE and privately-owned vehicles are used for on-Site and off-Site travel. Only vehicles on official DOE business will be included in this

Table 3-4. Mobile source emission factors (g/mi).

Vehicle Type				
	Light Duty Vehicle	Light Duty Truck	Heavy Duty Gas Vehicle	Heavy Duty Diesel Vehicle
PM-10 ^a	0.131 ^b	0.172 ^b	0.300	2.046
SO ₂	0.073	0.087	0.280	0.475 ^c
Pb	0.006	0.018	0.059	0.000
HC	1.22	1.63 ^e	3.06	2.50
CO	8.10 ^e	12.66 ^e	35.31	8.90
NO _x	1.06 ^f	1.22 ^f	4.87	10.24

- a. Emission factor total for exhaust and tire wear.
- b. Composite factors weighted for the population of gasoline and diesel vehicles.
- c. Based on diesel fuel sulfur content of 0.05%.
- d. Nonmethane hydrocarbons.
- e. Conservatively assumes gasoline vehicle.
- f. Conservatively assumes diesel vehicle.

assessment. Mileage estimates for personnel transportation for the INEL were obtained from EG&G Idaho (1989). The mileage for DOE vehicles is logged by type of vehicle for each calendar year. Mileage for 1988 was used for DOE vehicles.

The number of off-Site shipments in commercial vehicles is based on statistics for 1988. Assumptions have been made on vehicle types since that type of information is not recorded or readily available. The total number of off-Site shipments is 23,057 per year, for which the following breakdown will be assumed: 1,153 shipments (5%) in heavy-duty gas vehicles and 21,904 shipments (95%) in heavy-duty diesel vehicles. The miles traveled for off-Site shipments is assumed to be 160 km (100 mi) round trip in the affected area (INEL). Radioactive material shipments constitute the majority of on-Site shipments, totaling 1,650 shipments per year. Vehicle types for all on-Site shipments as well as radioactive shipments are assumed to be 50% heavy-duty gas vehicles and 50% heavy-duty diesel vehicles. On-site shipments that do not involve radioactive materials are not well documented and are assumed to number approximately 2,000 per year based on available information. The average mileage for on-Site shipments is assumed to be 48 km (30 mi) round trip.

Mileage for private vehicles for personnel transport driven to the INEL Site is based on private-vehicle traffic observed by Site security personnel (i.e., 300 to 500 private vehicles per day). For the purpose of this assessment, it is assumed that there are 300 private vehicles per day

for 5 days per week with an average round-trip mileage of 160 km (100 mi). All private vehicles are assumed to be light-duty vehicles.

The vehicle types with specified emission factors differ slightly from the vehicle categories of DOE vehicles. For the purposes of this assessment, sedans and ambulances are assumed to be light-duty vehicles. Trucks with a gross vehicle weight less than 3,856 kg (8,500 lb) and security vehicles are assumed to be light duty trucks. Trucks with a gross vehicle weight between 3,856 and 5,669 kg (8,500 and 12,499 lb) are assumed to be heavy-duty gas vehicles. Heavy-duty diesel vehicles include buses and trucks with a gross vehicle weight greater than 5,670 kg (12,500 lb).

Table 3-5 presents the vehicle miles traveled (VMT) per year by vehicle type for the INEL. The mileage estimates are based on miles logged for calendar year 1988 and on the above assumptions on number of shipments.

3.2.3.2.5 Emissions Calculations—The emissions associated with exhaust and tire wear from mobile sources are quantified by multiplying the appropriate emission factor based on vehicle type (Table 3-4) by the VMT (Table 3-5). Table 3-6 presents the total vehicular emissions per year for the INEL based on 1988 VMT.

3.2.3.2.6 Road Dust—According to EPA (1985), a major component of atmospheric particulate matter is due to dust emissions from paved roads. To determine a predictive emission factor for road dusts (TSP) attributed to vehicle traffic at the INEL, the following equation is used:

$$E = 0.077I \left(\frac{4}{n} \right) \left(\frac{s}{10} \right) \left(\frac{L}{1000} \right) \left(\frac{W}{3} \right)^{0.7} \left(\frac{1}{2.20 \times 10^{-3} \text{ lb/g}} \right) \frac{\text{g}}{\text{VMT}} \quad (3-1)$$

where

E = emission factor (g/VMT) (TSP)

I = industrial augmentation factor (dimensionless)

n = number of traffic lanes

s = surface silt material content (%)

L = surface dust loading (lb/mi)

W = average vehicle weight (ton).

For the calculation of the road dust emission factor, it is assumed that 20% of the vehicles are forced to temporarily travel with one set of wheels on the shoulder, resulting in an industrial augmentation factor of 3.5 (I = 3.5). All roads utilized are 2 lanes (n = 2). Because Site-specific road surface silt and dust loading data are not available for the INEL, the silt content and surface dust loading for concrete batch facilities from Table 11.2.6-1 of EPA (1985), Volume 1, was used

Table 3-5. Existing vehicle miles traveled per year for the INEL.

Vehicle Type	VMT
LDV	9.9E+06
LDT	4.6E+06
HDGV	2.2E+05
HDDV	8.1E+06
Total	2.3E+07

Table 3-6. Vehicular emissions for exhaust and tire wear at the INEL (g/yr).

Type of Emission	Type of Vehicle				
	LDV	LDT	HDGV	HDDV	Total
PM-10	1.3E+06	7.9E+05	6.6E+04	1.7E+07	1.9E+07
SO ₂	7.2E+05	4.0E+05	6.2E+04	3.8E+06	5.0E+06
Pb	5.9E+04	8.3E+04	1.3E+04	0.0	1.5E+05
HC	1.2E+07	7.5E+06	6.7E+05	2.0E+07	4.0E+07
CO	8.0E+07	5.8E+07	7.8E+06	7.2E+07	2.2E+08
NO _x	1.0E+07	5.6E+06	1.1E+06	8.3E+07	1.0E+08

in the above equation ($s = 5.5\%$ and $L = 5.9E-03$ lb/mi). The average vehicle weight was assumed to be 15 tons. Based on these assumptions, the emission factor for dust due to vehicular activity on paved roads at the INEL is $2.4E-03$ g/VMT.

From Table 3-5, the total VMT at the INEL is $2.3E+07$ mi/yr. Therefore, the total emission due to road dust is $(2.4E-03 \text{ g/VMT}) * (2.3E+07 \text{ mi/yr})$, or $5.5E+04$ g/yr of particulate matter. This quantity is insignificant when compared to particulate emissions from exhaust (Table 3-6).

3.2.3.3 Assessment of Potential INEL Nonradiological Impacts to the Public.

Atmospheric particulate matter is routinely monitored at the low-volume air sampling stations, although a high-volume sampler may be required to meet the TSP sampling requirement. A summary of the results for 1989 is given in Table 3-7.

Table 3-7. Low-volume particulate concentrations in the air for 1989.

Group	Locations	Concentration ^a ($\mu\text{g}/\text{m}^3$)	
		Range	Mean ^b
Distant	Blackfoot	30-50	40 $\pm$ 20
	Craters of the Moon	6-15	10 $\pm$ 8
	Idaho Falls	30-100	60 $\pm$ 50
	Rexburg	20-50	<u>40 $\pm$ 20</u>
	Grand Mean ^b		40 $\pm$ 14
Boundary	Arco	15-80	40 $\pm$ 40
	Atomic City	7-30	20 $\pm$ 20
	FAA Tower	8-16	12 $\pm$ 6
	Howe	13-40	30 $\pm$ 20
	Monteview	11-40	30 $\pm$ 20
	Mud Lake	19-50	40 $\pm$ 20
	Reno Ranch	10-30	<u>17 $\pm$ 13</u>
	Grand Mean ^b		30 $\pm$ 7
Site	ANL-W	14-30	25 $\pm$ 12
	ARA	10-19	15 $\pm$ 7
	CFA	8-20	14 $\pm$ 10
	EBR-I	6-19	13 $\pm$ 9
	EFS	9-40	20 $\pm$ 20
	ICPP	9-20	16 $\pm$ 9
	NRF	12-20	18 $\pm$ 10
	PBF	10-19	14 $\pm$ 7
	RWMC	2-40	20 $\pm$ 30
	TAN	20-20	22 $\pm$ 3
	TRA	11-20	15 $\pm$ 8
	VANB	7-19	<u>13 $\pm$ 8</u>
	Grand Mean ^b		17 $\pm$ 2

a. The approximate minimum detectable concentration is $10\mu\text{g}/\text{m}^3$. The EPA's national primary and secondary ambient air quality standard is $50\mu\text{g}/\text{m}^3$, annual average, for particulate with diameter less than or equal to $10\mu\text{m}$.

b. Arithmetic mean with the 95% confidence interval for the mean.

The analysis involves determining the net weight of the particulate matter on the quarterly composite of weekly filters at each station. The concentrations of the samples ranged from 2 to 100 $\mu\text{g}/\text{m}^3$. The distant mean was $40 \pm 14 \mu\text{g}/\text{m}^3$, the boundary mean was $30 \pm 7 \mu\text{g}/\text{m}^3$, and the on-Site mean was $17 \pm 2 \mu\text{g}/\text{m}^3$. The distant mean is greater than the on-Site mean, probably because of the amount of resuspended dust from agricultural operations near the distant sampling locations. Most of the airborne particulates in the vicinity of the Site are windblown dust from the desert floor. The above concentrations may be compared to the EPA national secondary ambient air quality standard for particulate matter of $60 \mu\text{g}/\text{m}^3$. On July 1, 1987, the EPA revised the standard for particulate matter to $50 \mu\text{g}/\text{m}^3$. The new standard is a primary and secondary standard, but it applies only to "particulates with an aerodynamic diameter less than or equal to a nominal 10 μm ." Measurements of total suspended particulates, such as those reported here, will overestimate particulate concentrations (appear greater than is actually true) in comparison with the new standard. For example, the distant mean of $40 \mu\text{g}/\text{m}^3$ appears to be 80% of the standard, whereas the actual percentage is lower. The standard applies only to particles on the filter with diameters of 10 μm or less, but many of the particles on filters at the Radiological and Environmental Sciences Laboratory are actually larger than that size because there is no device on the samplers to screen out the larger particles.

One sampler, dedicated to the measurement of total suspended particulates and having an approximate minimum detectable concentration of $2 \mu\text{g}/\text{m}^3$, is located at CFA. The sampler normally operates 24 hours/day, but it was not operating during most of the first quarter of 1989. The annual, arithmetic-mean, particulate-matter concentration of samples from the CFA sampler was $40 \pm 7 \mu\text{g}/\text{m}^3$ with a range of 5 to $88 \mu\text{g}/\text{m}^3$. This mean is 80% of the EPA standard mentioned above. This sampler is not equipped with a device designed to screen out large particles (i.e., greater than 10 μm in diameter); therefore, the CFA percentage is also overestimated.

To fulfill one of the conditions specified in the fuel processing restoration permit to construct, two NO_x monitoring stations were activated by the Radiological and Environmental Sciences Laboratory. One sampler is located near the intersection of the Highway 20/26 and Van Buren Boulevard, and the second is at the Experimental Field Station. The analyzers used are EPA equivalent methods. Both samplers operated satisfactorily 75 to 99% of the time they were online. At Van Buren Boulevard, the annual mean concentration of NO_x for 1989 was about $11 \mu\text{g}/\text{m}^3$ (11% of the applicable EPA standard). At the Experimental Field Station, the annual mean concentrations was $7 \mu\text{g}/\text{m}^3$ (7% of the standard). At these locations, the mean concentrations of these gases are calculated to be greater than at the nearest INEL boundary in the directions of the prevailing winds. Even at the on-Site locations, however, both annual means are well below the national primary ambient air quality standard of $100 \mu\text{g}/\text{m}^3$. Ambient SO_2 was measured at Van Buren Boulevard only during the fourth quarter, and the mean concentration was $0.20 \mu\text{g}/\text{m}^3$ (0.25% of the EPA annual standard). This measurement reflects SO_2 concentrations during a mild winter when boilers were not operated at peak levels.

The average SO_2 and NO_x concentrations at the INEL boundary are calculated each year using the total 1989 discharges as reported by the Industrial Waste Management Information

System. Concentrations are calculated from the releases from Coal-Fired Steam-Generating Facility monitoring data and the mesoscale diffusion air dispersion model.

Total SO₂ released in 1989 was about 2.4×10^5 kg (265 tons). The maximum concentration of SO₂ at the south INEL boundary, where the mesoscale diffusion model predicted the highest concentration, was $0.6 \mu\text{g}/\text{m}^3$, which is well below the national primary ambient air quality standard of $80 \mu\text{g}/\text{m}^3$.

The release of NO_x during 1989 was about 1.8×10^5 kg (198 tons). The calculated maximum INEL boundary concentration of NO_x was $0.5 \mu\text{g}/\text{m}^3$ from all INEL sources. This concentration is well below the national primary ambient air quality standard of $100 \mu\text{g}/\text{m}^3$.

3.2.4 Radioactive Effluent Monitoring

The total annual airborne radioactive effluent varies from year to year, depending on which processes are active at INEL facilities. The 1991 annual total of less than 14,000 Ci was much lower than the 1990 total. For purposes of comparison, total airborne radioactive effluent releases for the past 5 years were as follows: 1987—less than 165,000 Ci; 1988—less than 124,000 Ci; 1989—less than 22,000 Ci; 1990—less than 24,000 Ci; and 1991—less than 14,000 Ci.

3.2.4.1 Radiological Background at the INEL. At each monitoring location, a thermoluminescent dosimeter (TLD) containing five individual Harshaw (TLD)-700 chips is placed 1 m above ground level. The TLD at each location is changed semiannually. There are seven distant community locations and six boundary locations. See DOE (1992) for a map of these locations.

The mean annual exposures for distant and boundary community locations in 1991 were 123 ± 11 mR and 121 ± 5 mR, respectively, as measure by the TLDs. These exposures are approximately equivalent to 118 and 116 mrem, respectively, when an "f" factor of 0.96 is used to convert from mR to mrem in tissue.

There is a discussion of the Snake River Plain background radiation on page 31 of DOE (1992). Table IV on that same page summarizes the calculated dose equivalent rate an individual receives on the Snake River Plain from various background radiation sources. This calculated dose equivalent rate is 352 mrem/yr when internal doses are added to the external dose.

3.2.4.2 Existing Radiological Emissions Inventory. A summary of the radionuclides released to the atmosphere from INEL facilities in 1991 is shown on page B-12 of DOE (1992). Because of radioactive decay of the short-lived radionuclides and the overestimation of Kr-85 releases for classification reasons, the activity that would reach off-Site areas is less than the 14,000 Ci indicated. Noble gases comprised more than 98% of the total airborne radioactive effluent in 1991.

3.2.4.3 Assessment of Potential INEL Radiation Dose to the Public. Usually, the radiological impact of INEL operations on the resident public surrounding the INEL has been too small to be measured by the routine monitoring program. Therefore, the radiological impact of INEL operations by the air pathway has traditionally been estimated using the known amounts of various radionuclides released during the year from Site facilities and appropriate air dispersion models to determine the concentrations at selected locations in the vicinity. Figure 3-3 shows the possible exposure pathways by which radioactive material from Site operations could be transported to off-Site environments. Results of calculations are reported annually in the INEL Site Environmental Report. For 1991, these results are discussed starting on page 33 of DOE (1992). For example, the estimated dose to the maximally exposed individual for 1991 was given as 0.02 mrem effective dose equivalent (Table 3-8).

3.3 INEL Noise

3.3.1 INEL Ambient Noise

The 24-hour average ambient noise level on the INEL is appreciably lower than the EPA recommended upper level of 70 decibels (dBA). This noise level is on a scale ranging from approximately 10 dBA for the rustling of grass or leaves to 115 dBA, which is the unprotected hearing upper limit for exposure. The playas and remote lava flows of the INEL are exposed to relatively low ambient noise levels in the range of 35 to 40 dBA.

3.3.2 INEL Man-Made Sources of Noise

Noise generated at the INEL by day-to-day operations can be attributed to six general sources: Bus and car traffic to and from the INEL, Protection Technology Idaho training exercises, Bell Ranger class helicopter movements, reactor/industrial operations, construction, and the INEL railroad. Table 3-9 lists measured noise levels at the INEL, while Tables 3-10 and 3-11 are provided for reference.

3.3.2.1 Aircraft Movements. A number of aircraft are utilized at INEL for payload delivery to remote areas, ferry support, experimental observations, visiting executives, security and security training. Typically, noise levels are expected to be no greater than those experienced by a small commercial airport. See Table 3-10 for noise levels generated by typical aircraft.

3.3.2.2 Industrial Activities. The loudest noise generated by industrial activities at INEL will be produced by the shredder at CFA. Operators are required by OSHA regulations to be equipped with ear protection devices when exposed to noise levels above 85 dBA 8-hour time-weighted average. Other intermittent, raised levels of noise will occur during operation of lifting equipment, diesel-powered generators and locomotives, plasma-arc welders, spray painting operations, lawn mowing, and heavy-duty service vehicles. Even the highest levels of noise from industrial activities, as shown in Table 3-9, will have minor impact on the environment, and no noise will affect areas beyond the large INEL boundaries.

Figure 3-3. Detailed diagram of possible exposure pathways of INEL radioactive materials to members of the public.

Table 3-8. Maximum individual effective dose equivalent (1991) (DOE 1992).

Radionuclide ^a	Maximum Offsite Concentration ^b ($\mu\text{Ci/mL}$)	Maximum Effective Dose Equivalent ^c	
		(mrem)	(mSv)
Ar-41	1.3×10^{-12}	0.0089	9.0×10^{-5}
I-129	1.5×10^{-17}	0.0080	8.0×10^{-5}
Cs-137 + D	2.0×10^{-16}	0.0010	1.0×10^{-5}
Sr-90 + D	1.9×10^{-18}	0.0007	7.0×10^{-6}
Kr-88 + D	3.5×10^{-14}	0.0006	6.0×10^{-6}
Xe-138 + D	3.9×10^{-15}	0.0003	3.0×10^{-6}
Xe-135	1.6×10^{-13}	0.0002	2.0×10^{-6}
Dr-85	6.9×10^{-12}	<u>0.0001</u>	<u>1.0×10^{-6}</u>
Rounded Totals		0.02	2.0×10^{-4}

a. Includes only radionuclides that contribute a dose of 0.0001 mrem (1×10^{-6} mSv) or more. When indicated (+D), the contribution of daughter decay products was included in the dose calculation.

b. Estimate of radioactive decay obtained by using the 1991 average wind speed from 315–325 degrees of 17.2 km/h and a distance of 19.1 km from the Test Reactors Area/Idaho Chemical Processing Plant to the Atomic City area, the location where the hypothetical maximally exposed individual would have resided. For nuclides where parent-daughter equilibria were used in dose calculations, concentration of the parent is shown.

c. Effective dose equivalent estimated using dose conversion factors for inhalation, ingestion, submersion, and deposition.

3.3.2.3 Construction Activity. Temporary generation of noise will result from construction machinery operation and added vehicular traffic. Such short-term and episodic increases in noise will be insignificant relative to other noise levels produced on a daily basis at the INEL. Refer to Table 3-11 for construction noise sources.

3.3.2.4 Vehicular Traffic. Access to the INEL Site for the majority of workers is from either Blackfoot or Idaho Falls by Highways 26 or 20, respectively. Normal traffic to the INEL Site consists of personal automobiles and a fleet of 40- or 48-seat buses that transport employees to the various work areas at the INEL. During the week, the majority of the 4,000 to 5,000 employees are transported daily by bus. However, the majority of construction workers drive their own vehicles to the INEL.

Table 3-9. Measured noise levels at the INEL.

SOURCE	dBA	REMARKS
Industrial Activities		
Central Facilities	90.0	Painting Operations
Central Facilities	104.0	Shredding Operation
Central Facilities	99.0	Painting Operations
Central Facilities	87.5	00159-1 Painting Operations
Central Facilities	87.0	No Operations Description
Central Facilities	88.6	Sanding Operation
Idaho Falls	92.9	Plasma Arc Welding
Idaho Falls	94.5	Plasma Arc Welding
Computer Room	88.0	
Snack Bar	60.0	
Laboratories	58.0	
Elevator	62.0	
Idaho Falls	85.0	Machine Shop May Street
Undisturbed Areas		
Open Sage	40.0	Light Gusts (No Traffic)
150 m Tower	64.0	Light Gusts of Wind

Existing INEL traffic consists of approximately 150 buses and numerous automobiles. Buses travel to and from the INEL over two, 45-minute-per-day periods. Estimations of the L_{dn}/L_{10} for existing INEL traffic considered a 5-second time interval for each of the 150 buses during its pass. An additional time interval of 10 seconds was used for bus approach and pass sound levels. A reduction of 4.5 dBA was applied to the midpoint (76 dBA) for the approach and pass values. Therefore, all modeled data for the entire commuting period were calculated at sound levels substantially above the estimated background. Fifty percent of the morning commuter traffic is considered to occur prior to 7:00 a.m., for which a 10 dBA penalty was applied. Based on the above assumptions, the existing L_{dn} for the area 15.2 m (50 ft) from the roadway is estimated to be 67.5 dBA. The L_{10} is estimated to be 77.6 dBA.

3.3.2.5 Noise Abatement. A number of permanent and/or temporary measures may be taken to reduce noise levels at INEL. Potential noise abatement measures for any facility or operation include:

Table 3-10. Aircraft and weapons noise levels.

TYPE AIRCRAFT	TAKEOFF		LANDING	
	dBA	(EPNdBA) ^a	dBA	(EPNdBA) ^a
727,737,DC9,BAC11	94-100	92-96	85-90	97-104
707,720,DC8	100-105	--	94-100	--
747 Widebody	103	107-115	92	104-114
DC10, L1011	90	95-106	84	99-108
DC3, Propeller	85-90	--	75-82	--
Single-Engine Propeller	76-90	77-78	67-77	87-88
Multipropeller	79-93	--	70-80	--
Executive Jet	93-97	83-94	81-87	92-101
OH58 (Ranger Helicopter)	84	--	72	--
UH1 (Huey Helicopter)	77	--	77	--
Cl41 (Cargo Plane)	134	--	117	--

DISTANCE FOR DECIBEL LEVEL

TYPE WEAPON	mm	140 dBA	75 dBA	
		(ft) ^b	(ft)	(mi)
45 Pistol	--	75	18,000	3.4
M3 Machine Gun	--	75	18,000	3.4
M60 Machine Gun	7.6	50	9,950	1.8
MI Mortar	81	100	19,850	3.8
M72 Antitank	66	350	27,450	5.2
M114 Howitzer (tow)	105	400	28,100	5.3
M107 Self-Propelled	175	700	30,780	5.8

a. Effective perceived noise decibel level.

b. Assume atmospheric absorption of 1dBA/100 ft.

Table 3-11. Construction and vehicular noise sources (dBA).

DISTANCE FROM SOURCE ^a					
SOURCE	NOISE LEVEL (Peak)	15 m 50 ft	30 m 100 ft	61 m 200 ft	122 m 400 ft
Construction					
Heavy Trucks	95	84-89	78-83	72-77	6-71
Pickup Trucks	92	72	66	60	54
Dump Trucks	108	88	82	76	70
Concrete Mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Paver	109	80-89	74-83	68-77	60-71
Generator	96	76	70	64	58
Shovel	111	91	85	79	73
Crane	104	75-88	69-82	63-76	5~70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Caterpillar	103	88	82	76	70
Dragline	105	85	79	73	67
Shovel	110	91-107	85-101	7~5	73-89
Dredging	89	79	73	66	60
Pile Driver	105	95	89	83	77
Ditcher	104	99	93	87	81
Fork Lift	100	95	89	83	77
Vehicles					
Diesel Train	98	80-88	74-82	68-76	62-70
Mack Truck	91	84	78	72	66
Bus	97	82	76	70	54
Compact Auto	90	75-80	69-74	63-68	57-62
Passenger Auto	85	69-76	63-70	57-64	51-58
Motorcycle	110	82	76	70	64

a. Assume 6 dBA decrease for every doubling of distance.

- Proper siting of activities to take advantage of the INEL's large size as a buffer zone
- Landscaping with high, dense vegetation or earthen berm
- Noise insulation of buildings
- Erection of permanent noise barriers
- Proper scheduling (day/night/seasonal) of specified activities to eliminate or alleviate noise impacts during critical periods, such as antelope fawning periods.

During periods of construction, noise attenuation is generally not possible. Decreases in efficiency due to such efforts would increase construction costs and the time period over which the impacts would occur. However, by planning the use of portable sound screens and the strategic placement of stationary machinery, noise impacts can be significantly minimized.

3.3.2.6 Environmental Impacts of Noise. Noise can have both acute and chronic effects on man and others in the environment. The possibility for noise impacts is assessed for each proposed project at the INEL through the environmental checklist procedure.

3.3.2.6.1 Wildlife—Studies have been conducted on wading bird colonies subjected to military overflights [152 m (500 ft) of altitude] with noise levels up to 100 dBA. No productivity-limiting responses were observed at the Kennedy Space Center. Nesting birds were apparently more startled by human presence in the vicinity of the nest than by the noise impacts.

Bald eagles utilizing a nest adjacent to the Kennedy Parkway also at the Kennedy Space Center have received episodic sound exposures of 102 dBA during space shuttle launches. Observation showed that the startle response to such high noise levels was short-term and caused no significant impact.

3.3.2.6.2 Man—The effects of noise on man are summarized in Table 3-12. To ensure the protection of employees' hearing, OSHA has outlined permissible noise exposures (see Table 3-13). The INEL complies with 29 CFR Section 1910.95, which states that personnel exposed to an 8-hour time-weighted average of 85 dBA or greater must be issued hearing protectors. Exposure to impulsive or impact noise should not exceed 140 dBA peak sound pressure level.

Table 3-12. Summary table for effects of noise on man.

dBA	Potential Effect
20	No sound perceived
25	Hearing threshold
30	--
35	Slight sleep interference
40	--
45	--
50	Moderate sleep interference
55	Annoyance (Mid)
60	Normal speech level
65	Communication interference
70	Smooth muscles/glands react
75	Changed motor coordination
80	Moderate hearing damage
85	Very annoying
90	Affect mental and motor behavior
95	Severe hearing damage
100	Awaken everyone
105	--
110	--
115	Maximum vocal effort
120	--
125	Pain threshold
130	Limit amplified speech
135	Very painful
140	Potential hearing loss high

Table 3-13. OSHA permissible noise exposure levels.^a

Duration per day (hours)	Sound level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
2½	102
1	105
½	110
¼ or less	115

Source: From Table G-16, 29 CFR 1910.95.

a. When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C_1/T_1 + C_2/T_2 + C_n/T_n$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level.

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4. WATER RESOURCES

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ACRONYMS

ESRP	Eastern Snake River Plain
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory
NRF	Naval Reactors Facility
RWMC	Radioactive Waste Management Complex
SRPA	Snake River Plain Aquifer
TAN	Test Area North
TRA	Test Reactors Area
USGS	U.S. Geological Survey

4. WATER RESOURCES

4.1 Surface Hydrology

The Idaho National Engineering Laboratory (INEL) is located on the Eastern Snake River Plain (ESRP) in southeastern Idaho at an average elevation of 1,494 m (4,900 ft) msl. Mountain ranges located to the west and north of the ESRP strongly influence the climate on the Snake River Plain as does its latitude, longitude, and elevation. Air moisture tends to precipitate in the form of snow or rainfall over the mountains leaving little moisture available for precipitation on the Snake River Plain, which results in its semi-arid climate. Average annual precipitation on the INEL is 22 cm (8.7 in.) (Clawson et al. 1989). Prevailing winds are channeled into a southwesterly direction by mountains bordering the Snake River Plain.

Surface hydrology at the INEL includes water from three streams that infrequently flow onto the INEL and from local runoff caused by precipitation and snowmelt. The INEL has very little surface water except in years of heavy runoff from snowmelt and rainfall.

4.1.1 Stream Flow on the INEL

Most of the INEL is located in the Pioneer Basin into which three streams drain—the Big Lost River, the Little Lost River, and Birch Creek (Figure 4-1). These streams receive water from mountain watersheds located to the north and northwest of the INEL. Stream flows are often depleted before reaching the INEL by irrigation diversions and infiltration losses along stream channels. When water does flow onto the INEL, it either evaporates or infiltrates into the ground because the Pioneer Basin is a closed topographic depression (i.e., it has no outlet).

The Big Lost River is the major surface water feature on the INEL. Its waters are impounded and regulated by Mackay Dam, which is located approximately 4 mi northwest of Mackay, Idaho (Figure 4-2). Upon leaving the dam, waters of the Big Lost River flow southeastward through the Big Lost River Basin past Arco and onto the ESRP. When flow in the Big Lost River actually reaches the INEL, it is either diverted at the INEL Diversion Dam (Figure 4-3) or flows northward across the INEL in a shallow channel to its terminus at the Lost River sinks, where its flow is lost to evaporation and infiltration. Flow in the Big Lost River has not reached the INEL since 1987.

The Little Lost River drains slopes of the Lemhi and Lost River ranges. Flow in the Little Lost River is diverted for irrigation north of Howe, Idaho, and has not reached the INEL in recent years. Springs below Gilmore Summit in the Beaverhead Mountains and drainage from the surrounding basin are the source for Birch Creek. Flowing in a southeasterly direction between the Lemhi and Bitterroot ranges, the water of Birch Creek is diverted north of the INEL for irrigation and hydropower during the summer months. In the winter months when not used for irrigation, water is returned to a man-made channel on the INEL 6.4 km (4 mi) north of Test Area North (TAN) where it infiltrates into channel gravels, recharging the aquifer.

Figure 4-1. Surface water features near or on the INEL.

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Figure 4-2. Drainage basins affecting the INEL (Niccum 1973).

Figure 4-3. INEL Diversion Dam on the Big Lost River and associated spreading areas A, B, and C (Bennett 1986).

In addition to the infrequent flow of the three tributaries, INEL surface water hydrology includes local runoff from precipitation and snowmelt. The INEL has very little surface water except in years of heavy runoff from snowmelt/rainfall. Runoff has little effect on surface water, except perhaps locally. Snowfall is a major contributor to the total yearly precipitation for the INEL. Evapotranspiration rates are relatively high (greater than 80% of the available water).

4.1.2 Flooding Potential

In general, flood plains at the INEL are poorly defined, primarily because detailed topographic data are not available for much of the INEL Site. A regional flood-plains study was conducted by Koslow and Van Haaften in 1986. Several other flood studies have been conducted for smaller areas near specific INEL facilities.

To protect INEL facilities from flooding of the Big Lost River, the INEL Diversion Dam (Figure 4-3) was constructed in 1958 and consists of a diversion dam, a diversion channel, two 1.8-m (6-ft) diameter culverts, three dikes, four spreading areas, and two interconnecting channels. The diversion channel is capable of carrying 204.7 m³/s (7,200 cfs) from the Big Lost River into the spreading areas. Two low swales located southwest of the main channel carry an additional 59.5 m³/s (2,100 cfs), for a combined maximum diversion channel of 263 m³/s (9,300 cfs) (Bennett 1986). The total capacity of the spreading areas is 2.2×10^7 m³ (18,200 ac-ft) at elevation 1,536 m (5,040 ft) msl, and 7.2×10^7 m³ (58,000 ac-ft) at elevation 1,539.2 m (5,050 ft) msl (McKinney 1985; Koslow and Van Haaften 1986).

Mackay Dam is located approximately 6.4 km (4 mi) northwest of Mackay, Idaho (Figure 4-2). Mackay Dam is an earthen structure, completed in 1917, with a storage capacity of 5.5×10^7 m³ (44,500 acre-ft) and a surface area of 5×10^6 m² (1,241 acres) (Van Haaften et al. 1984). It has been classified as a high hazard dam by the state of Idaho, based on the Army Corp of Engineers guidelines for safety inspection. The following dam failure scenarios that could result in flood waters being routed downstream (via the Big Lost River) onto the INEL have been evaluated:

- Hydraulic (piping) failure of the dam, with the 100-year recurrence interval flood
- Hydraulic (piping) failure of the dam, with the 500-year recurrence interval flood
- Overtopping failure caused by the probable maximum flood
- Seismic failure of the dam, coincident with the 25-year recurrence interval flood.

In all four cases analyzed by Koslow and Van Haaften (1986), the peak water surface elevation of the reservoir was assumed to be above or up to the spillway crest elevation. They also assumed that the INEL Diversion Dam would be overtopped by flooding waters released from the Mackay Dam. This overtopping is expected to cause failure of the Diversion Dam, and thus contribute to downstream flooding on the INEL. The results indicate that in the event of a Mackay Dam failure, there would be flooding throughout the entire study reach with the flat, open topography on the INEL, allowing considerable spreading of the floodwaters. The facilities subject to encroaching floodwaters are the Idaho Chemical Processing Plant (ICPP), the Naval

Reactors Facility (NRF), and TAN. The low velocity and shallow depth of the water would not, however, pose a threat of structural damage to these facilities. The water velocity on the INEL ranges from 0.18 to 0.91 m/s (0.6 to 3.0 ft/s), and the calculated water depth outside the banks of the Big Lost River is typically 0.6 to 1.2 m (2 to 4 ft.) Figures 4-4 through 4-7 show the location of flood waters resulting from the above scenarios.

Snowmelt runoff on the INEL occurs in January, February, and March, while runoff from the surrounding mountains generally occurs in May or June. If the ground is frozen when snowmelt occurs, flooding can result because the infiltration capacity of soil is greatly reduced. The Radioactive Waste Management Complex (RWMC) has been flooded at least three times in past years (1962, 1969, and 1982) by local runoff from rapid spring thaws. In 1969, TAN also experienced similar snowmelt flooding. These flooding events were the consequence of rapid snowmelt caused by heavy rain and warm winds.

4.2 Subsurface Hydrology

4.2.1 Vadose Zone

A very complex, heterogeneous vadose zone exists at the INEL. It is a crucial component of the INEL hydraulic system. Insight into the importance of the vadose zone can be gained by examining its role in (a) filtration of contaminants, (b) buffering of dissolved chemical wastes, and (c) transport of water and contaminated liquids. The thick vadose zone affords protection to the groundwater by acting as a filter and preventing many contaminants from reaching the aquifer. The contaminants are immobilized through chemical sorption to vadose zone materials. The vadose zone acts as a buffer by providing storage for large volumes of liquid or dissolved contaminants that have spilled on the ground, migrated from disposal pits and ponds, or have otherwise been released to the environment. Finally, the vadose zone is important because transport of the contaminants through the thick mostly unsaturated materials can be very slow if dry conditions prevail.

The vadose zone extends from land surface down to the water table. It is a zone where the water content of the geologic materials is commonly less than saturation, and water is held under negative pressure (suction). Because the pores are usually only partially filled with water, it is also known as the unsaturated zone. An extensive vadose zone exists at the INEL ranging in thickness from 61 m (200 ft) in the north to greater than 274 m (900 ft) in the south. It consists of surface sediments, relatively thin horizontal basalt flows, and occasional interbedded sediments.

Surface sediments include clays, silts, sands, and some gravels. Thick surficial deposits of clays and silts are found in the northern part of the INEL. The surficial deposits thin to the south and basalt is exposed at the surface. Variation of the thickness of surficial deposits is due to topography and depositional history. The fine-grained sediments found in the north accumulated as thick lake deposits while those in the south are largely wind deposits that accumulated in topographic lows. Along stream channels such as the Big Lost River, alluvial deposits including gravels, sands, and fines are found.

Figure 4-4. Inundation map for the 100-year flood from Mackay Dam piping failure (Koslow and Van Haaften 1986).

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Figure 4-5. Inundation map for the 500-year flood piping failure.

Z93 0387a

Figure 4-6. Inundation map for the PMF-induced overtopping failure of Mackay Dam (Koslow and Van Haften 1986).

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Figure 4-7. Inundation map for the seismic failure of the dam, coincident with the 25-year recurrence interval flood.

Thick sequences of interfingering basalt flows comprise most of the vadose zone. These sequences are characterized by large void spaces resulting from fissures, rubble zones, lava tubes, undulatory basalt-flow surfaces, and fractures. Fractures are important vadose zone structures because they can provide preferential pathways for water movement. They develop in the basalt flows in response to lava flow emplacement processes, cooling, spalling, and dike emplacement. Some fractures are limited to individual flows while others extend hundreds of meters to several kilometers in depth (Hackett and Smith 1992; Rubin 1992). Fracture apertures range from microscopic to tens of centimeters. Fractures can be open or filled with sedimentary material transported from the surface by water and gravity. Figure 4-8 is an idealized cross-section of several basalt flows with fractures, other voids, and sedimentary interbeds.

Sedimentary interbeds found in the vadose zone are generally not continuous and consist of sands, silts, and clays. They may be compacted due to original deposition and subsequent overburden pressures. Under unsaturated conditions where water is limited, flow will move preferentially through small openings in sediment or basalt, avoiding large openings. Under these conditions, sediment-filled fractures can become conduits for water movement through the vadose zone. Arrow 1 (in Figure 4-8) shows unsaturated flow into filled fractures. However, if sufficient ponded water or a saturated interbed were located above the basalt, saturated flow conditions would prevail, and water would move into the open fractures or other voids (arrow 2). Under saturated conditions, rapid water flow through the vadose zone can occur.

Researchers have quantified rates of moisture movement in sediments and basalt under varying moisture contents. An investigation into water movement during unsaturated flow regimes near the RWMC using the chlorine-36 isotope found that infiltration ranged from 0.36 to 1.1 cm/yr (0.14 to 0.43 in./yr) (Cecil et al. 1992). At the same area, however, Kaminsky (1991) found that standing water at land surface moved under a nearly saturated regime 210 cm (6.9 ft) in less than 24 hours. Bishop (1991) measured moisture movement in a 50-cm (20-in.) long basalt block from the RWMC. Under saturated conditions and matrix flow, over 100 days were required for saturation of the basalt block to occur.

4.2.2 Perched Water Conditions

Perched water forms as discontinuous saturated lenses, with unsaturated conditions existing both above and below the lenses (Freeze and Cherry 1979). It occurs when water migrates vertically, and to a lesser extent, laterally from the source until an impeding layer is encountered (at the INEL, a layer of dense basalt or fine sedimentary materials where the hydraulic conductivity is sufficiently low that vertical movement of water is restricted). Once a perched water mound develops, lateral movement of the water can accelerate. Barraclough et al. (1967) indicates that water can move hundreds of meters laterally. Figure 4-9 is a generalized diagram of perched water movement at the INEL. Once perched water mounding and lateral spreading occurs on a perching layer, hydraulic head increases and water leaks through the less permeable layer and continues its generally vertical descent until it encounters another restrictive zone where perching may again occur. This process can continue, resulting in the formation of several

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Figure 4-8. Idealized cross-section showing fractured basalt flows, rubble zones, sedimentary interbeds, and surficial sediment.

Figure 4-9. Idealized cross-section of INEL perched water body.

perched water bodies between the land surface and the water table. Perched water at the INEL has been detected at the ICPP, the Test Reactor Area (TRA), TAN, and RWMC facilities. Its occurrence is generally related to the presence of disposal ponds or other surface water sources.

Fluids infiltrating into the vadose zone from ponded sources can flow rapidly under saturated conditions through open fractures and other preferred pathways; the perching behavior tends to slow this downward migration of percolating fluids.

The following sections briefly describe known perched water bodies and their hydraulic properties at the INEL. Water quality data for the perched water bodies is found in Appendix C-1.

4.2.2.1 Idaho Chemical Processing Plant (ICPP). Perched water at ICPP occurs in three areas at possibly three depth zones (Figure 4-10). The percolation ponds are sources for the perched water to the south of ICPP. Figure 4-11 shows superimposed neutron logs of USGS-51 run in 1984, 1985, and 1986. USGS-51 is completed in the Snake River Plain Aquifer (SRPA) near the infiltration ponds. The neutron logs permit vertical identification of three distinct perched water zones. The figures shows that by 1986, perched water bodies were formed at depth intervals of 9 to 32 m (30 to 105 ft), 41 to 54 m (135 to 177 ft), and 81 to 98 m (266 to 322 ft) (Cecil et al. 1991).

4.2.2.2 Test Reactor Area (TRA). Perched water bodies exist at two depths beneath TRA, one shallow and another deep. Both have been monitored since the 1960s. The shallow perched water body is believed to be leakage from the retention basin and/or associated pipelines (Figure 4-12). Water levels in boreholes completed in the shallow perched water body suggest that its extent has not changed significantly over the past 25 years. Surface ponds are also thought to be the source for the deep perched water at TRA (Figure 4-13). The general shape of the deep perched water body also has not changed appreciably over time although water levels have fluctuated in response to volume of water discharged to the surface ponds (Doornbos et al. 1991). Figure 4-14 shows a cross section through the deep perched water body. Transmissivity for the deep perched water body has been measured in several studies including those by Ackerman (1991b) and Bishop et al. (1992). Transmissivities have ranged from 2.8 to $4.0 \times 10^4 \text{ m}^2/\text{day}$ (30.5 to $4.3 \times 10^5 \text{ ft}^2/\text{day}$).

4.2.2.3 Test Area North (TAN). Two monitoring wells were completed during 1989 in the perched water at TAN (Figure 4-15). It is assumed that these ponds are the source for the perched water. Although the areal extent of the perched water body has not been determined, the thickness of the mound at TSFAG-7 is in excess of 12 m (36 ft) in TSFAG-7. Transmissivity for the perched water body ranges between 6.4×10^{-4} and $3.1 \times 10^{-3} \text{ m}^2/\text{day}$ (6.9×10^{-3} and $3.3 \times 10^{-2} \text{ ft}^2/\text{day}$)^a.

a. Private communication with Allan Wylie, EG&G Idaho, Inc., 1990.

Figure 4-10. Dashed outline of perched water bodies at ICPP.

Figure 4-11. Overlay of neutron logs for 1984, 1985, and 1986 for well 51. The shaded zone indicates perched water (Cecil et al. 1991).

Figure 4-12. Dashed line outlining shallow perched water at TRA, October 1985 (Pittman et al. 1988).

Figure 4-13. Deep perched water body at TRA, March 1991 (Doornbos et al. 1991).

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Figure 4-14. Cross-section map through deep perched body at TRA.

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Figure 4-15. Locations of perched water wells at TAN (areal extent of perched water body unknown).

4.2.2.4 Radioactive Waste Management Complex (RWMC). Figure 4-16 shows perched water wells at the RWMC. Standing water ranging from 0.27 to 3.2 m (0.91 to 10.4 ft) has been detected in six boreholes at various times. Perched water has been identified at two depth intervals at the RWMC corresponding approximately to the tops of sedimentary interbeds at depths of 32 and 68 m (104 and 223 ft).^b The source of the perched water may be flood events (1962, 1969, and 1982), water moving laterally from the spreading areas, or surficial infiltration.

4.2.3 Saturated Zone

Underlying the ESRP at depths up to hundreds of feet is the SRPA. The aquifer, consisting of basalt and sediments and the groundwater stored in these materials, is one of the largest aquifers in the United States. In terms of size and groundwater productivity, the SRPA is among the country's most productive aquifers. The significance of this natural resource is enhanced by the semi-arid surface climate, and its economic and environmental importance has been recognized by the U.S. Environmental Protection Agency's designation of it as a sole source aquifer.

Although groundwater flow in the SRPA is well understood on a regional scale, it can be very complex when small areas are considered. The complex nature of the aquifer results from its fractured volcanic structure and multiple recharge sources. SRPA hydrology has been investigated by U.S. Geological Survey (USGS) and U.S. Department of Energy scientists for over 40 years. These investigations have been well documented and are the foundations for the current understanding of the aquifer's hydraulic, chemical, and physical characteristics.

4.2.3.1 Geology of the SRPA. Approximately four million years ago, numerous vents and fissures extruded molten rock that, after cooling, formed basalt. This basalt, along with the rhyolite from earlier explosive eruptions, filled the structural downwarp that is now known as the ESRP. The SRPA exists in this structural downwarp and is located in the Quaternary basalts that overlie the more voluminous rhyolite (Figure 4-17). As basalt spilled from the vents and fissures, fingers of molten rock flowed in paths of least resistance. Over time, this eruptive pattern resulted in the interfingering of numerous flows, generating a highly complex flow structure incorporating void spaces resulting from lava tubes, cooling fracturing, vesicles, and irregular surfaces. These void spaces result in porosity and permeability, which are measures of the aquifer's ability to store and transmit water. As lithostatic pressure increased due to the weight of subsequent flows, many of the larger void spaces collapsed at depth decreasing original porosity, but regional fracturing has added secondary porosity to the aquifer. Regional fracturing is associated with dike intrusion along volcanic rift zones and is likely to affect the uppermost several kilometers of the crust (Hackett and Smith 1992). Figure 4-18 is a schematic block diagram showing regional fracturing resulting from tensional stresses above the propagating dike tip.

b. Private communication with Joel Hubbell, EG&G Idaho, Inc., 1992.

Figure 4-16. Wells drilled into the perched water at the RWMC.

Figure 4-17. Boundaries of the SRPA in Idaho.

Figure 4-18. Regional fracturing associated with dike emplacement (Hackett et al. 1992).

4.2.3.2 Location and Size of the SRPA. The SRPA arcs approximately 322 km (200 mi) through eastern Idaho's subsurface and varies in width from approximately 80 to 113 km (50 to 70 mi). Total area of the SRPA is estimated at 24,863 km² (9,600 mi²). Figure 4-19 illustrates approximate boundaries and locations of the SRPA. Aquifer boundaries correspond to surface physical features, i.e., mountains on the west and north and mountains and the Snake River on the east. Depth to groundwater at the INEL ranges from approximately 61 m (200 ft) below land surface in the north to over 274 m (900 ft) in the south. The aquifer is composed of numerous, relatively thin basalt flows extending to depths of 1,066 m (3,500 ft) below land surface. Over time, some of these flows have been exposed at the surface long enough to collect sediment and develop soil horizons. These sediments were deposited by dust storms, flood events, streams, and lakes. Eventually, these sediments were buried by subsequent basalt flows and are known today as the sedimentary interbeds that are found sandwiched between basalt flows at various depths. Although there is evidence supporting a thick, regionally extensive sedimentary sequence located at the base of the active aquifer (Anderson 1991), when viewed on a large scale, the interbeds are typically discontinuous.

The SRPA has been estimated to contain 2.5×10^{12} m³ (2×10^9 ac-ft) of water, which is approximately equivalent to the amount of water contained in Lake Erie, or to view it another way, enough water to cover the entire state of Idaho to a depth of 1.2 m (4 ft) (Hackett et al. 1986). Approximately 6.17×10^{11} m³ (5×10^8 ac-ft) of the water stored in the aquifer could potentially be pumped from it (Robertson et al. 1974). Annual discharge from the SRPA into springs in the canyon wall along the Snake River near Hagerman, Idaho, has been estimated at 6×10^9 m³ (4.9×10^6 ac-ft). Eleven of these springs are among the 65 largest springs in the United States. Among other purposes the discharge water is used for trout farming, producing about 65% of the nation's annual commercial trout production. During the summer, irrigation requirements divert the entire Snake River at Milner Dam, just downstream of the city of Burley. Between Milner and Hagerman, a distance of 145 km (90 mi), a new river is formed from 170 m³/s (6,000 ft³/s) of spring flow out of the aquifer, and from surface irrigation return flows (Hackett et al. 1986). Annual groundwater pumpage for irrigation is approximately 1.9×10^9 m³ (1.5×10^6 ac-ft). This provides enough water to irrigate over one-third of the three million irrigated acres of the Snake River Plain.

4.2.3.3 Recharge of the SRPA. The SRPA is recharged by infiltration from rain and snowfall that occurs within the 90,650-km² (35,000-mi²) drainage basin that surrounds the ESRP and from deep percolation of irrigation water. Although much of this precipitation is surface runoff and eventually drains into the Snake River, a significant portion infiltrates into the ground and eventually recharges the aquifer. However, the primary source of recharge is deep percolation of irrigation water diverted from the Snake River and tributary streams. These sources of recharge are supplemented by underflow from tributary stream valleys, rain and snowfall on land overlying the aquifer, and seepage from the Snake River and other surface water sources such as the Big Lost River. Annual recharge rates are dependent on precipitation (especially snowfall), but in general, recharge in the vicinity of the INEL is somewhat less than discharge.

Figure 4-19. Water table elevations of the SRPA and general direction of groundwater flow, spring 1980 (Lindholm and Goodell 1986).

Because the water table is the upper boundary to the SRPA, it has been designated an unconfined aquifer. However, in localized areas, the aquifer behaves as if confined by the dense basalt, sediment filled basalt, and/or fine interbed sediments. Determining the lower boundary of the aquifer is more difficult. At the location of INEL-1, the effective lower boundary of the aquifer is thought to range from 259 to 372 m (850 to 1220 ft) below land surface (Mann 1986). This estimate of the lower base of the aquifer is founded on several observations including (a) a significant portion of the groundwater moves in the upper 244 m (800 ft) of the saturated zone, (b) hydraulic conductivities within the upper 244 m (800 ft) of the aquifer range several orders of magnitude higher than those from greater depths, (c) chemical composition of groundwater changes from a calcium bicarbonate to sodium bicarbonate water at approximately this depth, (d) hydraulic head decreases with depth across the boundary, (e) a thick, fairly continuous sedimentary sequence exists between 256 to 466 m (840 and 1530 ft), and (f) carbon-14 age dating. Several well cores have shown extensive fracture filling by secondary mineralization deeper than about 457 m (1,500 ft) below land surface.

Regional groundwater flow is to the south-southwest, although locally, the flow direction can be affected by recharge from rivers, surface water spreading areas, and heterogeneities in the aquifer. Estimates of flow rates within the aquifer range between 1.5 to 6.1 m/d (5 to 20 ft/d) (Barraclough et al. 1981). Figure 4-19 is a contour map of water table elevations of the SRPA. The average hydraulic gradient for the SRPA is 1.2 m/km (4 ft/mi) across the INEL (Orr et al. 1991). Flow is primarily through fractures, interflow zones in the basalt, and in the highly permeable rubble zones located at flow tops.

Because permeability measured in the basalt and sediment that make up the SRPA show vertical and horizontal spacial variation, the aquifer is designated as heterogeneous. It is also known to be anisotropic (having properties that differ according to the direction of measurement) because permeability and hydraulic conductivity measured in a specific location have different values in the vertical direction than in the horizontal direction. This is especially true on a small scale where the aquifer's hydraulic conductivity is highly variable due to the nature of the basalt layers. The heterogeneity and anisotropy found in the SRPA make the system extremely complex.

The heterogeneous and anisotropic nature of the SRPA results from permeability variations within the aquifer caused by the basalt irregularities, fractures, void spaces, rubble zones, and sedimentary interbeds. This heterogeneity is responsible for the variability in transmissivity values throughout the SRPA. Transmissivity is a measure of the aquifer's ability to transmit water. A more rigorous scientific definition is the volume of water flowing through a face of a unit width extending the full saturated thickness of the aquifer under a unit gradient (Domenico and Schwartz 1990).

Transmissivity measured in wells on the INEL ranges from 0.1 to 7.1×10^4 m²/d (1.1×10^4 to 7.6×10^5 ft²/d) (Ackerman 1991). Storativity is the volume of water removed from a unit volume under a unit decrease in head. Storage coefficients at the INEL range from 0.01 to 0.06, while effective porosities, that portion of the total porosity which can transmit water, are estimated to range from 5 to 15%. Localized effective porosities are higher along the highly

permeable flow tops. The high permeability and effective porosity allow water to flow easily through the aquifer, making it one of the most permeable, large aquifer systems in the world.

4.2.3.4 SRPA Groundwater Quality. In general, the quality of most of the groundwater in the SRPA is excellent because the extensive vadose zone filters and retards chemicals and pollutants from irrigation water and waste water that passes through it. Limited water quality problems exist in the aquifer both inside and outside the INEL. Pollution can occur from accidental spills of toxic materials such as pesticides and industrial chemicals, leaching of nitrates from fertilizer, direct injection of chemical or agricultural wastes, disposal of radioactive compounds and nonradioactive metals in percolation ponds, and septic tanks and drainfields. Even though groundwater quality in the SRPA is generally excellent, local areas of concern exist both inside and outside the INEL.

To alleviate concerns and maintain excellent groundwater quality, the INEL monitors water quality in the SRPA. Since 1949, the USGS has conducted a Site-wide groundwater monitoring program at the INEL to determine effects of INEL operations on groundwater quality and quantity. Information has been collected and published that depicts hydrogeologic background conditions before reactor and other INEL operations. Since that time, the USGS has maintained a groundwater monitoring system and conducted investigations to determine changes in water quality and quantity resulting from activities at the various facilities at the INEL.

More than 120 wells completed in the SRPA are monitored for water quality on or near the INEL, and over 100 wells and auger holes are available for sampling perched groundwater. The objective of the USGS sampling program is to determine changes in water quality and quantity resulting from activities at the various facilities at the INEL. Periodic summaries have been published, including those by Nace et al. (1959), Barraclough et al. (1965), Barraclough et al. (1966), Robertson et al. (1974), Barraclough et al. (1976), Barraclough and Jensen (1976), Barraclough et al. (1981), Lewis and Jensen (1984), Pittman et al. (1988), and Orr and Cecil (1991). Well logs, water levels, and water chemistry data are available in files at the INEL office of the USGS.

Groundwater monitoring networks utilized by the USGS consist of a series of wells from which water-level and water-quality data are systematically collected. Appendix C presents the concentrations of the most frequently observed organic compounds measured in the monitoring wells during 1987 to 1989. Also, Appendix C presents more complete water chemistry data.

INEL operations have resulted in both groundwater contamination and have provided potential sources of groundwater contamination. Contaminant plumes containing both radionuclide and chemical constituents are delineated on the basis of the observation of radioactive and chemical constituents in groundwater samples from wells completed in the SRPA. The vertical extent of contaminant plumes is not determined (Orr and Cecil 1991). Inorganic chemical constituents detected in groundwater at the INEL include total chromium, sodium, chloride, and nitrate (Orr and Cecil 1991). Purgeable organic chemical compounds have been detected in groundwater at the INEL (Mann and Knobel 1987; Mann 1990). Radionuclides

detected in groundwater at the INEL include tritium, ^{90}Sr , ^{129}I , ^{60}Co , ^{137}Cs , ^{238}Pu , $^{239/240}\text{Pu}$ (undivided), and ^{241}Am (Orr and Cecil 1991). Existing areas of groundwater contamination have been identified at the ICPP, TRA, TAN, Central Facilities Area, and RWMC.

Tritium and ^{90}Sr concentrations in the aquifer are decreasing due to radioactive decay. More detailed information is presented in Appendix B. In general, contaminant concentrations in the groundwater are low, barely above detection limits. Due to near surface disposal, sources for many of the contaminants found in the groundwater are in the vadose zone. Techniques such as vapor vacuum extraction are under investigation for effectiveness in removing contaminants from the subsurface before they reach the groundwater. The monitoring data show that almost all of the contaminant levels in the aquifer are decreasing. Tritium from ICPP and TRA has been detected from 1983 to 1986 in wells near the southern boundary of the INEL at very low levels. The data and interpretations all strongly indicate that only limited concentrations of a few waste products will ever migrate south of the INEL. These waste concentrations do not pose a problem or threat to any downstream water users.

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5. ECOLOGICAL RESOURCES

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a. Parts of this section are being completed by EG&G Idaho and will be included in the next revision.

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b. Several tables in this section are currently incomplete. However, they are being updated by EG&G Idaho and will be included in the next revision.

ACRONYMS

BLM	Bureau of Land Management
DOE	U.S. Department of Energy
FWS	U.S. Fish and Wildlife Service
INEL	Idaho National Engineering Laboratory
INPS	Idaho Native Plant Society
NWI	National Wetlands Inventory
PLO	public land order
USFS	United States Forest Service

5. ECOLOGICAL RESOURCES

5.1 Biotic Resources

This section provides an overview of the biotic resources of the Idaho National Engineering Laboratory (INEL) with emphasis on the components of the ecosystem that may be impacted by current and future INEL activities. Comprehensive flora and fauna species lists and detailed descriptions of analytical methods applied to develop habitat and ecological associations are provided in Appendix D.

5.1.1 Overview

The INEL is a facility managed by the U.S. Department of Energy (DOE) and was originally established in 1949 as the National Reactor Testing Station. The INEL is one of five national environmental research parks established to provide protected lands for research and education in environmental sciences and to study the environmental impacts of energy development. The INEL occupies approximately 2305 km² (890 mi²) of the northwestern portion of the Eastern Snake River Plain in southeastern Idaho. It is nearly 63 km (39 mi) long from north to south and about 58 km (36 mi) wide in its broadest southern portion (Figure 5-1).

The INEL is bounded to the north and northwest by three major mountain ranges: Lost River, Lemhi, and Bitterroot. The Eastern Snake River Plain is to the east and south. The INEL is surrounded by agricultural lands, United States Forest Service and Bureau of Land Management lands managed as rangeland. Irrigated farmlands occur adjacent to approximately 25% of the INEL boundary and include alfalfa, wheat, and potatoes as principal crops. These areas provide food and water resources for some INEL wildlife.

In the western and northern portions of the INEL, intermittently flowing waters from the Big Lost River, the Little Lost River, and Birch Creek flow to the Lost River Sinks in the northwest portion of the INEL where the water evaporates and infiltrates into the Snake River Plain Aquifer. Generally, the water is diverted for irrigation before reaching the INEL and only occasionally flows onto the INEL when sufficient snowpack runoff is available. Until 1993, the last water to reach the INEL through the Big Lost River was in 1986. Runoff from the Birch creek drainage is diverted through a small hydropower plant and may then be released in sufficient quantities to move onto the INEL through a canal. This typically only occurs in the early spring. No surface waters flow off the INEL.

The surface of the INEL is a relatively flat, semiarid desert with several prominent volcanic buttes and numerous basalt flows that provide important habitat for small and large mammals, reptiles, and some raptors. With the exception of the buttes, elevations range from 1,460 m (4,790 ft) in the south to 1,650 m (5,913 ft) in the northeast. The East, Middle, and Big Southern Buttes are located in the southern portion of the INEL and have elevations of 2,003 m (6,571 ft), 1,948 m (6,389 ft), and 2,304 m (7,557 ft) above sea level, respectively. The average elevation of the INEL is 1,526 m (5,000 ft) above sea level. A broad topographic ridge, which extends

Figure 5-1. General map of the INEL.

northward, separates the drainage of the mountain ranges northwest of the INEL from the Snake River. INEL soils are derived from volcanic and Paleozoic rocks from nearby mountains, and buttes and are underlain by basalt. In the southern part of the INEL, soils are gravelly to rocky and generally shallow; the northern portion is covered by lake and eolian deposits, mostly composed of unconsolidated clay, silt, and sand.

The climate of the area is characterized by large diurnal and seasonal temperature fluctuations. Winters are cold, with 2 to 3 months having mean temperatures below freezing. Topsoils usually remain frozen from mid-to-late November through mid-February or early March. Snow cover typically persists for two to three months or more. In summer, low humidities and clear skies result in a high temperature from 30 to 35°C (86 to 95°F) and high evaporation rates during the day and cool temperatures at night. The average annual temperature is 5.4°C (41.7°F), and the frost-free period is about 90 days.

The INEL lies in the rain shadow of the numerous mountain ranges of south-central Idaho. Mean annual precipitation is 224 mm (8.74 in.). On average, over one-third of the precipitation falls early in the growing season during April, May, and June. Melting snow and spring rains account for virtually all of the annual recharge of moisture in the soil profile (Anderson et al. 1987).

The flora and fauna found on the INEL are typical of the northern Great Basin and Columbia Plateau region. The vegetation on the INEL consists primarily of a shrub-steppe community dominated by sagebrush and provides habitat for obligate sagebrush community species (e.g., sage grouse, pronghorn, sage sparrow) as well as species not as typical of sagebrush-steppe (e.g., elk, waterfowl). Other plant communities are distributed throughout the INEL in a mosaic fashion and consist of rabbitbrush, a variety of grasses and forbs, salt desert shrubs, and exotic/weed species. Juniper woodlands occur near the buttes and in the northwest portion of the INEL. Other, more dispersed juniper stands occur in several locations on the INEL. The juniper communities provide important habitat for raptors and big game animals. Exotic plant species including cheatgrass, halogeton, Russian Thistle are established on the INEL, particularly in disturbed areas. Crested wheatgrass, a European annual seeded on the INEL in the late 1950s (EG&G Idaho 1985), dominates disturbed areas where it was seeded to provide cover and to hold soils.

Limited riparian communities including cottonwood, willow, waterbirch, and chokecherry occur along the Big Lost River and Birch Creek. Intermittent natural wetlands include the rivers and creeks, playas that may fill in the spring, and the Big Lost River Sinks. Manmade wetlands include permanent evaporation ponds and drainage ditches as well as a series of spreading areas near the southwest corner of the Site used to contain water diverted from the Big Lost River when high flows occur.

5.1.2 Historic activities and effects on ecosystem

The INEL is one of DOE's principal centers for nuclear energy research and development and has been designated as a national environmental research park. The primary impacts that have occurred to the ecosystem are associated with roads and facilities, exploitation of gravel and borrow pits, fires (both natural and man-made), livestock grazing, and historic activities related to using portions of the INEL as a gunnery range. Impacts from these activities include the establishment and distribution of exotic plant species. Other less significant and generally unmeasurable impacts have likely occurred as a result of pesticide use, individual kills resulting from road traffic, redistribution of some fauna as a result of facility and traffic activities, and hazardous and radiological contamination. Off-Site activities that contribute significantly to population changes on the INEL include agriculture and water diversion activities. The exclusion of much of the INEL from public access has also provided a significant area where the community has been relatively undisturbed relative to off-Site areas in recent history.

Although the area currently occupied and used for facilities and operations is relatively small (about 4,616 ha, 11,400 acres) (see Section 5.2), a large network of roads and trails, borrow pits, nonnative seedings, and disturbance from numerous operations have impacted and fragmented some habitats on the INEL. Figure 5-1 shows the location of a few key INEL facilities, significant topographical features, and land uses in the vicinity of the INEL.

Approximately 95% of the INEL has been withdrawn from the public domain and is controlled by the DOE. The remaining 5% includes public highways crossing the Site, the Naval Reactor Facility (Department of Defense), and Experimental Breeder Reactor I historic landmark. A series of public land orders (PLOs), dating back to 1946, established the present uses of the Site. Lands originally under the control of the Bureau of Land Management were withdrawn from the public domain under PLO 318 (May 13, 1946), PLO 545 (January 7, 1949), and PLO 637 (April 7, 1950). From 1977 to 1982, 1,022 ha (2,555 acres) in the northeast corner of the INEL were sold to area farmers as compensation for land destroyed during the 1976 Teton flood.

Nine major facilities exist and currently maintain various levels of operation. The facilities include Test Area North, the Test Reactor Area, Idaho Chemical Processing Plant, Central Facilities Area, Power Burst Facility, Experimental Breeder Reactor I and Boiling Water Reactor Experiment, the Radioactive Waste Management Complex, the Naval Reactors Facility, and Argonne National Laboratory-West. These facilities are described in further detail in Section 1. Because operations at most facilities are involved in some capacity with nuclear operations, they represent sources of radioactive, chemical, and other environmental contamination. Areas surrounding facilities are part of the radioecological monitoring program conducted by the Radiological and Environmental Sciences Laboratory, which has conducted a detailed analysis of contamination impacts resulting from facility operations (see Section D.2.4). A summarized discussion is presented in Section 5.3. No measurable population effects have been observed as a result of environmental contamination.

During World War II, the U.S. Navy utilized about 700 km² (270 mi²) of the INEL as a bombing and gunnery range, and an additional area south of the Naval range was used by the U.S. Army Air Corps as an aerial gunnery range. Other large projects have involved clearing and/or disturbance of large areas of vegetation, including an 8-km (5-mi) long runway laid out for the Aircraft Nuclear Propulsion Project in the 1950s.

Prior to withdrawal from public domain in 1949, the INEL was primarily used as rangeland. Since 1957, the central portion of the INEL has been maintained as a grazing exclusion area (1,385 km², 535 mi²). Currently, grazing is allowed on 121,410 to 141,645 ha (300,000 to 350,000 acres) (see Section 5.2) around the perimeter of the INEL through permits administered through the Bureau of Land Management.

Dry canals and other irrigation excavations from early water management projects including the Powell Tract (1910) and the Mud Lake Project also remain on the INEL.

As a result of the disturbances from these and other activities, native vegetation communities on the INEL have been increasingly subject to the invasion of exotic annual species including cheatgrass, Russian thistle, and halogeton. In addition, approximately 4,000 ha (9,880 acres) of disturbed native INEL communities were re-seeded with crested wheatgrass.

Table 5-1 summarizes the areal extent of historic and current disturbance as a result of grazing, habitat loss and fragmentation, vegetation removal, and facility operations. These impact categories formed the basis upon which analysis of impacts described in Section D.2 were performed. Maps depicting the extensive system of roads and trails and grazing perimeters on the INEL are included in Section D.2.

5.1.3 Vegetation

Most of the natural vegetation at the INEL consists of a shrub overstory with an understory of perennial grasses and forbs. The most common shrub is Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) may dominate or be co-dominant with Wyoming big sagebrush on sites having deep soils or sand accumulations (Shumar and Anderson 1986). Communities dominated by big sagebrush occupy most of the central portions of the INEL. Green rabbitbrush (*Chrysothamnus viscidiflorus*) is the next most abundant shrub. Other common shrubs include winterfat (*Ceratoides lanata*), spiny hopsage [*Atriplex spinosa* (*Graya spinosa*)], prickly phlox (*Leptodactylon pungens*), and gray rabbitbrush (*Chrysothamnus nauseosus*). Communities dominated by Utah juniper (*Juniperus osteosperma*), threetip sagebrush (*Artemisia tripartita*), and/or black sagebrush (*Artemisia nova*) are found along the periphery of the INEL on slopes of the buttes and foothills of adjacent mountain ranges.

At the lowest elevations, the rhizomatous thick-spiked wheatgrass (*Agropyron dasystachyum*) is the most abundant graminoid; Bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), and Needle-and-thread (*Stipa comata*) are common bunchgrasses.

Table 5-1. Summary of disturbance coverage for INEL vegetation communities (being updated).

INEL vegetation communities	Total area (ha, a)	Percent grazed	Percent facilities	Percent roads	Percent exotic species	Percent other	Total percent disturbed	Disturbance index
Juniper woodlands								
Basin wildrye								
Sagebrush-steppe (off-lava)								
Sagebrush-steppe (on-lava)								
Sagebrush-winterfat								
Steppe bunchgrass								
Grassland								
Salt desert shrub								
Playa/bareground								
Lava								
Old fields, disturbed areas, seedings								
Saltbush - grass								
Sagebrush - low sagebrush (on lava)								

Patches of creeping wildrye (*Elymus triticoides*) and western wheatgrass (*Agropyron smithii*) are locally abundant. Communities dominated by Great Basin wildrye (*Elymus cinereus*) are found in scattered depressions between lava ridges and in other areas having deep soils. Bluebunch wheatgrass (*Agropyron spicatum*) is quite rare at the lowest elevations but common on slightly higher elevations in the southwest and east of the INEL.

Unlike much of the sagebrush steppe region, which has a long history of livestock grazing, the INEL supports a high diversity of forbs. Because of the richness of native forbs and protection from grazing by domestic livestock, the INEL is an important reservoir of the genetic diversity of sagebrush steppe ecosystems, which occupy some 45 million ha (111 million acres) of the Intermountain West (West 1983).

The flora and plant communities of the INEL have been studied and described by several researchers and substantial data and information exists (see bibliography, Section D.4). Plant species for the INEL are listed in Table D-1. Vegetation communities of the INEL have been defined and were recently mapped and classified using LANDSAT Thematic Mapper imagery and field measurements from INEL vegetation plots (Rope et al. 1993; Kramber et al. 1992; Anderson 1991).

Twenty-two vegetation communities were recognized as a result of the field work to support the 1990 vegetation mapping effort (Anderson 1991); some were represented by a single sample plot and may not be representative of a recognizable plant community type. The 15 vegetation cover classes that were recognized as a result of the vegetation mapping effort are discussed below. Some vegetation cover classes consist of several similar plant communities. Combining these communities was necessary because they have similar spectral signatures and could not be differentiated using the satellite data available. Characteristics of these 15 vegetation communities are summarized on Table 5-2 and discussed at length in Appendix D.

5.1.4 Fish and Wildlife

INEL supports a faunal community typical of Great Basin high desert. Approximately 239 vertebrate species have been observed at INEL including 37 mammal, 164 bird, nine reptile, six fish and one amphibian species (Arthur et al. 1984). Appendix D includes vertebrate species lists such as habitat distribution, seasonal occurrence and abundance, and an annotated bibliography of INEL ecological studies.

Aquatic communities on the INEL are largely dependent on the flow of the Big Lost River. The river flows intermittently across about 50 km (31 mi) of the INEL, from southwest to north, before it terminates in the Big Lost River Sinks (see Figure 5-1). Drought and upstream water diversion for agricultural and flood prevention purposes result in years when no water flow reaches the section of the Big Lost on INEL. However, in those years when flows are sufficient, six species of fish have been observed in the Big Lost River, including rainbow trout (*Salmo gairdneri*), mountain whitefish (*Prosopium williamsoni*), shorthead sculpin (*Cottus confusus*), kokanee salmon (*Oncorhynchus nerka*), brook trout (*Salvelinus fontinalis*), and speckled dace

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Table 5-2. Vegetation cover classes for the INEL.

Cover class description	Dominant species	Area (ha)	% Area	Comments (based on limited information)
Juniper woodlands		11,620	0.88	Unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin wildrye		4,366	0.33	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)		24,510	1.86	Common, but not abundant; provides forage
Grassland		88,051	6.67	Common, but not abundant; provides forage
Sagebrush-steppe off lava		366,689	27.79	Very abundant community
Sagebrush-steppe on lava		313,225	23.74	Most abundant community on INEL
Sagebrush-winterfat		46,732	3.54	Common, not abundant; more in north part of INEL; Winterfat is important forage
Salt desert shrub		54,741	4.15	Common, not abundant; more in north part of INEL
Sagebrush/rabbitbrush		59,490	4.51	Common, not abundant; more in north part of INEL
Sagebrush/low sagebrush rabbitbrush on lava		7,301	0.55	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits; These areas may also have juniper trees associated with them; Greater potential for archeological finds
Wetlands ^a		3,322	0.25	Unique; Big Lost River and spreading areas are mapped by FWS as wetlands; Big Lost River has significant vegetation (tree and shrub) and lava outcrops.
Playa/bare ground		12,738	0.97	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands; Area surrounding playa may include good forage habitat
Lava		24,028	1.82	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles; Also, good potential for archaeological sites; these areas may also have juniper trees associated with them
Old fields, disturbed areas and seedings		20,757	1.57	Potential for establishment and spread of exotic plant species
Saltbush-grass		8,083	0.61	Not adequately characterized yet; Associated with the grassland, sagebrush-winterfat, and sagebrush-steppe off lava cover classes

a. Described and discussed separately in Section 5.2.

(*Rhinichthys osculus*) (Overton 1977; Arthur et al. 1984). Intermittent natural ponds (playas) and permanent manmade ponds provide additional habitat for water dependent species including waterfowl. These and other surface water and wetland habitats on the INEL are discussed in detail in Section D.1.4.1 and are summarized in Section 5.2.

Some of the vertebrates known to occur at INEL are year-round residents. Approximately 154 of the 239 species occur as seasonal or migratory visitors; the remainder are residents. A large number of the seasonal vertebrates are birds (Arthur et al. 1984).

Thirty-four species of game animals have been observed at the INEL. Waterfowl constitute the largest number of game species present (22 species). Waterfowl utilize wetland and riparian habitat including the Big Lost River, and ponds or impoundments associated with INEL facilities. However, the most common game species are the morning dove, pronghorn, and the sage grouse found in upland habitats. INEL is used for breeding and wintering by sage grouse. A total of 67 active sage grouse leks (communal courtship assemblages) have been identified at the INEL (Connelly and Ball 1983).

INEL is an important habitat for big game. Approximately 40% of Idaho's pronghorn population may use INEL for winter range. In addition, a small population of elk has become resident on the INEL. This herd has grown dramatically from a very small number to its current size due to INEL hunting restrictions. In order to abate damage to crops on adjacent land, INEL and the State of Idaho have implemented live-trap removal of a majority of the elk population.

Some small mammal species such as the black-tailed jackrabbit exhibit large population fluctuations and influence the abundance, reproduction, and migration of predators such as the coyote, bobcat, and raptors.

Raptors and songbirds are important ecological components and are some of the more visible occupants of the sagebrush steppe. INEL is inhabited by 14 species of sparrows and allies; six species of swallows; 20 species of ducks and geese; and 24 species of raptors (Craig 1979; Arthur et al. 1984). However, many of the reported avifauna are only seasonal residents.

INEL's invertebrate fauna have not been investigated extensively; however, 740 insect species have been collected at INEL. For comparison, a thorough inventory of invertebrates at the nearby Craters of the Moon National Monument lists 2,064 species (Horning, 1966; Horning and Barr 1970). Due to their general importance in energy cycling in desert ecosystems, the harvester ant has received attention in several recent studies (Clark and Blom 1988, 1991).

5.1.5 Threatened, Endangered, and Sensitive Species

Rare, threatened, and endangered species are protected at the INEL by the Endangered Species Act, which provides protection by the Federal government and the Idaho Code. Both are discussed further in Section D.1.3.

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A complete evaluation of threatened, endangered, and sensitive Federal and state plant and animal species lists was conducted in preparation of this document. A comprehensive list of plant and animal species from Federal and state threatened, endangered, and sensitive lists is presented on Table 5-3. Although species of special concern and sensitive species do not receive legal protection, they are included here because of their regional importance.

5.1.5.1 Fauna. The only species that have been observed at the INEL and are currently recognized as threatened or endangered under the Endangered Species Act are the bald eagle, a winter visitor, and the peregrine falcon. Several species that are candidates for the Federal list are known to occur at the INEL. They are the ferruginous hawk, white-faced ibis, black tern, northern goshawk, pygmy rabbit, and the Townsend's big-eared bat (Arthur et al. 1984). These candidate species are those for which the Fish and Wildlife Service (FWS) has information suggesting that a change in status to threatened or endangered may possibly be appropriate, but for which conclusive data are not available. The long-billed curlew is currently designated 3c, and considered to be more widespread than previously believed and is not subject to identifiable threats (Moseley and Groves 1992).

The State of Idaho recognizes two separate classes of rare fauna: species of special concern and threatened and endangered wildlife. Species of special concern known to exist at the INEL include common loon, American white pelican, ferruginous hawk, Northern pygmy owl, California myotis, merlin, and great egret (Moseley and Groves 1992).

5.1.5.2 Flora. An extensive survey for rare and endangered plant species was conducted between 1980 and 1982 (Cholewa and Henderson 1984). With the exception of vegetation communities associated with wetlands (see Section D.3), no additional surveys were conducted for rare and endangered species for this environmental impact statement. Current work being conducted by Idaho State University will provide additional information on the INEL communities and the status of sensitive plant species. Rare and sensitive plant species found on the INEL are discussed in Section D.1.1.5.

No plant species at the INEL are currently considered Federally threatened or endangered. Several species known to exist at the INEL are listed on State of Idaho special species of concern, Bureau of Land Management (BLM), and U.S. Forest Service (USFS) lists (Table 5-3). Plants appearing on the state rare plant list include Lemhi milkvetch, plains milkvetch, thistle milkvetch, winged-seed evening primrose, nipple cactus, large-flowered gymnosteris, spreading gilia, King's bladderpod, Oxytheca, and painted milkvetch (recently removed from C2 status). Site and distribution information for these species is given in Section D.1.5.4.1.

5.1.6 Unique or Special Habitats and Communities

On the INEL, some soil and vegetation communities, wetlands (discussed separately in Section 5.2), other features including caves and buttes, and manmade structures offer unique habitat for wildlife. Some of the ecological characteristics for key INEL habitats, including those generally considered unique, are described on Table 5-4. A summary of important wildlife found on the INEL is given in Table 5-5. The importance of INEL plant and wildlife communities is discussed further in Section D.1.5.

Table 5-3. Threatened and endangered species, special species of concern, and sensitive species that may be found on the INEL.

Common names	Scientific name	Federal status ^a	State status ^a	BLM status ^a	USFS status ^a	INPS status ^a
Plants						
Lemhi milkvetch	<i>Astragalus aquilonius</i>	—	—	S	S	2
Painted milkvetch	<i>Astragalus ceramicus</i> var. <i>apus</i>	3c	—	—	—	M
Plains milkvetch	<i>Astragalus gilviflorus</i>	NL	—	S	S	1
Thistle milkvetch	<i>Astragalus kentrophyta</i> var. <i>jessiae</i>	NL	—	S	—	S
Winged-seed evening primrose	<i>Camissonia pterosperma</i>	NL	—	S	—	S
Nipple cactus	<i>Coryphantha missouriensis</i>	NL	—	—	—	M
Large-flowered gymnosteris	<i>Gymnosteris nudicaulis</i>	NL	—	S	—	M
Spreading gilia	<i>Ipomopsis (Gilia) polycladon</i>	NL	—	S	—	2
King's bladderpod	<i>Lesquerella kingii</i> var. <i>cobrensis</i>	—	—	—	—	M
Oxytheca	<i>Oxytheca dendroidea</i>	NL	—	S	—	S
Birds						
Peregrine falcon	<i>Falco peregrinus</i>	LE	E	—	—	—
Merlin	<i>Falco columbarius</i>	NL	—	S	—	—
Gyr falcon	<i>Falco rusticolus</i>	NL	SSC	S	—	—
Bald eagle	<i>Haliaeetus leucocophalus</i>	LE	E	—	—	—
Ferruginous hawk	<i>Buteo regalis</i>	C2	SSC	S	—	—
Black Tern	<i>Chlidonias niger</i>	—	—	—	—	—
Northern pygmy owl ^b	<i>Glaucidium gnoma</i>	—	—	—	—	—
Burrowing owl	<i>Athene cunicularia</i>	NL	—	S	—	—
Common loon	<i>Gavia immer</i>	—	SSC	—	—	—
American white pelican	<i>Pelicanus erythrorhynchos</i>	—	SSC	—	—	—
Great egret	<i>Casmerodius albus</i>	—	SSC	—	—	—
White-faced Ibis	<i>Plegadis chihi</i>	C2	—	—	—	—
Long-billed curlew	<i>Numenius americanus</i>	3c	—	S	—	—
Loggerhead shrike	<i>Lanius ludovicianus</i>	C2	NL	—	—	—
Northern goshawk	<i>Accipiter gentilis</i>	C2	S	—	S4	—
Swainson's hawk	<i>Buteo swainsoni</i>	—	—	S	—	—
Mammals						
Pygmy rabbit	<i>Brachylagus (Sylvilagus) idahoensis</i>	C2	NL	—	—	—
Townsend's western big-eared bat	<i>Plecotus townsendii</i>	C2	SSC	—	S2	—
Western pipistrelle ^b	<i>Pipistrellus hesperus</i>	NL	SSC	S	—	—
Fringed myotis ^b	<i>Myotis thysanodes</i>	—	SSC	—	—	—
California Myotis	<i>Myotis californicus</i>	—	SSC	—	—	—
Reptiles and amphibians						
Spotted frog ^b	<i>Rana pretiosa</i>	C2	—	—	—	—
Mojave Black-collared lizard ^b	<i>Crotaphytus bicinctores</i>	—	SSC	—	—	—
Ringneck snake ^b	<i>Diadophis punctatus</i>	NL	SSC	S	—	—
Night snake ^b	<i>Hypsiglena torquata</i>	—	—	S	—	—

a. Status Codes: C2 = Category 2 species; 3c = no longer considered for listing; E = endangered species; NL = not listed; SSC = species of special concern; T = threatened species; S=sensitive; S4=Sensitive, USFS Region 4; INPS=Idaho Native Plant Society, M=state monitor species, 1 = State Priority 1, 2=State Priority 2, S=Sensitive. This list was from USFS (letter dated December 21, 1992) and was cross-checked and incorporated with the Idaho Department of Fish and Game Conservation Data Center threatened, endangered, and sensitive species list for the State of Idaho (Moseley and Groves 1992).

b. Possible but no documented occurrences (Reynolds et al. 1986).

Table 5-4. Summary of vegetation classes on the INEL (this table is being updated).

Cover type	Dominant species	Total area on site	Number flora species	Number threatened and endangered Species of Concern (flora & fauna)	Uniqueness value (1-3) ^a	Disturbance Index (1-3) ^b	Comments
Juniper Woodlands							
Basin Wildrye							
Steppe (bunchgrass)							
Grassland							
Sagebrush-Steppe off lava							
Sagebrush-Steppe on lava							
Sagebrush-Winterfat							
Salt Desert Shrub							
Sagebrush-Rabbitbrush							
Sagebrush, Low-sagebrush							
Rabbitbrush on lava							
Wetlands							
Playa/Bareground							
Lava							
Old Fields, Disturbed							
Areas, Seedings							
Saltbush-Grass							

a. 1 = highly unique, based on acreage and distribution on INEL vs. Great Basin vs. sensitivity.

b. Percent total area impacted from roads (trails vs. major roads), facilities, grazed, fire, weeds.

Table 5-5. Summary of important wildlife found on the INEL (this table is being updated).

[illegible]

Although relatively common, all sagebrush habitats within the INEL are important because many species of mammals, birds, and reptiles are sagebrush obligates. Juniper habitats on the INEL are important to nesting raptors including the ferruginous hawk and other avian, big game, and furbearing species. Lava flows, sagebrush, and rabbitbrush communities on lava, wetlands, riparian areas and the grassland communities (Great Basin wildrye, steppe, grassland) also represent habitats with unique characteristics.

Lava tube caves on the INEL provide unique habitat for flora and fauna, including bats. The Townsend's big-eared bat, one of the two Federally listed Category 2 species found on the INEL, is one of several species that use the caves for roosting, reproduction, and hibernation. The unique aspects of caves are afforded specific protection under the Federal Cave Resources Management Plan.^c

Manmade structures including buildings, fences, and power lines provide roosting, nesting, and escape cover for raptors, reptiles, and small mammals. Raptors on the INEL are the primary species to benefit from manmade structures on the INEL. A detailed discussion of the characteristics of these habitats and their importance to the INEL ecosystem is included in Section D.1.4.

5.1.7 Historic and Current Impacts

Historic and current impacts affecting INEL wildlife species have been combined into general categories including grazing, habitat loss, habitat fragmentation, contamination, vegetation removal, fire, facility operations and human disturbance. Impacts associated with activities included within each of these categories are defined in Section D.2.

General topics to be discussed include altered habitat structure (habitat loss, fragmentation, fire, vegetation removal), water management (permanent and temporary water sources), traffic, noise, manmade facilities, possible disruption of breeding, nesting or migratory patterns, and physical hazards, contamination sources Radiological and Environmental Sciences Laboratory—airborne and liquid releases, manmade ponds, pesticides/herbicides, grazing exclusion, fencing.

Pronghorn, raptors, and other avian and mammal species have benefitted from the isolation and relatively large tracts of undisturbed habitat provided by the INEL. An analysis of historic and current impacts for INEL vegetation communities is summarized on Table 5-6. The disturbance patterns for vegetation communities were used to analyze impacts to associated threatened and endangered and sensitive plants (Table 5-7), animals (Table 5-8), and unique communities (Table 5-9) on the INEL. Impacts analysis for contamination incorporate radiological results presented in Section 5.3.

Additional discussion pending completion of geographical information system analysis.

c. Private communication with S. J. Miller, Chemical Services Unit, EG&G Idaho, Inc., Idaho Falls, ID, 1993.

Table 5-6. Summary of impacts on INEL vegetation communities (this table is being updated).

Vegetation class	Grazing	Habitat loss	Frag- mentation	Contam- ination	Vegetation removal	Fire	Facility operations	Human disturbance
Juniper woodlands								
Basin wildrye								
Steppe (bunchgrass)								
Grassland								
Sagebrush-steppe off lava								
Sagebrush-steppe on lava								
Sagebrush-winterfat								
Salt desert shrub								
Sagebrush-rabbitbrush								
Sagebrush, low-sagebrush rabbitbrush on lava								
Wetlands								
Playa/bare ground								
Lava								
Old fields, disturbed areas, seedings								
Saltbush-grass								

Table 5-7. Summary of impacts on rare plants found on the INEL (this table is being updated).

Species	Grazing	Habitat loss	Frag- mentation	Contam- ination	Vegetation removal	Fire	Facility operations	Human disturbance
<i>Astragalus aquilonius</i> (Lemhi milkvetch)								
<i>Astragalus ceramicus</i> var. <i>apus</i> (Painted milkvetch)								
<i>Astragalus gilviflorus</i> (Plains milkvetch)								
<i>Astragalus kentrophyta</i> var. <i>jassiae</i> (Thistle milkvetch)								
<i>Camissonia pterosperma</i> (Winged-seed evening primrose)								
<i>Coryphantha missouriensis</i> (Nipple cactus)								
<i>Gymosteris nudicaulis</i> (Large-flowered gymnosteris)								
<i>Lpomopsis (Gilia)</i> <i>polycadon</i> (Spreading gilia)								
<i>Lesquerella kingii</i> var. <i>corbrensis</i> (King's bladderpod)								
<i>Oxytheca dendroidea</i> (Oxytheca)								

Table 5-8. Summary of impacts on threatened and endangered species, and special species of concern (this table is being updated).

Species	Grazing	Habitat loss	Frag- mentation	Contam- ination	Vegetation removal	Fire	Facility operations	Human disturbance
Bald eagle (C2)								
Peregrine falcon (C2)								
Ferruginous hawk (C2) ^a								
White-faced ibis (C2)								
Loggerhead shrike (C2)								
Northern goshawk (C2)								
Gyr Falcon (SSC) ^b								
Common loon (SSC)								
American White Pelican (SSC)								
Great egret (SSC)								
Pygmy rabbit (C2)								
Townsend's western big-eared bat (C2)								
California myotis (SSC)								

a. C2 = Category 2 species , Fish and Wildlife Service Category.

b. SSC = species of special concern, Idaho Department of Fish and Game Category.

Table 5-9. Summary of impacts on unique or special habitats on the INEL (this table is being updated).

Habitat type	Grazing	Habitat loss	Frag-mentation	Contam-ination	Vegetation removal	Fire	Facility operations	Human disturbance
Caves								
Manmade structures and facilities								
Soil microflora								

5.2 Wetland Resources

5.2.1 Overview

Over 130 areas within the boundaries of the INEL have been assigned wetland status as part of the FWS National Wetlands Inventory (NWI) (Cowardin et al. 1979). The geographic coverage of the INEL includes 30 7.5-ft U.S. Geological Survey topographic quadrangles. Finalized NWI maps have been generated for 23 of these quadrangles.

A survey of a sample of these wetlands was conducted in fall of 1992. As part of this survey, designated wetlands from the completed NWI inventory maps were digitized and entered into a geographical information system at the INEL. A map of INEL wetlands was created and combined with other coverages already available in the geographical information system database. The survey methodology and results are described in detail elsewhere (Hampton et al. 1993). Habitat and ecological associations for INEL wetlands are presented in Section D.1.6.5.

5.2.2 Wetland Classes on the INEL

The wetlands of the INEL, as mapped by the FWS NWI, are shown on Figure 5-2. Sixteen separate NWI FWS classifications are represented by approximately 130 wetland sites within INEL boundaries. These NWI classifications are denoted by a descriptive acronym assigned by the FWS and are defined and summarized on Table 5-10. Two additional classes were created for the INEL preliminary wetlands survey to include investigation of (a) potential wetlands that exist in the seven quadrangles not yet mapped by the FWS NWI (UNMAP) and (b) areas within the mapped quadrangles that have characteristics similar to mapped wetlands, but were not classified as wetlands (UNCLASS).

Field descriptions were completed for 105 sites in 16 NWI and two special categories. In addition, 20 sites were inspected as part of the verification of grouped wetland sites. The survey sample sites are summarized on Table 5-10. Plant species identified during the survey are listed in Table D-12. Further details of the survey methodology and results are discussed in the formal survey documentation (Hampton et al. 1993).

5.2.3 Temporal Variability

Riverine (R4SBA, R4SBC, R4SBJ, R4SBJx and R2OWHx), lacustrine (L2USJ), and most palustrine (PAB4Hx, PEM1A, PEM1C, PEMJ, PEM1J) wetlands on the INEL are dependent on flows from the Big Lost River. Drought and upstream water diversion result in periods when no flow reaches either the river channel (R4SBA), spreading area (L2USJ), or the sinks (PEM1A, PEM1C, PEM1J). Historical streamflow records collected at U.S. Geological Survey gauging stations show that between 1921 and 1965, water reached the Big Lost Sinks 12 times in 45 years and 11 of 22 years between 1965 and 1987 (Bennett 1990). However, a normal snowpack and above normal 1993 spring rains have resulted in flows onto the INEL sections of the Big Lost River for the first time since 1986 (Bennett 1990). Riparian areas are maintained by the

Figure 5-2. Wetlands on the INEL.

Table 5-10. Summary of wetlands on the INEL.

Wetland acronyms ^a	Site number	Vegetation type	Unique sites ^b	Total mapped wetlands on the INEL	Number of wetlands surveyed
NWI classifications					
PAB4Hx	30	Old waste pond, mostly bare weeds	—	1	1
PEM1A	31	Mostly bare ground and litter, some grasses and weeds	31	3	1
PEM1C	32, 33	Bulrush and cattail area, now dry, weedy, litter covered	32, 33	2	2
PEM1J	34, 35	Mostly bare ground and litter, some grasses and weeds	34, 35	2	2
PEMJ	36, 37	Perennial grasses and forbs, disturbed areas with weeds	—	2	2
POWHx	42–52	Open water ponds at facilities, cattail and bulrush in one, most gravel with weeds, some misidentification, 3 sites inside facility fence lines were not checked	—	14	11
PUSC	38	Crested wheatgrass seeding in a borrow pit	—	1	1
PUSCr _x	39, 40	Old waste ponds, mostly bare, old willow and shrubs present	—	2	2
PUSC _x	41	Lined gravel waste pond, some weeds and native shrubs now		1	1
PUSJ	1–29	None, some with a few scattered weeds, important as seasonal water sources	1-3, 4, 7, 9–11, 13–22, 24, 25	88	45
L2USJ	53–56	Large open bare ground areas, mostly perennial weed cover	53 - 56	6	4
R20WHx	57	Cattail and bulrush in outflow channel, water present	57	1	1
R4SBA	58	Big Lost River channel, gravel with scattered weeds established includes important riparian habitats	58	1	1
R4SBC	59	Shallow sandy channel with weeds along edge	59	2	1
R4SBJ	60	Small sand channel with established weeds	60	3	1
R4SBJ _x	61, 62	Narrow gravel channel, scattered weeds with sagebrush invading		2	2
Total NWI classification				131	78
Special classifications					
UNCLASS	77–105	Similar to PUSJ in all respects, some seasonally important water sources	81, 82, 85, 92, 94–96, 102–105	Unknown	29
UNMAP	63–76	One with wetland vegetation in outflow channel, mostly seasonally wet areas with small channels and sections of the Big Lost River	63–65, 71–74	Unknown	14
Total				131	121
a. NWI classifications:					
P	=	Palustrine	A	=	Temporarily Flooded
AB	=	Aquatic Bed	C	=	Seasonally Flooded
4	=	Floating	J	=	Intermittently Flooded
H	=	Permanently Flooded	OW	=	Open Water
x	=	Excavated	US	=	Unconsolidated Shore
EM	=	Emergent Vegetation	r	=	Artificial Substrate
1	=	Persistent	L	=	Lacustrine
			2	=	Littoral
			R	=	Riverine
			SB	=	Streambed
			UNCLASS	=	Area not classified as a wetland by NWI
			UNMAP	=	NWI maps not complete
b. Site numbers correspond to location on Figure 5-2.					

intermittent flows along sections of the river and portions of the Birch Creek drainage. Playa wetlands (PUSJ) hold water longer than surrounding areas; however, little is known about their temporal characteristics. A 1993 survey of spring water conditions at a number of these wetlands has shown that some playas hold water for several weeks and the preliminary survey conducted in 1992 indicated that they may be important to INEL wildlife. Manmade ponds associated with facility operations offer the only permanent sources of water on the INEL. These ponds are important to a number of species, including bats, waterfowl, and big game (Howe 1986; Halford et al. 1976; Halford and Millard 1978). In addition, ponds at some facilities also provide open water in early winter and spring that normally would not exist on the INEL.

Further discussion pending analysis of 1993 survey data.

5.2.4 Ecological Significance

Permanent and temporary water sources are critical components of desert habitats. Limited water availability or availability at critical periods during the year is important to INEL plants and wildlife. The only permanent sources of water on the INEL are manmade ponds where flows are sustained through facility operations. These ponds represent important habitat on the INEL that would otherwise not exist.

The role and ecological significance of ephemeral playa wetlands on the INEL has not been studied and is poorly understood. Because these areas hold water for various periods, they may be important as breeding habitat for insects, supply physiological water needs for bird, mammal, and reptile species, and produce increased vegetation suitable for cover and forage.

The Big Lost River and Birch Creek drainages support riparian habitats that are unique and important to a diversity of desert fauna. These areas are important to breeding birds, with a large percentage being dependent of riparian systems. Studies have also shown that greater than 60% of vertebrates in southwestern deserts are obligate to riparian systems, and an additional 10 to 20% are facultative users (Jones 1986).

Completion of this section pending geographical information system analysis.

5.2.5 Potentially Important Wetlands

A subjective ranking of individual sites was compiled to prioritize INEL wetlands with regard to ecological uniqueness. The qualitative ranking for each site was based on unique or important habitats or vegetation observed, areal extent, hydrology, observation or signs of wildlife use, plant and animal diversity, disturbance, historical record, and archaeological evidence (Hampton et al. 1993). Sites ranked highest (1 or 2) with respect to relative uniqueness are summarized on Table 5-10.

Additional information to be generated from geographical information system analysis.

5.2.6 Historic and Current Impacts

The vegetation map was used as the basis for characterization of vegetation communities surrounding INEL wetlands. Ecological information from INEL studies and other sources was added to conduct an assessment of historic and current impacts for INEL wetlands as summarized on Table 5-11.

With the exception of playa wetlands (PUSJ), nearly all INEL wetland habitats are impacted by water management and diversion activities on and off the INEL. Agricultural demand and flood control diversions, combined with low regional precipitation, prevent permanent water in the Big Lost River and Birch Creek drainages and limit the existence of "classic" wetlands to inordinately wet periods. Those ponds and streams supporting permanent, obligate wetland vegetation are artificially maintained through facility operations. Riparian habitats appear to be sustained by infrequent flows in both the Big Lost River and Birch Creek drainages; however, studies in the desert southwest indicate that periodic flooding is necessary not only to maintain old vegetation but to reestablish cottonwood communities (Jones 1986).

___% of INEL wetlands are in areas where cattle or sheep grazing is allowed. Two major areas, the Big Lost River sinks and spreading areas, show signs of disturbance including soil erosion, vegetation damage, and exotic species invasion (Hampton et al. 1993). Impacts to playa wetlands as a result of grazing activities are unknown.

To be completed as part of geographical information system analysis.

5.2.7 Future FWS Survey Activities

Completion of the remaining seven NWI maps for the INEL is expected in the near future. A phone conversation during May of 1993 with Howard Browers of the FWS indicated that no further wetlands survey work will be conducted by the FWS until 1994.

5.3 Radioecology

Information for this section will be included in the next update.

Table 5-11. Summary of impacts on INEL wetlands (this table is being updated).

Wetland class or site	Grazing	Habitat loss	Frag- mentation	Contam- ination	Vegetation removal	Fire	Facility operations	Human disturbance
PUSJ								
L2USJ								
Manmade								
Riverine								
Unmapped								
Unclassified								

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6. SOCIOECONOMIC CHARACTERISTICS AND LAND USE

Ecology and Environment, Inc.^a

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ACRONYMS

ADA	average daily attendance
ANL-W	Argonne National Laboratory-West
B&W	Babcock and Wilcox
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
E&E	Ecology and Environment, Inc.
INEL	Idaho National Engineering Laboratory
ISU-IFRC	Idaho State University-Idaho Falls Resource Center
NRF	Naval Reactors Facility
PTI	Protection Technology, Inc.
TAN	Test Area North
WEC	Westinghouse Electric Corporation
WINCO	Westinghouse Idaho Nuclear Company, Inc.

6. SOCIOECONOMIC CHARACTERISTICS AND LAND USE

6.1 Socioeconomic Characteristics

This section provides a profile of the social and economic characteristics of the counties and communities surrounding the Idaho National Engineering Laboratory (INEL). Demographic characteristics, employment and income statistics, and data on housing, public schools, public revenues, and community services and facilities are included. In addition, a profile of the INEL workforce and estimates of the regional economic impacts of the INEL are discussed. This section focuses on the five counties that are contiguous to the INEL (Bingham, Bonneville, Butte, Clark, and Jefferson) and two others where a significant portion of INEL employees live (Bannock and Madison).

Table 6-1 shows the geographical distribution of INEL employees by their county of residence. The residency percentages displayed on the table were derived from a 1991 personnel survey conducted of contractor, naval, U.S. Department of Energy (DOE), and other Federal personnel who work at or for the INEL facility. Hereafter, these employees will be referred to as INEL employees. Results of the survey indicate that the majority of INEL employees (67%) live in Bonneville County. In addition, six counties on Table 6-1 (Bonneville, Bingham, Bannock, Jefferson, Madison, and Butte) account for more than 97% of the total INEL labor force.

Due to its proximity to the INEL, the Fort Hall Indian Reservation and Trust Lands, which are located in Bannock, Bingham, Caribou, and Power counties, will be included in this analysis. The reservation, which was established through a U.S. executive order in 1867, is the home of the Shoshone-Bannock Tribes. Socioeconomic characteristics of the reservation will be discussed.

6.1.1 Demographic Characteristics

The seven-county region had a population of 219,713 in 1990, which represented approximately 22% of the state's total population. The region affected by the INEL ranges from rural areas such as Butte and Clark counties, to urbanized areas such as Bonneville and Bannock counties (see Table 6-2).

Nearly 63% of the people living in the seven-county region in 1990 resided in the two most populous counties, Bonneville and Bannock. Only six cities in the seven-county region had more than 5,000 residents in 1990; the largest are Pocatello (located in Bannock County) and Idaho Falls (located in Bonneville County) (see Table 6-3).

Population growth in the seven-county region has mirrored population growth in Idaho as a whole. Although growth was not evenly distributed among the counties, the seven-county region experienced a 47% increase in population between 1960 and 1990. The region's growth rate was comparable to state-wide growth rate of 51%. Madison County experienced the most rapid growth in the region; from 1960 to 1990, its population increased by more than 150%. In contrast, the two smallest counties in the region, Butte and Clark, actually lost population between 1960 and 1990 (see Table 6-2).

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Table 6-1. Estimated geographical distribution of INEL employees by their county of residence as of January 1991.^a

County	Estimated Number of INEL Employees as of January 1991	INEL workers residing in county during 1991 (%)
Bonneville	8,334	67.07
Bingham	1,506	12.12
Bannock	1,009	8.12
Jefferson	683	5.50
Madison	296	2.38
Butte	262	2.11
Fremont	71	0.57
Custer	63	0.51
Cassia	61	0.49
Minidoka	22	0.18
Blaine	21	0.17
Clark	19	0.15
Teton	16	0.13
Oneida	14	0.11
All other counties	48	0.39
Total	12,425	100

a. U.S. Department of Energy (DOE) 1991b.

The worker distribution was determined by a survey sent to all INEL employees. Approximately 60% of all employees responded to this survey. The estimated number of employees was derived from the sample of respondents.

Idaho Falls and Pocatello are the two largest cities in the study region, with 1990 populations of 43,929 and 46,027 persons, respectively. Table E-1 in Appendix E shows these cities' populations from 1940 to 1990. The largest increases in population of Idaho Falls occurred during the 1950s, which can partially be explained by the formation and the development of the Nuclear Reactor Test Station. This facility evolved into the INEL. In contrast, Pocatello's growth occurred primarily in the 1940s and the 1960s. Idaho Falls has continued to grow; the total population of the city increased by 11% from 1980 to 1990. Pocatello's population, on the other hand, declined by 0.7% during the same time period.

According to the U.S. Bureau of the Census, 5,063 residents were living on the Fort Hall Indian Reservation and an additional 51 persons were residing on the Fort Hall Trust Lands during 1990. Approximately 52% of the total population of the reservation resides in Bingham

Table 6-2. Total population and average annual population change for the seven-county region and the State of Idaho.^a

Geographic area	Population				Average annual (%) population change		
	1960	1970	1980	1990	1960-1970	1970-1980	1980-1990
Bannock	49,342	52,200	65,421	66,026	0.6	2.3	0.1
Bingham	28,218	29,167	36,489	37,583	1.6	2.3	0.3
Bonneville	46,906	52,457	65,980	72,207	1.1	2.3	0.9
Butte	3,498	2,925	3,342	2,918	-1.5	1.3	-1.2
Clark	915	741	798	762	-1.8	0.8	-0.4
Jefferson	11,672	11,740	15,304	16,543	0.8	2.7	0.8
Madison	9,417	13,452	19,480	23,674	3.6	3.8	2.0
Seven-County Area Region	149,968	160,587	203,596	219,713	0.7	2.4	0.8
Idaho	667,191	713,015	943,935	1,006,749	0.7	2.8	0.6

a. U.S. Bureau of the Census 1992.

County. The remainder of the residents live in Bannock County (30%) and Power County (18%). No members of the reservation reside in Caribou County.

As shown on Table 6-3, households in the seven-county region tend to be larger than the state average household. Madison County has the largest average household size (3.84 persons) in the region, and Clark County the smallest (2.67 persons). Clark County is the only county in the seven-county region that has an average household size smaller than the state-wide average.

Based on population projections made by the Idaho Power Company and supplied to the Idaho Department of Commerce, from 1995 to 2005, moderate population growth is projected for the seven-county region. As shown on Table 6-4, population in the seven-county region as a whole is expected to grow at a rate slightly less than the overall rate for the State of Idaho. Jefferson and Madison counties are projected to have the largest relative increases (14.6%) in population in the seven-county region from 1995 to 2005.

These projections were made by an economic model designed to assist the Idaho Power Company in determining the future demand for electricity throughout the state. Data on job growth and construction levels were utilized in this model. Currently, these projections appear to predict a greater expansion in the state as a whole than is likely to occur. The large increases over 1990 or 1992 population estimates are a result of these smaller-than-projected population levels. Due to the region's heavy dependence on the INEL, as discussed in Section 6.6, expansion or contraction of the INEL work force significantly impacts regional population projections.

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Table 6-3. Mean household size and median ages for the seven-county region and the State of Idaho in 1990.^a

Geographic area	Population characteristics		
	% Urban	Mean household size	Median age
Bannock	83.6	2.78	29.5
Bingham	38.9	3.23	27.6
Bonneville	78.2	2.94	28.7
Butte	0.0	2.87	33.3
Clark	0.0	2.67	32.9
Jefferson	16.2	3.38	26.4
Madison	60.4	3.84	20.0
Seven-County Region	65.2	NA	NA
Idaho	57.4	2.73	31.5

a. U.S. Bureau of the Census 1992.

Table 6-4. Population projections for the seven-county region and the State of Idaho.^a

Geographic area	1995	2000	2005	Percent change 1995–2000	Percent change 2000–2005
Bannock County	73,800	79,480	83,510	7.7	5.1
Bingham County	42,850	45,710	47,740	6.7	4.4
Bonneville County	82,110	87,590	91,480	6.7	4.4
Butte County	3,340	3,560	3,720	6.6	4.5
Clark County	870	940	990	8.0	5.3
Jefferson County	18,390	19,960	21,070	8.5	5.6
Madison County	26,630	28,900	30,510	8.5	5.6
Seven-County Region	247,990	266,140	279,020	7.3	4.8
Idaho	1,126,300	1,220,900	1,290,800	8.4	5.7

a. Private communication with Richard Dwight, Idaho Department of Commerce, Boise, ID, February 23, 1993.

6.1.2 Economy, Employment, and Income

Historically, the economy of the seven-county region has relied predominantly on natural resource use and extraction. To this day, farming, ranching, mining, and tourism remain important components of the regional economy. Idaho Falls is a regional retail and service center for southeast Idaho. Similarly, the City of Pocatello has evolved into an important processing and distribution center for the surrounding agricultural areas and acts as a regional center for higher education.

The economy of the seven-county region currently revolves around agriculture and the INEL. Almost all manufacturing in the region is a form of food processing. Mining and mineral processing are significant to the regional economy (see Table E-2 in Appendix E), and tourism is also considered to be an important component of the regional economy, particularly in areas just outside the seven-county region. The abundance of outdoor recreational areas, including Yellowstone National Park, the Grand Teton National Park, and Craters of the Moon National Monument as well as nationally known winter recreation areas, such as Sun Valley and Jackson Hole, all contribute to the regional economic importance of tourism.

The INEL is the single largest employer in the seven-county region. As of January 1991, the DOE and its operating contractors employed more than 12,425 persons. The DOE Idaho Operations Office (DOE-ID), Naval Reactors Facility (NRF), and Argonne National Laboratory-West (ANL-W), with their 1991 annual payroll of \$440 million and annual funding of more than \$1,144 million, have an extremely large impact on the regional economy. Large portions of the retail trade and the service and construction industries located in the region are indirectly supported by the INEL. The City of Idaho Falls and Bonneville County are particularly affected due to the large number of DOE and INEL contractor personnel who work and live in the city and county. In addition to direct employment at the INEL, contracting and procurement activities at the Site greatly affect the regional economy by adding to regional employment and regional income. The growth of "spin-off" companies and consulting firms is a direct result of INEL expenditures.

As INEL employees spend a portion of their income locally and INEL contractors purchase materials and goods from the local suppliers, the sales and profits of local merchants and retailers increase. This increase in profits leads to an expansion of regional employment and regional output. As additional workers are employed and output is increased at local firms, additional income in the economy is created, thus continuing the positive economic impacts of the original injection of funds. See Section 6.6 for a more detailed discussion of the INEL's impact on the regional economy.

Current economic development at the Fort Hall Indian Reservation includes several retail and service establishments located on the reservation. Most of this development has occurred along U.S. Interstate 15. In addition, during the fall of 1988, the Shoshone-Bannock Tribes established a steel fabrication business in Pocatello. Agriculture and ranching, including buffalo ranching, are important components of the reservation's economy.

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Unemployment rates varied considerably in the seven-county region in 1990 and 1991. Clark County has consistently had unemployment rates significantly lower than those of the remainder of the region while Bingham County's annual average unemployment rates were significantly greater than the seven-county region's overall rates (see Table 6-5).

Retail trade and educational services are the two largest employment sectors in the seven-county region. During 1989, these sectors provided 17.6% and 11.4% of the total employment in the region, respectively. The other professional and related services sector employed 10.2% of the seven-county region's work force. This category includes most of INEL contractors and subcontractors. A detailed discussion of employment by industry by county can be found in Appendix E.

During 1989, each county in the seven-county region, with the exception of Bonneville County, had a median household income level between \$3,764 and \$7,056 less than the national median household income. In contrast, Bonneville County's median household income was more than \$400 over the national median household income. The wide disparity between income levels may in part be explained by the large number of INEL employees who live in Bonneville County.

Per capita income figures in the region were lower than per capita incomes in the rest of the United States. Although Bonneville County had a median household income greater than the national median, its median per capita income level was significantly less than the national per capita income due to its large average household size (see Table 6-6).

The percentage of persons living below the poverty line varies quite significantly throughout the region. As expected, Madison County, with its relatively low median family income and low per capita income, has the greatest percentage of residents below the poverty level of any of the seven counties in the region. However, Clark County, which has average household income and per capita income figures, also has the smallest percentage of persons below the poverty level (9.3%) (see Table 6-6). Approximately 49% of all persons living on the Fort Hall Indian Reservation during 1989 had annual income levels below the poverty level (U.S. Bureau of the Census 1992).

The percentage of persons living below the poverty level in 1989 has increased over the 1979 levels in most counties in the seven-county region. With the exceptions of Bonneville County and Clark County, which recorded decreases in the number of persons living below the poverty level, and Jefferson County, whose percentage of persons living below the poverty line remained the same, the region experienced a large growth in persons whose annual income placed them below the poverty level. Madison County experienced the greatest increase in the percentage of residents living in poverty, with a 1979 percentage of 10.9% rising to 28.6% in 1989 (see Table 6-6).

Table 6-5. Average annual labor force data for 1990 and 1991 for the seven-county region.^a

County	1990			1991		
	Labor force	Total employed	Unemployment rate (%)	Labor force	Total employed	Unemployment rate (%)
Bannock	30,493	28,548	6.4	30,635	28,700	6.3
Bingham	16,564	15,434	6.8	17,366	16,266	6.3
Bonneville	36,965	36,249	4.6	38,516	36,777	4.5
Butte	1,645	1,563	5.0	1,669	1,575	5.6
Clark	730	711	2.6	758	738	2.8
Jefferson	6,943	6,486	6.6	7,243	6,796	6.2
Madison	8,495	8,034	5.4	8,467	8,059	4.8
Seven-County Region	101,835	96,025	5.7	104,654	98,991	5.5

a. State of Idaho Department of Employment, Research and Analysis Bureau 1992.

Table 6-6. Income and poverty data for the seven-county region, the State of Idaho, and the United States in 1989.^a

Geographic region	Median household income in 1989	Per capita income in 1989	Below poverty level in 1979 (%)	Below poverty level in 1989 (%)
Bannock	\$26,275	\$10,976	7.3	13.8
Bingham	\$25,158	\$9,474	7.0	15.6
Bonneville	\$30,462	\$12,123	11.6	9.9
Butte	\$26,292	\$10,257	10.5	13.5
Clark	\$24,583	\$10,608	13.9	9.3
Jefferson	\$24,421	\$9,055	14.3	14.3
Madison	\$23,000	\$7,385	10.9	28.6
Seven-County Region	NA ^b	\$10,554	NA	NA
Idaho	\$25,257	\$11,457	9.6	13.3
U.S.	\$30,056	\$14,420	NA	13.1

a. U.S. Bureau of the Census 1992.

b. Not available.

6.1.3 Housing

The cities of Idaho Falls and Pocatello are the focal points of the housing market in the seven-county region. In 1990, 77,660 housing units were located in the seven-county region, with the cities of Idaho Falls and Pocatello providing 46% of these units.

Approximately 69.6% of all housing units in the region are single-family units, 17% are multi-family units, and the remaining 13.4% are mobile homes. Table 6-7 displays the number of single-family, multi-family, and mobile-home units located in the region. The majority (68%) of the multi-family units in the seven-county region are located in the cities of Idaho Falls and Pocatello (U.S. Bureau of the Census 1992).

Construction of multi-family units has slowed during the past decade. Between 1980 and 1986, the City of Idaho Falls issued 517 building permits for apartment construction. This figure declined to only 141 housing permits between 1987 and 1990. Permits for only seven apartment buildings were issued during 1991 (City of Idaho Falls 1991).

No multi-family rental housing has been constructed in the City of Pocatello for several years. The only multi-family housing activity in 1990 and 1991 in the City of Pocatello was the issuance of one building permit for a duplex (Intermountain Demographics 1992).

A deficit of single-family housing presently exists near Idaho Falls because construction has not kept up with increasing demand (Intermountain Demographics 1992). Vacancy rates for owner-occupied housing units illustrate this deficit situation. Table 6-8 displays the 1990 homeowner and rental vacancy rates for counties in the seven-county region. Typically, homeowner vacancy rates in the region are near the state rate of 2%. Madison, Clark, and Bonneville counties have vacancy rates below the state's rate. In contrast, Butte County's 4.6% homeowner vacancy rate is significantly higher than regional or state levels (see Table 6-8).

Vacancy rates for rental units in the seven-county region show much greater variation than homeowner vacancy rates between the counties. Rental vacancies range from a low of 2.8% in Madison County to a high of 16.2% in Butte County. Madison, Jefferson, and Bonneville counties all have rental vacancy rates significantly below the state-wide average of 7.3%. The rental vacancy rates in Bannock, Bingham, Butte, and Clark counties are all significantly above the average for the State of Idaho (see Table 6-8).

The estimated 1990 median value of owner-occupied housing in the State of Idaho was \$58,200. Factors such as the local economy, size and type of housing units, and demand for housing affect the median value of owner-occupied housing in each county. For this reason, the median value of owner-occupied housing units varies significantly throughout the region. Clark and Butte counties, which have the largest ratio of mobile homes to total housing units, also have the lowest median owner-occupied housing values. In contrast, Madison County, which has the highest median owner-occupied housing unit value, also has the lowest homeowner vacancy. Demand for housing in Madison County is greater than the supply; therefore, the price of housing has moved upward (see Table 6-8).

Table 6-7. Total 1990 housing units by type in the seven-county region.^a

County	Single family attached and detached	Multi-family unit	Mobile home, trailer, other	Total housing units
Bannock	17,448	5,406	2,840	24,694
Bingham	9,169	1,103	2,392	12,664
Bonneville	18,935	4,462	2,652	26,049
Butte	899	124	242	1,265
Clark	280	11	211	502
Jefferson	3,923	224	1,206	5,353
Madison	3,394	1,858	881	6,133
Seven-County Region	54,048	13,188	10,424	77,660

a. U.S. Bureau of the Census 1992.

Table 6-8. Homeowner and rental units, vacancy rates, median housing prices, and median rental rates in 1990.^a

Geographic area	Owner-occupied housing units			Rental units		
	Number of occupied units	Vacancy rates	Median value (\$)	Number of occupied units	Vacancy rates	Median monthly rent (\$)
Bannock	16,082	2.4	53,300	7,330	10.3	294
Bingham	8,830	2.0	50,700	2,683	9.2	284
Bonneville	17,371	1.9	63,700	6,918	6.2	366
Butte	744	4.6	41,400	253	16.2	243
Clark	174	1.7	37,300	103	9.6	281
Jefferson	3,920	2.0	54,300	951	4.1	314
Madison	3,476	1.3	68,700	2,325	2.8	299
Idaho	252,687	2.0	58,200	107,989	7.3	330

a. U.S. Bureau of the Census 1992.

Median monthly rents are relatively constant throughout the seven-county region. Typical average rents in the region range between \$280 and \$315. Bonneville and Butte counties are the exceptions. In 1990, median monthly rents in Bonneville County were \$366. The higher monthly rents can be partially explained by the high median property values and the large number of government contractors and naval personnel who reside in Idaho Falls. Butte County, on the other hand, has monthly rents that are significantly lower than any other county in the region. The high rental vacancy rates and the rural nature of the county all contribute to these low monthly rents (see Table 6-8).

Naval personnel receive compensation for housing expenses. The level of this compensation greatly influences the price of rental units in Idaho Falls. Rents in the area have a tendency to follow the housing allowances provided by the Navy.

In 1990, there were 1,740 housing units on the Fort Hall Indian Reservation and an additional 23 units on the Fort Hall Trust Lands. Approximately 14% of these housing units were vacant in 1990. Of the 1,510 occupied units on the reservation and trust lands, 830 units (55%) were occupied by American Indians. Approximately 23% of the units occupied by American Indians were rental units, while the remaining 77% were owner-occupied units. The median monthly rent for housing units on the Fort Hall Indian Reservation was \$221. The median monthly owner cost for housing units that had a mortgage was \$300 (U.S. Bureau of the Census 1992).

6.1.4 School Services

Seventeen public school districts provide educational services for 56,899 school-aged children within the seven-county region. As illustrated on Table E-9 in Appendix E, enrollments at the public school districts in the region range from only 90 students to nearly 14,000 students. Similarly, significant variations in student/teacher ratios exist throughout the study area. For example, Clark County School District has the lowest student/teacher ratio in the region with a 14-to-1 ratio, while the Swan Valley School District has a 30-to-1 student/teacher ratio.

The majority of the public schools in the seven-county region operate at levels at or above the design capacity of their classroom facilities. Many of the school districts currently operating over capacity are planning expansions of their existing facilities.

All public school districts in the region receive revenues from numerous sources, including local property tax levies and state and federal aid. Table E-9 displays the total 1990-1991 revenues and revenues per pupil for each public school district in the seven-county region.

In addition to the Federal education aid that all districts receive, Federal impact aid is provided to school districts that are adversely affected by Federal properties and installations located in or near the school district. Since the Federal government cannot be taxed by state or local governments, impact aid is provided to the school districts in lieu of property tax payments.

School districts receive impact aid based on the number and type of Federally connected students who attend their schools. The U.S. Department of Education provides aid for children that reside on Federal property, Indian reservations, or in a low-income housing project and/or have a parent who is employed on Federal property or is in the uniformed services.

By utilizing a formula that factors in a school district's average daily attendance and the number of Federally connected students who attend the school district, the U.S. Department of Education determines which school districts are eligible to receive impact aid.

Table 6-9 lists the school districts in the seven-county region that receive impact aid from the U.S. Department of Education. Included on this table is the number of federally connected students associated with the INEL. These totals include any student that was listed as having a parent employed at the INEL, the Nuclear Reactor Test Station, the ANL-W, the INEL Supercomputing Center, or the INEL Research Center in Idaho Falls. Military dependents from the NRF were not included in the INEL total because military dependents cannot be identified by facility. The military category on Table 6-9 includes all dependents of military personnel regardless of the actual facility to which the parents are assigned.

As expected, Idaho Falls School District No. 91 and Bonneville County School District No. 93 had the largest number of INEL-connected students during Fiscal Year (FY) 1992, with 2,269 and 1,771 students, respectively. In addition, Blackfoot School District No. 55, Snake River School District No. 52, and Pocatello School District No. 25 all had more than 485 INEL-connected students (see Table 6-9).

Table E-11 provides information on public school district expenditures and shows average expenditures per pupil for all public school districts in the seven-county region. During the 1990–1991 academic year, expenditures per student varied greatly throughout the seven-county region. The majority of school districts spent an average of \$3,000 to \$4,000 per student annually.

Higher education for residents of the seven-county region is provided by University of Idaho, Idaho State University, and Brigham Young University—Ricks College. The University of Idaho—Idaho Falls (UI-IF) has approximately 3,000 registrations each semester. About 600 registrations are for graduate classes in environmental resources and waste management programs. Courses are also available in science, technology, engineering, and computer science programs (Eld 1992).^b

The main campus of Idaho State University, which is located in the City of Pocatello, had an enrollment of 3,440 full-time students during the 1990–1991 school year. Idaho State University—Idaho Falls Residence Center (ISU-IFRC), located in Idaho Falls, offers general graduate and undergraduate course work as well as four degree programs supported by INEL education

b. Private communication from C. Jacobson, Ecology and Environment, Inc., Idaho Falls, Idaho, to Marvin Eld, Assistant Director, University of Idaho, July 21, 1992.

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Table 6-9. Average daily attendance of Federal and military students and total number of INEL-related students during fiscal year 1992.^a

County	INEL-related students ^a	Military "B" students ^b (ADA)	Total Federally connected students ^c (ADA)
Bannock County			
Pocatello, No. 25	485	113	1,106
Bingham County			
Snake River, No. 52	522	1	572
Blackfoot, No. 55	635	20	979
Shelley, No. 55	375	7	382
Bonneville County			
Idaho Falls, No. 91	2,269	153	2,367
Bonneville Joint, No. 93	1,771	93	2,001
Butte County			
Arco, No. 111	301	1	289
Clark County			
Clark County, No. 161	5	49	74
Jefferson County			
Ririe, No. 252	50	4	60
West Jefferson, No. 253	84	NA ^d	NA
Madison County			
Sugar-Salem, No. 322	<u>47</u>	<u>6</u>	<u>57</u>
Total	6,544	447	7,887

a. Private communication from K. L. Shelly, Ecology and Environment, Inc., Lancaster, New York, to Marilyn Galvin, U.S. Department of Education, Impact Aid Program, December 2 and 31, 1992.

b. Total number of Federally connected students claimed to be associated with the INEL, the INEL Supercomputing Center, the INEL Research Center, and the ANL-W. NRF is not included in this number. Also, this is not the average daily attendance (ADA) of INEL-related students.

c. ADA of military personnel dependents within the school district. All uniformed services are included within this figure.

d. This column is not the total of the two previous columns. Students from other Federal installations, including Indian reservations, are included in this total. This figure is the ADA of Federally connected students, which may be less than the total number of Federally connected students claimed.

e. Not available.

contracts in business, waste management, nuclear science and engineering, and physics/health physics. ISU-IFRC had 2,097 students enrolled in the fall semester of 1991; 1,224 were INEL-related students, although student counts may be exaggerated as each class registrant is counted as a student by ISU-IFRC.^c

Ricks College, a private junior college located in Rexburg, offers career programs in agriculture, secretarial science and word processing, nursing professions, preschool education, and several construction and manufacturing areas. During the 1990-1991 academic year, Ricks College enrollment was almost 11,700 students, with approximately 5,700 of these students living on campus.^{d,e}

Eastern Idaho Technical College (EITC) in Idaho Falls provided vocational and technical education to approximately 465 full-time students in 1991. Eastern Idaho Technical College provides training in the following technical occupations: chemical laboratory technician, electronic service technical, hazardous materials technician, nuclear security training, process technology, quality assurance/nondestructive testing, and radiation safety technology (Eastern Idaho Technical College 1991).

6.1.5 Taxes

The State of Idaho levies several different taxes on individuals and corporations located within the state. As shown on Table E-12 in Appendix E, income taxes (personal and corporate), sales and use taxes, and motor fuel taxes provide the state with the majority of its revenues. During FY-91, Idaho collected \$436.4 million from individual income taxes, \$60.2 million from corporate income taxes, \$400.7 million from sales and use taxes, and \$115.2 million from motor fuel taxes. In addition to these taxes, the state levies taxes on cigarettes, beer, travel and conventions, tobacco, electricity, hotels/motels, wine, mines, estates, illegal drugs, and railroad cars (Idaho State Tax Commission 1991).

Local governments in the State of Idaho raise the majority of their revenues through property taxes. Several districts within the counties have the authority to levy taxes, including cities, school districts, highway districts, cemetery districts, fire districts, library districts, and sewer districts. Property taxes may also be directly levied for pest extermination, flood control, ambulance services, recreation areas, mosquito abatement, and hospitals. Each of these property

c. Private communication from C. Jacobsen, Ecology and Environment, Inc., Idaho Falls, Idaho, to Sandra Martin, Director, Idaho State University, July 24, 1992.

d. Private communication from C. Jacobsen, Ecology and Environment, Inc., Idaho Falls, Idaho, to Alan Clark, Director of Institutional Research, Ricks College, July 21, 1992.

e. Private communication from C. Jacobsen, Ecology and Environment, Inc., Idaho Falls, Idaho, to Allen Young, Coordinator, Brigham Young University and Ricks College Continuing Education Center in Idaho, July 21, 1992.

taxes is assessed and levied locally. Table 6-10 illustrates the differences in tax rates between and within counties in the region of study. Tax rates are expressed as a percentage of a property's taxable value. Rural tax rates include the total taxes levied by all taxing districts within the county. Urban tax rates for each county are determined by averaging all of the taxes paid within incorporated cities that levy property tax in that county.

Urban areas in Bannock and Bonneville counties pay the highest property taxes per assessed value in the region, with tax rates of 2.5877% and 2.5360%, respectively. In contrast, rural areas in Clark County have the lowest rates in the seven-county area, with 0.9489%. In all counties in the region, the rural tax rate is significantly lower than the urban tax rate (see Table 6-10).

In addition to property tax revenues, local governments also receive a portion (7.75%) of the total revenues collected by the state from the sales and use tax. Table 6-10 depicts the distribution of sales tax revenue from the state government to county governments in the seven-county region (Idaho State Tax Commission 1991).

County governments in the seven-county region receive the majority of their revenues from taxes and intergovernmental transfers, which include sales tax disbursements and revenue-sharing programs. Approximately 60% to 85% of the total revenues received by each county in the region is derived from these two sources. Licenses, permits, fees, fines, charges, and forfeitures are also important revenue sources for some county governments in the region. Madison and Bannock counties received approximately 25% and 19%, respectively, of their total revenues from licenses, permits, fees, fines, charges, and forfeitures. See Table E-13 for more detailed information on government funding sources in the seven-county region.

On average, county governments in the seven-county region spend 27% of their total annual expenditures on general government services, 18% on road maintenance and improvements, 16% on public safety, 16% on health and welfare programs, and 9% on sanitation and public works. The remaining funds are spent on debt service (3%), trust remittances (2%), and other expenditures (9%). Detailed information regarding county government expenditures can be found on Table E-14.

The majority of the revenues collected by the Shoshone-Bannock tribal government on the Fort Hall Indian Reservation and Trust Lands are derived from the leasing of agricultural land and royalties generated by a phosphate mining operation located in Gay Mine. Revenues received from rights-of-way also contribute to the tribes' general fund.

The tribal government has the sovereign power to tax activities within the reservation. Also, the Fort Hall Business Council levies taxes and fees on members of the tribes and nonmembers doing business on the reservation (Tribal Health and Human Services Department, n.d.).

Table 6-10. 1991 average property tax rates for urban and rural areas and distribution of sales tax revenue in the seven-county region.^a

County	Assessed value of all taxable property in the county	Average urban tax rate ^b (%)	Average rural tax rate ^b (%)	Sales tax disbursements during fiscal year 1991
Bannock	\$1,177,116,724	2.5877	1.5800	\$ 978,893
Bingham	779,584,508	2.4879	1.5825	566,297
Bonneville	1,618,156,380	2.5360	1.7481	1,055,549
Butte	104,599,268	1.7678	1.1691	71,518
Clark	60,618,591	1.2442	0.9489	40,551
Jefferson	341,662,795	2.1982	1.4652	263,690
Madison	388,410,012	1.7930	1.4675	347,175

a. Idaho State Tax Commission 1991.

b. Rates are expressed as a percentage of a property's taxable value and include the total taxes levied by all taxing districts within the county.

6.1.6 Idaho National Engineering Laboratory

The INEL designs, constructs, and operates defense production and waste management facilities, and conducts defense, energy, nuclear reactor, and environmental research. There are seven primary contractors at the INEL: EG&G Idaho, Inc.; Westinghouse Idaho Nuclear Company, Inc. (WINCO); Babcock and Wilcox Idaho, Inc. (B&W); Argonne National Laboratory-West (ANL-W); Westinghouse Electric Corporation (WEC); MK-Ferguson of Idaho Company; and Protection Technology Idaho (PTI). All contractors report to DOE-ID except the WEC, which operates the Naval Reactors Facility and reports to the DOE-Pittsburgh Naval Reactors Office, and the ANL-W, which maintains and operates an experimental breeder reactor and research facility and reports to the DOE Chicago Operations Office.

EG&G Idaho provides general support services for the INEL, manages reactor safety and experimental programs, and conducts other programs, including waste management, environmental restoration, geothermal energy, and energy conservation. WINCO operates the Idaho Chemical Processing Plant, and B&W manages the Specific Manufacturing Capability program at Test Area North (TAN). MK-Ferguson of Idaho Company provides construction support to the INEL, while PTI provides security services for the INEL Site and in-town facilities.

As illustrated on Table 6-11, 12,803 contractors and government personnel were employed at the INEL in January 1992. This figure includes 9,808 operating contractors; 122 subcontractors; 1,056 architectural, engineering, and construction contractors; 518 DOE-ID personnel; and 1,299 Federal employees working for other U.S. Government agencies. Overall employment at the INEL has increased by more than 23% in the past four years. In January 1989, the total work

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Table 6-11. Total number of workers employed at the INEL during fiscal years 1989 to 1992.^a

Employer	January 1989	January 1990	January 1991	January 1992
Operating Contractors				
PTI	391	417	458	439
EG&G Idaho	3,731	4,376	5,092	5,265
Rockwell-INEL ^b	491	448	436	—
WINCO	1,498	1,534	1,619	1,796
ANL-W	710	728	800	858
WEC	1,002	1,031	996	980
B&W ^b	—	—	—	470
Subcontractors	144	238	295	122
A-E and construction contractors	315	620	1,156	1,056
Government Agencies (excluding DOE-ID)^c	1,750	1,459	1,207	1,299
DOE-ID	353	373	366	518
Total	10,385	11,224	12,425	12,803

a. DOE 1989a; 1990; 1991a; 1992b.

b. Rockwell-INEL employment was completely curtailed in 1991 when DOE-ID did not renew their contract. B&W received the contract to operate the former Rockwell-INEL projects.

c. U.S. Navy personnel are included in government agencies.

force at the INEL was 10,385 employees. By January 1990, the overall level had reached 11,224 personnel, and by January 1991, it had climbed to 12,425 workers (See Table 6-11).

The total INEL work force is expected to decline by nearly 1,000 workers over the next 10 years. This reduction will be primarily due to reductions in employment at EG&G Idaho, WINCO, and NRF. From FY 1993 to FY 2002, the total subcontractor work force is expected to fluctuate considerably. The remaining employers are projected to maintain a near constant staffing level through the next decade (see Table E-15 in Appendix E).

During FY 1992, DOE-ID, NRF, and ANL-W received a total of \$1,147.9 million to operate facilities at the INEL. DOE-ID was appropriated \$967.3 million for on-Site programs, NRF was appropriated \$102 million, and ANL-W was appropriated \$78.6 million. Table E-16 illustrates INEL funding sources by program sponsors for FY 1989 to 1992.

Since FY 1989, the total DOE-ID funding has increased by \$241.0 million. During the same time period, total INEL on-Site funding has increased by \$269.6 million. From 1989 to 1992,

funding at the NRF and at ANL-W increased by \$10 million and nearly \$19 million, respectively (see Table E-16).

Future financial planning projections for the INEL are expected to remain relatively constant through 2002. As illustrated on Table E-17, funding for NRF and ANL-W is expected to increase throughout the next decade. DOE-ID financial planning projections are expected to increase through FY 2001 and then to decline slightly in FY 2002. Almost the entire increase in DOE-ID planned funding will be directly related to the Environmental Restoration and Waste Management programs. Planned funding from the Assistant Secretary for Defense Programs is expected to drop during FY 1993, and funding for the Office of the New Production Reactor is expected to be eliminated by FY 1994. The remainder of the DOE-ID planned funding sources, including work done for other Federal agencies, is projected to remain relatively constant until 2000.

The INEL has a large impact on both the regional economy and the economy of Idaho as a whole. In 1991, the INEL injected approximately \$440 million through wages and salaries and \$153 million through procurement expenditures into the regional economy.^f In addition to this income effect, the INEL also provides a significant portion of Idaho's total employment. In 1991, direct INEL employment accounted for 12,425 jobs, or 12.5% of the total jobs available in the region.

Table 6-12 displays the INEL total annual payroll expenditures by county. Due to the large number of Bonneville County residents who work at the INEL, more than \$295 million annually is injected into the county's economy through payroll expenses. The other six counties in the region of study receive between \$53 million and \$660,000 annually from the INEL (see Table 6-12).

The direct impact of INEL's payroll disbursements onto total income in the regional economy is shown on Table 6-13. More than 16% of all income received by residents in the seven-county region can be directly attributed to INEL employment. Bonneville County receives the largest portion of INEL payroll disbursements. Approximately 30% of the county's total income can be directly traced to INEL employment (see Table 6-13).

The direct economic impact of the INEL is even greater than the levels shown in Table 6-13. Procurement activities at the facility also increase the sales and profits of local merchants and retailers.

In addition to the direct employment generated by the INEL, spending at the facility also indirectly supports many of the service, construction, and retail industries in the region. The multiplier effects of the injections of income expand the overall employment within the regional economy. As INEL employees spend a portion of their income in the regional economy, the sales

f. Private communication (data on INEL taxes and payroll expenditures) from K. L. Shelly, Ecology and Environment, Inc., to Seb Klein, DOE-ID, Financial Office, 1992.

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and profits of local merchants and retailers increase. The increased sales cause merchants and retailers to expand their work force. As additional workers are employed, the amount of income they spend in the local economy increases, thus continuing the positive economic impact of the original injection of funds.

While the DOE is a federal agency and therefore is exempt from paying state or local taxes, INEL employees and contractors are not. In 1991, INEL employees paid approximately \$57 million in federal withholding tax and \$22 million in state withholding tax. In addition, contractors paid approximately \$4.4 million in State of Idaho sales and use taxes during the same year.

Table 6-12. Estimated geographical distribution of INEL payroll by county.^a

County	INEL workers residing in county (%)	Total estimated annual payroll in 1990 (\$)	Total estimated annual payroll in 1991 (\$)
Bonneville	67.07	257,951,000	295,108,000
Bingham	12.12	46,614,000	53,328,000
Bannock	8.12	31,230,000	35,728,000
Jefferson	5.50	21,153,000	24,200,000
Madison	2.38	9,153,000	10,472,000
Butte	2.11	8,115,000	9,284,000
Fremont	0.57	2,192,000	2,508,000
Custer	0.51	1,961,000	2,224,000
Cassia	0.49	1,885,000	2,156,000
Minidoka	0.18	692,000	792,000
Blaine	0.17	654,000	748,000
Clark	0.15	557,000	660,000
Teton	0.13	500,000	572,000
Oneida	0.11	423,000	484,000
All other counties	0.39	1,500,000	1,716,000
Total	100.00	384,600,000	440,000,000

a. DOE 1991b; Private communication (data on INEL taxes and payroll expenditures) from K. L. Shelly, Ecology and Environment, Inc., to Seb Klein, DOE-ID, Financial Office, 1992.

Note: The worker distribution was determined by a survey that was sent to all INEL employees. Approximately 60% of all employees responded to this survey. The estimated number of employees was derived from the sample of respondents.

Table 6-13: INEL's estimated direct contribution through payroll disbursement to county income.^a

County	Estimated INEL 1990 payroll disbursements (\$)	Total 1989 county income from all sources (\$)	Estimated percent of total income directly related to INEL payroll disbursements
Bannock	31,230,000	724,701,000	4.3
Bingham	46,614,000	356,061,000	13.1
Bonneville	257,951,000	875,365,000	29.5
Butte	8,115,000	29,930,000	27.1
Clark	577,000	8,083,000	7.1
Jefferson	21,153,000	149,797,000	14.1
Madison	9,153,000	174,832,000	5.2
Total for seven- county region	374,793,000	2,318,769,000	16.2

a. U.S. Bureau of the Census 1992; DOE 1991b; Private communication (data on INEL taxes and payroll expenditures) from K. L. Shelly, Ecology and Environment, Inc., to Seb Klein, DOE-ID, Financial Office, 1992.

6.1.7 Fire Protection and Emergency Services

DOE established an Emergency Management System, which incorporates all the applicable requirements for emergency planning, preparedness, and response at the INEL. Each facility at the INEL is required to prepare an Emergency Plan that details contingency plans and emergency procedures. Site-wide emergencies and transportation-related emergencies are covered within a Site-wide emergency plan.^g

Emergency response organizations for a facility include primary and support responders. Primary responders are specifically assigned responsibility and authority for the major functions that must be accomplished during an emergency. Primary responders include personnel at the facility at which an emergency occurred, personnel at the facility that is affected by the emergency, managers of the DOE-ID, and DOE-Headquarters (DOE 1992a).

g. Private communication from C. Kouris, Ecology and Environment, Inc., Idaho Falls, Idaho, to Clayton Ogilvie, Emergency Planning Specialist, DOE Idaho Operations Office, Idaho Falls, Idaho, July 13, 1992.

Support responders provide personnel and equipment that may be needed to support the primary agencies. The DOE-ID Warning Communications Center operates 24 hours a day and receives initial calls in the event of an emergency that cannot be handled by primary responders alone. Support responders include the DOE-ID Fire Department; DOE-ID Medical Unit; DOE-ID Security; the DOE-ID Warning Communications Center; and other Federal, state, tribal, and local emergency or support agencies (DOE 1992a).

The DOE-ID Fire Department has three stations on the INEL Site. The main station is located in the Central Facilities Area; substations are located at TAN and ANL-W. All three fire stations are staffed 24 hours a day by career firefighters who have been trained as Emergency Medical Technicians. Each of the three stations has the equipment and expertise to respond to explosions, fires, spills, and medical emergencies. The DOE-ID Fire Department maintains a specially equipped hazardous materials vehicle that is utilized in the event of hazardous chemical incidents (EG&G Idaho 1991).

DOE-ID has a number of mutual aid agreements with Federal, state, tribal, and local agencies to provide emergency support.^h Under Emergency Planning and Community Right-to-Know Act, the State of Idaho established a State Emergency Response Commission and prepared a State Emergency Response Plan for emergencies involving hazardous substances. The Idaho Bureau of Disaster Services has direct responsibility for general planning and overall coordination of the state's emergency assistance in response to natural or man-made disasters as detailed in the State Emergency Response Plan. The Idaho Department of Health and Welfare has responsibility for the Radiation Emergency Response Plan, which appends the State Emergency Response Plan. The purpose of the Radiation Emergency Response Plan is to protect the public health and safety of the general populace from the hazards of a radiological emergency at the INEL. The Idaho State Police of the Idaho Department of Law Enforcement has an emergency response team for transportation emergencies on state roads and highways (DOE 1992a).

Bingham, Bonneville, Butte, Clark, and Jefferson counties, which surround the INEL, have developed emergency plans to be implemented in the event of a radiological or hazardous materials emergency. Each emergency plan identifies all facilities within the county with extremely hazardous substances, routes of transportation of these extremely hazardous substances, methods and procedures for notification and response, emergency equipment and facilities, evacuation routes, and training programs.

In addition, the seven-county area surrounding the INEL has 18 fire districts. The 18 districts operate a total of 30 fire stations staffed by 179 paid and 313 volunteer firefighters. Table E-22 in Appendix E shows the total numbers of fire stations, paid and volunteer firefighters, and firefighting vehicles based in each county in the seven-county region.

h. Private communication from C. Kouris, Ecology and Environment, Inc., Idaho Falls, Idaho, to Paul Martindale, DOE Idaho Operations Office, Fire Department, July 8, 1992.

6.1.8 Security Services

Security systems at the INEL apply to material control and accountability, physical protection, and personnel protection. Each facility at the INEL is required to prepare a site-specific Safeguards and Security Plan and/or Master Safeguards and Security Agreement, which defines the appropriate level and strategy for particular security interests on a site-specific basis that are consistent with operational requirements, applicable threat, target attractiveness, and potential risks. Environmental restoration and waste management facilities are primarily concerned with physical security to protect against unauthorized entry, which could endanger human health and the environment.

Security services are provided for most of the facilities at the INEL Site by PTI. ANL-W and the NRF have separate security services. PTI employs approximately 325 full-time, uniformed security personnel on a 24-hour basis. The primary security function performed by PTI personnel is the control of all access points at Site boundaries and within the facilities.ⁱ

PTI has a Memorandum of Understanding with the Bonneville County Sheriff's Office and the Idaho Falls Police Department to provide for law enforcement assistance upon request. The Idaho Falls Police Department provides police officers and the use of a narcotic detection canine unit. PTI also relies on state and county police for assistance in establishing and maintaining road blocks around the Site when necessary.^j

Law enforcement services in the seven-county area are provided by sheriff's offices in each county, 12 city police departments, and the Idaho State Police. Clark County has the highest ratio of law enforcement personnel per 1,000 people (6.3 per 1,000) and Butte County has the lowest ratio (1.3 per 1,000). County totals of sworn and civilian personnel are provided in Table E-23.

6.1.9 Nonhazardous and Nonradioactive Solid Waste Disposal

Nonhazardous and nonradioactive solid waste generated at the INEL facility is disposed of at the Central Landfill on the INEL property. Current intake at the Central Landfill averages 7,000 yd³/month and consists primarily of office refuse and construction debris. The waste is stored temporarily in onsite dumpsters, then transported to the landfill from one to three times per week. Originally, it was expected that the landfill would be completely filled by October 1993. Through waste minimization and recycling of paper, cardboard, and aluminum, the expected closure date has been postponed by more than two years. The landfill is now expected to receive solid wastes until 1994. After the landfill is closed, all nonhazardous and nonradioactive solid waste will be disposed of in an industrial landfill at the INEL. Approximately 220 acres of land

i. Private communication from C. Kouris, Ecology and Environment, Inc., Idaho Falls, Idaho, to Neil Rice, DOE Idaho Operations Office, Security Operations Branch, July 13, 1992.

have been dedicated for this industrial landfill. Only 5% of this land area is currently being used.^{j,k}

Nonhazardous solid waste generated in the seven-county area is transported to county landfills. Six landfills (one each in Bannock, Bingham, Bonneville, Clark, Jefferson, and Madison counties) are being closed prematurely for noncompliance with new EPA standards.

Bannock County is working on a design to comply with EPA standards at the Fort Hall Landfill in Bannock County. The McCammon Landfill in Bannock County is closing due to noncompliance issues. The new design will include composting and recycling.

Bonneville County is in the process of constructing a landfill and transfer station with a minimum lifespan of 50 years. The new landfill is scheduled to be opened by late 1993. Jefferson County is in the process of purchasing land from the Bureau of Land Management for use as a new landfill. Madison and Clark counties are looking into a regional landfill facility for solid waste disposal after 1993. Butte County has two landfills with anticipated lifespans of 30 years. Bingham County has three landfills, one of which will be closed in 1993. The other two landfills have anticipated lifespans of approximately five and three years, respectively. The expected lifespan of each landfill in the seven-county region is provided in Table E-24.

None of the seven counties have an organized community recycling program. Residents in all seven counties can and do recycle on a voluntary basis, however. To facilitate such efforts, the City of Idaho Falls maintains several receptacles for recycling plastic, aluminum, tin, and newspapers. Paper and aluminum are sometimes collected by local groups as part of a community service.

6.1.10 Health Care Delivery Services

The DOE-ID Fire Department provides ambulance service on the Site. In addition, six medical dispensaries located on the Site provide assessment and treatment for ill or injured personnel within the Site boundaries. The Central Facilities Area dispensary is staffed by a physician and nurses; the other dispensaries are staffed by nurses and a visiting physician who rotates among the five dispensaries.^l INEL emergency plans call for injured individuals to be transported to the Eastern Idaho Regional Medical Center (located in Idaho Falls) if none of the six dispensaries located on the INEL facility are sufficiently staffed or equipped (DOE 1992a).

j. Private communication from C. Kouris, Ecology and Environment, Inc., Idaho Falls, Idaho, to James Crandall, EG&G Idaho, Inc., Idaho Falls, Idaho, July 13, 1992.

k. Private communication from S. Myers, Ecology and Environment, Inc., Lancaster, New York, to James Crandall, EG&G Idaho, Inc., Idaho Falls, Idaho, June 10, 1993.

l. Private communication from S. Myers, Ecology and Environment, Inc., Lancaster, New York, to Marlene Brinkerhoff, EG&G Idaho, Inc., Idaho Falls, Idaho, June 11, 1993.

Ambulance services in the region are provided by some of the county governments and the cities of Blackfoot, Dubois, Idaho Falls, and Pocatello fire departments. Residents in Butte County receive ambulance service from a private ambulance company, the Lost River Ambulance Service. In addition to ambulance service, the seven-county area is served by four quick response units, two medical helicopters, and one clinic specializing in emergency medical services (Hardinger 1990; U.S. West Directories 1992).

Eight hospitals serve the seven-county region. No hospitals are located in Clark or Jefferson counties. The Eastern Idaho Regional Medical Center in Idaho Falls is the largest hospital in the region with 311 beds. Lost Rivers District Hospital in Butte County has only four licensed beds. Occupancy rates range from (22.0%) to (89.2%) in the region, with the State Hospital South (a psychiatric hospital) in Bingham County experiencing the highest utilization. Table E-25 shows hospital size, total patient-days, occupancy rates, and descriptions of services provided for area hospitals.

6.2 Land Use

This section describes existing land use and land use patterns at the INEL and areas surrounding the Site. Although the discussion focuses primarily on the INEL property, relevant facilities and land uses in the five surrounding counties and the City of Idaho Falls are addressed, and applicable land use plans and policies that apply to the INEL and the surrounding region are discussed.

6.2.1 Existing INEL Land Use, Plans, and Policies

6.2.1.1 General Description. The INEL is located approximately 47 km (29 mi) west of Idaho Falls on government-owned property encompassing 2,305 km² (890 mi²) or 230,417 ha (569,600 acres). Formerly used as a gunnery range during World War II, the INEL Site was established through a series of withdrawals from the public domain (Public Land Orders No. 318, 1946; No. 545, 1949; No. 637, 1590; and No. 1770, 1958) and purchases of Federal, state, and private lands. Between 1977 and 1982, 1,034 ha (2,555 acres) in the northeast corner were sold to area farmers as compensation for land destroyed during the 1976 Teton flood. The INEL is approximately 63 km (39 mi) long and 58 km (36 mi) wide at its broadest southern portion, displaying a flat to gently rolling topography. The Site encompasses portions of five Idaho counties, the majority located in Butte County, with the remaining portion located in Bingham, Jefferson, Bonneville, and Clark counties.

Only about 2% of the Site [4,614 ha (11,400 acres)] is used for facilities and operations supporting energy research and development. Approximately 450 buildings and over 2,000 other structures at INEL represent approximately 279,000 m² (3,000,000 ft²) of floor space for associated technical and support facilities.

6.2.1.2 Functional Areas. For operational efficiency, the INEL has been divided into geographically separate and distinct functional areas. Each area is intended for particular types of programmatic activities (large systems, reactors, laboratories, etc.) or support activities (office, crafts, warehouse, etc.). These functional areas are briefly described in Table 6-14 and illustrated in Figure 6-1.

6.2.1.3 Other INEL Land Uses. In addition to industrial and support land uses associated with each of the functional areas at INEL, other land uses exist within the Site boundaries. These include:

- Hazardous waste disposal areas
- Highway and utility rights-of-way
- Grazing/agriculture
- Resource-based recreational uses
- National environmental research park.

Table 6-14. Land area, floor space, and land use description of INEL facilities.

Facility Land Use Description	Land Area		Facility Floor Space	
	Hectares	Acres	m ²	ft ²
Test Area North (TAN)	89.0	220	64,766	697,157
Industrial facilities primarily involved in research in technical engineering and remote radioactive materials handling. Other uses include specialized rail facilities and wastewater ponds. Other facilities within TAN include:				
Technical Support Facility	54.2	134	—	—
Initial Engine Test	6.5	16	—	—
Containment Test Facility ^a	12.5	31	—	—
Water Reactor Research Test Facility	15.8	39	—	—
Test Reactor Area (TRA)	41.0	102	56,385	606,942
Industrial uses involved in nuclear reactor research associated with the Advanced Test Reactor. Other uses include support facilities (storage tanks, maintenance buildings, warehouses), laboratory uses, and sanitary and radioactive waste treatment facilities				
Idaho Chemical Processing Plant (ICPP)	68.8	170	NA ^a	NA
Industrial reprocessing, waste solidification, and analytical laboratory facilities. Other uses include a coal-fired generating plant, tank farm storage facility, and wastewater disposal facilities.				
Central Facilities Area (CFA)	58.7	145	47,751	514,000
Centralized support facilities for sitewide operation (e.g., security, warehousing, transportation, food service facilities). Other uses include laboratory and other government offices (e.g., National Oceanic and Atmospheric Administration, U.S. Geological Survey).				
Power Burst Facility (PBF)	7.7	19	11,148	120,000
Industrial uses associated with the PBF reactor (currently on standby mode), research and development of radioactive and mixed-waste technologies, and waste-reduction activities. Other areas within PBF include:				
PBF Control Area	3.6	9	—	—
PBF Reactor Area	1.2	3	—	—
Waste Engineering Development Facility (WEDF)	0.8	2	—	—
Waste Experimental Reduction Facility (WERF)	2.0	5	—	—

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Table 6-14. (continued).

Facility Land Use Description	Land Area		Facility Floor Space	
	Hectares	Acres	m ²	ft ²
Auxiliary Reactor Area (ARA)	NA	NA	NA	NA
ARA facilities are currently in shutdown mode and have undergone complete or partial D&D. ARA II and ARA III have been designated by the Idaho State Historical Preservation Officer as having historical significance. Other areas within ARA include:				
ARA I	NA	NA	—	—
ARA II	NA	NA	—	—
ARA III	NA	NA	—	—
ARA IV	NA	NA	—	—
Experimental Breeder Reactor I (ERB-I)	NA	NA	NA	NA
Industrial uses associated with experimental nuclear activities; however, not currently in operation.				
Boiling Water Reactor Experiment (BORAX)	NA	NA	NA	NA
Industrial uses associated with experimental nuclear activities; however, not currently in operation.				
Radioactive Waste Management Complex (RWMC)	44.5	110	13,935	150,000
Industrial uses associated with disposal and transfer of hazardous and radioactive waste. Other land uses include support-related facilities such as offices, maintenance shops, and change facilities.				
Navy Reactors Facility (NRF)	76.7	187	NA	NA
Industrial uses associated with reactor facilities operated for plant development and training of naval officers. Other land uses include support facilities such as offices, storage areas, wastewater treatment and disposal, and landfills.				
Argonne National Laboratory-West (ANL-W)	34.0	84	NA	NA
Industrial uses associated with nuclear reactor operations, including the Experimental Breeder Reactor-II (EBR-II) and the Integral Fast Reactor (IFR). Other land uses include support facilities, tank areas, and wastewater treatment and disposal.				
a. Not available.				

Figure 6-1. INEL Site map with primary functional areas.

6.2.1.3.1 Hazardous Waste Disposal Area—Portions of the INEL within and outside of the functional areas are contaminated with radioactive and other hazardous wastes resulting from INEL activities and the Site's past use as a gunnery range. Although closure of these areas under the Resource Conservation and Recovery Act or Comprehensive Environmental Response, Compensation, and Liability Act will be followed, it is likely that many of these areas will continue to be unsuitable for human habitation or use. These hazardous and potentially exclusionary areas are illustrated in Figure 6-2.

6.2.1.3.2 Highways/Infrastructure—Approximately 5% of the INEL land area or roughly 11,514 ha (28,450 acres) is devoted to public road and utility rights-of-way crossing the Site. Rights-of-way at the INEL are granted and administered by the Department of Interior and Bureau of Land Management.

6.2.1.3.3 Grazing/Agriculture—A significant portion of the INEL is utilized for grazing purposes. The hectares allocated for grazing at INEL are mutually agreed on by DOE and the Department of Interior. The Department of Interior administers the area through Bureau of Land Management grazing permits. Grazing is not allowed within 3.2 km (2 mi) of any nuclear facility, and dairy cattle are not permitted. The actual number of hectares of INEL land used for grazing varies from year to year but is usually between 121,410 and 141,645 ha (300,000 and 350,000 acres); in 1992, 121,853 ha (301,094 acres) were grazed.^m Thirty-four ranchers currently hold valid grazing permits on the INEL. The U.S. Sheep Experiment Station, which is located approximately 42.6 km (26.5 mi) northeast of the Site, has the use of a 364-ha (900-acre) portion of the INEL for a winter feed lot for about 5,000 sheep. The Mud Lake feed lot is used primarily between mid-October and mid-May, although the facilities are maintained year-round.ⁿ Other agricultural uses of the land are limited because of climate, lava flows, and general desert soil characteristics (EG&G Idaho 1990). The only INEL land potentially suitable for farming is near the confluence of the Big Lost River and the Little Lost River and in the northeastern portion of the INEL, near Mud Lake.

6.2.1.3.4 Resource-Based Recreational Uses—The INEL also supports periodic uses associated with on-Site resources. Two sites within the boundary of INEL are listed in the National Register of Historic Places: EBR-I, designated in 1966; and Goodale's Cutoff, a portion of the Oregon Trail that transverses the southwest corner of INEL, designated in 1974. EBR-I is open for tours by the public between the weekends of Memorial Day and Labor Day.

In addition to public tours, the INEL occasionally supports controlled hunting within the Site boundaries. Each year, the Idaho Department of Fish and Game and DOE determine whether or

m. Private communication between W. Green (E&E, Inc.) and M. Berain (Bureau of Land Management), Idaho Falls, Idaho, 1992.

n. Private communication between Dan Castle (E&E, Inc.) and S. Weller (U.S. Sheep Experiment Station), Dubois, Idaho, 1992.

Figure 6-2. Hazardous and potentially exclusionary areas.

not to allow controlled hunts of wild game populations on INEL property (DOE 1989b). The expressed purpose of the hunts is to reduce potential migration of animal populations off INEL property onto private lands where crops may be damaged. Therefore, each year, all wild game populations on INEL are evaluated to determine if such controlled hunts are warranted. Since 1992, such hunting has been restricted to pronghorn populations to within 0.8 km (0.5 mi) of the INEL boundaries and to certain seasons.^o Although the migration of elk off the INEL Site is a concern, elk hunting on the land has not been permitted to date.

6.2.1.3.5 National Environmental Research Park (NERP)—Several uses that are associated with the INEL's designation as a National Environmental Research Park occur on-Site. The Site's cool desert, sagebrush-steppe ecosystem provides a controlled outdoor laboratory where scientists from all fields can study natural environment changes caused by human activities. Since the INEL has a number of facilities capable of producing stresses on the environment, Site-wide studies of these stresses and potential mitigative measures are conducted to provide opportunities for significant research. A substantial body of information on geology, hydrology, wildlife, vegetation, and meteorology has been collected, with certain baseline information dating back over 40 years. Program management of the Idaho National Environmental Research Park is the responsibility of DOE-ID, while overall National Environmental Research Park policy is set by DOE's Office of Health and Environmental Research.

6.2.1.4 DOE Internal Land Use Plans. In accordance with DOE-HQ mandates, DOE-ID creates planning and management programs applicable to current and future operations at the INEL. These include:

- INEL Institutional Plan (FY 1992-1997)
- INEL Environmental Restoration and Waste Management Site-Specific Plan (FY 1993) - Draft
- INEL Site Development Plan
- INEL Long-Term Land Use Scenarios Document (Draft).

6.2.1.4.1 INEL Institutional Plan - FY 1992-1997—This 5-year plan provides a general overview of INEL facilities, outlines strategic program directions, identifies specific technical programs, outlines major construction projects and capital equipment needs, and identifies other plans guiding facility development through 1997 (DOE 1991c).

6.2.1.4.2 INEL Environmental Restoration and Waste Management Site-Specific Plan for FY 1993—The Site-Specific Plan outlines how DOE's national FY 1994-1998 Environmental Restoration and Waste Management 5-Year Plan will be implemented at the INEL. It also describes DOE's program for meeting the goal of cleaning up contamination at its facilities by the year 2019. Of particular relevance to land use are the cleanup programs, which

o. Private communication between L. Knorz (E&E, Inc.) and J. Naderman (Idaho Department of Fish and Game), Idaho Falls, Idaho, 1992.

will remediate the Site, and the waste management activities, which will require construction of new or expanded treatment facilities and infrastructure (DOE 1992c).

6.2.1.4.3 INEL Site Development Plan—The INEL Site Development Plans consist of three volumes: the Technical Site Information Report, the Landlord Site Development Plan, and the Technical Site Information 5-Year Plan. The purpose of these three documents is to provide a working management tool to ensure the orderly growth and development of facilities at the INEL. The Technical Site Information Report provides information on the Site as a whole and each functional area. It also presents a 20-year master plan for development activities at the Site. The Landlord Site Development Plan provides an overview of proposed "landlord" activities over a 5-year period, including sitewide maintenance and support for the INEL. The Technical Site Information Report 5-Year Plan sets forth specific construction projects and outlines incremental projects necessary to reach goals listed in the this plan (DOE 1992d).

6.2.1.4.4 INEL Long-Term Land Use Scenarios Document (Draft)—This Document outlines a process by which future land use on the Site is projected for the next 100 years. This analysis is based upon existing DOE development policies, goals and objectives, as well as an examination of existing development constraints and opportunities, which would influence the location of future INEL facilities. The preliminary findings of the document project the concentration and centralization of INEL facilities toward the southern portions of the Site, with long-term release of lands to the north of TAN (E&E 1993).

6.2.1.5 Other Plans and Policies Affecting the INEL. Several other Federal plans and policies, and county plans affect the use of land within and surrounding the INEL. These include various resource management plans, public land orders, memoranda of understanding, and county plans.

6.2.1.5.1 Resource Management Plans—Portions of the INEL Site are located within the Medicine Lodge and Big Butte Resource Areas. The Medicine Lodge Resource Area includes about 56,658 ha (140,000 acres) along the eastern and southern edges of the INEL Site (DOI 1985); the Big Desert Grazing Area includes about 13,521 ha (33,411 acres) along the western edge of the INEL. Dominant uses are grazing, wildlife habitat, and mining (DOI 1985). The Bureau of Land Management is planning to issue a Notice of Intent to prepare a resource management plan for the Big Butte Resource Area in 1994.

Among the Federal agencies with jurisdiction over lands (and therefore land use) within an 80-km (50-mi) radius of the INEL are the U.S. Department of Agriculture and the Forest Service (Challis and Targhee National Forests); the National Park Service (Craters of the Moon National Monument); the U.S. Fish and Wildlife Service (Camas National Wildlife Refuge); and the Army Corps of Engineers (a small National Guard rifle range). Planning and use of these lands and their resources are governed by Federal rules and regulations that include mandatory public involvement in their implementation.

6.2.1.5.2 Public Land Orders and Memoranda of Understanding—A series of Public Land Orders and Memorandum of Understanding relate to land use and land use decision-making at the INEL. Many of these documents provide information on potential uses and control of lands currently under DOE's jurisdiction.

As stated, the INEL as it is currently composed was established through a series of withdrawals and purchases of Federal, state, and private lands (see Section 1) (Table 6-15). The public land orders provide for certain responsibilities to remain with the Bureau of Land Management. These responsibilities include the administration of grazing permits on the INEL; granting of utility rights-of-way across INEL; extraction of materials; and wildfire control, weed/insect control, and predator control. However, the public land orders require that the DOE be consulted prior to final decisions regarding these actions (PLO 1953; DOE 1972).

A 1992 report describes the process to be followed in disposing real property owned by the DOE, including both land purchased from private land owners and property withdrawn from the public domain (DOE 1992e). After determination that the property will not be of use in the future and preparation of extensive supporting documentation, the property may be transferred from DOE ownership. Most land originally obtained from private owners must be transferred to the General Services Administration for transfer to another government agency (if needed) or sale to the public. Former public land will be returned to the public domain (i.e., Bureau of Land Management).

6.2.1.5.3 County Plans—Land use planning in the State of Idaho is derived from the Local Planning Act of 1975. The state currently has no land use planning agency. The Idaho legislature mandates that each county adopt its own land use planning and zoning guidelines. A review was conducted of the following county plans: Clark County Planning and Zoning Ordinance (1986), Clark County Interim Land Use Plan (1992), Bonneville County Comprehensive Plan (1991), Bingham County Zoning Ordinance and Planning Handbook (1986), the Jefferson County Comprehensive Plan (1988), and the Butte County Comprehensive Plan (1992).

Overall, review of county plans revealed that the INEL's remote location minimizes the likelihood of significant development occurring in proximity to the Site. Policies articulated in each of the five counties' comprehensive plans reveal that the planning principles of targeting areas for new development adjacent to existing developed areas are accepted in each county, thus reducing the need for extensions of infrastructure improvements and avoiding sprawl (Bonneville County 1991; Bingham County 1986; Jefferson County 1988; Butte County 1992). With the exception of Howe, Arco, Butte City, and Atomic City, lands surrounding the INEL do not meet these planning principles, as they are substantially removed from developed areas.

Although it has a relatively large employment base, the INEL has not generated any significant residential development in proximity to the Site. Currently, 67% of INEL employees reside in Bonneville County, predominantly in the City of Idaho Falls, which provides the necessary amenities to support a population base (DOE 1991b).

Table 6-15. Withdrawals or purchases of Federal, state, and private land to create the INEL.

Land withdrawals	Date(s)	Hectares	Acres
Public Land Orders 318, 545	1946, 1949	49,948	123,419
Public Land Order 637	1950	94,393	233,242
Public Land Order 1770	1958	49,948	123,419
State of Idaho	NA	14,279	35,282
Private Ownership	NA	9,966	24,627
a. Not available			

Furthermore, the INEL's importance to the regional economy suggests that a reduction or cessation of operations at the Site would result in a reduced demand for new residential development in the region. This is illustrated by the fact that population projections in three of the counties' comprehensive plans are tied to INEL activities (Bingham County 1986; Bonneville County 1992).

Comments made by Participation Forum of county and regional planning officials assembled for the INEL Long-Term Land Use Scenarios Document did not suggest that any significant new development is expected to occur in the immediate vicinity of the INEL (E&E 1993). However, the participants did expect an increase in recreational land uses, exhibited by increased visitation to the Craters of the Moon National Monument and an increase in demand for wilderness recreation. Agricultural uses were also expected to increase, as rangeland was converted to cropland, depending on irrigation limitations to the land.

6.2.2 Surrounding Land Use and Policies

6.2.2.1 General Description. The dominant land use in the area surrounding the INEL involves agriculture and open land, each accounting for 45% of the area, with the remaining 10% occupied by urban land (EG&G Idaho 1990). In the five-county area surrounding the INEL are 445,170 ha (1,100,000 acres) of cropland in use each year. Additionally, this area produces about 105,000 head of livestock (mostly beef) annually (EG&G Idaho 1990).

Several small rural communities (Howe, Mud Lake, Atomic City, Butte City, Arco) are scattered around the INEL's borders. The larger communities of Rexburg, Idaho Falls, Ammon, Shelley, Blackfoot, and Pocatello are located to the east and southeast of the INEL.

The INEL is bordered on the north and west by the Bitterroot, Lemhi, and Lost River mountain ranges and on the south by the Big Southern, Middle, and East buttes. Significant portions of these lands, most of which are Federally owned, are used for hunting, fishing, boating, hiking, cross-country skiing, and camping. Specific recreational and tourism sites exist nearby at Craters of the Moon National Monument, Hell's Half Acre, Camas National Wildlife Refuge, Market Lake State Wildlife Management Area, and the Birch Creek camping area.

6.2.2.2 DOE Idaho Falls Facilities. DOE owns or leases approximately 99,918 m² (1,075,540 ft²) in about 40 separate facilities for roughly 2,400 DOE-ID and contractor personnel throughout Idaho Falls. These facilities provide office, laboratory, computer, and storage space for personnel engaged in technical, analytical, and administrative work for the INEL. One example is the INEL Research Center located on 14.4 ha (35.5 acres) of DOE-owned property; the INEL Research Center houses about 400 people in five main buildings totaling 26,554 m² (285,831 ft²).

6.2.2.3 County Land Use. Although located primarily within Butte County, portions of the INEL are also located in Bingham, Jefferson, Bonneville, and Clark counties. County boundaries and land uses along the INEL boundary are illustrated in Figure 6-3. Table 6-16 provides a breakdown of land use for each of these counties. Brief descriptions of county land use abutting the INEL boundaries are provided.

6.2.2.3.1 Butte County—Approximately 60% of the INEL or 139,621 ha (345,000 acres) is located within Butte County. Lands adjacent to the INEL are used primarily for grazing and range management on lands administered by Bureau of Land Management and the Forest Service. One significant portion of private land used for cropland adjoins the northwest portion of the Site (Butte County 1992).

6.2.2.3.2 Jefferson County—Approximately 25% of the INEL or 57,366 ha (141,750 acres) is located in Jefferson County. Lands adjacent to the INEL are almost equally divided between private cropland and grazing lands administered by Bureau of Land Management (Jefferson County 1988).

6.2.2.3.3 Bingham County—Approximately 11% of the INEL or 26,053 ha (64,375 acres) is within Bingham County. Lands adjoining the INEL are primarily Bureau of Land Management lands used for grazing, with relatively small pockets of open land or private lands used for cropland (Bingham County 1986).

6.2.2.3.4 Bonneville County—Approximately 1% of the INEL or 2,934 ha (7,250 acres) lies within Bonneville County. Lands adjoining the Site include private, open land, and Bureau of Land Management lands used for grazing (Bonneville County 1991).

6.2.2.3.5 Clark County—Approximately 2% of the INEL or 5,261 ha (13,000 acres) is within Clark County. Lands adjoining the Site include both state and Bureau of Land Management lands used for grazing and range management purposes (Clark County 1992).

Table 6-16. Existing land use in counties adjacent to the INEL.^a

County	Land use in 1000s of hectares (acres)							County Total
	Farm	Range	Forest	Urban	Water	Wetland	Barren	
Bingham	173.3 (428.2)	255.9 (632.2)	21.0 (51.9)	1.3 (3.2)	7.4 (18.3)	6.5 (16.1)	81.7 (20,198)	547.1 (1,351.9)
% of County Total	31.7%	46.8%	3.8%	0.2%	1.4%	1.2%	14.9%	100.0%
Bonneville	143.4 (354.3)	136.4 (337.0)	159.9 (395.2)	5.2 (12.8)	10.8 (26.7)	7.7 (19.0)	26.9 (66.5)	490.3 (1,211.5)
% of County Total	29.2%	27.8%	32.6%	1.1%	2.2%	1.6%	5.5%	100.0%
Butte	35.3 (87.2)	375.5 (927.9)	47.8 (118.1)	0.3 (0.7)	0.4 (1.0)	0.0 (0.0)	120.8 (298.5)	580.1 (1,433.4)
% of County Total	6.1%	64.7%	8.2%	0.1%	0.1%	0.0%	20.8%	100.0%
Clark	33.7 (83.3)	347.1 (857.6)	70.5 (174.2)	0.1 (0.2)	0.3 (0.7)	0.0 (0.0)	2.1 (5.2)	453.8 (1,121.3)
% of County Total	7.4%	76.5%	15.5%	0.0%	0.1%	0.0%	0.5%	100.0%
Jefferson	108.6 (268.4)	77.2 (190.8)	0.4 (1.0)	0.7 (1.7)	3.3 (8.2)	6.4 (15.8)	90.7 (224.1)	287.3 (709.8)
% of County Total	37.8%	26.9%	0.1%	0.2%	1.1%	2.2%	31.6%	100.0%
Five-County total	494.3 (1,221.4)	1192.1 (2,945.7)	299.6 (740.3)	7.6 (18.8)	22.2 (54.9)	20.6 (50.9)	322.1 (796.2)	2,358.5 (5,828.1)
% of Five-County Total	21.0%	50.5%	12.7%	0.3%	0.9%	0.9%	13.7%	100.0%

a. Bingham County 1986, Bonneville County 1976, Butte County 1991, Clark County 1992, Jefferson County 1990.

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7. CULTURAL, AESTHETIC, AND SCENIC RESOURCES

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ACRONYMS

ACHP	Advisory Council on Historic Preservation
BLM	Bureau of Land Management
CRM	cultural resource management
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Field Office
ESQ	Environmental Safety and Quality
ESRP	Eastern Snake River Plain
INEL	Idaho National Engineering Laboratory
NEPA	National Environmental Policy Act
NHPASHPO	National Historic Preservation Act
NIQI	Northern Intermountain Quaternary Institute
SCAR-Lab	Swanson/Crabtree Anthropological Research Laboratory
SHPO	State Historic Preservation Office
SRP	Snake River Plain
TAN	Test Area North

7. CULTURAL, AESTHETIC, AND SCENIC RESOURCES

7.1 Cultural Resources

Cultural resources are defined as sites, structures, landscapes, and objects of some importance to a culture or community for traditional, historic, religious, scientific, or popular reasons. By convention, cultural resources include material remains of past human life or activities such as pottery, bone, projectile points (arrowheads), bottles, cans, rock carvings, stone circles, trails, quarries, forts, cabins, residential and commercial buildings, bridges, and natural features or geographic areas that have traditional use or religious importance. Historic sites and artifacts are generally viewed as being at least 50 years old although more recent features and materials are significant if they are associated with an important historic context, event, or trend. Prehistoric sites and artifacts are aboriginal in origin and predate Euro-American contact (circa 1800 A.D. in Idaho). Paleontological sites and artifacts are vertebrate, invertebrate, and plant fossils, which may be contemporary with or predate human occupation of the northeastern Snake River Plain (SRP). Fossils are used in paleoecological studies to re-create prehistoric landscapes and human and nonhuman adaptation to past conditions.

Cultural resources (including paleontological remains) are fragile receptacles of information about past human activities and the environment in which these activities took place. If properly managed, they will yield their information for the study of how humans have adapted to past circumstances. This knowledge of the past can then be applied to the solution of problems in the present and future. Because of their nonrenewable nature, cultural resources must be protected from adverse impact or their contents will be irrevocably lost. To prevent this loss and in recognition of the value of a long-range perspective on the intricacies and effects of human behavior, the U.S. Government has passed legislation that places these resources in the public trust to ensure that they are conserved for the benefit of all citizens.

7.1.1 Regulatory Overview

Appendix F presents an outline of Federal and Idaho State laws and regulations and Department of Energy (DOE) directives that guide cultural resource compliance activities on the Idaho National Engineering Laboratory (INEL) Site. These laws and their implementing regulations and directives provide the philosophical and regulatory foundation for the current INEL cultural resource management (CRM) program. Additional information on the effects of these laws can be found in detailed treatments by Schiffer and Gumerman (1977), Fowler (1982), Knudson (1986), Butler (1987), and Carnett (1991).

Fossils are not given the same level of legal protection on public lands as are archaeological remains. However, recent legislative and policy efforts at both the state and federal levels attempt to offer increased protection for paleontological resources. The 1978 reorganization of the National Natural Landmarks Program (which had principal federal responsibility for paleontological sites) and the Office of Archeology and Historic Preservation into a single Department of the Interior Heritage Conservation and Recreation Service is an indication of a

trend to include natural as well as cultural resources under the umbrella of stronger Federal protection. Consequently, while the full program of Federal laws and regulations is less specific in its protection of paleontological as compared with cultural resources, it is evident that there is an increase in concern for their identification and affirmative management (Knudson and Pfaff 1980).

Federal statutes that protect paleontological materials include (a) the Antiquities Act of 1906, (b) the National Environmental Policy Act (NEPA) of 1969, (c) the Archaeological Resources Protection Act of 1979, (d) the Federal Land Management Policy Act of 1976 (PL 94-579), and (e) the Federal Cave Resources Protection Act of 1988.

7.1.2 Procedural Overview

On the INEL, cultural resource protection activities are coordinated through the INEL CRM Office, where up-to-date records of all INEL cultural resource investigations are maintained by EG&G Idaho's CRM staff. However, the process of compliance with the directives and laws enumerated in Appendix F, particularly Section 106 of the National Historic Preservation Act (NHPA), involves several additional INEL organizations as well as a few outside agencies. Figure 7-1 illustrates the relationships among affected parties.

Every reasonably foreseeable action on the INEL is preceded by preparation of an environmental checklist, an environmental assessment, or an environmental impact statement, as warranted. Some activities qualify as categorical exclusions under NEPA. These documents are prepared by INEL project managers and are submitted to EG&G Idaho's office of Environmental Safety and Quality (ESQ) or directly to the DOE Idaho Operations Office (DOE-ID) for monitoring and coordination. When environmental documents are submitted for projects involving ground disturbance, INEL project managers are directed to consult with INEL CRM to determine if the proposed activity will impact significant cultural resources.

Communication between INEL project managers and INEL CRM is facilitated by CRM Action Request Forms (EGG-1644) that are completed by project managers and are archived at INEL CRM. Upon receipt of a completed form, the EG&G Idaho CRM staff conducts a search of INEL CRM project files to determine if the proposed project area has been previously surveyed and if it contains any resources that are potentially eligible to the National Register. Findings of the archival search are transmitted to project managers, ESQ, and DOE-ID in letter form with recommendations for further work.

If the proposed project area has been previously surveyed and contains no cultural resources, archaeological clearance is recommended for all project activities with the stipulation that all work must temporarily cease if unanticipated cultural materials are discovered during project implementation. However, if the archival search reveals that the project area has never been inventoried for cultural resources, an archaeological survey must be conducted before ground disturbance.

Figure 7-1. National Historic Preservation Act compliance.

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The tactics employed during field work are designed to provide intensive visual examination of all areas within project boundaries, thus ensuring that all cultural resources with visible surface remains are located. Crews conduct the reconnaissance in skirmish-line fashion with no more than 20 m (66 ft) of open space between individuals. This spacing is maintained as members of the crew walk over the entire project area using temporary markers to guide their movement.

When cultural materials are encountered during the course of a survey, an intensive search of the surrounding area is conducted to determine resource boundaries and to locate important site features. Prior to formal recording procedures, resources are designated as sites or isolates. In all projects on the INEL, archaeological sites are defined as discrete concentrations of ten or more artifacts separated from similar concentrations by natural barriers such as basalt ridges or the Big Lost River or by at least 100 m (328 ft) of open space. Existence of less than 10 artifacts under similar circumstances is classified as an isolated find. This distinction applies to historic resources (50 to 150 years old) as well as prehistoric resources (more than 150 years old). Once identified, sites are plotted on United States Geological Survey 7.5-ft maps and recorded on Intermountain Antiquities System forms. These forms require a variety of administrative, environmental, and descriptive information in a standardized format and their use is required by the Idaho State Historic Preservation Office (SHPO). Scaled plan maps are also prepared for all resources. After completion of the survey work, all Intermountain Antiquities System forms are submitted to the Idaho SHPO for registry in State archives.

If significant cultural resources (i.e., resources that are potentially eligible to the National Register) are encountered during any survey of the proposed project area, archaeological clearance is recommended for project activities only if all resources can be protected from adverse impact. Protection in this context usually involves some modification to project plans so that resources are avoided. In situations where project plans cannot be altered to avoid significant resources, then the unavoidable adverse impacts must be mitigated by further data collection in advance of any ground disturbance. Mitigation action plans/research designs are prepared at this time outlining the procedures that will be used to gather information from threatened resources.

All reports containing resource evaluations, recommendations for protection, and/or mitigation plans are transmitted to the SHPO for a 30-day review/comment period as required by Section 106 of NHPA. Mitigation documentation is always forwarded directly to the National Advisory Council on Historic Preservation (ACHP). Comment is also solicited from the Shoshone/Bannock Tribe at this time. Any disagreements between INEL management and the SHPO regarding the appropriate evaluation or treatment of the resources in question that arise at this point in the compliance process are directed to the ACHP for mediation. As required by NHPA, NEPA, and the American Indian Religious Freedom Act, DOE-ID also considers all comments from the Shoshone/Bannock Tribe in the implementation of preservation plans.

No ground disturbance may be initiated until all parties agree on the appropriateness of the proposed protection measures. After written comments are received from SHPO and ACHP (or if each of the 30-day review periods pass without word from the agencies), protection measures can be implemented and project construction can begin.

7.1.3 History of INEL Cultural Resource Management

Archaeological investigation of the area now set aside as the INEL has passed through four successive stages since its inception in the late 1950s. The first phase was intuitively based and involved numerous visits to areas where prehistoric sites were known or expected to exist. These initial projects were directed by E. H. Swanson, Jr., of the Idaho Museum of Natural History as part of a larger project to examine prehistoric sites in southeastern Idaho (Swanson et al. 1959; Swanson et al. 1964; Swanson 1972; Reed et al. 1987a). Later, from 1967 to 1972, additional intuitive surveys were conducted on INEL lands by individuals under the direction of B. R. Butler in an effort to discover the nature and distribution of archaeological resources in the vicinity of the nearby Wasden Site (Butler 1968, 1970, 1978; Reed et al. 1987a).

The early intuitive surveys conducted by Swanson and Butler were important in establishing the archaeological research potential of the INEL region. Many important archaeological sites in caves, on buttes, and near the margin of Pleistocene Lake Terreton were recorded. However, these early surveys stand in great contrast to the later systematic inventory projects because the latter projects have shown that the INEL not only holds a few large and complicated sites but also contains thousands of smaller resources that are equally important in understanding prehistoric lifestyles.

Beginning in 1974, the INEL entered into the modern era of cultural resource management and the second stage in the development of the current CRM program. The cultural resource inventories conducted during the past 2 decades are in general more intensive than previous work because they were conducted with the goal of meeting regulatory requirements to protect resources rather than simply discovering the largest or oldest sites. Within the past decade, subsurface testing has also become a fairly routine procedure in the management of INEL cultural resources.

The first surveys of this modern era were supervised by S. J. Miller from 1974 to 1984 and included many small construction projects [e.g. Central Facilities Area Helicopter Facility, Idaho Chemical Processing Plant Well #4, and Argonne National Laboratory-West Practice Range] as well as several large projects including the INEL perimeter boundary, grazing boundary, diversion area, Big Lost River seismic study, and New Production Reactor Area E (Miller 1983, 1984a, 1984b, 1985; Reed et al. 1987a). These larger projects are described in Table F-1 and appear on maps in Section F.6. Over 400 INEL localities from early prehistoric through historic time periods have been recorded as a result of this work.

Although all work within the boundaries of the INEL from 1974 to 1984 was directed by Miller, several other contractors also conducted research near the INEL during this period. These surveys provide data on the nature and distribution of cultural resources for comparison with information from the INEL. Projects conducted in the vicinity of the INEL included (a) an examination of Bureau of Land Management property in the Little Lost River and Birch Creek Valleys in 1976 by L. A. Kingsbury and personnel from the Idaho Museum of Natural History (Kingsbury 1977), (b) surveys in 1979 and 1980 by Commonwealth Associates, Inc. and

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Archaeological Services, Inc. of 3,200 acres of INEL land transferred to the Department of Interior in exchange for property loss during failure of the Teton Dam (Franzen 1980b; McCallum 1981), and (c) a 1979 sample survey by Commonwealth Associates, Inc. of Bureau of Land Management property in the Big Desert Planning Unit, which surrounds the INEL on all sides (Franzen 1980a). Many cultural resources were recorded during these projects, some of them actually within the boundaries of the INEL (Reed et al. 1987a).

Beginning in 1985, INEL CRM moved into a third stage of development with the initiation of a subcontract by EG&G Idaho with Idaho State University and the Swanson/Crabtree Anthropological Research Laboratory (SCAR-Lab) for large cultural resource inventory projects. The first projects involving archaeological test excavation on the INEL were also completed under this agreement. The success of the relationship between DOE-ID (through EG&G Idaho) and Idaho State University (through SCAR-Lab) is demonstrated by its continued support today [SCAR-Lab is now known as the Northern Intermountain Quaternary Institute (NIQI)].

The SCAR-Lab surveys are important because they set a methodological precedent for all subsequent archaeological investigations on the INEL. The standardized methods employed during these projects are still in use today because they are of sufficient rigor to ensure that all cultural resources with visible surface remains are identified in all project areas. A comprehensive catalog of all INEL projects completed by SCAR-Lab/NIQI from late 1984 through July 1992 is presented in Table F-1. This listing shows that 70 surveys have been completed and 1,050 cultural resources have been recorded. It is also significant to note that subsurface testing has been conducted by Idaho State University at 84 prehistoric resource locations. These projects are summarized in Table F-2.

The final stage in the development of the INEL program began in 1989 with the formation of the INEL CRM Office, administered by EG&G Idaho, to serve as a focal point for information flow regarding cultural resource compliance at the INEL. Presently, INEL CRM staff members coordinate all cultural resource-related compliance activities at the INEL by (a) overseeing all archaeological, paleontological, and historical subcontracts, (b) reviewing environmental documents that address ground disturbance, (c) preparing sections of environmental summary documents, (d) facilitating communication between INEL project managers, DOE-ID, SHPO, ACHP, and the Shoshone-Bannock Indian Tribe, (e) maintaining central files of all cultural resource investigations on the INEL, (f) conducting archival searches and small survey projects for INEL project managers, (g) conducting archaeological resource protection training, (h) participating in opportunities to educate INEL employees and the general public on the importance of INEL cultural resources, (i) representing the INEL at local and national scientific meetings and events, (j) monitoring and protecting known cultural resource locations on the INEL, (k) developing a predictive model to help determine where additional resources of National Register quality may be located on the INEL, (l) preparing interagency agreement documents for consultation, curation, and mitigation, (m) maintaining INEL/DOE-ID historical files, (n) developing a plan to manage INEL cave resources, (o) responding to, evaluating, and researching paleontological finds on the INEL, and finally (p) preparing and implementing an overall cultural resource management plan for the entire INEL.

Survey projects completed by INEL CRM are listed in Table F-1. Table F-2 provides information on testing projects. In addition to these field projects, over 40 consulting projects and archival searches have also been completed. Over 70 resources were recorded or tested during these projects.

7.1.4 Resource Overview

This section describes the regional paleontology, paleoecology, prehistory, ethnography, and history of the INEL. This section is based on regional summaries, nearly a decade of on-the-ground surveys, test excavations, and archival research on the INEL.

7.1.4.1 Physiographic Setting. The INEL occupies approximately 2,305 km² (890 mi²) of land in the northeastern portion of the Snake River Plain near the foothills of the Little Lost, Lemhi, and Bitterroot mountains in southeastern Idaho. The plain is composed of many superimposed flows of basaltic lava extruded from low shield volcanoes, fissures, and tubes over the past 2 million years during the Quaternary Period (Figure 7-2) (Greeley 1982; Mabey 1982). Weathering of the original lava flows, accumulations of alluvial and lacustrine deposits in low-lying areas, and deposition of a widespread but variable veneer of aeolian sediment have resulted in an overall smoothing of this land surface. Elevations range from 1,454 m (4,770 ft) to 1,652 m (5,420 ft) above mean sea level with isolated buttes that reach a maximum height of 2,003 m (6,572 ft).

The topographic results of Quaternary volcanic activity on the INEL are quite uniform across the area. Common features include low relief pressure ridges, pressure plateaus, collapse depressions, fissures, and lava tubes (Greeley 1982). Though pronounced changes in topographic relief are generally rare, several striking volcanic features are present. The most prominent of these are the three buttes: Big Southern Butte, Middle Butte, and East Butte, which dominate the horizon from any vantage point on the INEL. Other unique volcanic features in the area include caves, lava tubes, craters, and unusually high pressure ridges. All of these features exhibit a high density of cultural resources, possibly due to the sweeping vistas and/or shelter that they provided for prehistoric hunter-gatherers.

Many volcanic features were also of economic importance to prehistoric populations on the INEL. Early occupants needed easily accessible sources of lithic material that could be fashioned into tools for cutting, scraping, abrading, piercing, pulverizing, and other tasks. Many of these needs were met by rocks such as volcanic glass (obsidian), which is available at Big Southern Butte (Spear and King 1982) and may also exist on Middle and East Buttes (Kuntz et al. 1986). Another type of volcanic glass, vitreous welded tuff (ignimbrite), is available at Howe Point in the northern portion of the facility (Hackett and Morgan 1988). Both types of material were commonly used in the manufacture of projectile points, knives, and other tools that required a very sharp but generally short-lived edge. When a more durable implement was desired, other locally available volcanic rocks such as fine-textured basalt and rhyolite were also used. And finally, scoria, pumice, and other forms of highly vesicular basalt, which were used prehistorically as abrasives, are available in many areas on the INEL.

Figure 7-2. Cultural, geological, and ecological sequence of the INEL region.

While volcanic features dominate much of the contemporary landscape, a large portion of the INEL is contained within what is known as the Pioneer Basin (Butler 1968). This basin incorporates three important features: the alluvial deposits of the Big Lost River, the Little Lost River, and Birch Creek; the sink areas of these same watercourses; and the lake bed of ancient Lake Terreton.

The Big Lost River enters the INEL at its southwestern border and flows northeast approximately 48.3 km (30 mi) through the facility. The river channel is presently dry throughout most of the year but probably flowed year-round before upstream irrigation depleted local water flows. Evidence of this is seen in the extensive deposits of alluvial material that have accumulated near the watercourse and in some expanses that extend up to 8 km (5 mi) away. The myriad of abandoned stream channels and meander scars that cross the floodplain also testify to higher water levels in the past. All of these alluvial features probably gained much of their present character during the Pleistocene when higher moisture levels increased stream flow and provided the energy necessary for their creation (Pierce and Scott 1982).

The alluvial gravel of the Pioneer Basin may have figured into the economic pursuits of prehistoric inhabitants of the INEL. The hard, water-rounded cobbles were easily made into efficient tools for grinding and pounding with little or no modification to the original stone. In addition, the quartzites, chalcedonies, and cherts could be made into durable tools after heat treatment of the raw stone and seem to have been preferred for the manufacture of long-lasting items such as scrapers and knives.

The Big Lost River, the Little Lost River, and Birch Creek all terminate in sink areas near the northern boundary of the INEL. It is here that the watercourses cease all overland flow and enter the underground SRP Aquifer by seeping through porous basalt bedrock. If unimpeded by modern water control projects, most surface water on the INEL would eventually drain to one of these areas (Lewis and Jensen 1984).

During the Pleistocene, when high discharge from the Big Lost River combined with increased flows from the Little Lost River and Birch, Beaver, and Camas Creeks, the Sink areas were completely submerged by the waters of Lake Terreton. This shallow inland lake once covered approximately 91 km² (35 mi²) of INEL land now occupied by sagebrush grassland and extended far to the east (Butler 1978; Nace et al. 1975). While the lake probably reached maximum extent at the close of the last glacial period, palynological studies (Bright and Davis 1982) suggest that the basin may have been filled as recently as 700 years ago. However, decreases in the amount of available moisture during the Holocene have transformed the lake into a dry and relatively barren expanse of silts and clays. The only standing water held by the basin today occurs in early spring when runoff is high and the sinks become marshy.

The basaltic plains of the INEL also contain a number of scaled down and isolated versions of Pleistocene Lake Terreton; the area commonly known as Rye Grass Flats near the main INEL entrance is one example. Playas such as this generally exist in low lying areas atop the lava flows. However, unlike Lake Terreton, which was dependent upon the discharge of local rivers and

streams, the moisture levels in these features are maintained exclusively through the seasonal flow of intermittent drainages or high precipitation rates. Presently, the small playas rarely hold water. However, in the past when moisture levels were higher, each of the basins probably offered a reliable, albeit shallow, source of water on a year-round basis. Game animals would have been attracted by the grasses and forbs that would have thrived in this moisture-laden soil and prehistoric cultural materials found near the playa deposits offer evidence to suggest that hunters once took advantage of this game congregation.

All of the geographic features described in the previous paragraphs are blanketed by a discontinuous layer of windblown Holocene sands and silts derived from the easily eroded silicic deposits of nearby mountain ranges. The thickness of these aeolian deposits is variable, ranging from a thin dusting on top of the more recent lava flows to accumulations of more than 3 m (10 ft) in low lying areas and at flow margins (Nace et al. 1975). Wind action has also produced and continues to influence a series of dune fields in the north-central portion of the INEL. Human populations apparently took advantage of the relative comfort provided by these accumulations of soil and sand (as compared to the rocky discomfort of the exposed basalt and/or expanses of alluvium) because many prehistoric archaeological sites are located in areas where they have accumulated.

Given the close economic relationship between prehistoric hunter-gatherer populations (like those that once inhabited the INEL) and the natural environment (Ellen 1982; Winterhalder and Smith 1981), it is not surprising that some topographic situations on the INEL are more likely to contain cultural resources than others. In general, the results of previous surveys in the area indicate that prehistoric sites are more likely to exist in association with prominent landmarks (i.e., buttes, high ridges), near permanent or seasonally predictable water sources (i.e., the Big Lost River, sinks, Lake Terretton, isolated playas), or in sheltered areas (i.e., lava tubes, edges of the lava flows) (Reed et al. 1987b; Ringe et al. 1988; Ringe 1993).

Plant life on the INEL is strongly influenced by climate and topography and is generally similar to other cool desert environments of the Great Basin and Columbia Plateau. Communities range from shadscale steppe at lower altitudes through several sagebrush and grass-dominated communities to juniper woodland along the foothills of the nearby mountains and buttes. Although the boundaries of these general communities have migrated in response to variation in available moisture, palynological data indicate their continued presence throughout the late Pleistocene glacial periods and into recent times (Davis and Bright 1983).

Differences in vegetation cover are significant in the archaeological study of the INEL because many of the vegetation communities and their corresponding topographic situations provide microenvironments within the basaltic terrain. In turn, these microenvironments provided prehistoric people with a number of opportune camping locations; pressure ridges, in particular, offered shelter throughout much of the area. These protected areas were probably attractive mainly as shelter from prevailing winds, but they also tend to trap moisture in deep aeolian deposits and thus support a variety of useful plants in the spring and early summer. The Big Lost River channels and sink areas would have also provided a variety of useful vegetable materials.

During the Pleistocene, when moisture levels were considerably higher and the sinks were completely submerged by the shallow waters of Lake Terretton, a marshy environment rich in useful plants (Kelly 1988) was probably created. Each small playa in the area was probably also transformed into a small marshy oasis at this time. Although smaller than the Lake, these playa areas were probably equally rich in terms of natural resources. Hunting opportunities were probably abundant in all of these well-watered situations since animals were also attracted by the plant growth.

A total of 219 resident and seasonal vertebrate species live on or frequent the INEL today (Reynolds et al. 1986). Birds constitute the largest single class of wildlife in this census, although many of these are migratory. Small mammals are the most common year-round residents. Of special concern in this section are species that are known or expected to have been utilized by prehistoric peoples. Many of these, including mammoth and camel, are now extinct in North America. However, archaeological sites near the INEL, such as Bison and Veratic Rockshelters (Swanson 1972), Owl Cave (Butler 1978, 1986; Miller 1982), Wilson Butte Cave (Gruhn 1961, 1965), and Jaguar Cave (Dort 1975; Guilday and Adams 1967; Kurten and Anderson 1972) provide documentation of these animals' past presence and indications of their importance to prehistoric people.

Other big game animals, such as bison, no longer inhabit the area but were also exploited by prehistoric populations. Bison and Veratic Rockshelters, Owl Cave, and Wilson Butte Cave contained bison remains with associated cultural materials. Recent test excavations at a small prehistoric site near the Power Burst Facility on the INEL also indicate that bison were once hunted within the INEL boundaries (Ringe 1988).

The most abundant game animal currently in residence on the INEL is the pronghorn (*Antilocapra americana*). It is estimated that up to 40% of the pronghorn population of Idaho (as well as many from Montana) may utilize the area during the winter months (Hoskinson and Tester 1980). Deer, elk, and mountain sheep are also occasionally observed on the INEL. Many archaeological sites have produced remains of these animals, and Steward (1938) provides ethnographic documentation of their utilization.

Birds may have served as an important resource for prehistoric populations. Arthur et al. (1984) suggest that the sink areas on the INEL provide a crucial habitat for migratory species. If this migration pattern existed in the past, these areas would have provided a variety of fowl for prehistoric hunters. Steward (1938) confirms that several species of bird were important aboriginally.

Small mammals, such as rabbit and ground squirrel, are also known to have been important in the subsistence activities of aboriginal peoples (Steward 1938). The exploitation of these small animals for food can be easier than the regions larger game because rodents tend to remain in relatively restricted locales and can thus be taken in large numbers without the effort of a prolonged chase. They also reproduce rapidly, so that major hunts or drives would not have depleted populations for extended periods.

7.1.4.2 Regional Paleoecology and Prehistory. Systematic archaeological investigation of southeastern Idaho essentially began in 1958. Since that time, several major excavations have been completed, including Wilson Butte Cave southwest of the INEL (Gruhn 1961, 1965), the Birch Creek Sites/Bison and Veratic Rockshelters north of the INEL (Swanson 1972), the Wasden Site/Owl Cave just east of the INEL (Butler 1978, 1986; Miller 1982), and the Wahmuza Site to the south (Holmer 1986b; Jimenez 1986). Intensive survey and test excavation projects on the INEL over the past 6 years (see Reed et al. 1987a) have also contributed to a greater understanding of the region. All of these projects have helped to document human use of the Eastern Snake River Plain (ESRP) by hunting and gathering populations for a span of at least 12,000 years and provide the database for regional chronological sequences (Figure 7-2) (Butler 1978, 1986; Franzen 1980b; Ringe et al. 1988; Swanson 1972).

The prehistoric cultural chronology (Figure 7-2) for southeastern Idaho is broken into three major periods—Early, Middle, and Late Prehistoric—which are marked by major changes in weapon systems and in the morphology of the projectile point forms that were used (Ringe et al. 1988). A fourth period, the Protohistoric, begins with the first appearance of Euro-American trade goods in archaeological assemblages that still reflect a reliance on traditional practices of hunting and gathering. The most recent cultural period recognized in southeastern Idaho is the Historic, which is marked by the settlement of Euro-American people in the region.

7.1.4.2.1 Early Prehistoric Period: 15,000–7,500 Years Ago—One of the most significant features of ESRP prehistory is its time depth. The earliest evidence of human occupation in the region is found at Wilson Butte Cave, where cultural deposits have been radiocarbon dated to the Late Pleistocene at 14,500 years ago (Gruhn 1965). Environmental conditions during the terminal Pleistocene were probably considerably cooler and wetter than they are today. However, palynological studies in the region (Davis and Bright 1983) indicate that vegetation during this time was essentially modern. The main difference between then and now was in the distribution of vegetative zones.

During the Pleistocene, the mountains north of the SRP were wooded and glaciated (Knoll 1977) and the mountain valleys probably supported an alpine tundra biome (Sadock-Kooros 1972). Many of the higher prominence on the plain may have also supported a coniferous forest (Bright 1966). The plain itself was characterized by sagebrush grassland steppe much as it is today (Bright and Davis 1982). Small internal playas probably held shallow stands of water and equally shallow Lake Terretion was probably at maximum extent, covering more than 90 km² (35 mi²) in the northeastern portion of the INEL and extending a considerable distance to the east (Bright and Davis 1982). This environment supported a diverse fauna, including now-extinct forms of mammoth, camel, and horse, whose fossils have been found on the INEL, and also several modern species, such as bison and mountain sheep (Ringe et al. 1988).

The archaeological record indicates that the economy of Early Prehistoric people was based mainly on this large game, although it is certain that a wide variety of smaller animals and local plant resources were also exploited. The sagebrush grasslands and internal playas of the area

would have provided excellent browse for Pleistocene animals and productive hunting and gathering opportunities for people.

Large lanceolate spear points of several varieties are the diagnostic artifacts of the Early Prehistoric Period (Figure 7-2), suggesting that a spear hunting technology was in place. The earliest known styles, Clovis and Folsom, are leaf-shaped in outline and exhibit characteristic channel flake scars, or flutes, which extend from the base to the near tip of the implements. Although Clovis points have been recovered from the Simon Site (Swanson et al. 1959) and at several other surface sites (Titmus and Woods 1991) on the SRP, none are associated with radiometric dates. Folsom points, however, have been found in a dated context at the Wasden Site/Owl Cave, a collapsed lava blister near the INEL (Butler 1978, 1986; Miller 1982). The earliest cultural levels at Wasden revealed fragments of these fluted points in association with the remains of mammoth, bison, and camel. Radiocarbon dates place this association between 10,000 and 12,000 years ago. Several Folsom points have also been recovered from undated surface contexts on the INEL, including three near the Radioactive Waste Management Complex (Butler 1970) and several likely fragments from other INEL surface locations (Reed et al. 1987a; Ross et al. 1986).

Around 10,000 years ago, fluted points become rare in the archaeological record, and unfluted lanceolate and stemmed forms begin to exist in more significant numbers, a trend that continued until approximately 7,500 years ago. This change may be related to the extinction of some forms of Pleistocene megafauna and a concomitant change in the style of weapons used to bring down the creatures that remained. From approximately 10,000 years ago, the environment gradually warmed, although cold pulses were still common (Currey and James 1982). These changing conditions may have contributed to the demise of some megafauna species. Mammoth were gone from the SRP approximately 11,000 years ago, and others such as camel and horse were gone by 9000 years ago (Ringe et al. 1987).

Projectile point styles from this time are lanceolate in outline and many are stemmed or shouldered. Most are called by names originally coined in the Northwestern Plains, where a number of well-stratified sites have been investigated. This includes lanceolate varieties such as Agate Basin and Milnesand and stemmed or shouldered varieties known as Alberta, Eden, Scottsbluff, and Hell Gap (Frison 1978; Wormington 1954). Two lanceolate point varieties known as Haskett and Birch Creek were initially defined and continue to be found in many cave and surface sites on the SRP and the INEL. Haskett points were first recognized in south-central Idaho, where they were associated with bison bones and radiocarbon dates between 9,800 and 10,000 years ago (Butler 1978; Sargeant 1973), but they also have a wide distribution in surface sites throughout the region, including the INEL (Reed et al. 1987a). Birch Creek points were found in direct association with a series of 8,000-year-old bison kills at the Wasden Site/Owl Cave (Butler 1978, 1986; Miller 1982) and at Bison and Veratic Rockshelters in the Birch Creek Valley (Swanson 1972). Evidence from all locations, dated or not, suggest that the people who used these points were relying heavily on animal species such as bison and mountain sheep, which survived the Pleistocene to Holocene transition.

7.1.4.2.2 Middle Prehistoric Period: 7,500 to 1,300 Years Ago—The close of the Early Prehistoric Period and the beginning of the Middle Prehistoric Period is marked by a major change in projectile point morphology, which probably corresponds to a major shift in hunting technology. Large spear points characteristic of the Early Period are almost entirely replaced by smaller notched and stemmed forms. This transition probably represents the adoption of an atlatl (spear thrower) technology, which may have been more effective in exploiting newly evolved species of swift-footed sheep and bison that lived during the Holocene. The presence of ground stone in Middle Prehistoric contexts at some sites such as Wilson Butte Cave (Gruhn 1961) and the Birch Creek Rockshelters (Swanson 1972) also suggests that plant foods such as camas may have gained increased importance during this time. However, all available evidence suggests that hunting still remained the overwhelmingly dominant economic endeavor. Thus, the Middle Prehistoric on the ESRP is marked by some changes in lifestyle, but it does not represent a major break from the previous Early Prehistoric Period.

The environment during the Middle Prehistoric Period was changing and transitional. A general warming trend continued, reaching a point of maximum warmth and dryness at approximately 3800 years ago (Currey and James 1982), but all evidence seems to indicate that these conditions did not produce dramatic environmental changes in the area. Pleistocene Lake Terretion probably declined to its present seasonally marshy state and the internal playas held little, if any, standing water. Pollen profiles, however, indicate that modern xeric vegetation was present throughout the interval (Davis and Bright 1983). This essentially modern habitat supported many animals that were of economic importance to human populations, including modern bison and antelope on the grasslands and mountain sheep and deer in the higher elevations.

Projectile point forms from Middle Prehistoric contexts suggest that this was a time of some cultural reorganization and mobility. The archaeological record reflects this in a proliferation of point styles, which appear to have correlates in the Northwestern Plains and the Great Basin. It appears that people from these surrounding areas were moving in and out of the ESRP, perhaps in response to deteriorating environmental conditions (Benedict 1979; Madsen and O'Connell 1982).

The diagnostic time markers of the initial portion of the Middle Prehistoric are Bitterroot (Swanson 1972) or Northern (Greiser 1984; Gruhn 1961) side-notched points and sporadic stemmed-indent base points, which resemble the Pinto series of the Great Basin (Holmer 1986a). Both forms exist in contexts ranging from 7,500 to 5,000 years ago at sites such as the Birch Creek Rockshelters (Swanson 1972) and further south at Weston Canyon Rockshelter (Miller 1972). At both of these sites, mountain sheep appear to have been the preferred prey in an economy that continued to be focused on the acquisition of game animals.

Between approximately 5,000 and 3,500 years ago, large, side-notched points decrease in frequency, and around 4,500 years ago, stemmed-indent base points become the dominant style of dart in the region. Large, corner-notched varieties and new small lanceolate forms also make

their first appearance around 4,000 years ago but do not become dominant until later. Once again, mountain sheep and bison appear to be the favored game.

During the latter part of the Middle Prehistoric from approximately 3,500 to 1,300 years ago, ESRP assemblages continue to contain a wide variety of point styles, although the predominant type changes from stemmed-indented base to large, corner-notched points. These resemble the Elko series in the Great Basin (Holmer 1986a; Thomas 1981) and the Pelican Lake type in the Northwestern Plains (Greiser 1984; Reeves 1983). Lanceolate points such as the Wahmuza Lanceolate (Holmer 1986b) and the Humboldt (Holmer 1986a) or McKean Lanceolate (Greiser 1984) are also common in Middle Prehistoric assemblages. No major changes in the basic hunting adaptation are indicated during this subperiod.

7.1.4.2.3 Late Prehistoric Period: 1,300 to 150 Years Ago—The Late Prehistoric Period is the best represented and the most debated on the ESRP. It embraces Swanson's (1972) Lemhi Phase in the Birch Creek Valley, Gruhn's (1961) Dietrich Phase on the Plain, and Jimenez's (1986) Ahvish Phase in the Snake River Bottoms. The period is marked by another probable change in weapon technology—full scale adoption of the bow and arrow as opposed to the atlatl and dart weaponry of the earlier Middle Prehistoric Period.

Archaeologically, the Late Prehistoric is recognized by a decrease in projectile point size. Small, corner-notched points that closely resemble the Rosegate Series of the Great Basin (Thomas 1981) occur first and remain dominant until approximately 700 years ago. Small points with low side notches known as Avonlea in the Northwestern Plains (Greiser 1984) also occur between 1,300 and 700 years ago. These two styles are followed by small, side-notched and tri-notched arrow points known as Desert Side-notched points (Holmer 1986a; Thomas 1981), which dominate assemblages from approximately 700 to 300 years ago when stone-tipped arrows began to be replaced by firearms of Euro-American manufacture. Aboriginal ceramics also appear as diagnostic time markers of the Late Prehistoric Period. This pottery commonly occurs in ESRP assemblages after 700 years ago, but evidence from the Wahmuza site suggests that ceramics were in use at the much earlier date of approximately 1,200 years ago (Holmer and Ringe 1986). Finally, the larger lanceolate and corner-notched forms of the Middle Prehistoric Period also continue to persist in small numbers throughout the entire Late Prehistoric Period.

Modern environmental conditions prevailed throughout the entire Late Prehistoric Period except for a few cold pulses and a brief period of increased moisture at 700 years ago when Lake Terreton is thought to have once again filled its shallow basin (Davis and Bright 1983). A typical Holocene fauna, including modern bison, was also present throughout this period.

All available evidence suggests that subsistence strategies continued to be based largely on the hunting of large game animals. Plant foods must have also played some role in Late Prehistoric economics; however, there is little evidence to suggest that they were as important in the diet as they were in the Great Basin, Columbia Plateau, and even in southwestern Idaho. When they are found in the eastern part of the State, plant processing tools usually consist of mortars and/or pestles which would have been used to process root crops such as camas or

biscuitroot. The general lack of grinding stones suggest that seed products were not common dietary elements, perhaps because they are generally more costly than root crops or big game animals in terms of pursuit and processing time relative to caloric returns (Simms 1984).

Excavations at the Wahmuza Site (Holmer 1986b), an open campsite on the Fort Hall Bottoms of the Snake River, the Baker Caves (Plew et al. 1987), a series of three small lava tubes on the Plain east of Minidoka, and Aviators' Cave on the INEL (Lohse 1989) provide some indication of the overall economic activities of Late Prehistoric populations. The excavated assemblages from these sites suggest that people were spending the winter months at camps along the Snake River, where they probably relied on stored foods such as bison, deer, and camas or biscuitroot, that may have been obtained on an annual subsistence round that probably included the INEL area. During the winter, these people also probably made short forays into the surrounding sagebrush grasslands and mountain ranges to obtain fresh meat and apparently did some fishing in nearby rivers and streams. During the warmer months, people apparently dispersed to hunt and gather throughout the region and probably created many of the sites found on the INEL as they foraged. These activities are consistent with the observations of Indian groups in Idaho made by early Euro-American visitors to the area.

7.1.4.2.4 Protohistoric Period: 300 to 150 Years Ago—The nomadic hunting and gathering lifestyle of the Late Prehistoric Period continued in southeastern Idaho even after the introduction of horses and European trade goods about 200 to 300 years ago. However, adoption of the horse by some groups at this time led to significant changes in aboriginal lifestyles. These changes included increases in exploitative range, interaction with other groups, warfare, and the possible development of more formalized leadership roles.

7.1.4.3 Historic Native Americans. The INEL is included within a large territory once inhabited by two linguistically distinct Indian groups, the Shoshone and the Bannock. Both aboriginal groups (and a variety of subgroups within the Shoshone family) shared a common way of life that allowed them to effectively exploit a wide variety of locally available resources. Early explorers and later anthropologists who visited the area have left a record of these groups that is highly fragmented and incomplete but still useful in providing clues about the lifestyle that was practiced. Because of the overall continuity expressed in the prehistoric record of the area, the information provided by these early historic sources is also important in the inferential interpretation of archaeological sites.

The socio-political organization of the Shoshone and the Bannock as observed around the turn of the century was fluid and somewhat amorphous. Groups were loosely organized and had no real social boundaries. As a result, individuals and even entire families could move as freely from one social unit to another as they moved from one food resource to another (Liljeblad 1957). The introduction of the horse to these groups around the turn of the century caused a more distinct, formalized band organization to develop. Use of horses allowed the Shoshone and the Bannock to increase their exploitative range, to congregate in larger groups for longer periods of time, and to protect their wealth (which consisted of horses and the goods acquired through the use of horses) from groups of marauding Blackfoot Indians who also frequented the area

(Steward 1938). In spite of these tendencies toward more complex social organization, the Shoshone and the Bannock never developed the strong socio-political bonds exhibited by the mounted bands of the Great Plains.

The lack of strong socio-political organization is a reflection of the highly nomadic lifestyle of the Shoshone and Bannock. The groups were continually on the move in order to exploit a variety of seasonally available resources and, in contrast to their linguistically related kin in the Great Basin, probably enjoyed a relative abundance of food and other material resources. A large proportion of this general abundance was found in and near rivers and streams (i.e., Snake River, Big Lost River) which flow through even the driest and most desolate parts of southern Idaho. This led to an entire complex of subsistence, religious, and social activities that centered around the riverine habitat (Clark 1986). Consequently, many of the larger Shoshone and Bannock villages were located near the waterways. However, because the dispersed nature of the resource base required these groups to be highly nomadic, these villages were not occupied on a continuous, year-round basis. Instead, they were probably utilized again and again only during the winter months when weather forced people to be less mobile. During the remainder of the year, native groups apparently dispersed to exploit resources that were often found far from these wintering grounds.

This unique seasonal round, as augmented by the horse, has been documented by early anthropologists (Murphy and Murphy 1960, 1986; Steward 1938). These researchers report that the Shoshone and Bannock of southeastern Idaho gathered in large winter villages, primarily along the Snake River in the Fort Hall area. During the winter, they lived on stores of meat, fish, and plant foods. In addition, they fished in nearby streams and made short forays into neighboring areas to supplement their supplies with fresh meat. When winter came to a close, the people split into smaller groups and travelled to various other areas in southern Idaho as resources became seasonally available.

Many different areas were visited during these annual expeditions. Murphy and Murphy (1960) indicate that in the spring, the Indians traveled to salmon fishing areas along the Snake River west of Twin Falls and to the camas prairies in central Idaho near Fairfield and Dubois. Two main routes were followed during this springtime expedition: one followed the Snake River and thence north by a number of routes, and the other proceeded from the Fort Hall and Idaho Falls area across to the Big Lost River and thence west, skirting along the southern edge of the mountains. This latter route may have caused the Indians to pass directly through the INEL area. In the late summer and early autumn, big game hunting became an important activity and most groups moved east to participate. Many followed a trail from the Idaho camas prairies east along the edge of the mountains to the Big Lost River. From here the routes separated, depending on the destination. Some groups travelled up the Little Lost River, crossed east to the Lemhi River and over Lemhi Pass and continued east onto the Great Plain; others headed toward the Snake River near Idaho Falls and then north over Monida Pass; and still others followed a route along the Snake River to the Jackson Hole and Yellowstone area. Some groups also returned to Fort Hall and then went south to the Bear River Valley and into northern Wyoming. And finally, some groups chose to go north to the Salmon River area for the late season salmon run. It is

important to stress that these are only the major routes and destinations, and that all of the small groups probably ranged widely throughout the entire region.

The preceding discussion indicates that the INEL area appears to have served as a natural corridor for the seasonal movements of the Shoshone and Bannock. Although there are no large winter villages reported in the area, some relatively large camps were observed by early visitors; in the early 1830s, Ferris (1940:185-186) encountered over 200 Indians travelling near the three buttes and also reported a camp consisting of nearly 200 lodges on the Big Lost River. Wyeth (1899:228) also reported Indians camped near the Big Lost River. Thus, although the INEL area was probably not used as a wintering grounds, it seems certain that it was frequently visited either in transit to other areas or as a destination for groups interested in obtaining obsidian from Big Southern Butte or Howe Point or for those attracted by food resources such as bison, which are reported to have existed in great numbers in the INEL area (Ross 1956; Work 1923).

A list of animals and animal products utilized by the Indians of southeastern Idaho as reported ethnographically (Shimken 1947; Steward 1938) would include all of the following creatures: antelope, ants, badgers, bears, beavers, birds, bird eggs, bison, caterpillars, chipmunks, cicadas, crickets, deer, doves, eagles, elk, fish, grasshoppers, ground squirrels, mountain lions, mountain sheep, muskrats, owls, packrats, pronghorn, quail, rabbits, and sage hens. Most, if not all, of these products were available on or near the INEL when native populations were still relying on a hunting and gathering lifestyle.

The Shoshone and Bannock also knew and utilized many plants for food and other practical purposes. Useful plants which are known to have figured in the economic pursuits of the Indians are noted in Appendix F and Table F-1. All of these vegetable resources are available on or near the INEL today.

From approximately 1840 to 1860, the Indians in southeastern Idaho remained relatively undisturbed by the small groups of trappers, traders, and miners who worked or simply passed through Shoshone/Bannock territory on their way to California and Oregon. However, conflicts began to arise with increased Euro-American settlement in the 1860s. In the late 1860s, treaties putting an end to the autonomous lifestyle of the Shoshone and the Bannock were signed and the Indians of the area began to adapt with mixed success to reservation life.

7.1.4.4 Regional History. The first historic records of activities on the ESRP were written by Lewis and Clark in 1805. Events from this time forward are considered as the Historic Period in the region. In the discussion to follow, a variety of major historical trends that have influenced the Euro-American history of the area are briefly described. References that provide more detailed information on all of these topics are widely available (Beal 1942; Brosnan 1948; Conley 1982; Franzen 1981).

7.1.4.4.1 Fur Trapping and Trading—The first Euro-American explorers in the INEL region were fur trappers. Only a few of these individuals left records of their travels. Among those who did are Antoine Godin, who is credited with the discovery of the Little Lost

River in 1823 (Hammer 1967); Alexander Ross, Peter Skene Ogden, and Jedediah Smith, who worked together in the Lost River area until 1825 (Ross 1956); Captain Bonneville, who took a leave of absence from the U.S. Army in the early 1830s to trap and explore the region (Rees 1918); and Nathaniel Wyeth, who was responsible for establishing a supply post at Fort Hall (Trego n.d.). Movement of these individuals through the INEL area was probably limited, as very few of the animals that they trapped maintained residence in the desert. By the 1850s, the supply of beaver and other fur-bearing animals in the mountains dwindled to such a degree that trappers rarely frequented the area.

7.1.4.4.2 Immigrants—Although many settlers probably passed through the INEL area, few made the desert their ultimate destination during the early 1800s. Most of the settlers who found themselves near the present day INEL were on their way to the Oregon Territory via a northern spur of the Oregon Trail called "Goodale's Cutoff" (Idaho State Historical Society n.d.). Wagons used this trail as early as 1852. A portion of the trail is still recognizable in the southwestern corner of the present day INEL and is currently listed on the National Register of Historic Places.

7.1.4.4.3 Mining—In the 1860s, gold strikes in the Big Lost River mountains drew many miners into the INEL region. Boom towns sprang up in a number of areas including one at Howe near the northern boundary of the present day INEL. However, most of these towns folded when initial expectations of productivity in the surrounding mines were not realized (Bottolfson 1926a). The last major strike in the area occurred in 1925 when gold was discovered in the Lost River Sinks. But within the space of a single month, the claimants realized that the gold was in such minute quantities that extraction was not economically feasible (Crowder 1981).

7.1.4.4.4 Transportation—The mining booms of the late 1800s created a need for transportation systems between the newly established mining towns north of the INEL and their supply stations in older towns further south (i.e., Idaho Falls and Blackfoot). Freightage became a major business and a number of companies were formed in order to meet the demand for mining equipment, passenger service, dry goods and other supplies. Old wagon roads and trails became stage and freight lines virtually overnight, and several new trails were forged across the desert (Trego 1935).

Because of the freshwater springs that bubble from its slopes within the otherwise dry desert, Big Southern Butte served as a stop for nearly all stage and freight lines. Berryman and Rogers, Joe Skelton, and Henry Leatherman, three of the earliest freighters to cross the desert from Idaho Falls and Blackfoot to Arco, used Big Southern as a way station (Trego 1928). In 1901, the completion of the Oregon Shortline railroad between Blackfoot and Arco signaled the end of stage and freight lines in the area (Sedgewick n.d.). As horse-drawn wagons became obsolete, many drivers took up small farms and ranches in the area.

7.1.4.4.5 Ranching and Sheepherding—As transportation through the desert became more reliable, homesteaders began to make their way into the area. Many of these early occupants took up ranching in the northern reaches of the present day INEL. Sources report

that there were six or seven ranches in operation on the Little Lost River and Birch Creek in 1882 (Edelman n.d.). Chief among these early cattle barons were the Hawley brothers, who operated a large ranch on the Little Lost River near Howe (Edelman n.d.). The Hollands routinely ran their stock between Howe and Big Southern Butte (Pettite 1977, Gerard 1982). Dave Wood maintained several ranches in the area, one of which was located on the Birch Creek Sinks (Oberg 1970). Frank Reno still operates a ranch in the Birch Creek Sinks area today (Edelman n.d.). The disastrous winter of 1896–1897 killed so much stock that the local cattle industry never quite recovered, and sheep moved in on the territory once dominated by bovines.

Major sheep drives across the INEL area began in the 1860s, and the growth of this new industry paralleled that of the cattle industry (Wentworth 1948). As the demand for mutton and wool increased and sheep became a profitable commodity, many cattle ranchers added flocks to their cattle herds or completely switched to raising sheep. By the early 1900s, sheep were very common in the area and are still moved from pastures near Big Southern Butte across the INEL area to Howe today. Many of the isolated historic sites encountered within the boundaries of the INEL are remnants of these small temporary camps created by sheep and cattle drivers as they moved their stock through the region around the turn of the century.

7.1.4.4.6 Homesteading—While the northern portion of what is now the INEL was used primarily by ranchers, the western and northeastern portions were geared toward agricultural pursuits. The first settlers in the area were members of the Mormon Church who established residence near the northeastern boundary in 1855 (Clements n.d.). In these early days, farming was oriented toward family subsistence because transportation systems were not adequate to ship any supplies or produce in or out of the area. After freight and wagon lines became firmly established in the 1880s, settlers came in to the area in larger numbers and began to farm for commercial as well as subsistence purposes.

Most of the homesteaders who came into the area in the late 1800s settled along the Big Lost River. The first permanent settlers arrived in 1878 and the first official water right claim was recorded in 1879 (Bottolfsen 1926b). Most of the early homesteading activity in the Big Lost River area was spurred by the Homestead Act of 1862, which allowed the head of a family to obtain 65 hectares (160 acres) of land by residing on it and cultivating it for a period of five consecutive years. The Desert Claim Act of 1877 also encouraged settlement in the Big Lost River area by permitting families to acquire 259 hectares (640 acres) of land if water could be brought into it (Bottolfsen 1926b).

Water was truly a rare commodity in the desert areas of the ESRP, and the success of farming efforts in the area hinged on the homesteaders' ability to obtain it. With passage of the Carey Land Act in 1894 and the passage of the Reclamation Act in 1902, the Federal government stepped in to assist homesteaders in this endeavor. The Act of 1894 set aside one million acres of public land for homesteading provided that the settlers participate in state-sponsored irrigation projects, and the Act of 1902 provided the funding necessary to reclaim these arid and semi-arid acres. Idaho was a major beneficiary of this Federal aid and, as a result, the years from 1905 to 1920 were witness to a dramatic upswing in agricultural activity on land within and around the

present day boundaries of the INEL. Irrigation companies formed and, with financial backing by the Federal government, proceeded to start construction on a number of dams and canal projects that brought much-needed water to homesteaders (Pettite 1983). In addition, the town of Powell/Pioneer also sprang up along the Oregon Shortline near the present-day Diversion Area on the INEL to supply local residents with all necessary mercantile goods (Schmalz 1963). Unfortunately, gross miscalculations of water flow in the area led to the abandonment of all but a few of these projects in the 1920s (Pettite 1983; Staley 1978). In the absence of sufficient water, many of the small homesteads on and around the INEL also folded. Only those people who lived adjacent to the Big Lost River were able to make any real progress toward developing the land. Many of the historic sites located within the INEL boundaries are representative of these short-lived and futile efforts to create green pastures in the dry desert.

7.1.4.4.7 National Interests—The late 1920s and early 1930s saw only limited activity in the INEL area. Some ranchers (especially sheepherders) were still working in the area, but most agricultural activity was abandoned except for a few successful enterprises near Mud Lake (Pettite 1983; Staley 1978). However, during World War II, activity was stepped up when the U.S. Navy set aside approximately 700 km² (270 mi²) of the present INEL facility for fixed emplacement and aerial gunnery practice. Federal interest in the region increased during the late 1940s and is even stronger today. Geological surveys of the area were undertaken in 1949, and from 1950 to 1953, all military facilities in the area were purchased by the Atomic Energy Commission. In 1958, additional lands were added to the existing area to form what is now known as the INEL (known then as the National Reactor Testing Station). Many major contributions have been made in the nuclear testing arena and other scientific and technical fields since establishment of the INEL. Although all 52 of the reactors constructed at the facility have made important contributions, only one, the Experimental Breeder Reactor I, has been officially recognized through designation as a National Historic Landmark (Conley 1982).

7.1.4.5 Summary of INEL Cultural Resources. All of the archaeological investigations conducted to date have shown the INEL to be a major repository of cultural resource data. This is illustrated by the more than 1,500 cultural resources that have been identified in survey of little more than 4% of the 2,305 km² (890 mi²) facility. Given this figure, it can be conservatively estimated that at least 34,950 additional resource locations will be found within facility boundaries. Continuing investigations of differences in site distribution on the INEL (Reed et al. 1987b; Ringe 1993; Ringe et al. 1988) also suggest that this may be a low estimate and further indicate that nearly half of the unidentified resources will likely be potentially eligible for the National Register. The remainder are expected to be isolated finds that are certainly informative but ineligible for nomination due to a lack of research potential.

The majority of cultural resources identified on INEL lands thus far are representative of activities during Prehistoric periods (<1% are historic). The typology developed for these prehistoric INEL resources is reflective of the hunting and gathering lifestyle, that was the most prevalent system of settlement and subsistence on the ESRP for at least 10,000 years. The work of anthropologists in the early 1900s (Murphy and Murphy 1960; Steward 1938, 1943; has shown that this way of life was based on a high degree of residential mobility, wherein small family

groups foraged widely throughout southern and central Idaho during most of the year to exploit resources as they became seasonally available. In the winter, when most resource patches were rendered unproductive, these small groups probably congregated into larger bands in zones that remained marginally productive all year long. Areas along the Snake River or perhaps in the mountain valleys of east-central or extreme southern Idaho were apparently preferred for these wintertime occupations.

Residential bases are representative of prolonged occupation by one or more families in a single area that served as a center of operations for all foraging activity. The archaeological record reflects this intensity of activity in dense scatters of lithic debris and a wide variety of tool types. These sites also contain evidence of food preparation/processing in the form of cooking features (hearths, middens) and food refuse (burned bone). Only a few of these larger, more permanent sites have been identified on the INEL. This indicates that the area was not heavily used as a wintering grounds but was instead visited by many smaller groups of people.

Small prehistoric hunter-gatherer groups were probably attracted to the INEL region because it consistently offered big-game animals and a variety of plants for sustenance. Artifact assemblages suggest that these groups focussed on acquiring faunal resources, probably including birds, small mammals, deer, antelope, and bison. During the Early Period, they may also have taken mammoth, camel, and other big-game species that are now extinct in North America. The INEL region would have also offered a number of useful plants including several varieties of seed-bearing grasses and tender greens as well as edible root crops like biscuitroot and cattail during periods of increased moisture. However, the overall lack of significant numbers of large residential base camps in the INEL area argues that this resource base, although rich, was not sufficient to support prehistoric groups on a year-round basis. Instead, it was probably used on a temporary basis, perhaps during the spring or fall when the climate was less severe. During other times of the year, they probably travelled to other areas in southern and central Idaho.

Few historic resources have been recorded on the INEL although historic records provide a fairly clear idea of the types of activities that are represented on the desert (see **Section 7.4**). Most of the known resources are related to agriculture (i.e., canals, homesteads) or ranching (i.e., sheep camps). Presently, the approach to examination of the Historic period on the INEL is descriptive. Sites are recorded as they are encountered and added to the database. Future plans by INEL CRM call for an ambitious examination of all historic trends on the INEL, including a detailed examination of the nuclear industry.

7.2 Aesthetic and Scenic Resources

This section discusses the aesthetic and scenic resources of the INEL, the surrounding areas, and scenic resource policies.

7.2.1 Visual Character of the Project Vicinity

The northwestern edge of the ESRP, where the INEL is located, is bordered on the north and west by the Bitterroot, Lemhi, and Lost River mountain ranges. East Butte and Middle Butte are located near the southern boundary of the INEL and can be seen from most locations on the INEL, as can Big Southern Butte located southwest of the INEL's southern boundary. Circular and Antelope Buttes are located in the INEL's northeastern section. A number of smaller volcanic buttes dot the INEL landscape. The mountains and buttes provide a striking contrast to the relatively flat topography of the ESRP.

Two uplands of volcanic origin join in the vicinity of the INEL. The first extends from Big Southern Butte northeastward along the axis of the ESRP to Juniper Buttes near St. Anthony, Idaho. The second volcanic upland starts at the Craters of the Moon National Monument and extends northeastward. Lava rock outcrops are common.

The INEL landscape is dominated by large sagebrush, with four other significant vegetation communities/habitat types on or adjacent to the INEL: juniper, crested wheatgrass, agricultural, and wetlands. Juniper appears in the higher elevations, near the Buttes and the foothills of the Lemhi range. Crested wheatgrass seedings exist throughout the INEL. Irrigated farmlands, planted in alfalfa, grain, potatoes, and corn, border much of the INEL. Though dominated by sagebrush and grasslands, over 809 acres (2,000 acres) of wetlands may occur on the INEL during periods of high water flow in the Big Lost River (DOE 1990).

INEL facilities have the appearance of commercial/industrial complexes. Figure 7-3 is an aerial view of the INEL's Test Area North (TAN) facilities showing the industrial nature of facilities and low acreage involved. The facilities are relatively isolated from public views because of the large areal expanse of the INEL and hilly areas along access roads. Buildings are generally low density, dispersed, and do not dominate the scene. The most obtrusive features of the INEL landscape are stacks, stack emissions, night lighting, and high security fences. Cooling tower plumes are visible from public access highways and may occasionally be visible from Craters of the Moon National Monument and Wilderness Area, a Class I visual area.

A total of 145 km (90 mi) of paved highway used by the general public runs through the INEL: U.S. Highway 20 runs east and west and crosses the southern portion; Highway 26 runs southeast and northwest and intersects Highway 20; Idaho State Highways 22, 28, and 33 cross the northeastern part (Figure 7-4). U.S. 20 is the most heavily used by the INEL workforce and is also a direct route to Boise, Idaho, as well as recreational areas such as Sun Valley, Craters of the Moon National Monument, and Experimental Breeder Reactor I, a national historic landmark (DOE 1991).

Figure 7-3. Aerial view of the INEL's Test Area North facilities showing industrial appearance.

7.2.2 Views of the INEL from Surrounding Areas

Most of the area within the INEL consists of open land, with direct line-of-site views frequently interrupted by hilly areas along access roads. Large portions of the INEL around the perimeter and the midsection remain undeveloped and are used as a security buffer and livestock grazing zone (DOE 1991) (Figure 7-4).

A panoramic view of the INEL is offered from Highway 20. On a clear day, structures, parking lots, and stacks are visible in the background, and the open space security buffer and grazing zone is visible in the foreground. The facilities are a minor component of the landscape view and do not dominate the viewer's impression. The diminutive aspect of facilities viewed at a distance is consistent with the small proportion of the INEL land area covered by existing facilities.

The existing visual character of the INEL is illustrated by several photographs taken of the facilities from nearby sensitive viewpoints (e.g., residences and public roadways). Figure 7-5 indicates where the photographs depicted in Figures 7-6 through 7-9 were taken, and the directions of the views.

Southern Section. The majority of the facilities are in the southern section of the INEL and are made up of nine areas, including the Experimental Breeder Reactor I. These facilities have an industrial/commercial appearance and most are visible from Highway 20 traveling both west and east.

Area structures range in height from 3 m (10 ft) to approximately 30.4 m (100 ft). The 62-m (203-ft) stack and plume at the Idaho Chemical Processing Plant are highly visible from most surrounding viewpoints.

Central Section. The central section is undeveloped and consists of one road that connects the southern and northern sections of the INEL. This road is restricted and is not available for public use.

Northern Section. TAN is in the northern third of the INEL and is visible from State Highways 22, 28, and 33. TAN is broken down into four areas with numerous buildings and structures, including an aircraft hanger and reactor facility. Some structures and night lighting can be seen from the highways but are a minor part of the distant landscape. A large grazing and security buffer zone exists between TAN facilities and the highways.

ARA	Auxiliary Reactor Area	NRF	Naval Reactor Facility
ANL-W	Argonne National Laboratory - West	PBF	Power Burst Facility
CFA	Central Facilities Area	RWMC	Radioactive Waste Management Complex
EBR-I	Experimental Breeder Reactor I	TAN	Test Area North
ICPP	Idaho Chemical Processing Plant	TRA	Test Reactor Area

Grazing Land

Developed Area

Figure 7-4. Land use and public access roads on the INEL.

Figure 7-5. Site photo index of the INEL.

Figure 7-6. View 1: Southeastern section of the INEL from U.S. Highway 20.

Figure 7-7. View 2: Central Facilities Area guardgate from the junction of U.S. Highways 20 and 26.

Figure 7-8. View 3: Central section of the INEL from Idaho Highway 33.

Figure 7-9. View 4: Test Area North facilities from Idaho Highway 33.

7.2.3 Scenic Resource Policies

Immediately adjacent to the INEL are Bureau of Land Management (BLM), National Forest, private, and state lands. The BLM has four visual resource management classifications. Classes I and II urge preservation and retention of the existing character of the landscape. Class III allows for partial retention of existing character, and Class IV allows for major modifications. Lands adjacent to the INEL under BLM jurisdiction are designated as a visual resource Class III area. The BLM has considered several areas in the two districts surrounding the INEL for wilderness designation. Only one, the Black Canyon, is close to the INEL (adjacent to the northwest boundary). If approved, a wilderness study area may result in an upgrade of the visual resource class (BLM 1986). The BLM has applied visual classifications of III and IV to the acreage within INEL boundaries (DOE 1991). The use of INEL as a nuclear research, materials, and development facility is consistent with these classifications.

The CRM Office is located approximately 30.5 km (19 mi) southwest of the INEL and includes a designated wilderness area. Scenic values are rated very high. The CRM Office Wilderness Area is a Class I area under the Clean Air Act, which includes visibility and scenic view considerations. The CRM Office is under the jurisdiction of the National Park Service and is required to maintain Class I air quality standards or minimal degradation. The NPS National Park Service monitors and measures emissions from the Idaho Chemical Processing Plant and has identified it as a potential source of emissions contributing to degradation of air quality and visibility of Big Southern Butte and the Caribou Mountains (National Park Service n.d.; National Park Service 1992).

The U.S. Department of Agriculture (USDA) Forest Service manages both the Challis and Targhee National Forests which are located in the Lemhi and Lost River Ranges. The USDA has established five classes for visual quality management objectives: preservation, retention, partial retention, modification, and maximum modification (USDA Forest Service 1974). The area closest to the INEL boundary has been classified "modification," which means that management activities may visually dominate the original landscape. However, activities involving vegetative and land form alteration must borrow from naturally established form, line, color, and texture so that visual characteristics are compatible with the natural surroundings.

The State of Idaho owns several small pieces of land near the INEL and manages the Mud Lake Wildlife and Management Area and the Market Lake Wildlife and Management Area. No visual resource standards have been established for these areas.

Private lands around the INEL are mostly irrigated farmlands and grazing pasture and have no established visual resource standards.

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