DOE/EIS-0017

Final Environmental Impact Statement

(Final of Draft EIS, ERDA-1556-D, High Flux Neutron Source Facility)

FUSION MATERIALS IRRADIATION TESTING FACILITY

Hanford Reservation

Richland, Washington

U.S. DEPARTMENT OF ENERGY

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Responsible Official

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Washington, D.C. 20545

April 1978

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THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE HIGH FLUX NEUTRON SOURCE FACILITY (HFNS) WAS PUBLISHED BY THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION (ERDA) IN JULY 1977. ON OCTOBER 1, 1977, ERDA WAS ABOLISHED UNDER THE DEPARTMENT OF ENERGY (DOE) ORGANIZATION ACT, AND RESPONSIBILITY FOR THE HFNS PROJECT WAS TRANSFERRED TO DOE. SUBSEQUENTLY, THE PROJECT WAS RENAMED THE FUSION MATERIALS IRRADIATION TEST FACILITY (FMIT).

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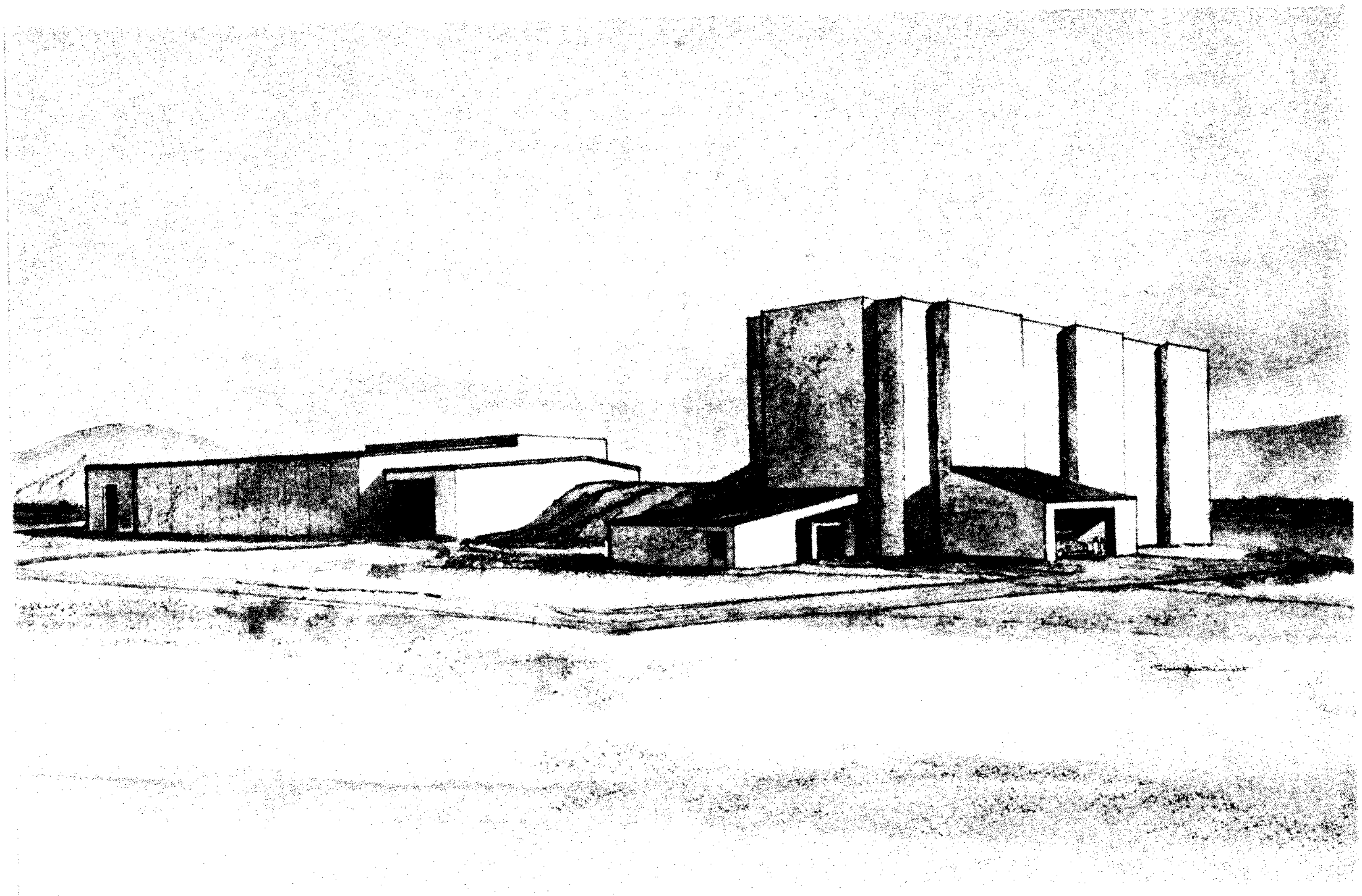

DEUTERIUM-LITHIUM HIGH FLUX NEUTRON SOURCE FACILITY

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ACRONYMS

a-f	acre-feet
ALE	Arid Land Ecology
ANSI	American National Standards Institute
BEIR	Biological Effects of Ionizing Radiation
BNL	Brookhaven National Laboratory
BPA	Bonneville Power Administration
BRP	Breeder Reactor Program
CAM	Continuous Air Monitor
DHX	Dump Heat Exchanger
D-T	Deuterium-Tritium
DOE	Department of Energy
FFTF	Fast Flux Test Facility
FMEF	Fuels and Material Examination Facility
FMIT	Fusion Materials Irradiation Test, formerly HFNS High Flux Neutron Source
HEDL	Hanford Engineering Development Laboratory
HEPA	High Efficiency Particulate Air
HMS	Hanford Meteorology Station
HPFL	High Performance Fuels Laboratory
HTSF	High Temperature Sodium Facility
INS	Intense Neutron Source
LCS	Lithium Characterization System
LINAC	Linear Accelerator
LLL	Lawrence Livermore Laboratory

ACRONYMS (Cont'd)

MFE	Magnetic Fusion Energy
MM	Modified - Mercalli Scale
msl	mean sea level
ORNL	Oak Ridge National Laboratory
PMF	Probable Maximum Flood
PNL	Pacific Northwest Laboratory
PRTR	Plutonium Recycle Test Reactor
R&D	Research & Development
RF	Radio Frequency
RTNS	Rotating Target Neutron Source
TLD	Thermoluminescent Dosimeter
Tri-Cities	Includes cities of Richland, Kennewick and Pasco, Washington.
WNP-	Washington Nuclear Plant Number-_____.
WPPSS	Washington Public Power Supply System
USGS	United States Geological Survey

SYMBOLS

Ci	curies
cfs	cubic feet per second
cm	centimeter
gpd	gallons per day
gpm	gallons per minute
keV	kiloelectron volts
kg	kilograms
kV	kilovolts
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
mA	milliamperes
MeV	million electron-volts
MHz	megahertz
ml	milliliters
MW	megawatts
n/cm	neutrons per centimeter
n/s	neutrons per second
ppm	parts per million
psi	pounds per square inch
SCFM	standard cubic feet per minute

GLOSSARY

anticline - an unparched fold in which the rock strata dip away from the fold's axis; the opposite of syncline

antithetic - as applied to faults, indicates faults with dips in the opposite direction from the dip of the enclosing rocks

caisson - a vertically oriented cylindrical structure used for the subsurface disposal or storage of materials

cladding - metal coating bonded to a metal core

coliform - a measure of the bacterial content of water

concentration guide - the average concentration of a radionuclide in air or water to which a worker or member of the general population may be continuously exposed without exceeding appropriate radiation dose standards (see maximum permissible concentration)

curie (Ci) - a unit of radioactivity defined as the amount of a radioactive material that has an activity of 3.7×10^{10} disintegrations per second (d/s)

decontamination - the selective removal of radioactive material from a surface or from within another material

decommissioning - the process of removing a facility or area from operation and decontaminating and/or disposing of it or placing it in a condition of standby with appropriate controls and safeguards

deuterium - an isotope of hydrogen, having twice the mass of ordinary hydrogen

deuteron - a positively charged particle consisting of a proton and a neutron, equivalent to the nucleus of an atom of deuterium

dose - a general term indicating the amount of energy absorbed from incident radiation by a specified mass

dose commitment - the integrated dose which results from an intake of radioactive material when the dose is evaluated from the beginning of intake to a later time (usually 50 years); also used for the long term integrated dose to which people are considered committed because radioactive material has been released to the environment

dosimeter - an instrument used for measuring or evaluating the absorbed dose, exposure, or similar radiation quantity

dump heat exchanger (DHX) - a structure to remove heat and release it to the atmosphere fusion - a thermonuclear reaction in which nuclei of light atoms join to form nuclei of heavier atoms

fusion reactor - an apparatus in which the fusion reaction is initiated, controlled and sustained

getter - a unit used to remove impurities through a chemical combination process

graben - a geological structure which is a generally linear block bounded by faults on each side, along which the block has dropped, relative to the sides

hydride - a compound of hydrogen

isotope - nuclides with the same atomic number, (i.e., the same chemical element) but with different atomic masses; although chemical properties are the same, radioactive and nuclear properties may be quite different for each isotope of an element

leaching trench - an excavation used for the disposal of liquids so that the solid will remove contaminants while allowing water and other solvents to pass through

linear accelerator - an accelerator in which particles are propelled in straight paths by the use of alternating electric voltages so timed that the particles receive increasing increments of energy

magnetic fusion - the fusion process whereby magnets are used to hold the plasma in place

maximum permissible concentration (MPC) - the average concentration of a radionuclide in air or water to which a worker or member of the general population may be continuously exposed without exceeding an established standard of radiation dose limitation

mrem - one thousandth of a rem

neutron - a particle existing in or emitted from the atomic nucleus; it is electrically neutral and has a mass approximately equal to that of a stable hydrogen atom

nuclide - a species of atom having a specific mass, atomic number and nuclear energy state

person-rem - used as a unit of population dose, often the average dose per individual expressed in rems times the population affected

pH - a measure of the relative acidity or alkalinity of solution; a neutral solution has a pH of 7, acids have pH's of 7 to 1, bases have pH's of 7 to 14 photon - a quantum of electromagnetic radiation, usually considered as an elementary particle that is its own antiparticle and that has zero mass and charge, and a spin of one

plasma - an ionized gas containing about equal numbers if positive ions and electrons

population dose (population exposure) - the summation of individual radiation doses received by all those exposed to the source or event being considered

radioisotope - a radioactive isotope

radionuclides - a radioactive nuclide

rem - the quantity of ionizing radiation whose biological effect is equal to that produced by one roentgen of x-rays

tectonic - of, pertaining to, or designating the rock structures resulting from deformation of the earth's crust

thermoluminescent - the characteristic of certain minerals to release previously absorbed radiation as light upon being moderately heated

thermonuclear - of or relating to the transformation in the nucleus of atoms of low atomic weight that require a very high temperature for their inception

tokamak reactor - a type of fusion reactor

Torr - a unit of pressure, being the pressure necessary to support a column of mercury one millimeter high at 0°C and standard gravity

tritium - an isotope of hydrogen having an atomic weight of three

trophic levels - pertains to groupings of organisms according to characteristics of their intake of nutrition

turbidity - a measure of the degree to which sediments and other foreign matter are suspended in water (cloudiness)

1.0 SUMMARY

Fusion reactor technology is of major importance to the United States' goal of continuing to provide energy at reasonable costs. Development of commercial fusion power cannot be achieved, however, without additional testing of candidate materials for fusion reactors. Tests must be performed on candidate materials to examine the mechanical property changes caused by high energy neutrons, basic effects of a high energy neutron spectrum on materials, and materials surface effects. The Deuterium-Lithium High Flux Neutron Source (HFNS) Facility is intended to provide the means for performing these tests.

The HFNS site is located in the 300 Area of the 559-square mile, federally-owned Hanford Reservation. The Reservation is part of the Columbia Basin geologic province which encompasses about 50,000 square miles. This province is underlain by the vast field of Columbia River Basalt Group flood lavas. Late in the Pleistocene epoch, large floods scoured and carved the Ringold formation surface beneath the Hanford Reservation. These floods deposited the sediments now found on the site. The sands and gravels underlying the Reservation provide excellent protection against seismic damage. On the basis of the damage experienced since 1840, the U.S. Coast and Geodetic Survey assigned the area a Zone 2 seismic probability, implying the potential for moderate damage from earthquakes. The HFNS Facility will be designed to withstand all credible earthquakes as needed.

The 300 Area is about 0.3 of a mile from the Columbia River. Although water needed for the HFNS will mainly come from this source, water requirements of the HFNS are insignificant compared to the river volume. Also, most of the water withdrawn from the river will be returned via the groundwater. Thus, the impact on the Columbia River will be minimal.

The climate on the Reservation is mild and dry. While occasional periods of high wind are characteristic of the region, tornados are rare in Washington and tend to be small with little damage when they do occur. The HFNS Facility, however, will be designed to withstand the effects of credible tornados thus assuring public and employe safety, and protection of the environment.

Essentially all of the land within the 300 Area has been removed from its natural habitat by activities in the Area. Among mammals on the Reservation, the mule deer is the only big game mammal normally found on the Reservation, while the cottontail rabbit is the only small game mammal. Small mammals are abundant, particularly the great basin pocket mouse.

On the Hanford Reservation land use includes nuclear fuel reprocessing and waste management activities, nuclear fuel fabrication and laboratory facilities, a plutonium production reactor, the Fast Flux Test Facility (FFTF) and ecological studies. Two commercial reactors are presently being built on the Reservation, and more are planned.

Adjacent to the Reservation are residential suburban, corporate city, agricultural, industrial and commercial, scenic, recreational, and general use land areas. The predominant land use within a 50-mile radius of the 300 Area is agricultural. The projected year 2000 population within this 50-mile radius of the HFNS site is 256,000.

During normal HFNS operations it is anticipated that small quantities of noxious substances may be released into the atmosphere. Releases of non-radioactive noxious substances into the atmosphere will be well below acceptable limits and are not expected to cause any health effects. The calculated doses to the population resulting from radioactivity releases are negligible. For example, the 50-year whole-body dose commitment received by the estimated 256,000-person, year 2000 population living within 50 miles of the HFNS site is 0.012 person-rem for one year of plant operation. When compared to the estimated 50-year whole-body population dose commitment for the population within 50-miles of the 300 Area of 0.23 person-rems for 1976 from all Hanford operations and of about 26,000 person-rems from natural radioactivity for the year 2000 population, the exposure from the HFNS operation is insignificant. The 50-year dose commitment for the rest of the United States population would be 0.061 person-rem. A conversion of the population dose to health effects using the data from the National Academy of Sciences Biological Effects of Ionizing Radiation (BIER) Report results in the conclusion that no identifiable health effects can be anticipated.

Radioactively contaminated waste will be collected for transfer to the Department of Energy waste disposal contractor. Concentrations of other noxious substances will be at levels that pose no threat to the environment when released.

Under postulated accident conditions the maximum environmental consequences are 50-year dose commitments of 0.37 rem to the lungs of a maximally exposed individual and 2.9 person-rems whole-body to the surrounding population. To evaluate the overall environmental dose risk represented by accidental conditions, both the consequences of an accident and its probability, the "relative annual risk", have been considered. Relative annual risk to individuals from accidental conditions is 3.3×10^{-4} rem/yr. This is seen to be very low when compared to the dose equivalent received from natural background radiation (less than 0.02% of background) and when compared to regulatory guidance (5.0×10^{-1} rem/yr) for routine releases.

Numerous studies have been and are being conducted to characterize the Hanford environs. These studies document the physical, ecological, and radiological conditions of the Reservation. There are also continuing special and routine studies of exposure paths and radioactivity in the Hanford environs. These efforts will be sensitive to HFNS impacts. To assure early detection in order to minimize environmental impacts, effluents (airborne and liquid) from the HFNS will be monitored for radioactive and chemical pollutants to assure that they do not exceed appropriate concentration guides for uncontrolled areas and that they are kept as low as practicable (ALAP).

The HFNS will be built in the 300 Area of the Hanford Reservation. As a result, little additional impact is anticipated during HFNS construction. Local mammal and bird populations not already displaced will be disturbed. Return of these populations will occur in proportion to the reestablishment of plant communities. No endangered species will be affected by the facility. The construction and operation of the HFNS Facility will result in the irretrievable commitment of only moderate amounts of materials and supplies. The facility is being designed to facilitate decontamination of the buildings and equipment. Some of the HFNS Facility could be reused or recycled after appropriate decontamination.

Because of its timing, HFNS construction will tend to provide an opportunity for continued employment as the major Hanford construction projects approach completion. Essentially all of the operational jobs at the HFNS could be filled by reassignment of Hanford Engineering Development Laboratory (HEDL) personnel from elsewhere in the laboratory. The effect of HFNS construction and operation will be relatively small yet largely positive since the HFNS project will aid in maintaining economic stability in the Tri-City area (Richland, Kennewick and Pasco).

Alternatives to be considered for the HFNS are:

- Abandoning the project
- Postponing the project
- Alternative designs
- Alternative sites
- Use of existing facilities

Without the construction and operation of the HFNS or a similar facility, it would be extremely difficult to generate the test data on behavior of materials under fusion reactor irradiation conditions required for the development of commercial fusion power. No other site was found at which the net impact of plant construction and operation would be less than at the 300 Area on the Hanford Reservation. The 300 Area site offers a location with some isolation from the surrounding populated areas and reserved for nuclear facilities.

On balance, it is concluded that the HFNS project represents a substantial benefit for the nation and the Hanford region. The program will provide the testing capability required to meet the materials design data necessary for development of fusion reactors. A Hanford location for the facility means that impacts on living things are negligible and that risks of natural disaster (and consequent releases of hazardous substances to the environs) are minimal. For the Hanford region the project means stability and continued diversity of the economy. Since the project aids in stabilizing the local labor force, impacts on housing, community services, and local merchants will be minimized.

2.0 OBJECTIVES OF THE PROPOSED FACILITY

This project will provide an irradiation test facility to generate test data on the behavior of materials under fusion reactor irradiation conditions.

2.1 Proposed Action

The Department of Energy is proposing the construction and operation of an irradiation test facility, the Deuterium-Lithium High Flux Neutron Source (HFNS) Facility. It will consist of a Test Building and an Accelerator Building with an interconnecting transport tunnel for the deuteron (deuterium ion) beam. A linear accelerator will generate 30 MeV deuterons to produce neutrons using the deuteron-lithium stripping reaction in a liquid lithium target. These neutrons will have a mean energy of about 14 MeV. This system will provide a maximum flux density of approximately 10^{15} n/cm^2/s, a one-liter test volume, and the neutron spectrum representative of fusion reactor conditions.

Test specimens will be fabricated into irradiation assemblies in existing Hanford Engineering Development Laboratory (HEDL) facilities. Irradiated test specimens will be transferred to existing HEDL facilities for examination.

2.2 Major Objectives

The major objectives of this project are to determine the effects of high energy neutrons on the mechanical properties of materials, basic bulk irradiation effects, and surface effects. Testing may also include areas such as electrical insulators, fundamental radiation damage, and tritium control and handling.

The structural components of controlled thermonuclear fusion reactor blankets will be subjected to a severe, high temperature irradiation environment. The safe and economical operation of Magnetic Fusion Energy (MFE) facilities will, to a large degree, depend on choosing metals and alloys that can retain adequate strength, ductility, and dimensional stability under such conditions.

Therefore, objectives for materials properties studies in the HFNS are to:

- determine the effects of a fusion reactor environment on the mechanical properties of candidate materials,
- perform screening tests on candidate materials,
- compare properties of materials irradiated in fission reactors and other MFE facilities with tests in HFNS,
- analyze and evaluate results, recommend limits of operating conditions, and develop other design information for candidate materials,
- prepare a comprehensive materials test program based on HFNS results.

2.3 Project Background

The potential shortage of U. S. and world energy supplies in the near future precipitated the recognition of the need for a concerted effort to evaluate and develop all energy sources for both the short- and long-term. The HFNS is one of the first major steps in the fusion reactor development program which will lead to commercial fusion power plants by the year 2000.

A review of the overall fusion program requirements based on the past 20 years of fission development indicates the need to obtain materials design data very early in the program. Knowledge of detailed material behavior under irradiation will permit reactor development to proceed without the contingencies, extra allowances or alternative designs necessitated by uncertainties in materials properties. Indeed, materials limitations have dictated design lifetimes for components of other nuclear systems and appear critical to fusion reactor systems as well. Thus, materials information is needed both to conduct development efforts more efficiently and to assure practical lifetimes for the developed system.

2.4 Relationship to Other Projects

The proposed HFNS is the second of two facilities needed to accomplish materials testing for the fusion program. The first is the Rotating Target Neutron Source-II (RTNS-II) at Lawrence Livermore Laboratory.

RTNS-II will be the first high energy, high intensity, neutron irradiation facility dedicated to the fusion reactor materials program. It is scheduled for completion in 1978 and will have a maximum source strength of 4×10^{13} n/s. Thus, it will provide high energy damage information at low fluences required for verification of theories of fission reactor data extrapolation.

The HFNS will have a source strength of 10^{16} n/s, a maximum flux density of 10^{15} n/cm^2/s, and provide the higher fluences and larger test volumes needed to generate engineering data required for the specification of reactor materials. Cancellation of a complementary neutron source facility due to budgetary limitations (the Intense Neutron Source, INS) has significantly increased the importance of timely completion of HFNS to the fusion program.

2.5 Need for the Facility

This facility will irradiate fusion reactor candidate materials and provide engineering data for the development of economical fusion power as a viable option for long-term energy independence.

The main candidate for fusion power reactors is the deuterium-tritium (D-T) reaction, which imposes the least severe pressure, plasma temperature, and confinement time requirements. However, the D-T reaction generates 14-MeV neutrons which bombard the components surrounding the plasma, such components as the vacuum wall, coolant channels, blanket elements, neutron shields, cryogenic insulators, superconductors and structural supports.

Initial engineering designs of MFE large scale facilities indicates one of the major radiation damage problems is the loss of ductility in the first wall; e.g., uniform elongation may be <0.5% after 1-2 years of operation. A major related problem area affecting materials properties is void-induced swelling, e.g., estimated to exceed 10% ΔV after <5 years operation. Likewise, wall erosion due to sputtering and blistering can cause first wall degradation as well as lead to plasma contamination. The potential high temperature gradients will lead to stress effects, cyclic loading; and, in pulsed MFE designs, possible fatigue problems. Thus, early assessment of the mechanical properties of materials is a major goal for the HFNS.

The bombardment of the first wall in a blanket or the divertor surface with neutral and charged particles can also cause blistering and sputtering. Both of these effects can have serious consequences in terms of wall erosion and plasma contamination if the flux density of particles is greater than 10^{15} particles/cm^2 s. Blistering can even be a problem if the helium ion flux density is less than 10^{12} He^{++}/cm^2 s. Spallation of large chunks of material due to the agglomeration of the blisters could result in unacceptable wall erosion rates. Both sputtering and blistering can cause plasma contamination. A number of experiments in the near-term must be performed utilizing current fission reactor and accelerator facilities. In order to properly interpret these experiments, it is necessary to correctly assess the damage produced by 14-MeV and fission spectra neutrons as well as by high energy heavy ions.

3.0 DESCRIPTION OF THE PLANNED FACILITY

3.1 General Description

This description is based on the Deuterium-Lithium High Flux Neutron Source (HFNS) Facility initial conceptual design. The proposed HFNS will utilize a linear accelerator to provide a high energy beam of deuterons which produce neutrons by a stripping reaction with flowing liquid lithium metal. The neutrons subsequently strike material test specimens. This system will provide a peak neutron flux of approximately 10^{15} n/cm^2s, in a one-liter test volume, with a neutron spectrum representative of fusion reactor conditions.

The HFNS consists of a single story Accelerator Building and a Test Building, with an interconnecting beam transport tunnel. Figures 3.1-1 and 3.1-2 present plan and elevation views of the facility. The overall facility is approximately 450 x 140 feet. The Accelerator Building will have an area of about 23,500 square feet. There will be about 10,600 square feet in the Test Building, of which approximately 2,100 square feet is for the lithium supply system equipment. The Accelerator Building and Test Building will be constructed of cast-in-place concrete wall frames and precast concrete wall panels. The roof will be of built-up composition over concrete tee panels which include integral beams.

The HFNS Facility will be designed for a service life of 20 years and constructed in accordance with DOE Manual Appendix 6301, Part 1, "General Design Criteria". It will be designed to withstand the effects of credible earthquakes, accidents, and tornados to assure public and employe safety, and protection of the environment.

Test specimens will be fabricated into irradiation assemblies in existing 300 Area facilities. The operating staff will receive the fabricated experimental assemblies, irradiate them and load them into casks for truck transport to existing 300 Area examination facilities where postirradiation handling, examination and testing will be performed. Offices for the Facility Manager and his staff will be provided in existing relocatable buildings.

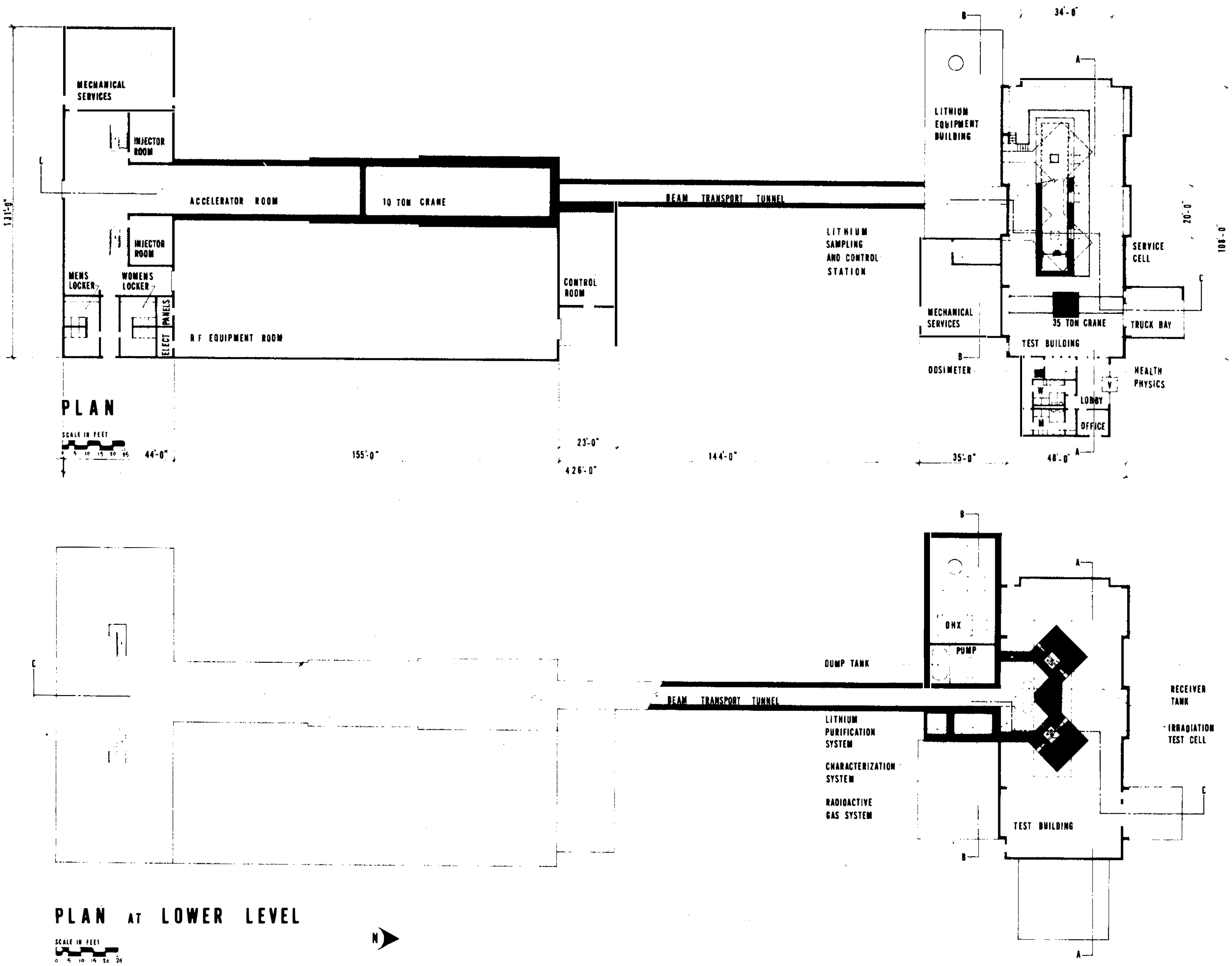

FIGURE 3.1-1. Deuterium-Lithium High Flux Neutron Source Facility - Plan View.

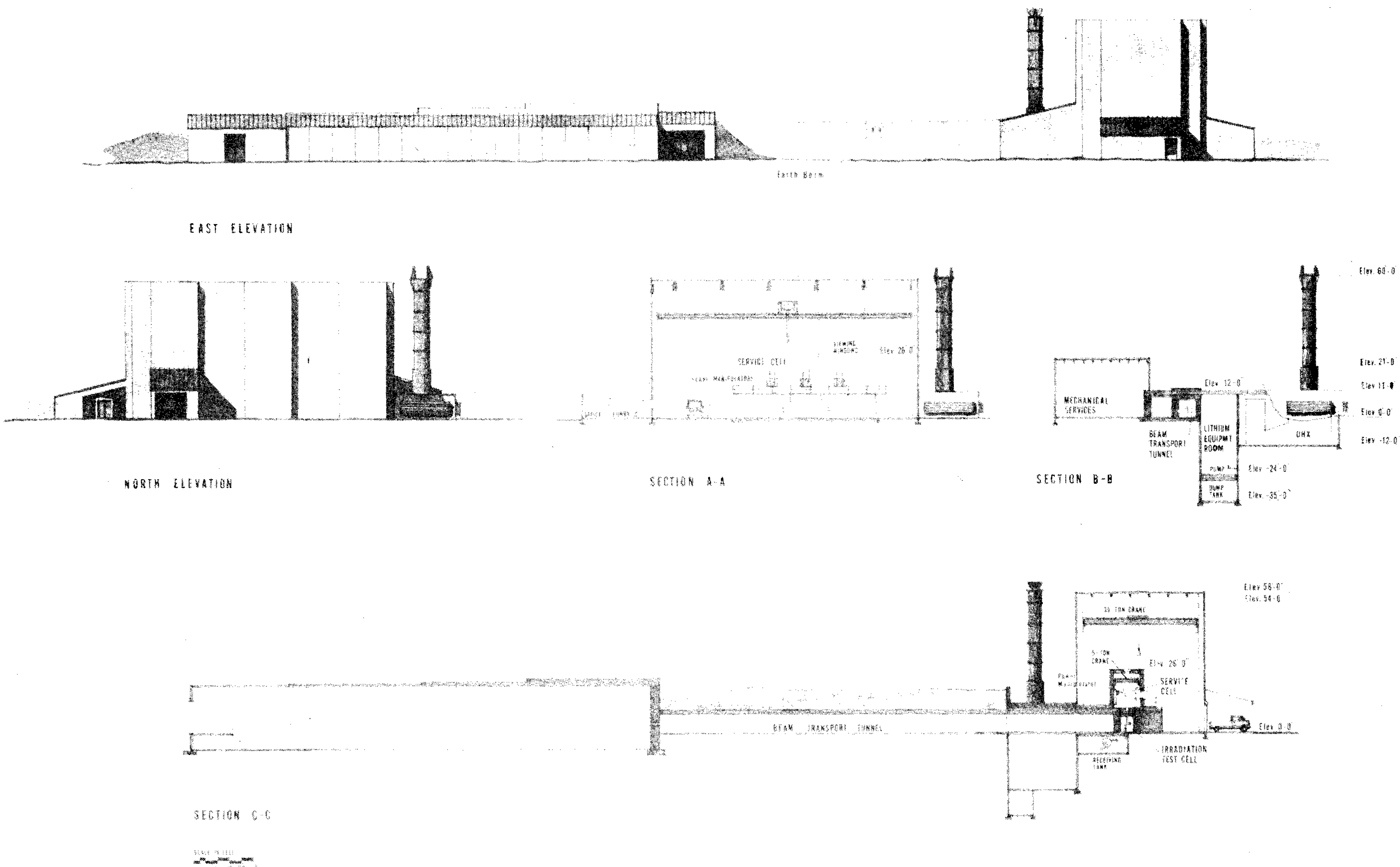

FIGURE 3.1-2. Deuterium-Lithium High Flux Neutron Source Facility - Elevation View.

Based upon HFNS approval as an DOE Construction Line Item Project for FY 1978, construction of the HFNS Facility is scheduled to begin in April 1979 and be completed in March 1981. Installation of the accelerator and lithium system equipment will begin in October 1980. Full beam-on-target testing will begin in April 1982, with the facility to be operational by October 1982.

3.2 Accelerator Building

The Accelerator Building will be a single story structure, approximately 220 x 110 x 30 feet. It will house the ion sources, the 30-MeV linear accelerator, radio frequency (RF) system, vacuum systems and power supplies. Personnel change rooms are provided. The facility control room for operating the accelerator and lithium systems, as well as for test data acquisition, is also located in the Accelerator Building. Support services provided include: an electrical load center and high voltage distribution center; heating, ventilation and air conditioning equipment for the Accelerator Building; and the accelerator cooling system. Shielding will be provided for the injector rooms due to the presence of X-rays and neutrons during operation. A small fraction of the deuteron beam will strike the linear accelerator and beam transport system structures producing high energy neutrons and gamma rays. Consequently, heavy shielding must be provided. The concrete shielding of the accelerator room will vary from two feet thick at the low energy end up to four feet thick at the high energy end, enabling unrestricted access to the RF equipment room and other adjacent areas during operation. A 10-ton overhead crane will be provided in the accelerator room, and a five-ton hoist in the RF equipment room.

The beam transport tunnel is approximately 180 x 7 x 7 feet. An evacuated tube will extend from the linear accelerator to the deuteron beam diverter switchyard in the Test Building. This tube will allow for the necessary debunching of the deuteron pulses from the linear accelerator to introduce a steady beam of deuterons into the lithium target. Beam transport magnets and vacuum systems are located along the length of the beam transport tunnel. The beam transport tunnel will be shielded by two feet of concrete, supplemented by an earth berm with a minimum thickness of eight feet.

3.2.1 Accelerator System

The accelerator system will generate a 0.1A beam of 30-MeV deuterons bombarding a target film of liquid lithium within one of two irradiation test cells located in the Test Building. These produce about 2 x 10^{16} n/s for materials testing. The accelerator system is comprised of four major elements: 1) the injector system in which the deuterium ions are formed and given an initial acceleration to 750 keV; 2) the injector beam transport system which transfers the deuteron beam to the linear accelerator (linac); 3) the Alvarez-type linac itself, which is an evacuated cavity system where radio frequency fields across a series of gaps between electrodes (drift tubes) produce high-potential gradients accelerating the beam to 30 MeV; 4) the exit beam transport system which transfers the deuteron beam to the selected test cell and lithium target. Each of these systems has its own vacuum pumping equipment and can be isolated by quick-closing valves.

In the injector system, deuterium is fed into a low-pressure chamber in which electrical currents produce a gaseous plasma of free electrons, charged molecular deuterium, and deuterium ions. The deuterons are focused into a continuous beam and accelerated by annular electrodes supported in a ceramic vacuum tube. The injector system operates at a direct-current potential of 750 kV, positive with respect to ground potential as required to accelerate the positive deuterium ions. The ion source, its controls, vacuum pumps, power supplies and ancillaries are housed in a large, polished aluminum electrode, approximately an eight-foot cube, supported on insulating columns. About 50 kW of electrical power is required by the ion source system and is generated within the electrode by an alternator driven by a motor at ground potential through a long insulating shaft. A 150 kW voltage multiplying system supplies the high-voltage electrode with 200 mA of current. The entire high-voltage system is enclosed in a room with walls spaced sufficiently far from the high potential surfaces to prevent electrical sparking. Vacuum pumps are located at each end of the accelerating tube to remove non-ionized deuterium escaping from the ion source and to maintain a sufficiently high vacuum to prevent sparking within the accelerating column. Two such injector systems are provided, each within its separate enclosure, and placed with the beam exits facing each other. A drawbridge lowered across the gap between the wall and the electrode provides access for servicing the ion source system within the electrode. Servicing of one injector can be done while the other injector is in operation.

The injector beam transport system is located between each injector beam exit connection and the linac beam entrance connection. It performs several functions in addition to that of transporting the beam. The deuteron beam entering the linac must satisfy a number of requirements for optimum system performance. It must be accurately aligned with the linac axis. Also, it must be precisely focused (matched) to avoid incidence on the drift tube bores and it should arrive in bunches timed to match with the accelerating phase of the linac radio frequency field. To accomplish this, the injector beam transport system provides a bunching system that includes a separately excited radio frequency cavity. This bunching system modulates the velocity of continuous current beam from the injector by applying a small alternating accelerating voltage across a gap through which the beam passes. By the time the ions have reached the first drift tube gap in the linac, the ions will be in bunches and in-phase with the gap accelerating voltage, thereby minimizing beam loss. Deuterons lost from the beam would strike the drift tubes and produce undesirable activation. Two 45-degree bending magnets in the beam path turn the beam 90 degrees from either injector into alignment with the linac axis. The first bending magnet in each beam-line also serves as an analyzer to separate unacceptable ions. The second bending magnet in the beam-line is common to both injectors; by means of reversible polarity, it can accept a beam from either injector. In addition to the bending magnets, the transport system includes quadrupole transport magnet sets and other magnets to correct aberrations produced by the bending, steering and focusing magnets.

The linac is a series of evacuated, cylindrical tanks, approximately 13 feet in inside diameter, which form a radio frequency resonant cavity structure operating at 50 MHz. The cavities have an estimated total internal length of 137 feet and are fabricated in three separate sections of approximately equal length. The tanks are designed as ring-stiffened vacuum vessels and are made from copper-clad steel as all surfaces exposed to the radio frequency electrical fields must have high electrical conductivity to minimize power losses. A total of 69 copper drift tubes are suspended in the cavity on hollow insulating stems. These drift tubes are about two feet in outside diameter with cylindrical bores varying from 1-1/2 inch diameter at the beam entrance to the first tank to 3-1/2 inches at the exit end of the third tank. Their lengths increase from 5 to 31 inches to accommodate the increasing velocity of the deuteron bunches. Each drift tube houses a quadrupole magnet. The first few drift tube magnets differ, but farther along the beam-line the magnets become similar enough in characteristics that they can be grouped into identical sets with common power supplies. The overall kinetic energy gain in the accelerator system is 30 MeV. Transverse diaphragms in the last two tanks permit operation at lower energies in about five MeV steps down to 10 MeV minimum. When the radio frequency power is turned off in a particular section of the linac the drift tube magnets remain energized to continue transporting the beam through the section.

The linac tanks are maintained at a vacuum better than 10^{-7} Torr by helium-refrigerated surfaces which trap the atmospheric gases. The high vacuum is necessary to keep ionization at a minimum in order to have the required high gradients in the gaps between drift tubes. High vacuum also minimizes growth of the deuteron beam and losses due to scattering by residual gas, thus reducing activation of linac components. Power is supplied to the linac tanks through coaxial transmission lines from radio frequency amplifiers fed, in turn, from a master crystal oscillator. Sensors in each tank supply information to a phase comparator which controls output of the amplifiers maintaining phase synchronization among all tanks.

The total electrical power consumption of the accelerator system is estimated to be nine MW. The deuteron beam dissipates three MW in the lithium target. Most of the remaining waste heat is removed from the linac vacuum tanks and other accelerator system components by a closed cooling water system. All surfaces of the linac vacuum tanks must be cooled to remove the heat generated in the copper cladding in order to maintain an accurately controlled temperature, since dimensional changes of the tanks would shift the operating frequency and result in loss of the beam. Longitudinal steel channels welded to the outside surfaces of the tanks will form cooling water passages. Manifolds at each end will provide parallel flow to give uniform temperatures around the cavity circumference. Water cooling for the drift tube surfaces and for the magnet coils, plus power for the magnets is carried to the interiors of the drift tubes through the drift tube supporting stems. The approximately six MW of waste heat will be transferred to an evaporative cooling tower circuit and dissipated to the atmosphere.

The beam exiting the third linac tank will pass through one or more debunching cavities. These cavities perform the reverse function of the bunching cavity following the injectors. They produce an energy spread within each deuteron bunch such that, by the time the beam traverses the length of the exit beam transport system, the beam will be continuous due to spreading of the bunches. This is a highly desirable feature from a materials testing standpoint and also reduces temperature peaking in the lithium target.

The exit beam transport system consists of a series of magnets spaced along the length of an evacuated transport tube. Quadrupole magnets are spaced at regular intervals between the debunching system and a diverter magnet which directs the deuteron beam onto one of the two lithium targets or permits it to pass through to a beamstop position. Multi-pole focusing magnets are located near the lithium target to insure proper beam shape and uniformity at the target surface. The exit beam transport system vacuum envelope is comprised of sections of evacuated stainless steel tubing and expansion bellows. Several small pumped apertures serve to isolate the accelerator vacuum system from a low pressure helium blanket maintained in front of the lithium target. The magnets are positioned outside the tubes and are supported on individual stands for adjustment and alignment.

3.3 Test Building

The Test Building will be about 120 x 90 x 60 feet. The deuteron beam diverter switchyard, two irradiation test cells and an overhead service cell will be located on the grade-level, 110 x 50-foot operating floor. These structures will be constructed of high density concrete and steel. Their design will provide sufficient shielding to permit unrestricted access to the operating floor and adjacent support areas during operation. The switchyard wall and roof shielding will be four feet thick based on an assumed 0.1% continuous beam loss. This thickness will also accommodate postulated operational events such as an accidental beam spill. A 10 foot-thick beamstop section will provide for accelerator commissioning and diagnostic work.

Activities on the operating floor will include charging and discharging of irradiation assemblies; handling of transfer casks for irradiated experiments, test hardware, and target assemblies; monitoring out-of-cell experimental instrumentation and equipment; maintenance of the beam switchyard.

A shipping and receiving area of the operating floor will accommodate ordinary shipments as well as shipments of irradiated materials casks. A 35-ton overhead crane is provided to move the transfer casks from the charging-discharging positions to the truck loading area. This crane can also remove irradiation cell and beam switchyard roof shield plugs as required for access. Vestibules for truck and personnel access will minimize the intermixing of building and outside atmospheres.

Lithium flow from the in-cell target assemblies discharges into the receiver tank of the lithium supply system. The receiver tank, and a radioactive gas system to provide holdup and decay of activated air from the irradiation test cells, are located beneath the beam switchyard. The remainder of the lithium system equipment and dump heat exchanger (DHX) are located in two rooms of an adjacent shielded area, 12-feet high and extending approximately 35 feet below grade.

A support facilities area provides for lobby, health physics office, shift supervisor office, and change rooms. A mechanical and electrical services and equipment room, adjacent to the operating floor, contains an electrical load center; the heating, ventilating and air conditioning equipment for the Test Building; and the pump and chiller unit serving the test cell cooling system.

3.3.1 Irradiation Test Cells

The design of the irradiation test cells is based on an assessment of testing requirements anticipated for the fusion program, and on conceptual designs of the experimental assemblies. The analysis indicated that 70% of the irradiations can utilize self-contained irradiation assemblies which are amenable to straightforward handling as encapsulated modules. However, 30% of the irradiations will involve more complex test assemblies with requirements to prepare and disassemble tests involving special in-cell hardware. This requirement implies a need for remote handling of irradiated test hardware. A shielded service cell immediately above the irradiation test cells and large interconnecting ports will provide that capability. The service cell will also be used for required irradiation cell maintenance such as changeout of the lithium target assembly.

The irradiation test cells will provide a 5 x 5 x 6-foot interior cavity. Their design will permit the rapid charging and discharging of modular, encapsulated tests from the operating floor through horizontal side ports in the test cell walls, and vertically downward from the service cell through the large shield plug normally positioned in the overhead port in the top of each of the test cells. This overhead shield plug will be segmented to be completely removable by a five-ton overhead hoist into the service cell. This will permit ready access to the test cell interior for tests requiring remote handling, or for maintenance operations.

The side walls of the irradiation test cells will be a minimum thickness of six feet of high density concrete. The rear walls, which receive the most intense and direct neutron beam, will be ten feet thick. The test cell roofs will be four feet thick. All shield plugs and access ports will be stepped to provide protection from radiation streaming.

The neutron beam will deposit 25-35 kW of heat in the rear of the irradiation test cells. Neutrons will also deposit an additional 25-35 kW of heat in the other interior walls of the cells. The lithium target and supply piping, test specimens and fixtures will contribute a total of about five kW. Heat transfer fluid will be circulated near the inner wall surface of the cell walls and shield plugs by a closed-loop test cell cooling system to maintain concrete temperatures below 150°F. An intermediate heat exchanger will isolate this system from a secondary chilled water loop. The heat exchanger and the pumps for the test cell cooling system will be located within the service cell. The cell atmosphere will be air, circulated by fans within the cell. Radiators will be used to regulate the temperature of the cell atmosphere, if necessary.

3.3.1.1 Modular Tests

The encapsulated experimental modules will be fabricated as an integral assembly with a stepped shield plug which will extend through an irradiation cell wall or overhead shield plug. The shield plugs will be supported on a linear bearing system and will engage tapered alignment pins at the cell inner wall to position the test specimen relative to the neutron beam. Mockups and jigs will be used to check out the final irradiation assembly dimensions prior to insertion into the cell. Test plugs will be used to measure and maintain the dimensions of the shield plug support sleeves. The shield plug will also accommodate the test specimen instrumentation leads as well as electrical, gas or fluid services for specific tests. Disconnect fittings will enable the separation of the shield plug/module assembly from the instrumentation and support equipment located outside of the irradiation cell.

After irradiation, the modular tests will be placed into a shielded transfer cask. The support service connections to the shield plug will be broken, and a mobile support stand or the Test Building overhead crane will position the cask adjacent to the cell interior. The shielded transport cask will be about ten feet long and will provide radiological shielding equivalent to eight inches of lead. A self-contained grapple mechanism will extract the shield plug/module assembly from the cell and position it within the transfer cask. Shutting an end closure gate will seal the cask and permit the safe transfer of the test assembly to an examination facility. This shielded cask can also be used to insert modules containing test specimens activated during a previous irradiation.

3.3.1.2 Remotely Handled Tests

The service cell is designed to provide a capability for accommodating the more complex tests which require remote handling. Two foot thick, high density concrete walls will supplement the test cells' shielding to permit unrestricted access to work stations during "beam-on" operations. The floor plan for this service cell provides for: (1) laydown spaces for the segmented test cell shielded plugs; (2) the large access ports opening into the two irradiation test cells; and (3) a test preparation area. A work station with a slave manipulator and shielded window will be provided at the test preparation area for final assembly of test fixtures and changing of specimens. Another work station with a shielded window and a slave manipulator is provided beside each access port. A power manipulator, track-mounted on the rear wall, can service each of the work stations.

After setup and checkout in the test preparation area, the five-ton overhead hoist in the service cell will be used to lower the test assembly into position on a support frame at the top of an irradiation cell. This frame will be machined and indexed using tapered pins to provide initial location and alignment of the experiment relative to the neutron beam. Screw adjustments using the power manipulator will permit final positioning with verification by a remote readout system. One candidate readout system, commonly used on precision milling machines, would include an in-cell fiber optic light source and a prismatic viewing system. This system will provide the precision registering of fiducial marks on the experiment with references on the target assembly or cell wall. Instrumentation and test support equipment will be positioned outside the service cell with leads penetrating the cell walls at a service panel. In turn, the service leads to the test apparatus penetrate the segmented shield plug through a removable conduit or instrument stalk. The connections between the service panel and the instrument stalk will be made using the power manipulator.

Some tests require the irradiation of a series of specimens in the same test assembly. The irradiated specimens can be removed from the test apparatus in the service cell and placed in small casks for subsequent transfer from the service cell for postirradiation examination elsewhere. Removable shield plugs in the service cell roof and a large bottom-loading transfer cask will enable removal of larger test specimens or disassembled test apparatus. This cask will provide a 2 x 3 x 5-foot interior cavity with six-inch lead equivalent in shielding and will be positioned and handled by the Test Building crane.

3.3.1.3 Other Test Capability

The test cell design will include other access ports. One will be located through the cell rear wall and will be positioned in direct line with the neutron beam center line. Another identical port will be located approximately 45 degrees from the beam direction. These two ports will accommodate shielded tubes extending outward from the cell for time-of-flight measurements by instruments such as the Madey-Waterman self-contained system. The top region of the cell will have two other experimental ports for beam-monitoring system instrumentation. Active neutron level monitors will give real-time indication of flux magnitude changes. The monitors and depleted uranium fission chambers will be located within the cell and/or in shielding ports. This information will help monitor and control the accelerator beam.

Other unassigned shielded access port plugs in the cell walls will permit testing of components, equipment or materials which can be irradiated advantageously in less intense neutron fluxes.

3.3.1.4 Lithium Target

A target assembly within the irradiation test cells will provide a hydraulically stable, downward flowing film of lithium for deuteron bombardment and neutron production, and for removal of the heat deposited by the deuteron beam. The target conceptual design contains the film of lithium in a curved three-sided trough. The face of the lithium film struck by the deuteron beam will be open to the vacuum of the beam tube. For optimum neutron production and heat removal capacity the lithium film thickness will be 1.5 cm. The film will be 12 cm wide to provide some margin for a 10-cm wide deuteron beam. Sufficient vertical height will be available to permit a 10 x 10 cm beam pattern if desired for some tests. The rear wall of the target will be 0.125-inch-thick stainless steel.

The irradiation target assemblies will require changeout about every nine months because of irradiation damage to the back wall. Target replacement will be accomplished through the large shield plug opening over the test cell cavity. The irradiated target assembly will be withdrawn into the service cell using the service cell hoist following remote disassembly of the vacuum connection with the deuteron beam tube and the remote disassembly of the mechanical connections in the lithium piping. The target assembly will then be transferred to the bottom-loading transfer cask, previously described, for removal by truck and transfer to other hot-cell facilities for target refurbishing or disposal. A remotely operated, motorized service fixture will be positioned in the test cell to prepare the mechanical joint surfaces for reassembly. Redundant piping sections and joints can be replaced if necessary in the event that the sealing surfaces have been damaged in disassembly. The new or refurbished target assembly will be installed through the overhead cell opening. Fixed alignment devices in the cell floor and walls will assist in the accurate positioning of the service fixture and target assembly. Retention brackets will support the target assembly during operation and accommodate thermal expansion in the target system.

3.3.2 Lithium Supply System

The HFNS lithium supply system will be a closed loop, recirculation system that provides lithium flow of approximately 320 gpm to the selected target assembly. The nominal lithium target inlet temperature will be 200°C. The deuteron beam will deposit three MW at full power and cause a temperature rise of about 70°C in the lithium stream. The heated lithium will flow downward from the target through a downstream isolation valve into a 500-gallon receiver tank located beneath the beam switchyard. The lithium supply system equipment and the liquid metal-to-air dump heat exchanger will be located below grade in adjacent shielded rooms. This arrangement will provide the necessary hydrostatic head between the receiver tank and the electromagnetic pump, and simplifies system filling and startup. Under normal operating conditions, the receiver tank will be approximately one-half full. Lithium will drain by gravity from the receiver tank to a six-inch diameter standpipe. The system pump is immediately adjacent to the bottom of the standpipe. The 15 feet of hydrostatic head in the standpipe will supply approximately 3 psi of net positive suction head to the pump and eliminate any possibility of pump cavitation. The pump will discharge lithium directly to the dump heat exchanger, except for 15 gpm diverted through liquid metal purification and characterization systems. The dump heat exchanger will feature multiple, serpentine, finned-tube bundles with counterflow, forced-convection air cooling. Lithium will enter the heat exchanger at 270°C and exit at 220°C. Air flow will be nominally 200,000 lbs/hr to achieve the required lithium temperature drop. After passing through the dump heat exchanger, the lithium will flow through an upstream isolation valve and return to the target inlet nozzle. Radioactive products will build up in the lithium system, due to interactions between the deuteron beam and the flowing liquid lithium target stream, to R/hr radiation levels near the lithium piping and equipment during operation. During maintenance operations the lithium system will be drained into a 1500-gallon dump tank to minimize radiation doses to the maintenance crew.

Tubular electrical resistance heaters of sufficient capacity to maintain isothermal system conditions up to 275°C will trace-heat all liquid metal piping and components. Sufficient mineral fiber thermal insulation will be applied to all heated surfaces to maintain a maximum heat loss of about 20 watts per square foot of surface area at the system design temperature of 275°C.

The lithium system design and fabrication will conform to the ASME Code for Boilers and Pressure Vessels, Section III, Class 3, Nuclear Power Plant Components. With the exception of mechanical seals in the target inlet and outlet piping to facilitate routine changeout of the target, the system will feature all-welded pressure boundary construction, using Type 304 stainless steel throughout. Standard-weight piping affords sufficient corrosion allowance for continuous operation of the lithium system for 20 years. All major components will have rigid anchors to the building structure. Seismic snubbers will supply dynamic restraint of other portions of the lithium system where necessary.

3.4 UTILITIES AND SERVICES

3.4.1 Electrical

The HFNS Facility will consume about 11 MW of electrical power supplied by the Bonneville Power Administration (BPA). No additional land commitment for transmission lines will be necessary since the electrical power requirement can be met by modifications to the existing primary electrical substation in the 300 Area. The 300 Area is fed from the BPA 115 kV line between Richland and the Benton Switching Station north of the 300 Area. Power can be supplied from either direction but under normal operating conditions the line is energized straight through from the Benton Station to Richland. Temporary faults such as a lightning strike are cleared automatically, and power is restored within about one second. Permanent faults in the BPA line such as broken conductors are cleared through a system of circuit breakers and sectionalizing switches, and power is automatically restored to the 300 Area from the unfaulted side. Switching will result in a temporary loss of power for about one minute.

In the event of total loss of electrical power to the 300 Area, emergency generators in the 300 Area start up automatically, and the emergency distribution system is energized automatically. Each building that is provided with emergency power has an automatic normal-to-emergency power transfer system which operates on loss of normal power. Generating facilities consist of a 1500 kVA diesel generator, three 937 kVA diesel generators, and a 1000 kVA steam turbine generator (based on nameplate ratings). The HFNS backup power needs include maintaining test cell ventilation, power to key instrumentation and control circuits, and emergency lighting. An emergency source will be provided for the HFNS Facility from the existing 300 Area emergency system if the capacity is available. If not, a local emergency generator will be provided. Battery-operated lights will be used for emergency lighting.

3.4.2 Water

The HFNS Facility operations will require approximately 45 gpm of potable and process water, principally for makeup to the evaporative cooling towers serving the accelerator system. This requirement will be met by interconnections with the existing 300 Area water system.

Water for the 300 Area is obtained from the Columbia River, with sanitary water from the City of Richland as backup. The river pump house provides raw water to the 300 Area Filter Plant. There are two submersible pumps rated at 8000 gpm. The 300 Area Filter Plant provides sanitary, process, and fire protection water for the 300 Area. This plant is a concrete structure with a nominal rated capacity of 2400 gpm.

3.4.3 Heating, Ventilation and Air Conditioning

The heating, ventilation and air conditioning systems for the HFNS Facility will be located in the two mechanical services wings of the Accelerator and Test Buildings. These systems are designed to provide full service, year-round environmental control for all the main areas of the Accelerator Building/beam transport tunnel/Test Building complex. The lithium system equipment rooms and pipeways are ventilated only, exhausting through high efficiency filters. The outdoor supply of air to the facility will be filtered. The bulk of the conditioned air will normally be recirculated.

The test cells and service cell ventilation will be handled by separate systems, which will maintain them at slightly negative pressure to preclude release of radioactivity to other parts of the facility. The test cells will exhaust into the radioactive gas system. Air from the service cell will be passed through a HEPA filter prior to discharge to the Test Building exhaust.

About six MW of waste heat will be dissipated by the accelerator cooling system during full-power operation. The feasibility of using this waste heat for facility heating will be investigated.

3.4.4 Communications

The HFNS telephone system will be connected to the present system serving the 300 Area and will provide voice communications between telephone stations within the facility and with outside telephones connected to the public telephone system.

3.4.5 Controls and Alarms

Operators will control the accelerator system, lithium system and testing operations from a central control room. A digital computer system will perform data acquisition, processing and display functions for manual control of the accelerator system. Direct digital control of the lithium system is planned. The computer will monitor various signals and alarm out-of-limits conditions for appropriate operator action. The computer will also generate automatic responses, such as facility shutdown, if given parameters exceed operational limits.

The HFNS Facility control room will be staffed at all times during operation. However, the facility will be interconnected with the existing 300 Area signal cable system. This will permit transmission of facility and process alarm signals to the centralized 300 Area building operations headquarters for monitoring during shutdown or unusual conditions. Signals requiring the response of patrol personnel will be transmitted to Patrol Headquarters.

3.4.6 Fire Protection

Automatic fire detection and signal transmission to the 300 Area fire station will be provided for the HFNS Facility. An automatic wet-pipe sprinkler system will provide protection to the areas of the facility that do not house liquid metal equipment. Electrical equipment containing flammable fluids, such as insulating oils, will be provided with catch basins to contain the fluids in the event of a container rupture. The HFNS Facility operation will consume less than 1000 liters (STP) of deuterium gas in a year of full-power operation. The deuterium will be supplied from a pressure bottle system located in the injector terminal. Care will be taken in facility design to avoid explosive burning in the unlikely event that the deuterium inventory is released.

Radioactivity will be induced in the lithium target stream by both deuteron and neutron interactions. This radioactivity poses a potential radiological hazard in lithium spill accidents. The chemical toxicity of lithium oxide fumes which can be released in a lithium fire is also a concern. Assuring the high integrity of the equipment and piping containing the lithium will be a principal safety requirement. In addition, the HFNS Facility will provide specific protective features to detect, control and minimize the effects of lithium leaks should they occur.

The lithium supply system components will be enclosed in air-filled rooms and piping chase ways. These areas will be steel lined to prevent lithium contact with the concrete and to confine the liquid metal in the event of a leak. Water systems will be excluded to avoid the possibility of lithium-water reactions. The design of the facility will permit visual inspection during shutdown of piping and equipment for leak detection. All liquid metal valves will be equipped with bonnet leak detectors for continuous monitoring for bellows rupture. Individual equipment rooms will be isolated from one another and piping penetrations will be sealed to provide enclosure for argon purge in the unlikely event of lithium leakage. Redundant ionization and smoke detectors will provide annunciation of a fire if it should occur. Receipt of such signals will initiate immediate, automatic shutdown of the accelerator and lithium systems, draining of the lithium supply system, and isolation of the equipment rooms from the ventilation system. The affected room will then be flooded with argon gas, thereby excluding air entry and quenching the fire. The lithium equipment rooms will be ventilated through high efficiency filters during normal operation. The exhaust from the room will also be vented through a water spray fume scrubber system of conventional design in the event of a fire to prevent release of lithium oxides to the atmosphere. Similar provisions will be made to detect leaks and extinguish fires in the irradiation cells.

The dump heat exchanger (DHX) will be specially designed to permit rapid draining, isolation and containment since the walls of the finned-tubes are thin. The large surface areas offer more potential for leaks to develop, and detection of small leaks is made difficult by the high air flow rate. The DHX exhaust stack will be equipped with ionization detectors and smoke detectors. A program of periodically taking and analyzing samples of the DHX exhaust air for trace quantities of lithium and radioactivity is also planned to indicate incipient leaks. Upon receipt of a signal that a leak has occurred, operation will be shut down, and the unit will be immediately drained and isolated. Shutting down the fan and closing isolation gates on the air inlet ducts through the shielded walls of the DHX room and outlet dampers on the exhaust stack will effectively localize the lithium spill in a confinement similar to the other lithium equipment rooms for initiation of argon purge and venting through the fume scrubber system.

The 300 Area fire station is located in the southwest corner of the 300 Area and is manned on a rotational shift basis at all times.

The fire apparatus consists of three 750 gpm pumpers, two 1250 gallon tankers (each equipped with a 500 cfm high expansion foam unit), one rescue truck and one dry chemical truck. Water for fire protection is obtained from the filtered water plant and from storage tanks of 600,000 gallons capacity and is distributed through a gridded system of underground mains which exceed minimum size requirements of the National Fire Code. Pumping capability includes two 4000 gpm pumps which discharge to the grid system at 125 psig, with five standby pumps rated at 9150 gpm total. Two water lines from the City of Richland serve as a backup and enter directly into the storage tanks. The Fire Department is also equipped and trained for liquid metal fire fighting.

3.4.7 Liquid Waste Systems

There are three liquid waste systems serving the 300 Area that can be used to dispose of sanitary, uncontaminated and radioactive wastes from HFNS operations. HEDL operates the 300 Area disposal sites for sanitary and uncontaminated process wastes. The Hanford Waste Contractor operates the 200 Area radioactive waste disposal facilities such as the waste evaporators, special facilities for unloading large shielded casks, and the underground storage tanks. It has been verified that evaporator operation is scheduled to 1986 and beyond, with HEDL 300 and 400 Area liquids part of the anticipated evaporator input. Management of liquid waste from the HFNS is shown schematically in Figure 3.4-1.

3.4.7.1 Sanitary Liquid Wastes

Sanitary wastes, approximately 1000 gpd from the HFNS Facility, will be collected in the sanitary sewer system which is connected to all 300 Area buildings with restrooms, change rooms and toilet facilities. The sewer pipes form a network which delivers sewage to septic tanks with a total volume of 95,000 gallons. The liquid from the septic tanks is chlorinated,

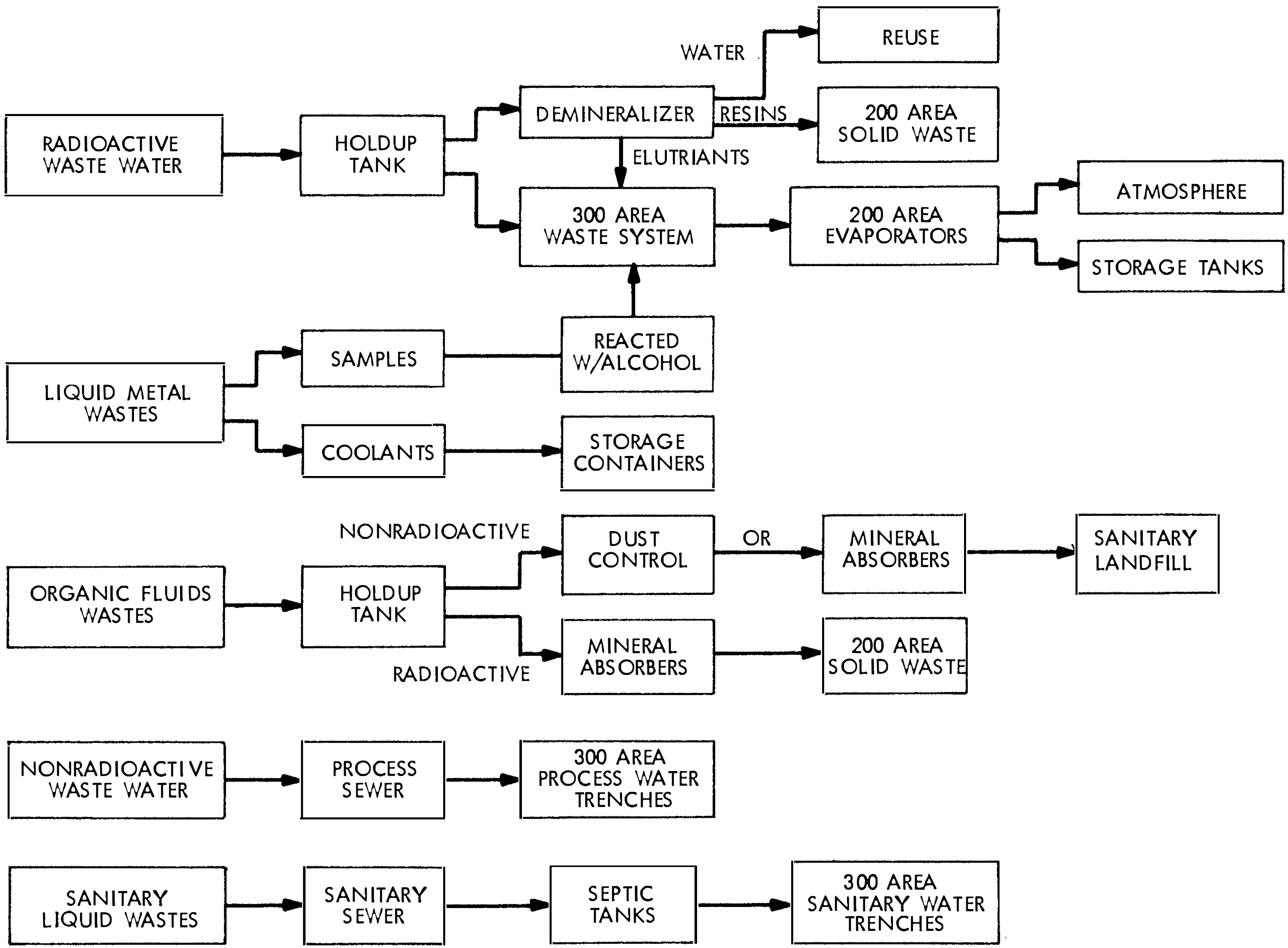

FIGURE 3.4-1. HFNS Liquid Waste Management System.

and subsequently flows to one of the two 600 x 10-foot leaching trenches. Liquid percolates into the ground from the trenches which are located to the northeast of the 300 Area within approximately 500 feet of the Columbia River. Flow through the sanitary sewer system varies from 350,000 gpd in the winter to 600,000 gpd in the summer.

3.4.7.2 Process Liquid Wastes

The HFNS conceptual design provides for evaporative cooling towers to dissipate the waste heat from the accelerator cooling system. It is anticipated that the evaporation rate from the cooling tower will be approximately 35 gpm during full-power operation.

To control the level of concentrated solids in the water circulating within the cooling tower, a small quantity of the circulating water will be bled off, in a blowdown stream. The blowdown water will not contain radioactive materials. Consistent with the proposed operation of other evaporative cooling towers in the vicinity of the proposed HFNS site,[1,2] it is anticipated that the required rate of blowdown will be 10 to 15 gpm. To control the pH and minimize the deposits of alkaline scale, small amounts of sulfuric acid (15-20 lbs/day) will be added to the circulating cooling water. Similarly small amounts of chlorine will be added intermittently to the circulating water system just in front of the circulating water pumps to control and prevent algae and slime.

The blowdown water will be released into the 300 Area process sewer system. As presently operated the process sewer system handles approximately 2.5 million gallons of waste daily. The blowdown will be diluted with this waste stream prior to discharge into one of two 1500x10-foot leaching trenches, located to the north of the 300 Area about 1000 feet from the Columbia River. Water percolates into the ground through penetration at the bottom of the trenches.

3.4.7.3 Radioactive Liquid Wastes

The HFNS will utilize the 300 Area Radioactive Liquid Waste System where low level radioactive wastes are stored in tanks, neutralized with sodium hydroxide and shipped to the 200 Area in railroad tank cars. This waste will be disposed of as described in the Final Environmental Statement Waste Management Operations, Hanford Reservation, Richland, Washington, ERDA-1538, 1975.

3.4.7.3.1 Accelerator Cooling Water

A small fraction of the deuteron beam current (assumed to be 0.1% continuous loss) will be lost on the accelerator drift tubes and other structures, giving rise to the production of high-energy neutrons along the length of the accelerator. In turn, radioactivity will be induced in the accelerator vacuum tanks and other equipment, and in the water which cools them. The radiation levels induced in the accelerator structures by beam losses are expected to be in the range of tens of mr/hr. The principal activity induced in the cooling water itself will be the short-lived ^{16}N (7.11 s). The accelerator cooling water will be completely isolated in closed systems located within shielding rooms.

The initial charge of cooling water, approximately 2500 gallons, will be filtered and demineralized. Consequently, induced activity due to the presence of contaminants in the water will be low.

Organic sulphide or amine cathodic inhibitors will be used in the accelerator vacuum tank cooling system to minimize corrosion of the carbon steel circuits. Only trace quantities of radioactive corrosion products, such as ^{54}M (312d), should be present in this cooling water system. Certain of the other accelerator cooling circuits may require on-line demineralization to maintain very low conductivity in the cooling water. These circuits will be made of corrosion-resistant copper. However, trace quantities of ^{64}Cu (12.75 m) and ^{66}Cu (5.1 m) in this cooling water will be present. This radioactivity will concentrate in the demineralizers.

There will be no release of radioactive cooling water from the closed cooling systems during normal operation. The cooling systems will be connected to one or more shielded storage tanks for draining the systems as necessary. The ^{16}N activity will decay rapidly. If it should prove necessary to dispose of the cooling water, it will be transferred to other tanks or drums and delivered to the 300 Area Radioactive Liquid Waste System. The wastes from regenerating the demineralizers will also be delivered to the 300 Area Radioactive Liquid Waste System. Residual resin from the demineralizers operation will be buried in the 200 Area as solid radioactive waste.

3.4.7.3.2 Test Operations Coolants

Candidate coolants for the test cell walls and irradiation assemblies include water and organic fluids which can become radioactive. Approximately 200 gallons/year of radioactive liquid waste could result from test operations. Waste water will be held for decay and demineralized if necessary prior to discharge to the process sewer system. Organic fluids are expected to contain only short-lived radionuclides. These fluids will be held for radioactive decay, or stabilized on mineral absorbants and buried in the 200 Area as solid waste.

Liquid metals may be used to cool irradiation test assemblies, involving less than 50 gallons/year of waste. Activated liquid metal coolants will be sealed in steel containers and stored.

3.4.7.3.3 Lithium Samples

Samples of the radioactive lithium coolant will be taken periodically for characterization of impurity levels. Approximately 20 samples/year, totaling about one kilogram of contaminated lithium, will be transported in special-purpose shielded casks. This relatively small amount of material will be reacted with alcohol and discarded through the Radioactive Liquid Waste System.

3.4.7.3.4 Other Liquid Wastes

A relatively small amount of liquid contaminated wastes (approximately 100 gallons/year) is anticipated from decontamination or cleaning operations. These wastes will be collected in carboys and delivered to the Radioactive Liquid Waste System.

3.4.7.4 Chemical Wastes

A number of nonradioactive chemicals will be used in HFNS operations, principally cleaning compounds and organic fluids. Table 3.4-0 presents a summary representation of these chemicals, estimated yearly usage, disposition and release forms.

TABLE 3.4-0

HFNS CHEMICAL INFORMATION

	CHEMICAL	AVERAGE AMOUNT USED PER YEAR	DISPOSITION	RELEASE FORM
1.	Wax Stripper	30 gal	Sanitary Landfill	Liquid
2.	Soap	60 gal	Sanitary Sewer	Liquid
3.	Wax	120 gal	Sanitary Sewer	Suspended Solids
4.	Acetone	20 gal	Ventilation	Vapor
5.	Alcohol	50 gal	Ventilation	Vapor
6.	Hydraulic Fluid	30 gal	Sanitary Landfill	Absorbed on Solid
7.	Hi-Vac Oil	30 gal	Sanitary Landfill	Absorbed on Solid
8.	Other Lubricants	50 gal	Sanitary Landfill	Absorbed on Solid

Facility cleaning compounds will be discharged to the sanitary sewer system. Acetone and alcohol will be used to clean electrical and other equipment and will be released to the environment as vapor through the facility ventilation system. Organic fluid wastes will include hydraulic fluids, vacuum pump oils, and cutting oils. In facilities where significant quantities of organic wastes are produced, such as in machine shop operations, holdup tanks are provided. These organic wastes are then collected and sprayed on unpaved roads within the Hanford Reservation for dust control. In view of the limited quantities of such fluids that will be generated in HFNS operations, however, a more practical method of disposal will probably prove to be to stabilize these fluids or mineral absorbants for disposal as solid nonradioactive waste in the Hanford sanitary landfill (see Section 3.4.9).

3.4.8 Gaseous Waste System

Radioactive gases will be generated during HFNS operation by activation of air in the irradiation test cells and around the linear accelerator and beam transport system and by production of tritium in the lithium target stream. A radioactive gas system and other provisions will be designed to assure that any releases to the environment will be as low as practicable, and will not exceed the maximum permissible levels specified for uncontrolled areas in DOE Manual Chapter 0524, "Standards for Radiation Protection." Radioactive particles incident to facility operation will be removed by HEPA filters.

3.4.8.1 Test Cell Air

About 2×10^{16} n/s will be produced within the irradiation test cell as the 0.1A deuteron beam interacts with the flowing lithium target stream. The normal atmosphere in the test cell will be air which will become activated. A radioactive gas system will provide a sealed transfer compressor on the test cell exhaust, a HEPA filter stage, and a pressurized tank to provide holdup for decay of the activated air. The air will then be released to the environment in the dump heat exchanger stack exhaust at or below the DOE Manual Chapter 0524 Guidelines for uncontrolled areas.

The production rate of radioactive gases in the test cell air during full power operation is given in Table 3.4-1, based on the following composition: nitrogen 78.1%, oxygen 21.0%, and argon 0.9%. Consideration was also given to the presence in the test cell atmosphere of standard quantities of carbon dioxide, neon, helium, krypton, xenon, hydrogen, etc. However, because of small abundance, short half-lives, and small production cross sections, the activities produced were found to be negligible.

The release rate of radioactivity from the test cell will depend on the average air change time. The test cell pressure will be maintained at about 0.5 inches of water below the operating floor pressure to eliminate leakage to other areas of the facility. Careful fit-up and sealing of cell closures and penetrations will limit the net inleakage of air into the cell to about one SCFM. Since the test cell volume is about 150 cubic feet, the average in-cell holdup time is about 150 minutes. Consequently, the shorter-lived

TABLE 3.4-1

TEST CELL AIR ACTIVATION

Radioisotope	Reaction	Half-Life	Production Rate Ci/s
^{13}N	^{14}N (n,2n)	9.97m	1.1×10^{-2}
^{14}C	^{14}N (n,p)	5730y	3.5×10^{-9}
^{16}N	^{16}O (n,p)	7.11s	1.2
^{41}Ar	^{40}Ar (n,γ)	1.83h	1.4×10^{-5}
^{39}Ar	^{40}Ar (n,2n)	269y	5.5×10^{-10}
^{40}Cl	^{40}Ar (n,p)	1.42m	2.2×10^{-3}
^{37}S	^{40}Ar (n,α)	5.06m	3.1×10^{-4}
^{3}H	^{14}N (n,T)	12.3y	2.0×10^{-9}

species will approach equilibrium concentrations; the longer-lived will be released at about the same rate that they are produced.

The conceptual design of the radioactive gas system includes a 200 cubic feet tank, with internal baffles and operating at ten atmospheres pressure, to hold up the activated air for radioactive decay. The annual releases of the various gases from the test cell and from the facility are listed in Table 3.4-2. These releases are based on a facility schedule of 20 shifts/week of full-power operation for 50 weeks/year. It is seen that the limiting factors on the radioactive gas system design are the ^{13}N and ^{41}Ar releases. Shorter lived species decay to inconsequential levels prior to their release, while the longer lived ^{14}C, ^{39}Ar and ^{3}H have much lower production rates.

3.4.8.2 Accelerator Air

The high energy neutrons resulting from deuteron beam losses and interactions with the accelerator and beam transport system structures will activate the air atmosphere of the shielded accelerator room, beam transport tunnel and switchyard. These beam losses will be kept very low to prevent damage and to minimize radioactivation and consequent radiation exposures during maintenance. A 0.1% beam loss has been assumed as a design basis for radiation protection. It has been estimated that approximately 10^{12} n/s will be produced within the shielded rooms and tunnel housing the accelerator and beam transport system, with an average air path length of about three meters. By comparison, the neutron production in the test cell is 2×10^{16} n/s with an air-activation path length of approximately one meter.

Therefore, the production rate of radioactive gases in air within the accelerator system structures is expected to be approximately 1.5×10^{-4} of the test cell production rates presented in Table 3.4-1. These activities are deposited in the relatively large volumes of air associated with the accelerator room and beam transport tunnel and switchyard. Correspondingly, the concentration of radioactivity is expected to be very low. The bulk of conditioned air is recirculated in normal practice and is not released immediately. The average holdup time of the air will be approximately 40 minutes for 15 air changes/hour and 90% recirculation. Consequently, there will be considerable decay of the

TABLE 3.4-2

RELEASE RATES OF RADIOACTIVE GASES

Radioisotope	Released From Test Cell (Ci/yr)	Released From Facility (Ci/yr)
^{13}N	27,000	13
^{14}C	0.10	0.10
^{16}N	38,000	0.0000
^{41}Ar	210	17
^{39}Ar	0.02	0.02
^{40}Cl	86	0.0000
^{37}S	420	0.003
^{3}H	0.06	0.06

short-lived radioactive species before they are exhausted. No other special requirements for retention during operation or holdup after shutdown are anticipated in order to assure that releases to the atmosphere are well below the guidelines specified in DOE Manual Chapter 0524 for uncontrolled levels.

3.4.8.3 Tritium Generation in Lithium

Tritium will be produced in the target stream by deuteron and neutron reactions with the light lithium isotopes at a rate of about 54 Ci/day. The tritium will be entrained along with the incident deuterons in a 1:48 ratio as lithium hydrides. The tritium will build up in concentration to an equilibrium atom fraction of tritium in the circulating lithium of about six ppm after approximately three years of full-power operation. This concentration is established by the co-precipitation of the entrained deuterium and tritium as their concentration approaches the solubility limit of lithium hydride in the coolest part of the system, i.e., the cold trap operating at 190°C.

A small amount of tritium will escape from the HFNS Facility exhaust at extremely low levels of concentration due to permeation of the stainless steel boundaries of the lithium system. The total release to the environment, based on full power operation at the maximum concentration permitted by hydride precipitation, will be approximately 0.06 Ci/year.

Vacuum system exhausts represent a potential release path for tritium of about 18 Ci/year. The gravity-drain lithium system will have several free surfaces, all at low pressure because of the vacuum interface between the accelerator beam tube and the lithium target stream. The accelerator will operate in a hard vacuum of 10^{-7} Torr. The HFNS conceptual design provides a low pressure (10^{-3} Torr) helium blanket immediately in front of the lithium target to inhibit any atoms escaping from the front surface of the target from migrating into the beam tubing. A differential vacuum pumping system will simultaneously maintain the pressure of helium at the target and the hard vacuum of the beam tube. A vacuum pumping station will also maintain low cover-gas pressure at the liquid surface in the receiver tanks. Since tritium and other hydrogen species will be released from the free lithium surfaces, zirconium-aluminum alloy getter units will be installed upstream of the roughing pumps for these vacuum systems to control this potential release path.

3.4.8.4 Test Operations Coolants

Gas mixtures may be used to cool irradiation assemblies. The gas mixtures will be held up for radiation decay and discharged through the facility radioactive gas system.

3.4.9 Solid Waste System

Solid radioactive wastes resulting from HFNS operations will consist largely of the lithium target assemblies, miscellaneous test assembly hardware, the paper and rags used in controlling contamination, and air filters. There will be no transuranic waste. Components wetted with radioactive liquid metals will be cleaned, prior to refurbishment or disposal, in the sodium removal/decontamination facility under construction in the 300 Area.

All solid radioactive wastes will be packaged and monitored to comply with Hanford Waste Management procedures. About 1000 cubic feet of radioactive solid waste will be trucked from HFNS to 200 Area burial grounds for disposal annually.

Replacement of lithium system components and eventual decommissioning, will generate tritium and beryllium (^{7}Be)-contaminated lithium wastes. The maximum inventory of this waste will be present at the end of long term HFNS operations. It is expected to be about 237,000 Ci of tritium and 70,000 Ci of ^{7}Be. The final form will be as lithium tritide and elemental beryllium in bulk lithium coolant; precipitated on the steel mesh of the lithium system cold traps; on wetted surfaces and possible heel areas of lithium system piping and components which cannot be completely drained. Testing is in progress to characterize the transport of radioactive products in the system. Most of the tritium waste is expected to be precipitated in the cold traps. After a trap is removed from the lithium system and the trap pressure boundary resealed, the trap containing the frozen lithium will be doubly encased in steel drums filled with asphalt to prevent the release of radioactivity. Present plans are to store the encased traps and other lithium wastes in one of several suitable shielded repositories currently existing on the Hanford Reservation. Lesser amounts of tritium will be collected on the vacuum system getters which will also be routinely replaced. These will also be sealed but they will be buried as solid radioactive waste in the 200 Area.

Common trash (approximately 10,000 ft^3 per year) which is free of radioactive contaminants will be collected and transported to a central sanitary landfill maintained near the 200 Area for Hanford operations.

3.4.10 Radiation Protection

Operation of the HFNS Facility will follow the basic radiation protection policy that radiation exposure to employees, visitors, and the general public be held to the minimum practicable. Radiation protection is a key consideration in establishing the physical features of the HFNS Facility for safe and efficient operation and maintenance within the radiation exposure limits specified in DOE Manual Chapter 0524.

One of the underlying concepts in the control of radiation is the use of multiple zones and barriers between areas that are free of radiation and those containing the highest levels of radioactivity. The facility will be divided into a number of different zones in accordance with Table 3.4-3 to establish a design basis for shielding to permit necessary access to all locations. Shielding will be provided for the ion sources, accelerator, beam transport tunnel, irradiation cells, and for service systems and equipment that will contain radioactivity. The shielding design will be based on continuous operation at full power, will provide for facility maintenance and handling of target and irradiation assemblies, and will include provisions for postulated operational events such as accidental beam spills due to equipment failure.

In the Accelerator Building, the injector room will be inaccessible during operation due to the presence of X-rays and neutrons. The accelerator room and beam transport tunnel will also be inaccessible during operation. Routine access to the mechanical services and RF equipment areas will be permitted at all times. Access to the accelerator room and beam transport tunnel and switchyard will be limited after shutdown dependent on the levels of induced radioactivity.

TABLE 3.4-3

RADIATION SHIELDING - ZONING CRITERIA

Zone	Zone Description	Maximum Design Dose Rate
I	Uncontrolled area routinely occupied	0.02 mrem/hr
II	Controlled area routinely occupied	0.2 mrem/hr
III	Controlled area nonroutinely occupied	2.0 mrem/hr
IV	Controlled area limited access for routine tasks	20.0 mrem/hr
V	Controlled area limited access for nonroutine tasks	200.0 mrem/hr
VI	Normally inaccessible	>200.0 mrem/hr

The interiors of the irradiation test cells in the Test Building will become highly activated and will be inaccessible at all times. The cell design will provide heavy shielding to permit routine access to the operating floor and adjacent support areas during operation. The operating floor will be treated as limited access during insertion and withdrawal of irradiation assemblies through the access ports in the test cell walls and during any other operations where a cell interior is potentially exposed.

The radioactive gas inventories of the irradiation test cells and the radioactive gas system treating the test cells exhaust air represent potentially significant sources of radiation. The test cell atmosphere will be ventilated to safe levels after shutdown before they are opened. The radioactive gas system will be located in a separately shielded area of the equipment room beneath the beam switchyard.

Shielding of the lithium equipment and the dump heat exchanger is an important design consideration. The radiation level in the lithium loop due to buildup of radioactive corrosion products from the target assemblies is negligible.

However, activation of the lithium coolant and its impurities results in calculated radiation dose levels in the R/hr range in the immediate vicinity of unshielded equipment. The largest source of radioactivity is ^{7}Be, which emits a 0.477-MeV photon 12% of the time. The ^{7}Be has a 53.3-day half-life and builds up to a 70,000-Ci maximum expected, equilibrium inventory in the lithium system. Consequently, the lithium supply system will be inaccessible during operation. The facility conceptual design provides two feet of ordinary concrete shielding over the equipment rooms. The exhaust stack of the dump heat exchanger is also to be shielded to a height of ten feet by concrete one foot thick. The lithium supply system dump tank is located at the lowest elevation in a separate compartment shielded by three feet of concrete. This feature permits the draining of the lithium system and reduction of radiation in the equipment pits to levels necessary for the desired contact maintenance. Separately shielded areas will be provided for the lithium purification system cold trap and for the lithium characterization system (LCS) equipment. The limited-access LCS service room will be provided with local shielding for removal of lithium samples for analysis. The facility design will allow cutting and cap welding of the lithium system piping for cold trap replacement without undue personnel exposure. If an appreciable amount of ^{7}Be is concentrated in the trap, at least 12 months decay time will be allowed before attempting trap removal. An alternate cold trap is provided to enable continued facility operation.

3.5 DECOMMISSIONING

A minimum of contamination will result from operation of the HFNS Facility. The primary concern is with components which will become radioactive due to neutron bombardment. Under DOE regulations, procedures for decommissioning of HFNS will be subject to specific DOE approval and will be required to meet the standards for protection of workers and the general public.

It is doubtful that this facility will be used for any function other than its original design purpose. Therefore, dismantling of the facility is the most probable decommissioning approach. At present, the most probable dismantling procedure is to proceed in two steps:

1. Isolation of the facility for a time to allow the shorter lived activities to decay.

2. Dismantle and remove activated hardware to the Hanford Radioactive Waste Disposal Area for burial. Materials not suitable for direct burial will be processed for disposal by presently known techniques.

The HFNS will meet design criteria for decommissioning specified in DOE Manual Chapter Part 6301, "General Design Criteria".

3.6 REFERENCES

1. Environmental Statement, Hanford Number Two Nuclear Power Plant, Washington Public Power Supply System Docket No. 50-397, December 1972. Issued by USAEC Directorate of Licensing.

2. Environmental Report, WPPSS Nuclear Project No. 1, Washington Public Power Supply System, July 1974, Vol. 1 & 2.

4.0 THE SITE

The proposed site for the Deuterim-Lithium High Flux Neutron Source (HFNS) Facility is in the 300 Area of the Hanford Reservation (Figure 4.1-1). The 559-square mile, federally-owned Hanford Reservation is located in parts of Benton, Grant, Adams, and Franklin Counties in south-central Washington State. The 300 Area is in the southeast corner of the Reservation.

Buildings and facilities within the 300 Area are used primarily for conducting nuclear research and development, including reactor fuels development, liquid metal technology, Fast Flux Test Reactor support, and life sciences programs. Facilities on the Reservation closest to the 300 Area are the Fast Flux Test Facility (FFTF) about six miles northwest and nuclear power plants being built by the Washington Public Power Supply System (WPPSS) about seven miles northwest. Figure 4.1-2 shows the facilities on, and the land use of, the Hanford Reservation.

The Richland, Washington city limit is approximately one mile south, with the city center about seven miles south of the 300 Area. The northern 2-1/2 miles of Richland is zoned as an industrial park. The nearest dwelling to the 300 Area is a farm house approximately one mile east across the Columbia River.

4.1 Site Features

A more complete description of the Hanford Reservation site features may be found in the Appendix.

4.1.1 Geology

The Hanford Reservation lies in the Pasco Basin, a structural and topographic low point of Eastern Washington and the Columbia River Basalt Plateau. The region is underlain by three major geologic units: (1) the basaltic lavas and intercalated sediments of the Columbia River Basalt Group at the base; (2) the Pleistocene-age Ringold Formation; and (3) the Pasco (glacio-fluvial) gravels and associated sediments of the late Pleistocene age at the surface.

The surface geology of the site is characterized by a one to three foot layer of light brown, fine, slightly silty eolian sand, sparsely covered by

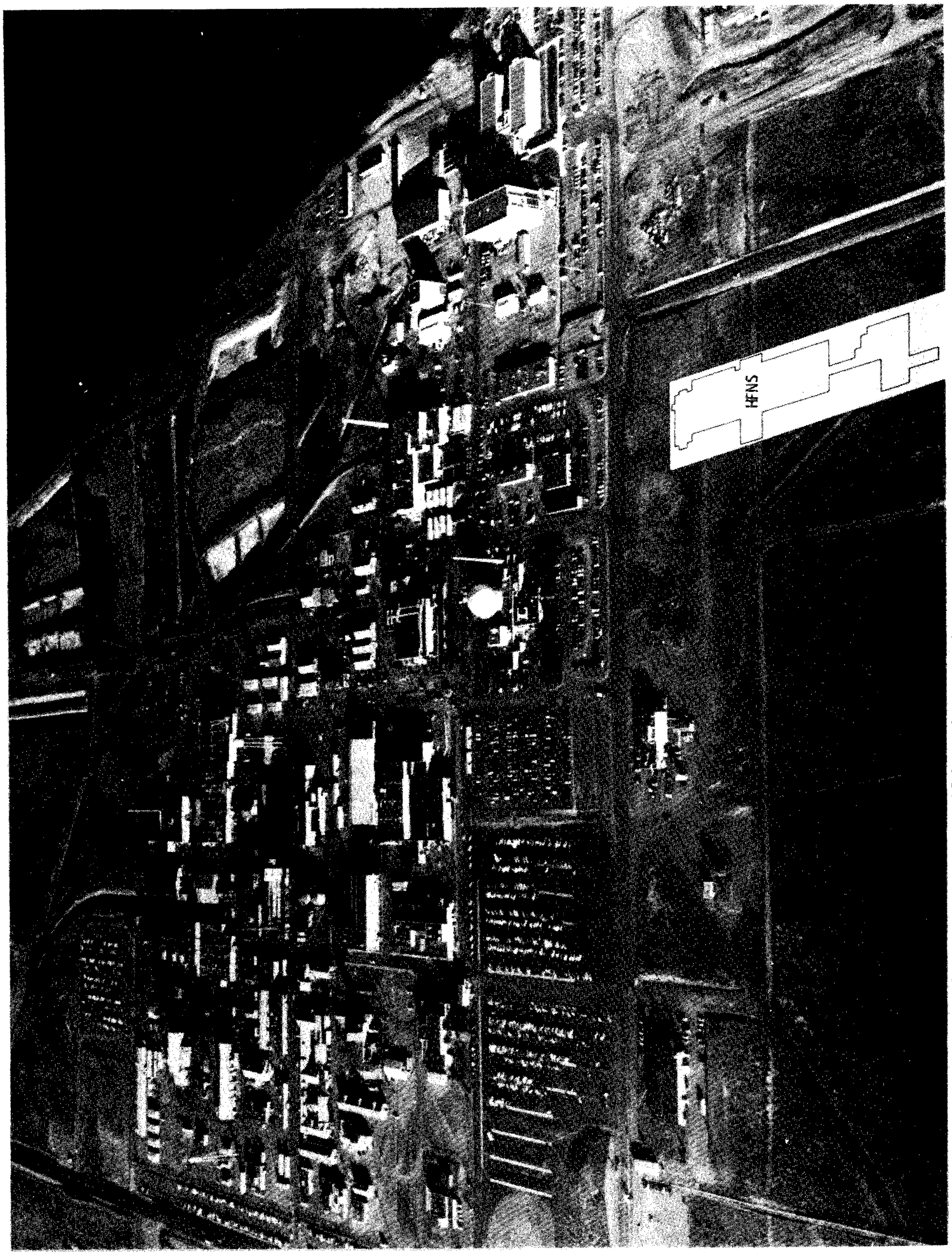

FIGURE 4.1-1. Location of HFNS Facility in 300 Area

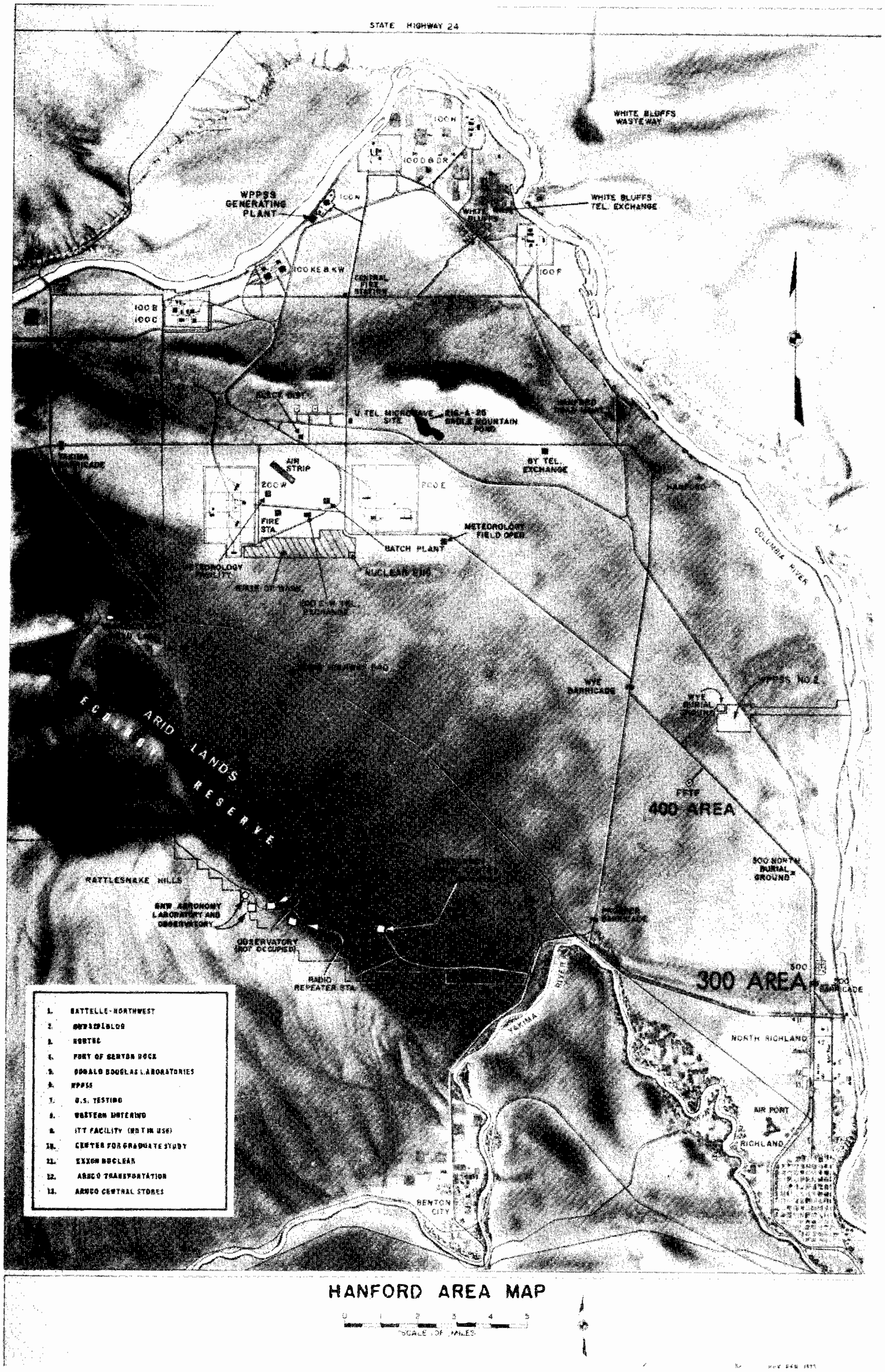

FIGURE 4.1-2. Map of Hanford Reservation.

vegetation. Although the surface soil is fertile, it has no agricultural value without irrigation. Underlying the surface sands is a mixture of sand and gravel ranging in depth to about 200 ft. Basaltic bedrock starts at a depth of approximately 200 ft and extends downward over 10,000 feet.

Altitudes range from a low of about 345 above mean sea level (msl) in the southeastern part of the Hanford Reservation to a maximum altitude of 3,586 feet at the crest of Rattlesnake Mountain to the west.

Numerous geological faults have been hypothesized through topographic expression and aerial photointerpretation bases. The most important fault postulated is the Rattlesnake-Wallula-Milton Freewater segment and the Rattlesnake-Wallula segment of the Olympic-Wallowa Lineament. To date, no strike-slip faults of any magnitude have been demonstrated in the Pasco Basin.

4.1.2 Seismology

Eastern Washington is in a region of low to moderate seismicity that lies between the western Washington and western Montana zones of considerably greater seismicity. On the basis of the damage that has occurred since 1840, the U.S. Coast and Geodetic Survey designated eastern Washington as Zone 2 seismic probability, implying the potential for moderate damage from earthquakes.

The maximum earthquake intensity recorded in historic times within the surrounding areas of Washington and Oregon occurred in 1893 when the Umatilla, Oregon area experienced a shock that measured MM-VII and in 1936 an MM-VII was experienced in the area of Walla Walla, Washington and Milton-Freewater, Oregon. Eastern Washington earthquakes that have occurred in historic times have not been as intense or as frequent as those in Western Washington. The strongest earthquakes at Hanford within historic time have not been greater than four on the Modified Mercalli Scale (MM-IV).

The design basis for the HFNS of 0.25g on the Hanford Reservation allows for an MM-VIII intensity quake epicentered at the same location.

4.1.3 Hydrology

The Hanford Reservation lies along the Columbia River just upstream of the confluence with the Yakima River. Surface runoff is minimal. The average annual precipitation of 6.5 inches mostly evaporates resulting in small amounts of water available for runoff or infiltration.

The Columbia River, which provides the eastern border of the 300 Area, has a long term annual flow of about 120,000 cubic feet per second (cfs). The Yakima River is approximately 4-1/2 miles to the west with a mean flow of 3240 cfs. The flow rates of the Columbia are influenced by water usage and upstream reservoir projects. The reservoirs provide active storage of more than 37,000,000 acre feet of water.

The ground water below the Pasco basin is in an unconfined aquifer that ranges between 340 feet above msl (river level) to 350 feet above msl at the west boundary of the Hanford Reservation. The depth of the water table varies greatly from place to place, depending chiefly on local topography, and ranges from less than one foot to more than 300 feet below the land surface. Current estimates of the maximum saturated thickness of the unconfined aquifer is about 230 feet. The water table at the 300 Area is approximately 160 feet below ground surface.

4.1.4 Meteorology

The Hanford Reservation lies east of the Cascade Mountains and, as a result, has a semi-arid climate reflecting the rain shadow effect that the mountains have in blocking most of the moisture carried in from the Pacific Ocean by the prevailing westerly winds. The summer season is characterized by hot, clear, dry weather with occasional strong winds and some clouds associated with mild disturbances moving in from the Pacific. In the wintertime, the intrusion of clouds and limited rainfall is associated with the relatively intense weather disturbances moving eastward over the Pacific Northwest. These are occasionally interrupted by intrusions of continental polar air masses moving southward from Canada which bring colder, dryer air to the Hanford Reservation.

The local topography also affects the area's climate. Due to the distribution of hills, ridges, and the valleys lying between them feeding into the Reservation, the winds in various parts of the reservation have preferred directions. The topography not only channels light winds resulting from large-scale pressure patterns, but also funnels drainage winds flowing up or down the sloping valleys in response to differential ground heating and cooling.

On the average, January is the coldest month with an average temperature of 29.4°F; whereas July is the warmest month of the year with an average temperature of 76.6°F. The coldest temperature recorded was -27°F in December of 1919. The maximum temperature recorded was 115°F in July of 1939. In the summer maximum temperatures of over 100°F may be expected for 13 days and winter minimum temperatures of or below 32°F will, on the average, occur for 115 days of the year.

The relative humidity of the area is low, averaging 75.7% in January and 31.8% in July. Values as low as 6% were recorded in July of 1951.

The average annual precipitation for the Hanford Reservation measured at the Hanford Meteorological Station (HMS) is 6.25 inches. Ten percent of this amount falls from July through September, while forty-two percent falls from November through January. The greatest amount of rainfall recorded in a 12 hour period was 1.88 inches.

Tornados are rare in the area, averaging less than one per year for the entire state. Thirteen tornados have been confirmed within 100 miles of the HMS since 1916; no loss of life or major damage was associated with them. The maximum wind speed for the Hanford site is estimated as 175 mph.

The predominant wind direction at the HMS is northwesterly, however, because of local topographic influences the predominant wind direction in the 300 Area is southwesterly.

4.1.5 Ecology

The Hanford Reservation is an isolated, controlled access area and has been used for production and test reactor operations and related activities for over two decades. Essentially all of the 300 Area has been disturbed from its natural state. However, the proposed site within the 300 Area is dominated by big sagebrush and bitterbrush with an understory dominated by cheatgrass and sandberg bluegrass.

The 300 Area soil may be described as dark-colored, coarse or medium textured soil generally about 30 inches thick and underlaid by gravel. The sparse vegetation supported by these soils can be used for grazing, but is severely limited by the shallow soil, eroded, rough, stony or very dry sandy conditions.

The mule deer, racoon, beaver, muskrat and mink are present within the Hanford Reservation and are usually found in the areas adjacent to the Columbia River. Coyotes and jackrabbit are widely distributed throughout the Reservation. Small mammals are abundant with the great basin pocket mouse being the most plentiful.

The chukar partridge, Chinese ringneck pheasant, California quail, ducks, and Canadian geese may be found during the year within the confines of the Hanford Reservation. Migratory birds are usually found along the Columbia River.

The animal and bird population of the proposed HFNS site is minimal due to the existing disturbed state and the daily influx in transient human population to the 300 Area.

The Columbia River (fifth largest river in North America) is the dominant aquatic ecosystem on the Hanford Reservation. Numerous dams have been built on the river, with the only free-flowing U.S. section occurring between Priest Rapids Dam and McNary Reservoir (along the Hanford Reservation). No significant tributaries enter the stream in this section. The entire Columbia River is exceptionally clean for a river of its size.

4.1.6 Radiological Condition

The radiological condition of the 300 Area, as part of the Hanford Reservation, has been studied since the beginning of operations at Hanford. An extensive environmental surveillance and evaluations program provides measurement and interpretation of Hanford operations radiological impact upon its environs, both onsite and offsite. All significant potential pathways are evaluated, including particularly those resulting in direct exposure to the public and those wherein environmental reconcentration is likely to occur.

Environmental data collected during 1975 showed compliance of Hanford operations with the applicable State and Federal regulations. Levels of radioactivity in the atmosphere from Hanford operations at all offsite sampling locations were indistinguishable from levels due to natural causes and world-wide fallout from the atmosphere. Routine radiological analyses of Columbia River water upstream and downstream of the Hanford Reservation have not shown any identifiable effect due to Hanford operations.

4.2 The Surrounding Region

The Hanford Reservation is a restricted access area; land south of the Columbia River is under DOE control and land north of the Columbia River is controlled by the Bureau of Sport Fisheries and Wildlife as a game refuge.

4.2.1 Land Use On The Reservation

The present use of Reservation lands surrounding the 300 Area is indicated in Figure 4.1-2. Current operation includes a plutonium production reactor, fuel reprocessing and waste management activities, the Fast Flux Test Facility (FFTF) and support facilities. Also, WPPSS is building commercial nuclear plants on the Reservation.

The 77,000-acre area in the southwest corner of the Hanford Reservation is set aside for long-term ecological studies. With the exception of the Arid Lands Ecology (ALE) Reserve and the Columbia River Islands Reserve, other areas of ecological study shown on Figure 4.1-2 are only temporarily restricted. Islands in the upper portion of the Columbia River adjacent to the Hanford Reservation are excluded from public use by the DOE and are used for wildlife refuge and DOE environmental research.

The 300 Area is bounded on the west by a DOE-constructed four-lane highway connecting to the public highway system at Richland, Washington. The DOE-owned railroad system includes the 300 Area.

The 300 Area is about four miles north of the Richland Airport and 11 miles northwest of Vista Field near Kennewick and the Tri-Cities Airport near Pasco.

4.2.2 Land Use Adjacent to the Reservation

Land use within a 30-mile radius of the site includes residential, suburban, corporate city, agricultural, industrial and commercial, scenic, recreational, and general use land areas. The predominant use of lands within the 30-mile radius of the 300 Area is agricultural, with the nearest farms located along the east bank of the Columbia River in Franklin County.

4.2.3 Regional Demography

Population in the area surrounding the Hanford Reservation is sparse, consisting primarily of farms and farming communities to the north, east, and west of the Reservation. The Tri-Cities, located to the south and southeast of the Reservation, represent the major population concentrations in the area.

In the year 2000, an estimated 67,000 people will be living within a 10-mile radius of HFNS and 256,000 people within a 50-mile radius.

4.2.4 Historic and National Landmarks

There are no historical structures or archaeological sites in the immediate vicinity of the HFNS. The nearest historical site to the HFNS is the Wooded Island Archaeological District which is located approximately 4-1/2 miles north. Several historic sites are entered on the Washington State and/or National Registers of Historic Places or National Register of Historic Landmarks that are within approximately 50 miles of the HFNS site (see Appendix). The Columbia River shoreline, from Vantage in the north downstream to Umatilla, is rich with Indian artifacts. The construction and operation of the HFNS is not expected to have any impact on any of the existing or potential historic sites or districts.

4.2.5 Wild and Scenic Rivers

The stretch of the Columbia River from the headwaters of the McNary Reservoir upsteam to Priest Rapids Dam has been named under the provisions of Section 5 (d) of the Wild and Scenic Rivers Act as amended through Public Law 94-486 (October 12, 1976). This stretch flows through and adjacent to the Hanford Reservation and from the eastern reservation boundary in the southeastern corner. The HFNS facility will be located approximately 1/3 mile west of the Columbia River. The facility will not necessitate construction of any additional water intake or discharge structures. The site, being entirely within the existing 300 Area of the Hanford Reservation, will not have any impact on the scenic and recreational values of the Columbia River.

5.0 EXPECTED ENVIRONMENTAL IMPACTS OF FACILITY CONSTRUCTION AND OPERATIONS

The Deuterium-Lithium High Flux Neutron Source (HFNS) Facility is in a preliminary design stage. Thus, very conservative estimates were used in evaluating the environmental effects of the HFNS during construction and normal operations.

5.1 Summary

The proposed site for HFNS construction is in the 300 Area of the Hanford Reservation. As a result, little additional impact is expected at the construction site. The isolation of the HFNS site will preclude the detection of any increment in atmospheric levels of dusts, heavy equipment exhaust fumes, or other temporary atmospheric contaminants beyond the Hanford Reservation. Also, the remoteness of the site prevents any significant impact from construction noises or lights for night work beyond the Reservation boundaries. All of the land required for the HFNS has been removed from its natural habitat and is within the 300 Area perimeter fence. Thus, impacts on local biota will be minimal and only temporary.

All HFNS operations will be conducted in accordance with appropriate Department of Energy (DOE) requirements. Consumption of resources will be minimized. The design facilitates decontamination of equipment and structures to allow maximum salvage and recycle and to allow decommissioning of the facility and the site in the future. Environmental acceptability is a major design goal of the HFNS program.

During routine HFNS operations there will be a potential for releases of small amounts of radioactive gases, but the calculated doses to the population resulting from these potential releases are very low. For example, the estimated maximum dose rate at the HFNS site boundary is 1.2×10^{-8} rem/hr to the whole body, as compared to natural background radiation of about 1×10^{-5} rem/hr.[1] The 50-year whole-body dose commitment to the nearest resident, approximately 1.5 miles southeast of the HFNS, is about 6×10^{-6} rem. For comparison, this same individual will receive a whole-body dose of about 5 rem[2] from background radiation exposure during this 50-year period. Based on the first year of operations, the whole-body 50-year dose commitment to the year 2000 population within a 50-mile radius of the HFNS site, is approximately 1.2 x 10^{-2} person-rem from air submersion and inhalation. The dose received by the same population during that year from radiation due to natural causes is estimated to be 26,000 person-rem.

5.2 Impact of Site Preparation Activities, Construction and Resource Commitments

Construction of the HFNS will entail certain unavoidable impacts upon land use and ecology of the site environs.

5.2.1 Land Use Impacts

The proposed site for the HFNS is essentially devoid of native vegetation as a result of activities in the 300 Area. As a result, little additional impact is expected on the actual construction site. It is anticipated that an additional six acres will be temporarily required for working and storage areas. All of this additional area has already been affected by 300 Area activities. It is highly probable that this additional land area will either be intentionally or inadvertently denuded temporarily of its ground cover. Routine dust control measures will be applied during construction.

Approximately four acres of land within the 300 Area will be required to accommodate the HFNS buildings and grounds. All of this land is presently within the 300 Area perimeter fence and has been removed from its natural habitat (see Figure 4.1-1). Highway, rail and electrical transmission links to the 300 Area have already been furnished for 300 Area activities.

Excavation of subsoil material will be required for construction of foundations and subgrade areas of buildings for the HFNS. This material will be required for subsequent backfilling of building areas with the remaining material being used as a shielding earth berm.

5.2.2 Impact on Plant Communities

The immediate loss of ground cover from excavation and grading at the construction site and surrounding area will result in some localized increase in dust from soil erosion. Early invasion of plant species will consist of cheatgrass and tumbleweed.[1] Cheatgrass is an annual plant that must reseed itself each year, but it is extremely well adapted to the climatic conditions of the area.[3] It also is effective in preventing wind erosion due to the extensive shallow root system and abundance of standing litter which helps reduce wind speed near the surface of the soil. An abundance of cheatgrass is expected to become reestablished naturally in the disturbed area due to the close proximity to a seed source.

5.2.3 Impact on Animal Communities

There are few bird species that actually use the shrub-steppe habitat around the 300 Area for nesting areas.[4] The use of the 300 Area for nesting areas has already been affected by 300 Area activities. Thus, this facility would have only a minimal effect on the birds. The effect on small mammals from this project will be minimal since most of the affected area has previously been disturbed. Both the great basin pocket mouse and deer mouse populations would probably be adversely affected locally by vegetation removal. The mule deer is the only large animal on the Hanford Reservation. Deer usage of this site has been prevented by the 300 Area perimeter fence. The deer herd tends to remain near the river and other water bodies, probably due to the availablity of relatively lush riparian vegetation.[5] Coyotes and black-tailed hares are residents of the sagebrush-bitterbrush vegetation type. The hares seem to prefer the shrub canopy over more open areas. The perimeter fence about the 300 Area excludes both medium and large sized mammals but does not interfere with small mammal movements. There are no rare or endangered species that will be affected by construction of the facility.

5.2.4 Impact on Air and Water Quality

Despite dust control measures (watering), localized atmospheric dust loadings will occur during construction, especially during windy periods. However, the isolation of the site will prevent any distinguishable increment in airborne dusts beyond the Hanford Reservation. The same benefit of isolation will apply to heavy equipment exhaust fumes or other temporary atmospheric contaminants from construction activities. Construction traffic will contribute at most a small increment to existing impacts from normal Hanford plant and Washington Public Power Supply System (WPPSS) traffic.

Both precipitation at the site and waste water from construction activities will seep into the soil in the immediate vicinity of the site, with no runoff to surface streams. Percolation to groundwater should be minimal and will have no significant impact on groundwater quality.

5.2.5 Other Potential Impacts

The isolation of the site prevents any significant impact beyond the Reservation from construction noises or lights for night work except for the very localized bird and rodent population, discussed previously.

Excavations required for completed facilities that are in the immediate vicinity of the proposed site have not revealed any previously unknown cultural resources. Thus, discovery of previously unknown cultural resources is not deemed to have a high probability. Nevertheless, cognizant construction personnel will be made aware of the requirement that should a previously unknown cultural resource be identified during construction, which are eligible for inclusion in the National Register of Historic Places, the Advisory Council on Historic Preservation must be afforded the opportunity to comment in accordance with the "Procedures for the Protection of Historic and Cultural Properties", C36C.F.R. Part 800, as appropriate.

5.3 Expected Radiological Impact of Operation

Mankind has received radiation dose continuously since the beginning of time. Radioactivity from natural sources is present in the air we breathe, the food we eat, and the soil we walk on. The magnitude of this dose rate from natural sources in the Hanford environs is approximately 0.1 rem/yr.(1) Scientific committees, such as the International Commission on Radiation Protection (ICRP), National Council on Radiation Protection and Measurements (NCRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have evaluated the effects of radiation exposure on mankind and proposed measures for control of man-made radiations. Exposure guidelines adopted by the Federal government, based on recommendations set forth by the various committees, are intended to allow beneficial uses of radiation while preventing unacceptable public health effects. Existing DOE radiation standards[6] impose an annual limit on the whole-body dose of 0.5 rem to individuals at points of maximum probable exposure and 0.17 rem average to a suitable sample of the exposed population from DOE operations. Annual dose received by particular organs such as the lung, liver, and bone is limited to 1.5 rem for individuals. DOE is committed to keeping radiation as low as practicable (ALAP) and always within DOE Manual Chapter 0524 guidelines. In practice, doses resulting from DOE facilities are a small fraction of these guidelines and well within the Environmental Protection Agency standards[7] for population doses from the uranium fuel cycle of a maximum annual dose of 0.025 rem to any member of the public.

Table 5.3-1 summarizes the calculated whole-body doses to various segments of the population from HFNS operations. Background, DOE guidelines and public dose from 1976 operations on the Hanford Reservation are also given for comparison.

5.3.1 Exposure Pathways and Dose Model Used

During normal operations, exhaust air from HFNS test cells will be held up to provide for decay before it is released to the atmosphere. However, in order to estimate potential population doses resulting from routine HFNS operations, it is assumed the maximum expected amounts of radioactivity listed in Table 3.4-2 are released to the atmosphere via the plant ventilation system. Routine wastes from the HFNS will have no significant effect on waste disposal procedures discussed in the "Waste Management Operations Environmental Impact Statement."[1] The dose from air submersion was evaluated at the nearest Reservation boundary (Columbia River shore). The dose to the "maximum individual" from air submersion, inhalation, ground contamination, and the consumption of locally grown foods and animal products was estimated. (The "individual" is one whose residence, life style, or dietary habits result in the highest exposure to radioactive plant emissions.) Doses to the 50-mile and U.S. population via air submersion and inhalation were evaluated for the estimated year 2000 population. Also, the dose from air submersion and direct exposure was estimated for 300 Area workers.

TABLE 5.3-1

ESTIMATED FIRST YEAR WHOLE-BODY DOSE COMMITMENT
FROM HFNS OPERATIONS
(rem)

	HFNS Operations	Background	ERDA Guidelines	Hanford Operations 1976[11] (Dose from airborne effluents.)
Individual				
Site Boundary	6×10^{-6}[a]	6×10^{-3}[b]	5×10^{-1}	4×10^{-6}[b]
Nearest Resident	6×10^{-6}	1×10^{-1}	5×10^{-1}	1×10^{-5}
Population				
50-mile (Annual Average per Person)	5×10^{-8}	1×10^{-1}	1.7×10^{-1}	$<6 \times 10^{-8}$
U.S. (Annual Average per Person)	2×10^{-10}	1×10^{-1}	--	--
300 Area Worker				
Maximum	2×10^{-5}[c]	1×10^{-1}	5	--

(a) Air submersion, 500 hrs/yr

(b) 500 hrs/yr exposure

(c) Air submersion 45 hrs/week, 50 weeks/yr

The models[9,10] used for the following estimates are those previously employed to evaluate radiological impacts from various fuel cycle facilities for industry, NRC and DOE as well as the environmental impact statement[1] for Hanford waste management operations and routine Hanford environmental surveillance reports.[11] Table 5.3-2 gives the estimated food consumption for the maximum individual; References 9 and 10 describe in full the assumptions and paramenters used. The inhalation dose estimate was calculated employing the methodology of the International Commission on Radiological Protection (ICRP).[12] Average overall atmospheric dilution factors ($\bar{\chi}/Q$) (see Appendix Table A.1-5) were calculated using climatological data from the 33 ft level of the WNP-2 meteorology tower approximately seven miles northwest of the HFNS site. A ground level release was assumed. The atmospheric dispersion model is described in Reference 13. The dose from inhalation is calculated assuming no cloud depletion whatsoever between the release point and the receptor.

For the dose calculations, the foods consumed by the exposed population were assumed to be produced on land contaminated by releases during 20 years of HFNS operation, allowing for accumulation and decay in the soil but not leaching. The doses received during the twentieth year of operation from that year's ingestion of such foods and the resulting 50-year dose commitments were calculated. The dose from external radiation due to previous deposition was estimated for the same year.

5.3.2 Impact of Airborne Releases

Airborne release of HFNS materials is assumed to occur via an 80-ft high dump heat exchanger stack located northeast of the Test Building. However, to be conservative, a ground level release was assumed for the dose calculations.

5.3.2.1 Maximum Individual

Site Boundary

For the airborne release rates given in Table 3.4-2, the maximum exposure at the Hanford Reservation boundary would occur at a location approximately 0.3 mile southeast of the HFNS stack, where $\bar{\chi}/Q$ is 1.5×10^{-5} s/m^3. This is a

TABLE 5.3-2

FOOD CONSUMPTION RATES FOR MAXIMUM INDIVIDUAL[9]

Pathway	Consumption Rate (kg/yr)
Produce and Cereals	
Leafy vegetables	30[a]
Other above ground vegetables	30[a]
Potatoes	110
Root vegetables	72
Berries	30
Melons	40
Orchard fruit	265
Wheat	80
Other grain	8[a]
Eggs	30
Milk	274[b]
Meat	
Beef	40
Pork	40
Poultry	18

(a) Only fresh vegetables considered; grown locally five months of the year.
(b) Cows grazed on pasture nine months of the year.

location on the Columbia River just offshore from the 300 Area where an angler might fish from a boat. There is no other point outside the Hanford Reservation (to which the public might have access) which has a higher $\bar{\chi}/Q$. From air submersion, the average dose rates to the whole-body and skin of a fisherman at this point would be 1.2×10^{-8} rem/hr and 1.8×10^{-8} rem/hr, respectively, at this near shore location. An avid fisherman spending 500 hr/yr here would receive an annual dose of 6×10^{-6} rem to the whole-body and 9×10^{-6} rem to the skin.

Nearest Resident

The point at which people live with the highest $\bar{\chi}/Q$ for the HFNS is on the east side of the river, approximately 1.5 miles southeast of the facility. Here the calculated $\bar{\chi}/Q$ would be 9.8×10^{-7} s/m^3.

Tables 5.3-3 and 5.3-4 summarize the doses calculated for the maximum resident individual from the radioactive materials released during normal operations of the HFNS for a one-year intake and the 50-year dose commitment from that year.

5.3.2.2 Population Dose

Table 5.3-5 gives the estimated annual dose commitment from air submersion to the population living within 50 miles of the HFNS in the year 2000. The 50-year dose commitment for the estimated 256,000 people from one year of operation is given in Table 5.3-6. None of these estimates include occupational doses which may be received by the HFNS work force.

The 50-year dose commitment to the population of the continental USA (including those residing within 50 miles of the facility) from one year of operation was estimated from normalized air concentrations derived from a variable trajectory, puff advection model,[14,15] and the 1970 Bureau of Census data[16] increased by 40% to correct for population increases by the year 2000. Table 5.3-6 shows the U. S. population dose commitment in person-rem from inhalation and air submersion.

5.3.2.3 On-site Exposures

The maximum annual doses to a 300 Area worker (excluding HFNS workers) were estimated. Doses were calculated for 2550 hrs of exposure per year (9 hrs/day,

TABLE 5.3-3

ESTIMATED FIRST-YEAR DOSE COMMITMENT TO A MAXIMUM RESIDENT FROM GASEOUS EFFLUENTS RELEASED FROM HFNS[(a)]

(rem)

PATHWAY	ANNUAL USAGE	SKIN	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
Air Submersion	8766 hr	7×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}
Air Inhalation	8766 hr	--	3×10^{-8}	3×10^{-8}	3×10^{-8}	6×10^{-8}	3×10^{-8}	6×10^{-8}	3×10^{-8}
Ground Exposure	4383 hr	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}
Food Crops									
Produce	665 kg	--	1×10^{-6}	1×10^{-6}	1×10^{-6}	5×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Milk	274 liters	--	2×10^{-7}	2×10^{-7}	2×10^{-7}	9×10^{-7}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Eggs	30 kg	--	5×10^{-8}	5×10^{-8}	5×10^{-8}	2×10^{-7}	5×10^{-8}	5×10^{-8}	5×10^{-8}
Meat	98 kg	--	3×10^{-7}	3×10^{-7}	3×10^{-7}	1×10^{-6}	3×10^{-7}	3×10^{-7}	3×10^{-7}
TOTAL		7×10^{-6}	6×10^{-6}	6×10^{-6}	6×10^{-6}	1×10^{-5}	6×10^{-6}	6×10^{-6}	6×10^{-6}

(a) Residing all year 1.5 miles south of facility, $\bar{\chi}/Q = 9.8 \times 10^{-7}$ s/m^3.

TABLE 5.3-4

ESTIMATED 50-YEAR DOSE COMMITMENT TO A MAXIMUM RESIDENT FROM GASEOUS EFFLUENTS RELEASED FROM HFNS[a]

(mrem)

PATHWAY	ANNUAL USAGE	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
Air Submersion	8766 hr	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}
Air Inhalation	8766 hr	3×10^{-8}	3×10^{-8}	3×10^{-8}	7×10^{-8}	3×10^{-8}	6×10^{-8}	3×10^{-8}
Ground Exposure	4383 hr	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}
Food Crops								
Produce	665 kg	1×10^{-6}	1×10^{-6}	1×10^{-6}	6×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Milk	274 liters	2×10^{-7}	2×10^{-7}	2×10^{-7}	1×10^{-6}	2×10^{-7}	2×10^{-7}	2×10^{-7}
Eggs	30 kg	5×10^{-8}	5×10^{-8}	5×10^{-8}	3×10^{-7}	5×10^{-8}	5×10^{-8}	5×10^{-8}
Meat	98 kg	3×10^{-7}	3×10^{-7}	3×10^{-7}	2×10^{-6}	3×10^{-7}	3×10^{-7}	3×10^{-7}
TOTAL		6×10^{-6}	6×10^{-6}	6×10^{-6}	1×10^{-5}	6×10^{-6}	6×10^{-6}	6×10^{-6}

(a) Residing all year 1.5 miles south of facility, $\bar{\chi}/Q = 9.8 \times 10^{-7}$ s/m^3.

TABLE 5.3-5

ANNUAL AIR SUBMERSION WHOLE-BODY DOSE TO THE 50-MILE POPULATION

Cumulative Radius (Miles)	Cumulative Population*	Cumulative Dose (Person-Rem)	Average Annual Dose (rem)
1	0	0	0
2	100	3.7×10^{-4}	3.2×10^{-6}
3	500	9.4×10^{-4}	1.7×10^{-6}
4	3,600	2.8×10^{-3}	$8. \times 10^{-7}$
5	14,000	6.2×10^{-3}	4.4×10^{-7}
10	67,000	1.1×10^{-2}	1.7×10^{-7}
20	121,000	1.2×10^{-2}	$1. \times 10^{-7}$
30	139,000	1.2×10^{-2}	8.9×10^{-8}
40	193,000	1.2×10^{-2}	6.4×10^{-8}
50	256,000	1.2×10^{-2}	4.8×10^{-8}

*Figures rounded to nearest 100.

TABLE 5.3-6

50-YEAR WHOLE-BODY DOSE COMMITMENT TO THE 50-MILE POPULATION AND UNITED STATES

Pathway	Whole-Body (Person-rem)
0-50 Miles	
Air Submersion	1.2×10^{-2}
Inhalation	2.9×10^{-4}
Total	1.2×10^{-2}
Total U.S.	
Air Submersion	6.1×10^{-2}
Inhalation	4.1×10^{-4}
Total	6.1×10^{-2}

5 days/week, 50 weeks/yr). A maximum worker would be located in a building about 800 ft north of the HFNS stack. From air submersion this individual would receive an annual whole-body dose of approximately 2.2×10^{-5} rem and an annual skin dose of about 3.4×10^{-5} rem. The dose from direct exposure would be approximately 2×10^{-2} rem/yr.

5.3.3 Postulated Health Effects

The BEIR Report [(2)] recommends a method for estimating "health effects" from radiation exposure at very low doses and dose rates. There are responsible views to the effect that assumptions used in calculating such health effects are not correct[(17)] and even the BEIR Report concedes that "such estimates.... are fraught with uncertainty." However uncertain these estimates are, though, they are conservative and they do provide a basis for estimating the impact of one aspect of HFNS operation. Calculated population doses resulting from operation of the facility (see Table 5.3-5) are so low that the probability of even one health effect is extremely small.

As another approach, the EPA has developed a concept called the "environmental dose commitment" to assess the total impact of a nuclear facility on the environment. "The concept encompasses the total projected radiation dose to populations committed by the irreversible release of long-lived radionuclides to the environment, and forms a basis for estimating the total potential consequences on public health of such environmental release."[(18)] Because of the difficulty of making projections of radionuclide transport on the basis of present knowledge, EPA has calculated these potential consequences only for the first 100-year period following release. Of radionuclides considered by EPA, only tritium is released from HFNS. For pessimistic assumptions used in Reference 18, a total of 440 health effects (as defined in the BEIR Report) for the entire U.S. population of 300,000,000 in the year 2000 was calculated from a total postulated release of 200 million curies of tritium escaping to the environment from year 1970 to 2000. For comparison, the total release from routine HFNS operations using the release quantity given in Table 3.4-2, would amount to 1.1 curies of tritium for the entire projected facility life to the year 2000. By simple ratio to the preceeding numbers, again the occurrence of even one health effect (less than 3×10^{-6} from tritium) from HFNS releases is not probable.

5.3.4 Other Potential Radiological Impacts

The HFNS will generate only small volumes of radioactive waste. It is expected that less than 500 gallons/yr of liquid radioactive waste (Section 3.4.7.3) and about 1000 cubic feet/yr of solid radioactive waste (Section 3.4.9) will be generated. This waste will be disposed of as described in the impact statement on Hanford Waste Management Operations.[1] The effects of waste management due to the HFNS are not to be expected to be significant from a radiological standpoint.

The environmental cost and radiation exposure associated with decommissioning the HFNS will depend on DOE criteria applied at that time. Under DOE regulations, procedures for decommissioning will be subject to specific DOE approval and will minimize both environmental impact and radiation exposure. The HFNS Construction Project Data Sheet identifies a budgetary estimate of $5 million for decommissioning costs as part of the total project funding.

5.4 ANTICIPATED NONRADIOLOGICAL IMPACT OF OPERATION

The HFNS will utilize only small quantities of nonradioactive noxious chemicals, such as cleaning compounds and oils for pumps. Some will be discharged to the atmosphere via the facility stacks. Some will be discharged to the process sewer trenches and sanitary sewer trenches and some will be placed in the Hanford sanitary landfill.

5.4.1 Impact on Humans

Small quantities of nonradioactive noxious chemicals (see Table 3.4-1) will be consumed in operations at HFNS. However, concentrations at the stack will be far below threshold limit values (TLV)[19] due to the small quantities released, and the exhaust flow rates. Threshold limit values are intended for use in workroom environments and not ambient air. Concentrations at ground level beyond the facility fence will be even lower due to rapid atmospheric dispersion.

The proximity of the waste trenches to the Columbia River from which 300 Area draws its water supply warrants control of chemical releases to these trenches to near recommended drinking water limits. The City of Richland takes a major portion of its water from the Columbia River approximately four miles south of the waste trenches. Extensive programs that evaluate the water quality of both the groundwater and Columbia River have never evidenced an impact from use of process and sanitary disposal ponds and trenches. No effect is expected from operation of the HFNS Facility.

5.4.2 Impact on Other Biota

Noxious chemicals released (see Table 3.4-4) to the atmosphere will be in such small quantities and at such low concentrations that no impact on other biota is anticipated.

Sanitary waste water will be discharged into the existing sanitary leaching trenches. Normal process waste water will be disposed of via two existing trenches, each about 30,000 ft^2 in size. Some chemical substances will be released to the trenches (see Section 3.4.7.2). HFNS represents such a small fraction of the discharge to the trenches and the noxious chemicals inventory at HFNS is so small that it is not anticipated the waters in the trenches would ever contain concentrations of waste products harmful to biota as a result of even unusual occurrences in the HFNS. Large animals are prevented access by the fence that surrounds the trenches. The small trench size should preclude all but incidental use by most waterfowl.

5.5 TRANSPORTATION

Shipments of hazardous substances to and from the HFNS will be afforded a degree of protection that is equivalent to that provided by Department of Transportation regulations. Most shipments of radioactive materials will be on the Hanford Reservation with off-site shipments limited to metal test assemblies shipped in Department of Transportation approved shipping casks. All shipments of radioactive materials from the HFNS will comply with DOE Manual Chapter 0529. As such, no impact resulting from releases of shipped material is anticipated. The number of shipments will be very small compared to the volume for the Hanford Reservation. Thus, traffic-connected effects from HFNS operations will be negligible.

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6.0 UNAVOIDABLE ADVERSE IMPACTS

The unavoidable adverse effects of the Deuterium-Lithium High Flux Neutron Source (HFNS) Facility construction and operation are very few and largely temporary.

The local mammal and bird habitat will be disturbed in only a minor way during the construction phase because the site and surrounding area have already been disturbed by 300 Area activities. It is anticipated that the small mammal and bird population will return to near normal shortly after the facility is operational and the revegetation process is underway. No endangered species are affected by this facility.

The vegetative cover that is destroyed during construction will be restored by natural processes to near normal levels within a few years. The first of the vegetative species to be naturally reintroduced are cheatgrass and tumbleweed.

The loss of the ground cover due to construction activities will result in an increased potential for wind erosion. This will, in spite of routine dust control measures, be a source for an increased dust loading of the atmosphere during high wind episodes. This condition will be temporary and will return to near normal soon after completion of construction.

There is a potential for an adverse ecological effect due to the presence of chemicals in the sanitary and process waste water disposal trenches. However, the HFNS represents such a small fraction of the total effluent to the trenches that no discernable impact from HFNS operations can be anticipated. Nonetheless, waste management procedures will be developed to reduce this very low potential for harmful effects to an as low as practical (ALAP) level.

The probability of an adverse environmental effect due to release of volatile organic solvents to the atmosphere through the HFNS stacks is very remote because the concentrations of chemicals from this facility will be extremely low.

Radiological effects resulting from operation of the HFNS will be negligible. The predicted dose values at the Hanford Reservation boundary and nearest resident locations are a very small fraction of that due to the natural background radiation.

7.0 ECONOMIC AND SOCIAL IMPACTS OF FACILITY CONSTRUCTION AND OPERATION

7.1 Irreversible and Irretrievable Commitments of Resources

Construction and operation of the Deuterium-Lithium High Flux Neutron Source (HFNS) facility will result in the irretrievable commitment of moderate amounts of resources. Principal construction materials for the Accelerator and Test Buildings will commit approximately 400 tons of reinforcing steel and 6,000 cubic yards of concrete. In addition, quantities of welding rods, inert gases and miscellaneous construction materials will be consumed, as well as the petroleum base fuels required to power construction machinery. The major items of equipment, the linear accelerator and the lithium supply and target system, will commit approximately 120 tons of carbon steel, 25 tons of copper, and 10 tons of stainless steel.

Materials and supplies consumed during facility's operation will include test and lithium target assemblies. There will also be miscellaneous supplies used in operating and maintaining the accelerator and test equipment and for cleaning and decontamination. About 45 gallons per minute of water from the 300 Area water system and 250,000 kWh of electrical energy per day of operation will be used. The electrical energy will be drawn from the Bonneville power pool and will be supplied from an indeterminant mix of hydroelectric, fossil and nuclear generating plants, resulting in some fossil and nuclear fuel consumption. The electrical energy distributed by the Bonneville Power Administration is generated predominately by hydroelectric generating plants. The proportion that each power generating source contributes is indeterminate due to the electric power wheeling arrangements within the Northwest Power Pool. The HFNS Facility is being designed to facilitate decontamination of buildings and equipment. However, the irradiation test cells will be highly activated and the recovery of resources committed for its construction or for alternative use of the test cells may not be economically feasible. Alternative use may be feasible for the linear accelerator and the beam transport tunnel but could require extensive decontamination and modification would be required prior to commencing the alternative use. Approximately four acres of land is expected to be utilized as the site for the HFNS buildings, parking areas and shipping and receiving areas. The proposed site is within the 300 Area on the Hanford Reservation. Essentially all of the land affected by the HFNS has already been disturbed by other 300 Area activities and would continue to be periodically disturbed in the normal course of 300 Area usage. Temporary rerouting of the normal traffic flow or parking may be required during the construction phase and is not expected to require permanent commitment of 300 Area resources.

7.2 Relationship between Short-Term Uses and Long-Term Productivity

The proposed site is within the 300 Area of the Hanford Reservation, an area devoted to nuclear-related activities for over 30 years. Consequently, the HFNS Facility harmonizes with the existing facilities. The entire Hanford Reservation is set aside for nuclear activities with no competing land use contemplated. The 300 Area location and the HFNS design implies maximum utilization of currently existing facilities. It is anticipated that the existing facilities will be used to fabricate the irradiation assemblies and to perform the necessary post-irradiation handling, examination and testing. The availability of these facilities will allow increased utilization of their capabilities.

Required support services such as security, fire protection, water supply, and waste sanitary disposal systems presently exist within the 300 Area with sufficient capacity to absorb the HFNS Facility requirements. In most instances provisions are necessary only for interconnection into these systems. In the case of the electrical system, the HFNS requirements can be met by modifications to the existing 300 Area substation. Therefore, the HFNS service support requirements would not cause additional environmental burden to the existing 300 Area support service systems.

The HFNS will provide the necessary irradiation testing capability for the development of materials and the generation of engineering test data on the behavior of those materials under fusion reactor irradiation conditions.

Long-term losses of resources that may occur due to construction and operation of the HFNS Facility appear to be miniscule by comparison to potential long-term national and short-term regional benefits. Effects on the nearby communities are beneficial due to the complementary time-phasing of the construction manpower demand. This demand will provide continued construction employment for approximately 100 workers at a time when manpower requirements for other major construction activities on the Hanford Reservation are declining, as projects are completed. Other environmental effects of HFNS construction and operation would appear to be primarily those associated with the human occupation of the site and are expected to be essentially fully contained within the 300 Area location. The additional burden, if any, will occur within an area that is presently being utilized for nuclear related activities.

7.3 Relationship of Proposed Action to Land Use Plans, Policies and Controls

The construction and operation of the HFNS does not appear to conflict with the applicable regulations of the United States, the State of Washington, or Benton County. The proposed site on the Hanford Reservation lies within an area designated by both the State and the County as being suitable for nuclear facilities. County zoning is for industrial use with nuclear facilities specifically permitted.

Construction and operation of the facility will be planned and executed in a manner that conforms to federal, state and local regulations, including those concerning air and water quality, industrial and occupational safety and transportation.

Indirect effects on housing requirements, commercial activity and community services are expected to be beneficial to the nearby cities because employment of construction and operations personnel will contribute to the regions economic base.

7.4 Construction and Operation Costs

The construction and operation of the HFNS will have a positive impact on the economic and societal values of the surrounding areas. The construction workers required for HFNS would not cause an increase in the total number of construction workers employed on major projects within the Hanford Reservation. Rather, construction of the HFNS would tend to provide an opportunity for continued employment as the major Hanford construction projects approach completion.

Essentially, all of the jobs required for the operational phase could be filled by reassignment of Hanford Engineering Development Laboratory (HEDL) personnel from within the laboratory. If additional personnel are hired, they would be replacing employes who had accepted employment outside of the area due to the forecasted declining trend in staffing needs for Breeder Reactor Program (BRP) efforts.

7.4.1 Costs of Construction

Based on HFNS approval as an DOE Construction Line Item Project for FY 1978, construction is scheduled to begin in 1979 with completion by mid-1982. The construction labor force is estimated to average about 75 workers with the peak employment of approximately 110 during calendar year 1981. HFNS construction is scheduled to begin during a period when construction manpower needs are lessening for major Hanford area projects. These projects are the Fast Flux Test Facility (FFTF), High Performance Fuels Laboratory (HPFL), Fuels and Materials Examination Facility (FMEF), and the Washington Public Power Supply System (WPPSS) nuclear power plan projects Washington Nuclear Plant WNP-1, WNP-2 and WNP-4. The total peak manpower demand, Figure 7.4-1, is expected to occur in early 1977 as the WPPSS construction activity is rising and before the FFTF manpower requirements begin to ramp down in late 1977, reflecting project completion in the latter half of 1978. The HPFL and FMEF manpower requirements tend to parallel the HFNS, but are relatively small and serve to aid in leveling the Hanford area construction manpower requirements.

The project dollar cost of construction is estimated to be approximately $70 million based on the initial conceptual design presented in Chapter 3.0

Cost estimates were made of the engineering, material and labor cost components for each of the buildings, the utilities, and engineered systems. A proposed schedule was developed based on realistic time spans for the various project activities, and the timing of actual expenditures was estimated. Escalation rates, appropriate for the Hanford area, were then applied to the engineering, material, and labor cost components. Finally, contingency factors were applied, consistent with the degree of design maturity, to arrive at the total estimated cost.

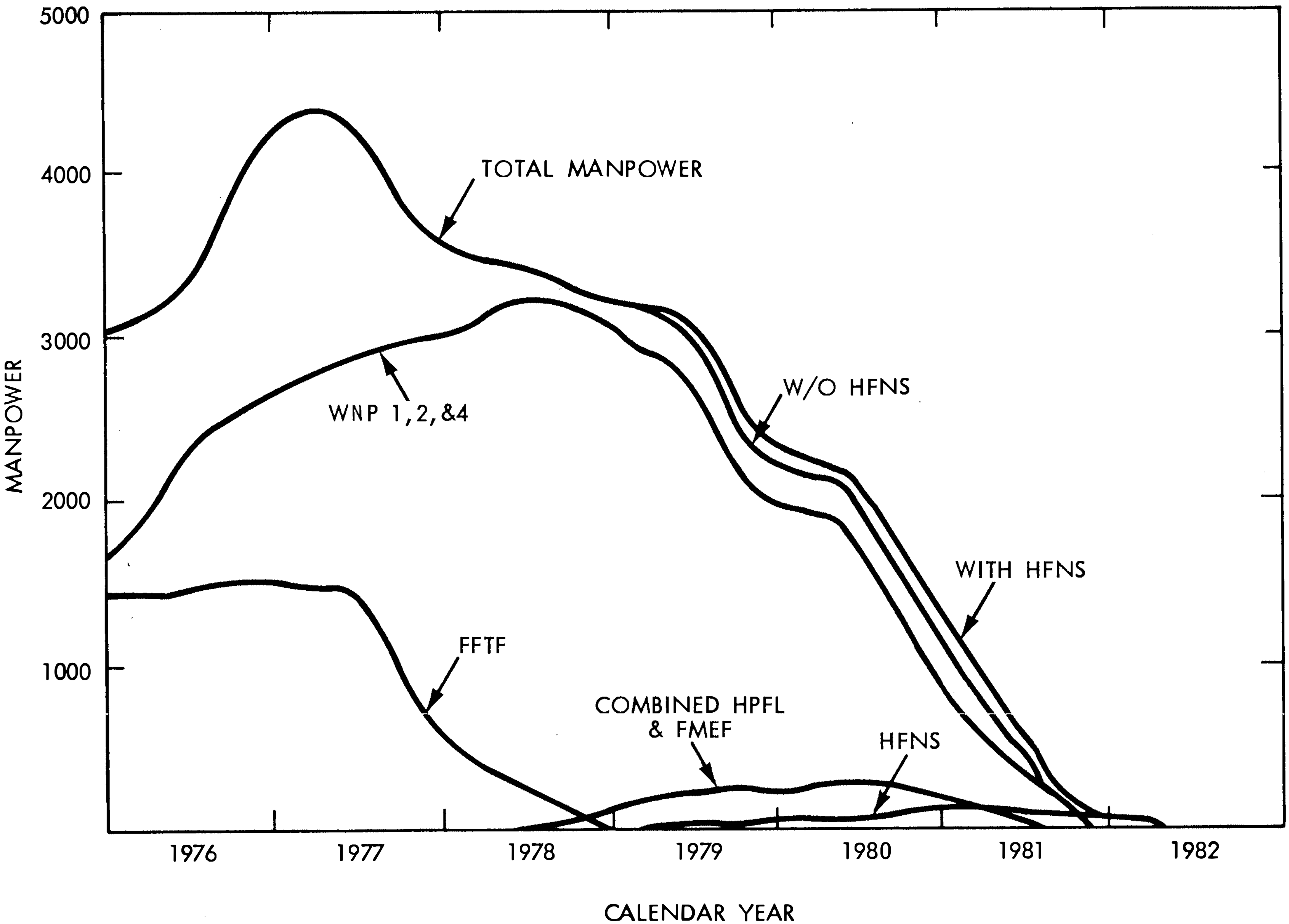

FIGURE 7.4-1. Hanford Reservation Major Construction Manpower Projections.

The estimated cost will again be evaluated in the reference concept phase of the HFNS engineering design prior to commitment of the project as a DOE Construction Line Item.

7.4.2 Costs of Operation

The facility is expected to operate on a four-shift, seven-day week and employ an operating staff of about 33 people for facility operations, testing, maintentance and management.

Operating costs, including supporting research and development costs, are estimated at approximately $9.9 million annually throughout the facility's 15-to-20 year useful life. Also included in the annual operating cost is the expense of special test fixtures and instrumentation to meet experimental needs. (Operating costs are given in 1976 dollars.)

7.5 Employment, Income and Staff Maintenance

The HFNS construction and operation employment will benefit the nearby urban areas, providing continued employment for construction manpower. Maintaining of employment in the primary job sector enables continued employment in the secondary job sector. Secondary jobs are those that are mainly in the service and retail trade areas such as gasoline station operators and attendants, grocery store clerks, TV repairman, etc.

Construction of the HFNS will require peak employment of approximately 110 workers with an average of about 75 workers over the three-year construction and installation period. A large percentage, if not all, of the construction work force will have been previously employed in the Tri-City area prior to the start of HFNS construction (Richland, Pasco, Kennewick located on the Columbia River in southeastern Washington State). A socioeconomic study conducted by Woodward-Clyde Consultants(1) for the WPPSS reports on a survey by Woodward-Clyde consultants(1) for the WPPSS reports on a survey by the Field Research Corporation of the building trades workers employed at the WNP-2 construction site on the Hanford Reservation. The survey reported that 85% of the construction workers indicated that they would attempt to seek similar work in the Tri-City area when their work at WNP-2 terminated.

Assuming the WNP-2 workers survey is indicative of the attitude of all the construction workers employed on major projects within the Hanford Reservation, a sufficient number of workers may be expected to remain in the Tri-City area to fill the projected labor requirements for construction of the HFNS Facility. HFNS construction will begin in early 1979, when Hanford construction manpower requirements will have declined from a 1977 level of about 4200 workers to approximately 3100 in early 1978. Therefore, construction of the HFNS Facility has the beneficial effect of providing employment for Tri-City construction craft workers. The personnel required for project management responsibility, approximately 18 professionals and four nonexempt personnel, may be transferred from HEDL FFTF construction management to HFNS project management. This would be accomplished as FFTF needs are decreasing. Though relatively minor, the sustaining effect on the overall Hanford project employment outlook is beneficial to the surrounding urban areas.

Operation of the HFNS will provide employment for approximately 33 professional and nonexempt personnel comprising the Operations, Irradiation Testing, and Maintenance and Service groups. In addition, staffing requirements for engineering development personnel to plan, design, conduct and evaluate the test program will begin buildup during the pre-operational period, reaching approximately 44 personnel in fiscal year 1988. This will decline after FY 1990 to approximately 24 personnel in the final year of operation. It is expected that these staffing requirements will be met by transferring suitable personnel to the HFNS project as they complete their responsibilities to the LMFBR program. The HFNS direct employment is illustrated in Figure 7.5-1. The sustaining of employment levels resulting from the HFNS project benefits the surrounding urban areas.

The income earned during the construction and operation phases of the HFNS will contribute toward maintaining the level of economic activity of the nearby area. Expenditures during construction for labor and materials, engineering support and project management are projected to total approximately $25 million to the local economy. This represents about 35% of the total project cost. However, since the wages and salaries paid during the construction and operational phases are not attributable to increased employment, the amounts are

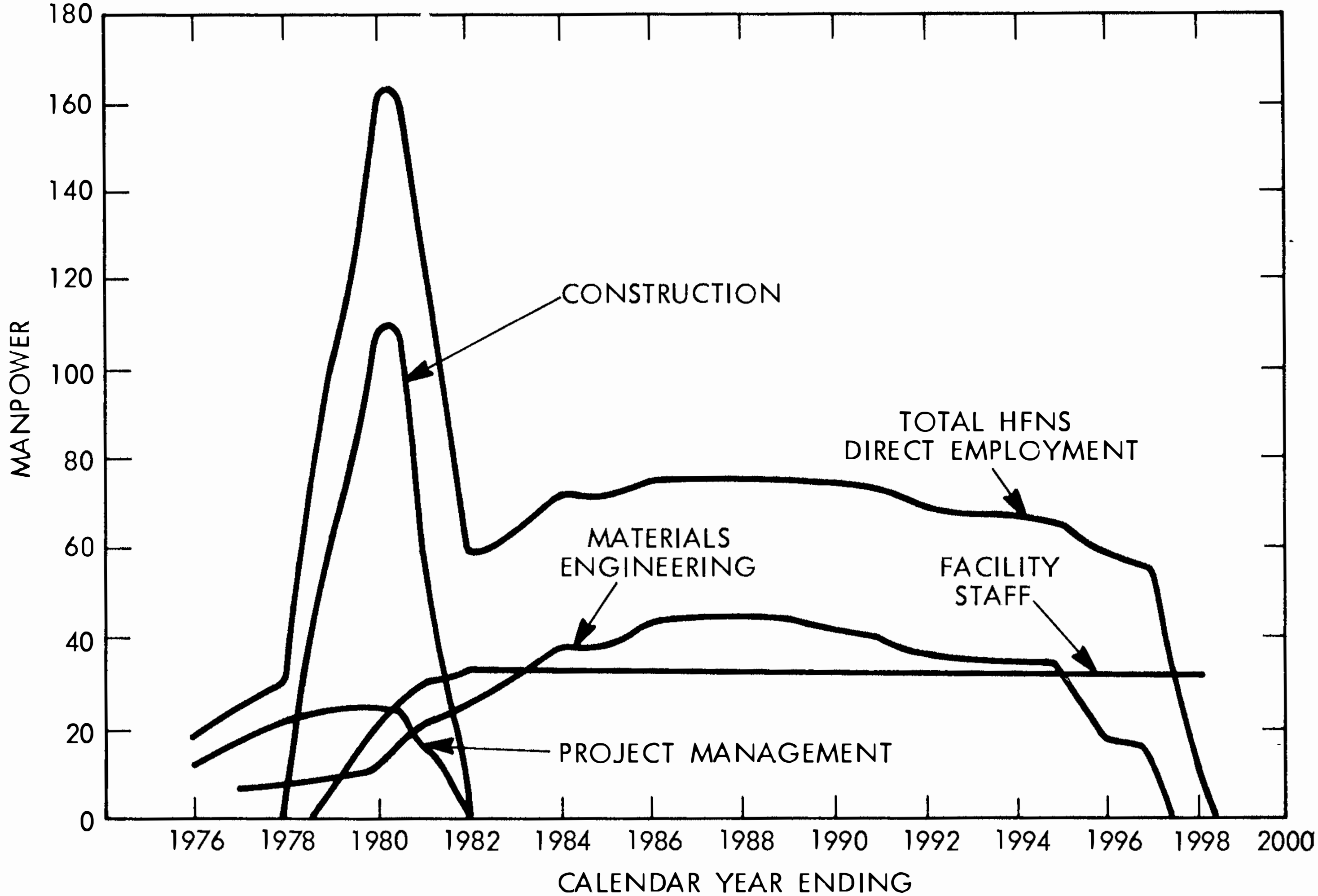

FIGURE 7.5-1. HFNS Direct Employment.

creditable as prolongation of previously existing economic support levels for the area.

7.6 REFERENCES

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8.0 EFFLUENT AND ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

8.1 Preoperational Environmental Program

Numerous studies[1] have been conducted which document the physical, ecological and radiological characteristics of the Hanford Reservation, including the 300 Area. These studies have included general observations and detailed analyses of the effects of nuclear reactor operation, fuel reprocessing, fuel fabrication and related activities in the Hanford environs. This existing program is sufficiently broad in scope to be sensitive to incremental impacts due to HFNS operations without modification of the program.

8.1.1 Air

8.1.1.1 Meteorological Data Base

Several sources of meteorological data are available within the Hanford Reservation. The principal source is the 622R meteorology tower, also known as the Hanford Meteorology Station (HMS) tower. This is a 408-foot tower that has been in operation since the mid-1940s to record temperature, humidity and wind velocity. The tower is located in a plateau near the center of the Hanford Reservation adjacent to the 200 West Area and about 19 miles northwest of the 300 Area.

From March 1974 to April 1976, meteorological data have been collected at the Washington Public Power Supply System Nuclear Plant No. 2 (WNP-2) site, approximately seven miles north-northwest of the 300 Area, using a 240-foot tower. A temporary meteorological system began collecting data at the same location during March 1972.

Since 1969, surface meteorological data have been obtained for the 400 Area about six miles northwest of the 300 Area at 13 feet above the ground surface. In addition, there is a 300-foot tower at N-Reactor, built in 1968, and a remote network of stations around the Reservation that measure wind velocity at about 15 feet above the ground surface.

8.1.2 Water

8.1.2.1 Surface Water

Samples of surface water have been collected from the Columbia River at several locations, as well as from waste water ponds and ditches at the Hanford Reservation, since the beginning of operations at Hanford. Integrated river water samples were analyzed to determine ^{3}H, gross alpha, gross beta, ^{131}I, ^{239}Pu, and gamma emitter activity levels.[2,3] Water quality measurements on river water included pH, dissolved oxygen, turbidity, coliform, fecal coliforms, biological oxygen demand and nitrate ion. Gross alpha, gross beta and gamma spectroscopy analyses were generally run on the pond and ditch samples.

River flow rates are obtained from continuous U.S. Geological Survey (USGS) river stage measurements at a gauge station immediately downstream from Priest Rapids Dam.[1] The river elevations are available immediately on site via telemetering. Continuous temperature monitoring is also done at the Priest Rapids gauge station and at Richland.

8.1.2.2 Groundwater

Approximately 1500 wells have been drilled at the Hanford Reservation to monitor groundwater. More than 30 wells are located within five miles of the 300 Area and another 22 wells are in the 300 Area.

Extensive environmental monitoring programs concerned with studying the physical, chemical, and radiological characteristics of the groundwater have been conducted.[1] It is expected that these programs will be continued routinely as part of the DOE program.

8.1.3 Land

Extensive data are available which describe in detail the geological formation, seismic properties, soil characteristics, and terrestrial ecology of the Hanford Reservation.[1]

8.1.3.1 Seismology

USGS has been actively engaged in performing seismic research on and surrounding the Hanford area since 1968.[1] The monitoring devices provide meaningful data for earthquake prediction, including measurement of strain buildup.

8.1.3.2 Terrestrial Ecology

Numerous studies have been conducted to classify the Hanford Reservation soils[(2)] (including the physical and chemical characteristics of the major series of soils[(3)]), the vegetation types present on the Reservation,[(1)] and the different species of mammals, birds, snakes, and insects to be found on the Reservation. Studies of the 300 Area, as part of the Hanford Reservation, were included in the above studies.

8.1.4 Radiological Surveys

Numerous special and routine studies of radioactivity in the Hanford environs have been conducted since the beginning of Hanford operations. Studies have been conducted of the exposure pathways in the Hanford environment.[(4)] The results of these studies constitute an unusually large amount of data which is available for review.

Preoperational data available include:[(1,5)]

Air - Gross beta, gross alpha, gamma emitting radionuclides, ^{90}Sr, ^{131}I, and ^{239}Pu.

Water - Gross beta, ^{3}H, NO_3, and gamma emitting radionuclides.

Land - Gamma emitting radionuclides, ^{90}Sr, and ^{239}Pu in soil and vegetation samples.

Foodstuffs - Gamma emitting radionuclides and ^{90}Sr, and ^{131}I in commercial and locally grown samples.

Wildlife - Gamma emitting radionuclides and ^{90}Sr in muscle tissue samples of deer and gamebirds.

External Radiation - Monthly measurements of the external radiation exposure with thermoluminescent dosimeters.

The results available provide a description of the present levels of radioactivity in the environment and a baseline to which future levels can be compared.

8.2 Planned Effluent Monitoring Programs

8.2.1 Exhaust Air Monitoring

Radioactivity (see Table 3.4-2) in air exhausted from the High Flux Neutron Source (HFNS) will be measured and recorded continuously by means of continuous air monitors (CAM). Assay of the amount of these radionuclides discharged into the atmosphere will be determined by analysis of a continuously drawn isokinetic sample of the effluent stream. Identification of gaseous radionuclides and chemical contaminants will be based on grab samples obtained in a manner appropriate to the material measured.

Only in the irradiations test cell air are significant levels of radioactivity anticipated. This atmosphere will be exhausted via the dump heat exchanger (DHX) stack after suitable holdup to assure that remaining radionuclide activity concentrations are within the limits specified for uncontrolled areas in DOE Manual Appendix 0524, "Standards for Radiation Protection." Should the CAM unit on the DHX stack indicate abnormal activity levels in the effluent, immediate steps will be taken to confirm the activity and to identify the source and take corrective action or cease operations.

The atmosphere of the lithium equipment rooms will be monitored with a CAM before release from the facility. Detection of radioactivity in this effluent stream will require action to confirm the activity and to locate the source and take corrective action or cease operations. This CAM will monitor beta-emitting particulate and gas activities.

The bulk of the conditioned atmosphere of the Test Building operating floor will be recirculated. To assure that contaminated air is not returned to the breathing air, a CAM unit will monitor the air just ahead of the return grill. Should activity be detected, the air will be discharged to the atmosphere and steps will be taken to confirm the reading and to identify the source of the activity and take corrective action. This CAM unit will measure beta-emitting particulate activity and gaseous activity.

Sample probes in the ducts will be designed to meet American National Standards Institute (ANSI) Standard N13.1-1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities."

In addition to the CAM units which will provide early warning of abnormal conditions, discharges will be sampled downstream of all exhaust air treatment. The air will be passed through appropriate collectors and analyzed weekly to determine beta-emitting particulate activity and tritium levels. These measurements, along with radioactive gas measurements from the CAMs, will become the official record of HFNS radioactivity releases and will be used to meet discharge reporting requirements of DOE Manual Chapter 0513, "Effluent and Environmental Monitoring and Reporting."

Exhaust from the vacuum pumps on the accelerator and lithium supply systems will be sampled routinely to evaluate tritium being discharged. Once steady-state conditions are achieved, tritium discharge will be constant so that periodic confirmation of tritium activity will be sufficient to determine routine tritium release levels. Samples of the stack effluent will be collected occasionally for determination of chemical contaminant concentrations. These data will also be used to meet reporting requirements of DOE Manual Chapter 0513.

8.2.2 Waste Water

The bulk of the waste water generated at the HFNS will be sanitary water and blowdown from the accelerator system cooling tower. Radioactive liquid waste will be collected and disposed of in the 200 Area by evaporation and storage in waste tanks (see Reference 1). Radioactivity will not normally be present in the cooling tower water. This or any other waste with a potential for contamination will be monitored prior to release from the HFNS. Should the monitor indicate radioactivity, the waste water will be retained for disposal as radioactive liquid waste and operations will cease until the source is located and the situation corrected.

300 Area Sanitary and Process sewers are presently monitored and will continue to be during the operation of the HFNS. Data from these monitors are used to meet reporting requirements of DOE Manual Chapter 0513.

8.3 Planned Environmental Impact Measurement Programs

A comprehensive environmental surveillance program designed to evaluate all significant potential pathways including, in particular, those resulting in direct exposure to the public and those wherein environmental reconcentration is likely to occur has been conducted for several years under the auspices of the DOE through its contractors. Summaries of the data and interpretations are published in a series of annual reports. Groundwater data and evaluations are reported in the series, "Environmental Monitoring Report on Radiological Status of the Groundwater Beneath the Hanford Site..." the latest issue being BNWL-2198 for 1976.[6] Data from locations within the plant boundaries are presented in the annual "Environmental Status of the Hanford Reservation for..." report series, the most recent report being BNWL-2246 for 1976.[7] Data from off-plant locations are presented in the annual "Environmental Surveillance at Hanford..." series of reports, the latest being BNWL-2142 for 1976.[5]

8.3.1 Air Evaluation

Present sampling efforts for air evaluation involve collecting particulate filters and iodine charcoal cartridges at 44 onsite and offsite locations. These provide 360° directional coverage at several distances plus background samples. Silica-Gel cartridges for collection of tritiated water vapor are situated at two onsite and two offsite locations. The frequency of sample collection and analysis is generally biweekly. Most of the iodine cartridges are not routinely analyzed but provide "in-place" sampling for emergency evaluation.

8.3.2 Water Evaluation

Presently, two weekly and two biweekly integrated samples of river water, three weekly integrated samples of river sanitary water, and one weekly and two monthly grab samples are collected from the river for analysis for radioactivity. Also, a continuous monitor of radioactivity in the river is maintained with an automatic alarm system and sampling capabilities.

8.3.3 Groundwater Evaluation

The groundwater is routinely measured at about 220 different wells for tritium, nitrate ion, and gross beta concentrations. Other specific radioanalyses are made at several locations. Sampling frequency varies from monthly to semiannually depending on the location of the well. In general, only the shallower, unconfined aquifer is sampled, but the deeper, confined aquifers are sampled at a few wells routinely.

8.3.4 Miscellaneous Evaluations

Several programs can be combined under the general categories of a) monitoring the radiological quality of the Hanford site and vicinity and b) the measurement of levels of radioactivity in various foodstuffs. The programs in the first category (which include soil and vegetation sampling, control plot surveys, road and railroad surveys, thermoluminescent dosimeter (TLD) penetrating dose measurements, waste water and burial ground audits, and aerial surveys) are primarily intended to measure the present levels of radioactivity in the environment and to determine whether containment and control of site operations are functioning as planned. Programs in the second category are primarily the measurements of radioactivity levels in milk, meat, eggs, poultry, vegetables, deer, game birds, and fish in the vicinity of Hanford and in oysters from Willipa Bay. Additional surveillance programs are conducted on a year-to-year basis as they become of interest.

It is expected that information available from the routine environmental surveillance program conducted under the auspices of DOE will provide sufficient environmental data to determine any observable environmental impacts from HFNS operations. The program is subject to modifications to place greater emphasis on potential problem areas and lesser emphasis on areas of lesser concern as warranted by Hanford ongoing and planned activities and by the data obtained from the program.

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7. J. J. Fix, et al., Environmantal Status of the Hanford Reservation for CY 1976, BNWL-2246, Battelle Pacific Northwest Laboratories, Richland, WA, May, 1977.

9.0 HFNS ACCIDENT ANALYSIS

The environmental consequences and probability of conceivable accidental conditions in the Deuterium-Lithium High Flux Neutron Source (HFNS) Facility were analyzed. The calculated maximum environmental consequences of postulated accidents would be low radiation doses to the lung, 3.7×10^{-1} rem 50-year dose commitment maximum to an individual and 2.9 person-rem whole-body 50-year dose commitment to the surrounding population.

In addition, the calculated total imposed environmental risk to individuals from all postulated accidental conditions (3.3×10^{-4} rem/year) is very low when compared to that received from natural background radiation (approximately 1.0×10^{-1} rem/year)[1] and when compared to current regulatory guidance for routine releases (5×10^{-1} rem/year).[2] Therefore, the design and operational plans for the HFNS are judged not to represent an undue environmental risk from accidental conditions.

9.1 Accident Analysis Philosophy

The HFNS is being designed to minimize the effect of credible accidental conditions. This safety design effort includes careful definition of the general scope and nature of the facility, the provision of specifically engineered safety features, and the institution of procedural and operational controls.

Even though safety is a design goal, facility operations may involve a small but finite potential for accidents in such areas as direct radiation, and the spread or release of radioactive contamination. Possible safety problems of a more conventional industrial safety nature (e.g., fire, explosion, release of toxic chemicals or gases) may involve a potential for personal injury, property damage or may result in radiological consequences.

The purpose of this section is to present an analysis of the HFNS design to assure that accidental conditions will not lead to undue hazards to individuals and the general population near the facility. This assurance would be given by determining that a postulated accident was incredible (due to the nature of the facility or its engineered safety features) or by determining that the consequences of that accident would be negligible. Whenever the analysis indicated that an accident could have significant environmental consequences and a high probability of occurring, a design change was made which would reduce that accident's probability or consequences.

The kinds of accidents considered in the analysis included process failures, equipment failures, failure to follow procedures, failure of engineered safety features, and effects of natural forces. To be certain that all accident conditions and consequences were adequately considered, the analysis began with a listing of accidents conceivable for the HFNS. A detailed cause and effect scenario was then developed for each accident. Using this scenario, the credibility (probability) of each accident was then analyzed. Finally, the consequences of any credible accident were analyzed. Radiation doses to man were used as the most significant reference for this analysis.

Methods of analysis were pertinent to the technological considerations of each scenario. They ranged from frequently used industrial reliability and probability calculations (often based on previous experience) to computer calculations of the movement of radioactive materials through environmental pathways. In the development of scenario details, and whenever a judgment needed to be made regarding a variable in the analysis, due to an uncertain technical basis, selections were made which led to maximum probability or consequences. This conservative approach assures that "worst case" conditions have been analyzed and that, should any of the postulated accidents actually occur, their consequences would be no greater than estimated here.

Once the analysis of all the accidents was completed, the environmental risk from an accident was defined from previous research as the product of the consequence from that accident and the probability of its occurrence. By use of this definition of risk, the accidents were compared on more or less the same basis, and their relative risks were determined. Further, the individual risk values were summed to give a total imposed risk to the public from possible HFNS accidents. This total imposed risk from accidents then yields a quantitative comparison to other risks such as those imposed by routine releases.

9.2 Selection of Accidents to be Analyzed

Accident conditions were selected for analysis by a careful review of the initial conceptual design of the HFNS. The review was directed toward the goal of assuring that no accident which could ever occur in HFNS' operating history would have worse consequences than accidents analyzed here. Also, the review was directed toward assuring that all kinds and numbers of accidents possible in the HFNS were considered. Previous research on safety in the design of accelerators and past safety experience in the nuclear industry were used extensively in the review.

Since the design of the HFNS is not yet final, the accident conditions have been purposely kept broadly scoped in nature. To place these conditions in a manageable form for analysis, a cause and effect scenario was developed based on the review described above. The scenarios are more generic than detailed. Therefore, all assumptions were made very conservatively toward maximum consequences and probability. Whenever regulatory guidance was available on accident conditions for use in safety analysis, this guidance was considered in selecting the accidents and developing the scenarios.

In reviewing potential accidents, aspects of the facility design were studied with respect to potential offsite hazards. Hazards judged to be excessive were reviewed as to methods of reducing their consequences to man. Design criteria were made to accomplish this reduction. An example of such a hazard was an occurrence involving a complete release of all of the radioactivity in the lithium supply system to the outside environs. The only credible events which could cause such a release were found to be earthquakes or tornados. Therefore, the facility will be designed to withstand all credible earthquakes and tornados to the degree necessary to ensure public and employee safety and protection of the environment.

Several other accidents were identified, considered, and then dropped from this discussion because of 1) incredibility of occurrence, 2) no identification of environmental consequences, or 3) coverage of their occurrence and consequences by analysis of another accident. Some accidents in this group are:

- Loss of beam tube vacuum pump (dropped on basis of engineered safeguards)
- Welding gas bottle failure resulting in radioactive release (dropped on basis of incredibility of occurrence)
- Valve on beam tube closes inadvertently (dropped on basis of no environmental consequences)
- Industrial fire (dropped on basis of no environmental consequences)

Some occurrences were reviewed and determined not to cause releases of radioactive material to the environment. Such incidents include accelerator beam misalignment with switchyard failure and breach of the accelerator cooling water systems and failure of electrical system components. In reviewing these accidents as well as others associated with the accelerator it was found that most accelerator accidents are of the common industrial types which produce no environmental hazards. The presence of high voltages and radiation constitute hazards which are now well understood and protected against throughout the user community. Ozone will be produced in significant quantities only in the event of an equipment failure, and can be immediately detected and safely handled by ventilation. Radioactive areas will be marked and their access controlled. A fail-safe interlock system will prevent access to hazardous areas or forestall operation if unsafe conditions in occupied areas can be produced.

Component failure or physical damage in the injector or injector beam transport system would not create a radiological hazard to the environment. Personnel exposure to high-voltage and to physical damage are safety problems to be considered in the facility design.

Component failure in the linear accelerator or exit beam transport system could be of radiological consequence if the failure resulted in a large fraction of the accelerated beam striking a machine component, producing a high secondary flux. Electrical current, water flow monitors and interlocks will anticipate an imminent breakdown and shut down the system before an untoward incident occurs. Furthermore, radiation monitors within the accelerator and exit beam transport enclosures will shut down the system within milliseconds if a rise in radiation level occurs, thus preventing excessive radiation levels outside the shielding or in the cooling and ventilating systems.

Under operating conditions, the accelerator and transport systems are closed and cryo- or getter-pumped, therefore, no evaporated or particulate matter can escape to the atmosphere. Any incident resulting in the production of trappable material would permit subsequent decontamination of the trapping surfaces.

Physical damage resulting from natural or man-made causes would be anticipated by seismometers, shock sensors, or acoustic monitors which will be used to shut down the system the same as would be done by the radiation monitors. However, physical damage resulting in the rupture of closed system cooling water lines would result in flooding of the basement areas under the accelerator with approximately 2500 gallons of water. This water could be mildly radioactive and would be held until the activity had decayed to levels acceptable for discharge to waste. There would be no release of radioactive materials to the environs.

Several of the accidents considered may have more than one possible scenario. In such cases the accident/scenario combination with the maximum radiological consequences was chosen and the probability for occurrence was adjusted for potential in several different circumstances.

9.3 Methodology

In assessing the source terms for accidents postulated in this section it was necessary to investigate the hazards involved with operation of the HFNS. Operations within the HFNS are characterized by high energy deuteron or neutron beams and activation products resulting from those beams. All of the accidents were related to releases of activation products to the environment and had associated risks limited by the availability of source term material. In these so called "source term limited" accidents, the radioactivity available for release was postulated to be released by the mechanism discussed for each accident. In each accident, the total radionuclide inventory of the system involved in the accident was analyzed and a release fraction was calculated considering physical and chemical form of the material and containment characteristics. The estimated airborne concentration, ventilation rate and duration of the accident were used to calculate the quantity of radioactivity available for release. Credit for building air cleanup systems was taken in those cases considered applicable. Removal efficiencies for these systems are noted in the individual accident scenarios.

In the calculation of doses for all accident cases, the maximum individual was assumed to be exposed to the release during the entire duration of the accident. This individual was conservatively assumed to be located at the site boundary closest to the HFNS Facility, (the Columbia River 0.3 mile away). These calculations used meteorological data from the Washington Nuclear Plant No. 2 (WNP-2) meteorological tower. The maximum individual dose calculations were based on a 95% cumulative frequency of occurrence centerline χ/Q for releases of 1-hour to 8-hours duration. The population dose calculation used joint frequency of occurrence meteorological data.

To insure conservatism on the dose calculation results, the form of radionuclide causing the highest dose (soluble or insoluble) per curie inhaled was assumed. All particulate activity that reached the environment was assumed to be of respirable size. Total body doses in the tables include both external and internal exposure components.

9.4 Accident Scenarios

9.4.1 Radioactive Gas System Failure

Air activated in the test cell will be ventilated to the radioactive gas system. This air will be retained in a holdup tank until the radionuclides decay to acceptable levels and then will be released to the environment. The maximum radionuclide inventory the holdup tank will contain is listed in Table 9.4-1.

TABLE 9.4-1

Equilibrium Radionuclide Levels in the HFNS Radioactive Gas System Holdup Tank

Radionuclides	Inventory (Ci)
^{13}N	0.80
^{14}C	0.0004
^{16}N	0.01
^{41}Ar	0.06
^{39}Ar	0.00006
^{40}Cl	0.004
^{37}S	0.006
^{3}H	0.0002

In this accident the release of the entire radionuclide content of the tank is postulated. The entire inventory was assumed to leak to the environment over a period of one hour except for that part removed by decay. Dose potentials for this release are shown in Table 9.4-2.

An occurrence probability of 4×10^{-4} per year was established on the basis of industrial equipment failure data.(3)

9.4.2 Loss of Test Cell Ventilation

Air in the test cell is continually ventilated to the radioactive gas system for holdup and decay. In the event that the ventilation were to fail, the radioactive gases in the test cell would slowly leak to other parts of the facility and eventually leak to the environment. The most probable failure of the ventilation system would be a loss of electrical supply to the facility. With a power outage to the facility, the accelerator will be inoperative

TABLE 9.4-2

Potential Radiation Dose Commitments Resulting From
Radioactive Gas System Failure

	Total Dose Commitments		
	Maximum Individual at 0.3 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	3.8×10^{-6}	3.8×10^{-6}	1.3×10^{-4}
GI Tract	3.8×10^{-6}	3.8×10^{-6}	1.3×10^{-4}
Thyroid	3.8×10^{-6}	3.8×10^{-6}	1.3×10^{-4}
Bone	3.8×10^{-6}	3.8×10^{-6}	1.4×10^{-4}
Lung	3.8×10^{-6}	3.8×10^{-6}	1.4×10^{-4}
Skin	6.2×10^{-6}	6.2×10^{-6}	2.1×10^{-4}

and the production of radioactive gases will cease. If the ventilation system were to fail for other reasons the accelerator would be shut down in order to stop the production of radioactive gases.

As a result of air activation by high energy particles, the test cell will contain the maximum radioactive gas inventory as shown in Table 9.4-3.

Table 9.4-3

Maximum Radioactive Gas Inventory in Test Cell

Radionuclide	Inventory (Ci)
^{13}N	8.4
^{14}C	0.00003
^{16}N	11.9
^{41}Ar	0.7
^{39}Ar	0.000005
^{40}Cl	0.27
^{37}S	0.13
^{3}H	0.00002

These radionuclides are assumed to slowly leak from the test cell into the environment over a period of eight hours. All of the activity is postulated to escape except for that which decays and no building cleanup systems are assumed to be operable. The resulting dose potentials are shown in Table 9.4-4.

The probability of occurrence was conservatively established to be 10^{-4} per year based on previous experience with electrical supply losses to emergency power busses at the Hanford Reservation.[4]

Table 9.4-4

Potential Radiation Dose Commitments Resulting From a Loss of Test Cell Ventilation

	Total Dose Commitments		
	Maximum Individual at 0.3 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	2.8×10^{-4}	2.8×10^{-4}	9.6×10^{-3}
GI Tract	2.8×10^{-4}	2.8×10^{-4}	9.6×10^{-3}
Thyroid	2.8×10^{-4}	2.8×10^{-4}	9.6×10^{-3}
Bone	2.8×10^{-4}	2.8×10^{-4}	9.6×10^{-3}
Lung	2.8×10^{-4}	2.8×10^{-4}	9.6×10^{-3}
Skin	4.6×10^{-4}	4.6×10^{-4}	1.6×10^{-2}

9.4.3 Accidental Releases of Lithium

Liquid metal system failures and spill accidents in the HFNS pose potential hazards due to buildup of activation products in the lithium system. Failure modes of sodium systems have been investigated extensively by the Hanford Engineering Development Laboratory (HEDL) and others. Sodium-air and sodium-concrete reactions have been well-characterized for both small and large spills. The consequences of spills in large systems such as the Fast Flux Test Facility (FFTF) have been analyzed in depth in a variety of safety studies.[5] A comparable depth of background of lithium experience does not exist. However, several comparisons can be drawn. For example, one would expect a lithium fire to be more difficult to start than a sodium fire; to be more exothermic and to possibly burn at higher temperatures; and to react with a wider range of materials and be more difficult to extinguish. The lithium system for the HFNS Facility would have a relatively large safety margin for leakage compared with most liquid metal systems due to its low operating temperatures and pressure. The relatively small equipment sizes and inventory of lithium in the HFNS compared to many other liquid metal systems in operation reduces the consequences of a spill.

Several protective features will control and minimize the effects of lithium spills. High integrity of the stainless steel piping and vessel, which provide containment for the lithium, will be a principal safety requirement. The lithium system will be designed and fabricated in accordance with American Society of Mechanical Engineers (ASME) Nuclear Power Plant component code classification and will be subjected to rigid inspections and quality control procedures. The extensive analyses and experiments conducted on the FFTF project have led to the conclusion that even if a piping defect escaped detection and was large enough to grow, it would first penetrate the wall, would leak, and the leak would be detected long before the pipe could possibly rupture.[5] The HFNS Facility will provide redundant measures for early detection and control of lithium leaks.

These design features provide for automatic shutdown of the accelerator and lithium systems, draining of the lithium supply, isolation of the affected equipment room, and flooding with an inert gas purge and venting through a fume scrubber system.

Because of the many safeguards to detect and prevent large lithium leaks, conceiving an accident which could lead to a rupture of the lithium system and complete loss of all lithium is extremely difficult. However, due to the potential radionuclide inventory in the lithium system, the consequences of a breach of the lithium system were analyzed.

The complete rupture of a pipe in the lithium system was assumed to occur causing a spill of the entire contents of the active lithium loop (750 gallons) containing 70,000 Ci of ^{7}Be and 37,000 Ci of ^{3}H, the expected maximum inventories. It is further assumed that the lithium would ignite and burn (no credit taken for inert gas purge) with 50% of the lithium going off as an aerosol containing ^{7}Be.[6] Ninety percent of the aerosol is assumed to plate out on room walls and exhaust ducts.[6,7,8] All tritium is assumed to be released from the lithium. The building transmission factor for ^{7}Be and ^{3}H is 1.5×10^{-1} (scrubbers).[9,10] Using these assumptions, 525 Ci of ^{7}Be and 5550 Ci of ^{3}H are released to the environment by this incident. Dose potentials resulting from this occurrence are shown in Table 9.4-5.

The maximum consequences to an individual working in the 300 Area of the Hanford site from this worst postulated accident (total loss of lithium) would be a 2.1 rem 50-year dose commitment to the lungs. This assumes that the individual is in the closest building which is located 600 feet away. This dose assumes no evacuation and that the individual remains in the radioactive plume for the duration of the accident. In actuality all persons working in the 300 Area would be expected to evacuate immediately to a location not effected by the accident.

More realistically, a leak in the lithium system would be expected to develop slowly and would be detected by leak and smoke detectors. The leak at the expected alarm limit for alkali metal ionization detectors is 10^{-11} g of lithium per cm^3 of air. This level is equivalent to 4.8×10^{-7} mCi $^{7}Be/cm^3$

Table 9.4-5

Potential Radiation Dose Commitments as a Result of
Total Loss of Lithium

	Total Dose Commitments		
	Maximum Individual at 0.3 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	8.5×10^{-2}	8.5×10^{-2}	2.9
Lung	3.7×10^{-1}	3.7×10^{-1}	12.7
Bone	2.2×10^{-1}	2.2×10^{-1}	7.4
G.I. Tract	7.5×10^{-2}	7.5×10^{-2}	2.6

of air and 2.5×10^{-7} μCi $^{3}H/cm^{3}$ of air at maximum expected radionuclide concentrations (the values compare with controlled area radioactivity concentration guides of 1×10^{-6} $\mu Ci/cm^{3}$ for ^{7}Be, and 5×10^{-6} $\mu Ci/cm^{3}$ for ^{3}H). The maximum air flow from the lithium supply system is through the dump heat exchanger (DHX) stack at 200,000 lbs/hr. If a minimum detectable leak in the DHX occurs, the release rate of radioactivity would be equivalent to 0.87×10^{-3} Ci/min of ^{7}Be and 0.46×10^{-3} Ci/min of ^{3}H. If it is assumed that ten minutes elapses before corrective action is initiated 8.7×10^{-3} Ci of ^{7}Be and 4.6×10^{-3} Ci of ^{3}H would be released to the environment. Upon detection of a leak, immediate automatic shutdown of the accelerator and lithium systems will occur, with draining of the lithium supply system into the dump tank and flooding of the DHX with argon gas. If it is assumed that the leak can continue at its detected rate for another 30 minutes, an additional 3.9×10^{-3} Ci of ^{7}Be and 13.8×10^{-3} Ci ^{3}H will be vented to the environment through the scrubber system (transmission = 1.5×10^{-1}). The dose potentials for this occurrence are shown in Table 9.4-6.

An occurrence probability of 2.5×10^{-2} per year for a leak in the system was established on the basis of a 1966-74 Hanford Summary of unplanned releases to the environs.(11) Due to the rigid design and quality control procedures in the construction of the lithium system and the low temperatures and pressures at which it will operate, the probability of a rupture of the lithium piping is estimated to be less than 10^{-6} per year based on information presented in the FFTF FSAR.(5)

9.4.4 Experimental Test Module Malfunction

A sodium-potassium (NaK) liquid metal coolant system may be utilized to support experimental tests. This equipment would be located in the Test Building service cell. Despite the design and procedural safeguards associated with the fabrication and use of this cooling system, minor leaks could develop during the lifetime of the facility.

Through corrosion or stress cracking the cooling system is postulated to leak its contents into the service cell environment. A fire results and the radioactive activation products in the NaK are released to the room air. The NaK coolant could contain up to 80 Ci, ^{22}Na; 2 Ci, ^{24}Na; 3 Ci, ^{38}Cl;

Table 9.4-6

Potential Radiation Dose Commitments as a Result of Lithium System Leak

	Total Dose Commitments		
	Maximum Individual at 0.3 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	1.1×10^{-6}	1.1×10^{-6}	3.8×10^{-5}
Lung	8.0×10^{-6}	8.0×10^{-6}	2.8×10^{-4}
Bone	4.2×10^{-6}	4.2×10^{-6}	1.4×10^{-4}
G.I. Tract	8.1×10^{-7}	8.1×10^{-7}	2.8×10^{-5}

11 Ci; ^{41}Ar, 4 Cl, ^{42}K. Approximately 50% of the Na and K would be released in the aerosol form with 90% being plated out on walls and ventilation ducts.[6,7,8] Therefore, it is conservatively assumed that 4 Ci of ^{22}Na, 1×10^{-1} Ci of ^{24}Na, and 2×10^{-1} Ci of ^{42}K are released to the environment (no credit taken for the HEPA filter on the service cell exhaust). All of the ^{41}Ar and ^{38}Cl is assumed to be released to the environment. The resulting dose potentials are shown in Table 9.4-7.

The probability of occurrence was established to be less than 2.5×10^{-2} per year based on industrial equipment failure data for corrosion and stress cracking[4]

A viewing window oil fire was also considered as a potential accident scenario for release of radionuclides from a NaK cooling system. This accident would have the same consequences as are given for the Experimental Test Module Malfunction and the probability of occurrence is much less.

9.4.5 Transportation Accidents

This section discusses the potential accidental environmental impact associated with transportation of materials to and from the HFNS. Environmental impact from on-site accidents is analyzed. The transportation requirements used in these accident analyses are representative for future years. While the exact numbers of any particular shipment may vary, no marked change in the overall transportation requirements is expected in the foreseeable future.

Operation of the HFNS requires that some radioactive materials be transported away from the facility. These shipments will consist of lithium contaminated with ^{7}Be and ^{3}H, the waste ^{3}H contained in the Zr-Al getter units, activated experimental hardware and lithium target assemblies.

Approximately 20 lithium samples will be shipped between HFNS and 300 Area support facilities per year. Each sample can be expected to contain about 2.5 Ci of ^{7}Be and 1.3 Ci of ^{3}H. Four Zr-Al getters will be transported each year. These getters will contain approximately five Ci each of ^{3}H. Activated experimental assemblies will consist of metals such as steel irradiated by the neutron beam. A typical test specimen will contain 5000 Ci of radioactivity, mainly ^{51}Cr, ^{55}Fe, ^{57}Ni, and ^{60}Co. Target assemblies will be shipped twice per

Table 9.4-7

Potential Radiation Dose Commitments Resulting From

Experimental Test Module Malfunction

	Total Dose Commitments		
	Maximum Individual at 0.3 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	1.2×10^{-2}	1.2×10^{-2}	4.1×10^{-1}
G.I. Tract	1.2×10^{-2}	1.2×10^{-2}	4.1×10^{-1}
Thyroid	1.2×10^{-2}	1.2×10^{-2}	4.1×10^{-1}
Bone	1.2×10^{-2}	1.2×10^{-2}	4.1×10^{-1}
Lung	1.2×10^{-2}	1.2×10^{-2}	4.1×10^{-1}
Skin	1.8×10^{-3}	1.8×10^{-3}	6.2×10^{-2}

year. These targets will contain approximately 500 Ci of radioactivity. Radioactive materials will be transported from the HFNS by truck. Some potential exists for a fire involving the transport vehicle and its fuel. The worst transportation accident was assumed to involve the collision of a gasoline transport vehicle with a transport vehicle carrying samples or Zr-Al getters from the HFNS. Gasoline was assumed spread over both vehicles, and the vehicles and contents were assumed to be burned.

A release fraction of 100% for radioactivity contained in lithium samples and Zr-Al getters was assumed. No release is expected from the solid experiment or target assemblies, due to the nature of the material irradiated and the packaging requirements for such highly radioactive samples. Thus, for an accident involving the yearly shipments of lithium samples 2.5 Ci of ^{7}Be and 1.3 Ci of ^{3}H would be released to the environment without filtration. For the accident involving Zr-Al getters, 20 Ci of ^{3}H would be released to the environment. The resulting dose potentials are shown in Tables 9.4-8 and 9.4-9. The probability of these unlikely accidents is calculated by assuming that each shipment travels 25 miles or less. Multiplying the number of transportation miles per year from these data by the probability of an accident per mile[(12)] yields a probability of 2×10^{-8}/year for accidents involving lithium sample shipments and 4×10^{-9}/per year for the accidents involving transportation of Zr-Al getters.

9.4.6 Accelerator Beam Tube Failure Involving Air-Lithium Reaction

The beam tube for the accelerator operates at a pressure of approximately 10^{-7} Torr. The target for the production of neutrons will contain a hydraulically stable, downward flowing film of lithium exposed to deuterons traveling in the beam tube. The beam tube will contain a series of gate valves which will automatically close upon fault signals from radiation monitors, pressure or seismic sensors. Therefore, the small amounts of air which could leak into the beam tube-target interface would not be expected to result in significant air-lithium reactions at the beam tube-target interface. However, it is possible to hypothesize a catastrophic failure of the beam tube with a rapid influx of air to the lithium target. This would result in an air lithium reaction and an associated release of ^{7}Be and ^{3}H. The

Table 9.4-8

Potential Radiation Dose Commitment Resulting From Transportation Accidents (Zr-Al Getters)

	Total Dose Commitments		
	Maximum Individual at 0.06 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	1.3×10^{-3}	1.3×10^{-3}	2.2×10^{-3}
Lung	1.3×10^{-3}	1.3×10^{-3}	2.2×10^{-3}
Bone	1.3×10^{-3}	1.3×10^{-3}	2.2×10^{-3}
Thyroid	1.3×10^{-3}	1.3×10^{-3}	2.2×10^{-3}

Table 9.4-9

Potential Radiation Dose Commitments Resulting From Transportation Accident (Lithium Samples)

	Total Dose Commitments		
	Maximum Individual at 0.06 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	2.2×10^{-3}	2.2×10^{-3}	3.7×10^{-3}
Lung	3.5×10^{-2}	3.5×10^{-2}	6.0×10^{-2}
Bone	1.8×10^{-2}	1.8×10^{-2}	3.1×10^{-2}
G.I. Tract	1.0×10^{-3}	1.0×10^{-3}	1.7×10^{-3}

target area would be automatically bypassed and isolated, limiting the total amount of lithium which would be available for reaction. The time involved to initiate isolation would allow approximately ten gallons of lithium to react with air. In addition, another ten gallons of residual lithium will be available for reaction. Therefore, 20 gallons of lithium could react with air. Maximum expected radionuclide levels in the lithium would be 1880 Ci of ^{7}Be and 1000 Ci of ^{3}H. One-half of the lithium is assumed to go off as an containing ^{7}Be and 90% of the aerosol is assumed to plate-out on room walls and exhaust ducts.[6,7,8] All of the ^{3}H is assumed released. Using these assumptions 94 Ci of ^{7}Be and 1000 Ci of ^{3}H would be released to the environment. Dose potentials resulting from this occurrence are shown in Table 9.4-10.

An occurrence probability of 4×10^{-4} per year[3] was established on the basis that the only credible mechanism for the initiation of such an event would be a large magnitude earthquake (>0.125 g) as shown in Table 4.3-2 "Approximate Relation Connecting Earthquake Intensity with Acceleration".

9.5 Consideration of HFNS Accidental Environmental Risk

To evaluate the overall environmental risk represented by accidental conditions, both the consequences of an accident and its likelihood (probability) must be considered. Facility design or engineered safeguards must be provided to assure that any accident having severe consequences should have a very remote chance of occurring. Conversely, any accident calculated to have a high probability must have insignificant consequences. Otherwise additional design or procedural control effort is required. Analysis of each of the credible accidents demonstrates that the maximum off-site consequences would be low radiotoxic doses of 3.7×10^{-1} rem 50-year dose commitment to the lungs of an individual and 2.9 person-rem whole-body 50-year dose commitment to the surrounding population. The maximum on-site consequences would be low radiotoxic doses of 2.1 rem 50-year dose commitment to the lung of an individual.

A further perspective to the two variables of consequences and probability is gained by formation of a risk index, the product of consequences (in this case, dose) and probability. Risk indices for the postulated HFNS accident

Table 9.4-10

Potential Radiation Dose Commitments Resulting From Accelerator Beam Tube Failure Involving Air Lithium Reaction

	Total Dose Commitments		
	Maximum Individual at 0.3 Mile		50-Year Population Dose Within 50 Miles
Organ of Reference	One-Year Dose (rem)	50-Year Dose (rem)	Year 2000 Population (Person-rem)
Total Body	1.5×10^{-2}	1.5×10^{-2}	5.2×10^{-1}
Lung	6.6×10^{-2}	6.6×10^{-2}	2.3
Bone	3.9×10^{-2}	3.9×10^{-2}	1.3
G.I. Tract	1.3×10^{-2}	1.3×10^{-2}	4.5×10^{-1}

conditions are given in Table 9.5-1 for both the off-site maximum individual and the surrounding population.

A summation of all the risk indices has been defined by previous research (conducted for the Nuclear Regulatory Commission) as the total imposed environmental risk of the facility from accidental conditions.[13] Since no regulatory guidance is presently available as to the absolute risk acceptable from accelerator facilities, the fact that the HFNS accidental risk index for the maximum individual (3.3×10^{-4} rem/year) is much less than regulatory guidance for routine release risks (5×10^{-1} rem/year with a probability of one)[2] is used to indicate that accidental conditions from HFNS operation represent a very low environmental hazard. Also the total imposed risk is less than 0.02% of the risk caused by natural background dose (1.0×10^{-1} rem/year with a probability of one)[1] and the maximum individual exposure from a single accident is less than guidance given in 10 CFR 100 (25 rem whole-body, 300 rem thyroid) for reactor accidents of very low probability.

Based on the calculated maximum doses and supported by the consideration of risk indices, the initial conceptual design and planned operation of the HFNS represent a very low environmental risk from accidents at the facility.

Table 9.5-1

Annual Environmental Risk From Postulated HFNS Accidents

Accident	Contaminant	Maximum Individual: Critical Organ	Maximum Individual: Dose (rem)	50 Year Population: Critical Organ	50 Year Population: Dose ÷ 50 (person-rem)	Release Probability ($year^{-1}$)	Relative Annual Risk: Individual (rem/year)	Relative Annual Risk: Population (person-rem/year)
Radioactive Gas System Failure	Air Activation Products	Skin	6.2×10^{-6}	Skin	2.1×10^{-4}	2.5×10^{-2}	1.55×10^{-7}	5.3×10^{-6}
Loss of Test Cell Ventilation	Air Activation Products	Skin	4.6×10^{-4}	Skin	1.6×10^{-2}	10^{-4}	4.6×10^{-8}	1.6×10^{-6}
Lithium System Leak	^{7}Be, ^{3}H	Lung	3.7×10^{-6}	Lung	2.8×10^{-4}	2.5×10^{-2}	9.3×10^{-8}	7.0×10^{-6}
Total Loss of Lithium	^{7}Be, ^{3}H	Lung	3.7×10^{-1}	Lung	12.7	$<10^{-6}$	$<3.7 \times 10^{-7}$	$<1.3 \times 10^{-5}$
Experimental Test Module Malfunction	Activated NaK	Total Body	1.2×10^{-2}	Total Body	4.1×10^{-1}	2.5×10^{-2}	3.0×10^{-4}	1.0×10^{-2}
Transportation Accident (Zr-Al getters)	^{3}H	Total Body	1.3×10^{-3}	Total Body	2.2×10^{-3}	4×10^{-9}	5×10^{-12}	8.7×10^{-12}
Transportation Accident (Lithium Samples)	^{7}Be, ^{3}H	Lung	3.5×10^{-2}	Lung	6.0×10^{-2}	2×10^{-8}	7×10^{-10}	1.2×10^{-9}
Accelerator Beam Tube Failure Involving Air Lithium Reaction	^{7}Be, ^{3}H	Lung	6.6×10^{-2}	Lung	2.3	4×10^{-4}	2.6×10^{-5}	9.2×10^{-4}
	TOTAL					Bone	1.4×10^{-4}	1.0×10^{-2}
						Lung	3.3×10^{-4}	1.0×10^{-2}
						Total Body	3.0×10^{-4}	1.0×10^{-2}
						Skin	4.5×10^{-5}	1.6×10^{-3}

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10.0 ALTERNATIVES TO THE PROPOSED FACILITY

The Deuterium-Lithium High Flux Neutron Source (HFNS) Facility will fulfill a key mission in the plan for attaining commercial fusion power and providing the test capability for determining the adequacy of materials for fusion reactor construction. A number of alternatives with environmental implications were considered in developing the initial conceptual design of the HFNS facility. These alternatives included consideration of: 1) abandoning the project; 2) postponing the project; 3) alternatives to the facility design; 4) alternatives to the facility sites and; 5) modification of existing facilities. However, these alternatives would entail either higher costs, greater environmental or socioeconomic impact, or decreased benefits compared to proceeding with the basic HFNS Facility design selected for the Hanford Reservation's 300 Area.

10.1 Abandoning the Project

If the HFNS project were abandoned, the small short-term environmental impacts associated with construction and operation of the HFNS at Hanford would be avoided. However, fusion energy is considered one of the best potential solutions to the problem of meeting the nation's and the world's long-term energy needs. Since the HFNS is essential to meeting the design data needs of the demonstration fusion power reactors planned for about 1990, abandonment is not a reasonable alternative.

The U.S. and world fusion programs are projecting large fusion experiments in the late 1970s to resolve outstanding physics problems. An engineering phase will follow, with experimental test reactors and demonstration plants leading to commercial fusion power about the turn of the century. One could consider designing and building these reactors using materials irradiation data from fission test reactors, complemented by data produced from other fusion neutron source projects already underway. However, fission reactor data cannot be used directly, because of the differences in the neutron energy spectra of fission and fusion reactors, without extensive irradiation data from HFNS or other irradiation sources simulating fusion environments. The 14-MeV source neutrons from the deuterium-lithium (D-T) reaction may well cause marked differences in materials behavior from that experienced in fast or thermal fission reactors. Consequently, the adequacy of materials for fusion reactor construction can be determined only by testing under conditions similar to these encountered through service in a fusion neutron environment.

The fusion neutron sources now available or planned for near-term operation are limited to small sample irradiation tests, and are not suitable for accelerated testing of materials to component lifetime fluences. The history of the development of both thermal and fast fission reactors emphasizes the need for timely test data concerning irradiation effects on component materials. Data at low fluence have provided misleading information; only irradiation effects data at component lifetime fluences clearly have defined the problems. Abandoning the HFNS project would preclude the gaining of such lifetime fluence data.

A reason not to pursue the HFNS project would be the possibility that its technical basis is incorrect and that the design goals will not be met. However, four Department of Energy (DOE) laboratories have conducted detailed, independent investigations of alternate methods for meeting the HFNS programmatic objectives. They are: Hanford Engineering Development Laboratory in association with William M. Brobeck & Associates; Brookhaven National Laboratory; Oak Ridge National Laboratory in association with the Fermi National Laboratory; and the Lawrence Livermore Laboratory in association with the Lawrence Berkeley Laboratory. They all agreed that the most practical method of obtaining the intense neutron fluxes required is by using a high energy beam of deuterons produced by a linear accelerator to generate neutrons through a stripping reaction in a flowing liquid metal target. The HFNS design is based on this principle of operation. In addition, two independent ad hoc panels of technical experts from other national laboratories and universities in: 1) accelerator design, operation and liquid metal technology; and 2) materials irradiation testing technically evaluated the proposed HFNS concepts. These panels reached several significant conclusions: 1) that current linear accelerator designs can be extended to the proposed operating conditions; 2) that the lithium system is within the limits of current technology (with the exception of the target assembly where substantial R&D is already underway to confirm extrapolations from existing state-of-art); and 3) that irradiations in a deuterium-lithium HFNS will indeed provide a good simulation of the radiation damage expected in fusion reactors.

There are preliminary indications of interest in constructing testing facilities similar to the HFNS in other countries. However, there are no firm plans. Thus no foreign facilities will provide the testing capabilities afforded by the HFNS.

The short-term, socio-economic effects of not building the HFNS would affect the surrounding Tri-City area, whereas, the long-term effect would impact not only our nation but the entire world. Probable short-term effects would be an increase in unemployment, and a decline in the overall economic activity of the area. The long-term effects would be felt by the nation and the world through increasing the cost of, or delaying, a demonstration fusion reactor and threatening the promise of achieving economical fusion power.

10.2 Postponing the Project

The HFNS is an integral part of DOE's plan for the development of fusion power in which demonstration reactors are planned for about 1990. The only option for obtaining necessary materials data prior to beginning the first demonstration plant design is the combination of HFNS and fission reactors. Delay of HFNS would result in either commitment of the demonstration plant design without the desired design data base, or a corresponding slip to the demonstration program and the attainment of commercial fusion power. The first option could result in an overly conservative plant design and high capital costs. Neither this risk to commercialization, nor a slip in the overall fusion program which would impact the national goal of self-sufficiency, appears responsible.

The project could be delayed until completion of requisite R&D in key areas, such as the accelerator injector and lithium target assembly development. The design of the injector will be based on proved features of prior devices. The design measures which must be incorporated to permit the continuous mode of operation necessary for the HFNS appear amenable to straight-forward engineering solutions. Moreover, limited testing of a prototype injector is planned to demonstrate meeting of beam requirements. Analytical and experimental programs are already underway at national laboratories, universities, and industrial research centers addressing the thermal hydraulic performance of the lithium target assembly. Preliminary overall scopes and schedules for these programs have been prepared. In both areas technical milestones fully support construction of the HFNS, as an DOE Construction Line Item Project for FY 1978. The resolution of key questions, then, can be assured prior to the commitment to construction. Consequently, there appears to be no gain in postponing the project.

It is anticipated that much of HEDL's ongoing breeder reactor work will be transferred from the 300 Area as new facilities are completed in the 400 Area of the Hanford Reservation. The HFNS Facility design already benefits from the maximum use of existing 300 Area buildings to support HFNS operations. None of this use conflicts with breeder reactor activities due to their scheduled availability. Therefore, there appears to be no beneficial environmental consequences to postponing the project, particularly because all of the land affected by HFNS construction has already been disturbed by other 300 Area activities.

Delay in the construction and operation of the HFNS for more than approximately two years would have a negative effect on the socio-economic system of the surrounding Tri-City area. After approximately two years the available construction labor force would have found other work either within the surrounding area or outside of the area. Thus, the required skilled labor pool would not be immediately available.

10.3 Alternatives to the Facility Design

The HFNS Facility description is based on an initial conceptual design and reflects features that involved a choice between alternative measures to minimize and contain effluents that have the potential for a small degree of environmental impact. The alternatives investigated included engineered design features and procedural safeguards to minimize environmental hazards during and after conceivable natural occurrences and accidents, as well as during normal operation.

Where a potential impact was judged potentially significant, quantitative engineering studies were performed to scope the magnitude of pollutant source terms, their release fractions and the consequences. When these analyses indicated a significant difference in environmental consequences or probability of occurrency between alternative design choices, the selection of the preferred solution was based on the philosophy of as near zero release to the environment, or as low as practicable (ALAP).

Nevertheless, certain design alternatives were identified by HEDL and the other three DOE laboratories who conducted independent conceptual design studies of the HFNS Facility which deserve further comparative evaluation. This is true particularly with respect to their relative merits in reducing releases of radioactivity or other pollutants to the environment as compared with their costs. These design alternatives include:

- alternative irradiation test cell atmospheres such as air, inert gas, vacuum (to minimize the most significant active pollutants during normal operation);
- changes in the radioactive gas system such as increasing its capacity (to provide additional decay of radioactive species prior to their release to the environment);
- use of an intermediate heat exchanger system (to reduce the consequences of a lithium spill accident by further isolating the radioactive lithium system from the environment);
- use of inert gas filled cells (to further reduce the probability of a fire following a postulated lithium spill accident);
- providing a cleanup system(s) for the lithium supply (to minimize the amount of entrained radioactive tritium and ^{7}Be);
- sealing the shielded acceleration room, beam transport tunnel, and beam diverter switchyard during operation, and restricting access after shutdown (to permit decay of short-lived radioisotopes induced in the air in these areas rather than permitting continuous release during operation);
- alternative methods of dissipating HFNS waste heat (specific consideration will also be given to utilizing this waste energy for facility space heating and possibly cooling).

The program plan for the HFNS Facility specifically provides an Advance Title I period during the HFNS preliminary engineering design phase to examine and evaluate these alternatives thoroughly. These considerations will be thoroughly documented, and all findings will be reported in the Advance Title I Report for the HFNS Facility.

10.4 Alternatives to the Facility Site

Alternative facility locations were examined to determine whether any other sites are preferable to constructing the HFNS Facility in the Hanford Reservation's 300 Area. A preferable site would be one that offers the potential for reduction of environmental impact from facility construction and operation. Alternatives considered include other DOE national laboratories and various other locations within the Hanford Reservation.

10.4.1 Site at a National Laboratory

In the selection process for the HFNS contractor/site, DOE evaluated proposals from four major DOE laboratories as potential sites for the HFNS Facility. These were the Hanford Engineering Development Laboratory (HEDL) at Richland, Washington; Brookhaven National Laboratory (BNL) at Upton, New York; Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tennessee; and the Lawrence Livermore Laboratory (LLL) at Livermore, California. HEDL was selected primarily on the basis of technological considerations; however, the issue of site environmental considerations was also addressed. It was found that in view of limited potential for significant environment impact due to the facility construction and operation, the environmental effects of siting the HFNS Facility at any of the proposed locations would be comparatively small.

Each of the four sites considered have relatively small population centers in their immediate vicinity. BNL and LLL have much higher concentrations of people within a 50-mile radius. HEDL is by far the most isolated. On the other hand, radiation exposure to the general public will be extremely small, constituting a negligible addition to the normal background exposure of residents or persons temporarily in the vicinity. Consequently, any further reductions in exposure that one site would offer over another would be of marginal value. Likewise, since the facility waste discharges are minimal, the presence of rivers which could offer greater dilution of liquid process wastes was not considered. The specific sites proposed by the various laboratories were generally on land which had been affected or disturbed to some degree by other past or ongoing laboratory activities. Correspondingly, the impact on local flora and fauna was considered minimal for any of the sites considered. The HFNS design is considered inherently "hardened" and capable of withstanding most credible natural phenomena, due to the heavy structures that surround the radioactive systems and equipment. Therefore, the potential differences in earthquake and wind loadings were not judged to be significant factors in making the selection. The number of people to be involved in the HFNS construction (about 110 peak), operation (about 33) or scientific use (about 44 peak) is relatively small. It was judged that siting the HFNS in any of the candidate regions would either prolong employment opportunities in the area, or create few problems in attracting the necessary skills, thus having little impact on the communities affected.

HEDL is currently conducting major programs on materials irradiation effects for the breeder reactor program and is beginning to conduct similar programs for the Magnetic Fusion Energy (MFE) program. Locating the HFNS at Hanford will take advantage of this depth of scientific expertise. HFNS construction is scheduled to begin when the construction manpower requirements will be declining, reflecting completion of major Hanford area projects. This will assure the availability of construction craft personnel.

At the Hanford location of the HFNS Facility there are currently existing HEDL facilities for test assembly fabrication, postirradiation examination and office space. These can be used for fusion power work without conflict with breeder reactor programs. Having all of the irradiation testing and waste disposal capabilities at one site eliminates or minimizes offsite irradiated material shipments. Thus, transportation associated potential hazards are minimized.

10.4.2 Hanford Reservation Locations

Alternate locations on the Hanford Reservation for siting the HFNS Facility were examined. No significant differences in environmental impact were found.

The 300 Area was selected as the HFNS site since this location places the facility in closest proximity to; 1) the existing facilities in the 300 Area that will be used to support HFNS operations, 2) the HEDL and PNL users, and 3) the Tri-Cities facilities for offsite users and visitors.

The 300 Area is closest to the population centers bordering the Hanford Reservation. The Richland city limit is about one mile south. However, the radiation doses to the general public due to HFNS operation and effluents will be negligible. Therefore, an alternate location such as the 400 Area, six miles north, offers no improvement of any consequence in radiation exposure.

Locating the HFNS in the 400 Area could result in an increased displacement of desert flora and fauna as compared with the minimal impact to the 300 Area. However, most of the candidate sites in the 400 Area are also, or will be, in a disturbed state due to construction activities at adjacent sites of on-going or planned breeder reactor projects.

10.5 Modification of Existing Facilities

Modification of existing facilities could be considered to provide the physical plant equivalent to the Accelerator Building and/or the Test Building. This would reduce the commitment of resources (principally concrete and reinforcing steel), further reducing the small impact of siting new buildings, and might offer a cost advantage to the project. The existing facilities in the 300 Area were surveyed as to their suitability and availability. The 309 Building was identified as a potential candidate to serve as the HFNS Test Building.

The 309 Building was constructed in late 1950s to house the Plutonium Recycle Test Reactor (PRTR). The facility consisted of an 80-foot diameter containment vessel for the PRTR with a one-story attached building which provided shops, laboratories and office space. The PRTR was decommissioned in 1969.

The facility currently houses offices and development laboratories. The PRTR containment vessel is used as a "clean room" for fabricating nuclear systems hardware. Utilizing the 309 Building would entail reinforcing the existing operating floor of the containment vessel to support the diverter beam switchyard, and the irradiation test cells and overhead service cell. The existing polar crane would be raised and modified to provide the necessary clearance for cask handling. Openings through the containment vessel would be modified or built for the beam tunnel and for a truck entry vestibule. The lithium supply system would be installed in an existing below-grade annex and cells below the level of the operating floor. The Accelerator Building could be located on a parking lot west of the 309 Building.

The benefits gained from modifying the 309 Building to serve as the HFNS Test Building will be offset by the cost of: 1) modifying the building structure as necessary to support the heavy test cells; 2) removing contaminated equipment to make room for the lithium supply system; 3) restraining the design of equipment (such as the dump heat exchanger) to conform to space limitations; and 4) displacing on-going activities in the facility. Further detailed studies are required to determine if there is a cost advantage relative to building a new Test Building.

A new Test Building will offer significant advantages to achieve the objectives identified for the HFNS. A superior building layout should be achieved without the constraints of existing structures which should enhance operational flexibility and lower operating costs. A new building should also have lower maintenance cost. Therefore, a new test building is proposed.

11.0 ENVIRONMENTAL TRADE-OFF ANALYSIS

The costs and benefits of the Deuterium-Lithium High Flux Neutron Source (HFNS) Facility construction and operation have been discussed previously on an itemized basis. Environmental costs were described in Chapters 5, 6, 7 and 9. Social costs and benefits were discussed in Chapters 2 and 6. Comparative costs of alternatives to the proposed facility and benefits of the Hanford site were discussed in Chapter 10. This chapter weighs the social and environmental costs of the HFNS against the benefits of the project.

11.1 Environmental and Other Costs of Proposed Facility and Alternatives

Social and environmental costs cannot easily be expressed in terms of dollars, but the impacts can be estimated and quantified in some cases. The forecasted decline of construction employment on major Hanford area projects negates the minor effect that the HFNS construction employment may have had on the community in terms of additional traffic, housing requirements, school space and public services. Employment for HFNS construction activities will be a small fraction of the total Hanford construction employment. Effect of constructing the HFNS will be to allow opportunities for continued employment to workers who otherwise may be affected by a declining level of construction activity occurring on the Hanford Reservation.

Environmental costs are summarized in Table 11.1-1. As mentioned previously, the HFNS Facility site is within the 300 Area of the Hanford Reservation reserved for nuclear facilities. Thus, the HFNS land use does not displace or forego other development such as agricultural or residential. All services (water, sewer, and electricity) are available from existing 300 Area systems and only require connection. Relatively minor modifications will have to be made to the existing 300 Area electrical substation. The radiation dose commitments to the public from operation of the HFNS are insignificant. The maximum calculated dose is orders-of-magnitude below permissible levels or background doses.

Social costs are expected to be negligible. During the HFNS Facility construction period, construction employment in the region is expected to be rapidly declining.

Thus, the effect on the surrounding communities is expected to be beneficial, by decreasing the local unemployment level. The construction and operation of the HFNS may cause a slight increase in traffic density in and around the 300 Area of the Hanford Reservation. The expected social effects of HFNS construction and operation are tabulated in Table 11.1-2.

The estimated costs and programmatic effects of alternatives to the planned HFNS Facility were discussed in Chapter 10. A recapitulation of these costs is given in Table 11.1-3.

11.2 Summary of Benefits

Benefits from the construction and operation of the HFNS Facility are expected to be multifaceted. However, in some instances, the ultimate benefit may not be realized until electrical energy is generated by a fusion reactor. The expected benefits discussed in Chapters 2 and 6 are summarized in Table 11.2-1.

Locating the HFNS at Hanford will take advantage of the depth of scientific expertise in materials irradiation effects both at HEDL and the Pacific Northwest Laboratories, also located at Hanford. Personnel experienced in construction and operating major engineer test facilities are also available to staff the HFNS project. Significant capital cost savings are associated with the Hanford location of the HFNS Facility, achieved through using existing Hanford Engineering Development Laboratory (HEDL) facilities for test assembly fabrication, postirradiation examination and office space. Existing buildings can be dedicated to fusion power work without conflict with Breeder Reactor Program (BRP) programs. Having all of the irradiation testing and waste disposal capabilities at one site eliminates or minimizes offsite irradiated material shipments. Thus, transportation costs and associated potential hazards, and the time required for complete test cycle completion (from program definition to irradiation effects data evaluation) are minimized.

11.3 Conclusion

Development of test data concerning irradiation effects on materials and demonstrating the satisfactory performance of these materials will provide a firm base for the engineering phase of the fusion power program. The ultimate development of fusion energy is expected to result in a safe, environmentally attractive, competitively priced energy source that may represent one of the best long-range solutions to the worldwide energy shortage.

Construction of the HFNS Facility will directly contribute about $24.5 million to the local economy in the 1979 to 1982 time period. The employment opportunities will facilitate continued employment for workers affected by the forecast decline in Hanford Reservation construction activity. Also, operation of the HFNS will provide continued employment for approximately 33 materials engineers and operational personnel. On balance, the benefits of HFNS construction and operation more than offset the economic investment and the negligible social and environmental costs.

TABLE 11.1-1

SUMMARY OF ENVIRONMENTAL COSTS

	Cost	
CATEGORY	ONSITE	OFFSITE
Land Use	4 Acres	None
Water Use	45 gpm	None
Electricity	250,000 kWh/day	Indeterminate
Resources Irretrievable		
a. Manpower	220 Man Years	Indeterminate
b. Materials	400 Tons - Reinforcing steel 6,000 Cu/yds-Concrete	None
Ecology		
a. Flora and Fauna	Presently in Disturbed State - No New Effects	None
b. Air and Water Quality	Negligible Impact	Negligible Impact
Radioactive Dose		
a. Site Boundary		1×10^{-8} rem/hr (whole-body)
b. Nearest Resident		
1. Annual	-	7×10^{-6} rem/yr (skin and bone)
2. 50-yr Commitment	-	8×10^{-6} rem (bone)
c. Maximum Accident Risk to an Individual		3×10^{-4} rem/hr (whole-body)

TABLE 11.1-2

SUMMARY OF SOCIAL COSTS

ITEM	EFFECTS OF CONSTRUCTION	EFFECTS OF OPERATION
Area Population	Reduce rate of decline	Aid in sustaining present level
Worker Influx	None expected	None expected
Municipal Facilities		
Schools Fire and Police Water and Sewage Streets	Negligible*	Negligible*
Housing	Slight sustaining of price levels	Slight sustaining of price levels
Traffic Density		
On Hanford Reservation	Slight increase within 300 Area	Possible negligible Increase in 300 Area
In Communities	Slows decline	Negligible

*May have slight positive impact because it will slightly increase use of facilities.

TABLE 11.1-3

COST-BENEFIT COMPARISONS FOR HFNS ALTERNATIVES

ALTERNATIVE	EFFECTS ON COSTS-BENEFITS ECONOMIC	ENVIRONMENTAL	SOCIAL
Reference	Base	Base (Table 11.1-1)	Base (Table 11.1-2)
Abandon the Project	Local short-term downward push; national long-term threat to fusion program goals	Avoids small short-term impacts; long-term threat to achieving fusion program benefits	Short-term increase in local unemployment; no long-term effect
Postpone the Project	Capital Cost increase due to escalation	No change	Short-term increase in unemployment
Alternative Designs	Capital Cost increase and/or slight increase operating cost	Reduced amount or probability of radionuclide release	Slight increase in construction employment
Alternative Sites	Capital Cost increase if new support facilities required	Possible increase if new support facilities required	Possible slight increase in construction employment
Modifications of Existing Facilities	Possible Savings in Capital Cost operating cost probably higher	No change	No change

TABLE 11.2-1

SUMMARY OF BENEFITS

BENEFITS	DURING CONSTRUCTION	DURING OPERATION
Economic		
Local	Approximately $24.5 million for wages and materials.	Approximately $2.5-3 million annually for wages.
	Sustaining and/or slowing decline due to other major project completion.	Sustaining level of employment.
Programmatic	Negligible	Ultimately, high benefits realized from availability of fusion energy.
Environmental		
Local	Negligible	Negligible
Programmatic	Negligible	Ultimate development of fusion energy believed to be environmentally attractive.
Technical		
Local	Negligible	Improve use factor of existing facilities.
Programmatic	Negligible	Aid in materials development for fusion reactors.

12.0 SUMMARY OF CHANGES IN RESPONSE TO COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

The draft environmental impact statement for this proposed action was issued by the Energy Research and Development Administration as ERDA-1556-D for review and comment in July 1977. Comments letters were received from the Departments of Agriculture, Health, Education and Welfare, and Interior; the Advisory Council on Historic Preservation; the Environmental Protection Agency; the Nuclear Regulatory Commission; the Federal Power Commission; the States of New Jersey and Washington; the City of Richland, Washington, and a private individual.

The technical concerns identified include: nonradiological aspects of normal operation, radiological aspects of the existing environment, and decommissioning. The text has been modified, as appropriate, and individual letters have been sent to each commenter responding to these concerns. Copies of the comment letters are included in appendix B.

12.1 Nonradiological Aspects of Normal Operation

Comments on nonradiological aspects of normal operation were received from the Environmental Protection Agency, the Advisory Council on Historic Preservation, and the City of Richland, Washington. Appropriate changes in the text were made in section 1.0 and sections 5.2.5 and 5.4.1 which provide additional information on use of Columbia River water and excavation activities associated with the proposed facility. A new section 3.4.7.4 has been added to summarize the chemical wastes produced by the proposed facility each year.

12.2 Radiological Aspects of Normal Operation

Comments on radiological aspects of normal operation were received from the Environmental Protection Agency and the Department of the Interior. Appropriate changes in the text were made in section 3.4.7.3.1 and 3.4.8.3, which expand the description of radionuclides, including type, quantity, and disposition, in cooling water and lithium systems. A new section 5.3.4 has been added which includes additional information on disposition of radioactive waste from normal operations.

12.3 Nonradiological Aspects of the Existing Environment

Comments on nonradiological aspects of the existing environment were received from the Department of the Interior. Appropriate changes were made in appendix A and section 4.2.5 has been added, to evaluate potential effects on portions of the Columbia River designated in the Wild and Scenic Rivers Act and to correct minor errors of fact.

12.4 Decommissioning

Comments on decontamination and decommissioning of the HFNS were received from the Environmental Protection Agency. Information has been included in new section 5.3.4 to provide additional data on decommissioning, including preliminary cost estimates.

APPENDIX A

A. THE SITE

A.1 Site Features

A detailed description of the Hanford site features can be found in the Final Environmental Impact Statement for the High Performance Fuel Laboratories, ERDA-1550, September 1977.

A.1.1 Geology

Eastern Washington is dominated by the Columbia Basin geologic province, which encompasses about 50,000 square miles of southeastern Washington and adjacent parts of Idaho and Oregon (Figure A.1-1). The Basin is underlaid by the vast field of flood lavas of the Columbia River Basalt Group. Today those lavas and the ground surface generally dip radially inward toward the Pasco Basin, the slightly off-centered physiographic low of the larger Columbia Basin.

The Department of Energy (DOE) Hanford Reservation overlies the structural low point of the Pasco Basin. The Reservation is bounded to the southwest, west and north by large anticlinal ridges that trend eastward from the Cascade Range, enter the Pasco Basin and die out within its confines. The Columbia River and the steep and imposing, westfacing White Bluffs on the Ringold formation bound the Reservation to the east. Beyond the river and bluffs the gently rising basaltic lava flows lead into the Palouse country of eastern Washington. To the southeast the Reservation is bounded by the confluence of the Yakima and Columbia Rivers and by the City of Richland.

The Hanford Reservation is on the low-lying, partly dissected and modified alluvial plain of the Columbia River, within the central part of the Pasco Basin. Altitudes range from a low of about 345 feet in the southeastern part of the Reservation to a high of 800 feet in the northwest corner. Beyond the plains, the bordering White Bluffs rise to a maximum altitude of 980 feet above sea level. The anticlinical ridges to the west rise to a maximum altitude of 3,586 feet atop the crest of the Rattlesnake Hills.

The Hanford alluvial plain contains a mix of aggradational and degradational features that reflect part of the complex geological history and development (Table A.1-1) of the Pasco Basin.

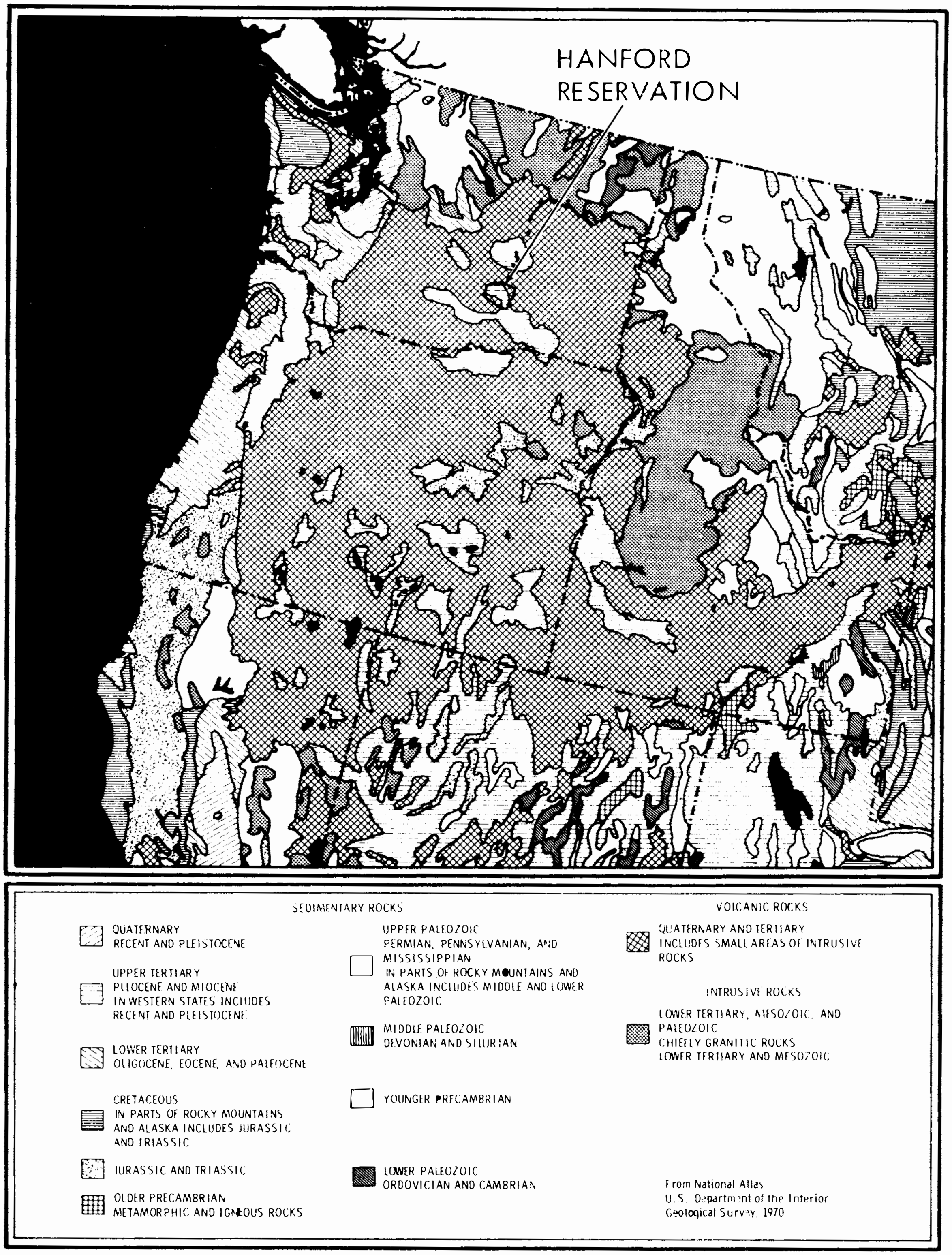


FIGURE A.1-1. Regional Geologic Map.

TABLE A.1-1

GEOLOGICAL HISTORY OF PASCO BASIN

ERA		SERIES		AGE YEAR BP*	GEOLOGICAL UNIT	MATERIAL
Cenozoic	Quaternary	Holocene		12,000	Dunes and Eolian Sediments (0-40 Feet Thick)	Sands, Increasingly Finer and Quartz-Rich to The Northeast
					Alluvium, Colluvium, Landslides (0-100 Feet Thick)	Unsorted Rubble and Debris, Locally Interfinger with Ringold Formation and Pasco Gravels
					Pasco Gravels and the Touchet Beds (0-400 Feet Thick)	Sands and Gravels Occurring as Glacial Flood Deposits, Commonly Roughly Graded, Unconsolidated but Highly Compact.
					Palouse Soils (0-30 Feet Thick)	Wind-Transported and Deposited Silt, Locally Weathered to Clay
		Pleistocene		2-3,000,000	Ringold Formation (0.1200 Feet Thick)	Well-Bedded Fluvial and Flood-Plain Silts, Sands and Gravel Poorly Sorted, Compact But Variably Cemented. Basal Portion Largely Silt and Clay of Highly Variable Thickness. Remainder of Formation is Interbedded Gravel, Sand and Silt. Gently Deformed.
	Tertiary	Pliocene		12,000,000	Ellensburg (20-200 Feet Thick) Formation	Volcaniclastic Rocks and Their Weathering Products, Largely Clays. Grades into and Inter-Fingers with Ringold Formation Sediments. Locally Folded and Faulted.
			Columbia River Basalt Group Prob. 12,000 Ft. Thick		Yakima Basalt Formation (Prob. 2500 Feet Thick)	Basaltic Lavas with Interbedded Stream Sediments in Upper Part, Locally Folded and Faulted.
		Miocene		26,000,000	Picture Gorge Formation Equivalent (?) (Prob. 1500 Feet Thick)	Basaltic Lavas
		Oligocene		37-38,000,000	?	Basaltic Lavas Possibly Comparable to the Teanaway Basalts
		Eocene		53-54,000,000		Probably Sandstones Comparable to the Swauk and Roslyn Formations
		Paleocene		65,000,000	?	
Mesozoic					Rocks of Uncertain Age Type and Structure	Probably Metasediments and Metavolcanics Intruded by Granitic Rocks

*U. S. Geological Survey, Bulletin 1350, "Lexicon of Geological Names of the United States, 1961-67," G. C. Koroher, 1970, Wash., D.C.

The 300 Area has unconsolidated sands and gravels of the fluviatile series of sediments (Pasco Gravels) underlying the site to a depth of about 20 to 25 feet. Beneath these fluviatile sediments, to a depth of approximately 200 feet, are the semiconsolidated to consolidated or cemented silts, sands, clays, and gravels of the Ringold formation. Basaltic bedrock starts at a depth of approximately 200 feet and extends downward over 10,000 feet. (See Figure A.1-2)

A.1.1.1 Anticlinal Uplift and Faulting

Creation of the anticlines, which are major structural features of the Columbia Basin, was primarily by uplift, probably relating from long-term basining. Some faults may have developed as an early phase, but folding is a predominant reaction, with renewal of fault movement as an alternative. Generally, the stresses that developed in deformation were relieved by slippage along the many joints and bedding planes, oftentimes on clay-rich sediments of the Ellensburg Formation, which thereby give the impression of fault gouge and major faults. Folding of the basalt sequence with no super-incumbent cover also resulted in sinuous fold axes at the ground surface; in some areas, en echelon fold axes. At other sites, cross folds complicate the structures. In all instances the divergence from single, well-defined, regular axes can be attributed to differing responses to folding of the variably-jointed, highly-layered basalt sequence. The sinuousity and en echelon nature of the fold axes and the presence of cross folds have led investigators to assume the presence of cross faults with strike slip offset up to one-third of a mile. This situation prevailed at Gable Mountain on the Hanford Reservation. To date, no strike-slip faults of any magnitude have been demonstrated in the Pasco Basin.

The dominant type of faulting is normal faulting, in some instances developing into graben-like structures as inferred in the Badger Canyon area and as occurs in parts of the Saddle Mountains. Thrust faults locally are significant, especially where folding has been intense. In some instances antithetic faulting developed, with portions of the uplifted anticlines downdropped.

Numerous faults are hypothesized on various bases, including topographic expression and aerial photointerpretation. The most important fault postulated is that along the Olympic-Wallowa Lineament, particularly the Rattlesnake-Wallula-Milton Freewater segment and the Rattlesnake-Wallula segment.

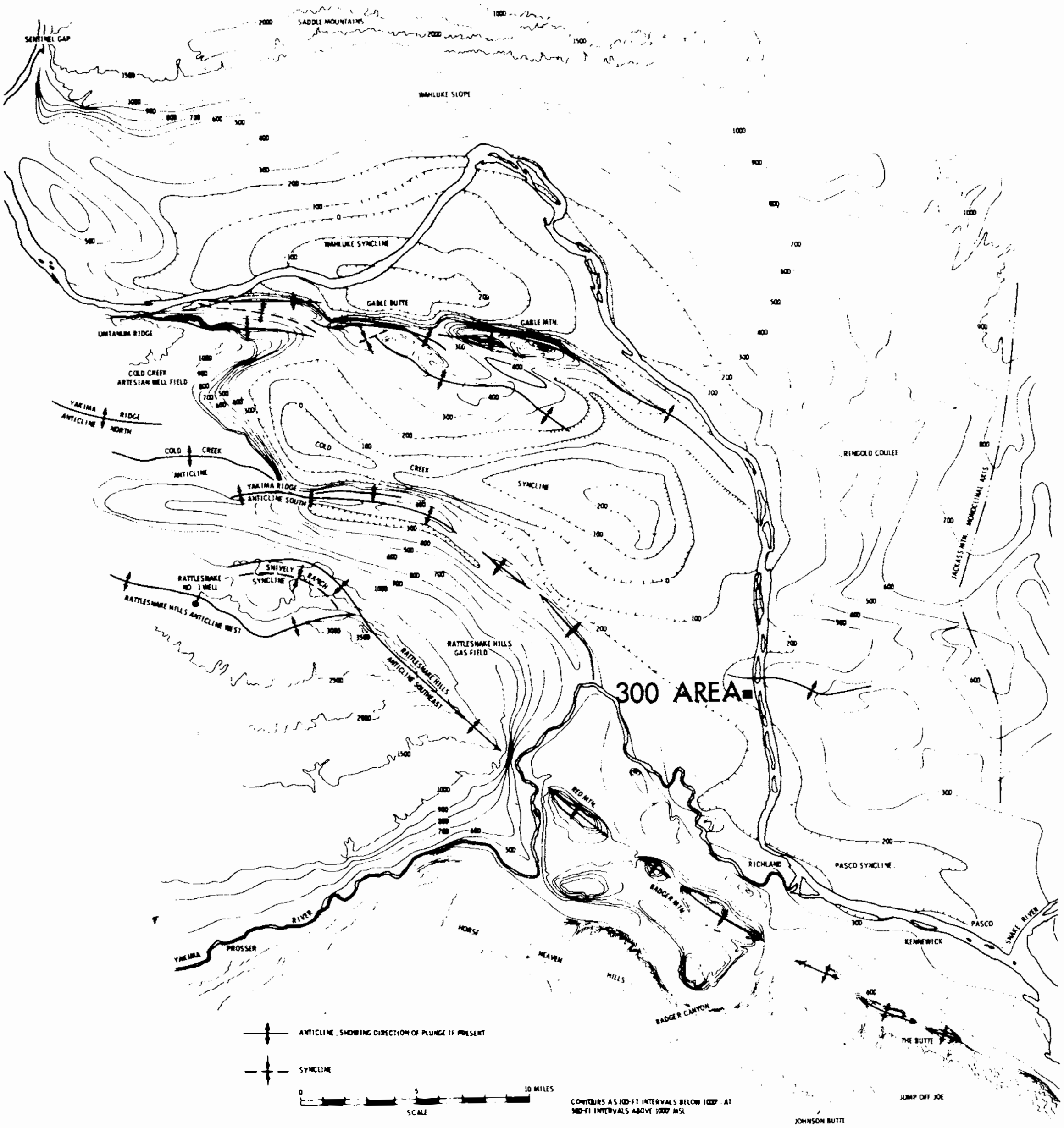


FIGURE A.1-2. Map of the Basalt Surface in the Pasco Basin, Identifying Major Structures.

One hypothesis attributes gross amounts of strike-slip movement to this hypothesized lineament fault, analogous to the San Andreas fault, but specific evidence for the fault or its offset is lacking. Neither the Oregon geologic map (1969) nor the Oregon gravity map acknowledge or submit evidence in support of such a fault in Oregon.

Numerous signs of at least local faults are present along the various named segments of the Olympic-Wallowa Lineament. The maximum inferred stratigraphic offset on a postulated fault is 300 feet in the Badger Canyon area, compared to a maximum of about 1500 feet of total stratigraphic offset by combined folding and faulting along the same segment. Thus, this fault offset is less than a major part of the total offset, a situation generally prevalent in southcentral Washington. In the same general area 500 feet of stratigraphic offset, as determined from drilled wells, may be largely fault offset. In some sites along the Olympic-Wallowa Lineament faults are spatially removed from the fold axes, hence, are "primary" in origin.

A.1.1.2 The Ringold Formation

The Ringold Formation (Figure A.1-3) was deposited in response to a flattening of the gradient of the Columbia River and consequent deposition of the sediments it carried. Previous basining was accompanied by basalt flow extrusion into the topographically and structurally low areas. Cessation of emission permitted the deposition of a continuous sequence of sediments. Slightly prior to the emission of the latest basalt flows, the beginning of anticlinal uplift, especially to the west, locked the Columbia River into the Pasco Basin and halted its east-west migration. Somewhat later, uplift of the Horse Heaven Hills resulted in a continuously rising base level for the river and continued deposition of sediment. Today the Ringold Formation is recognized only upstream of the Horse Heaven Hills, reflecting the control of deposition by those Hills. The Ringold Formation has been arbitrarily divided into a lower blue clays member, a gravel or conglomerate member, and an upper sand-silt member. However, sands, silts, clays and gravels are interbedded and interlayered throughout the basin in a manner indicating a nearly continuous stream flow and continuous fluvial deposition.

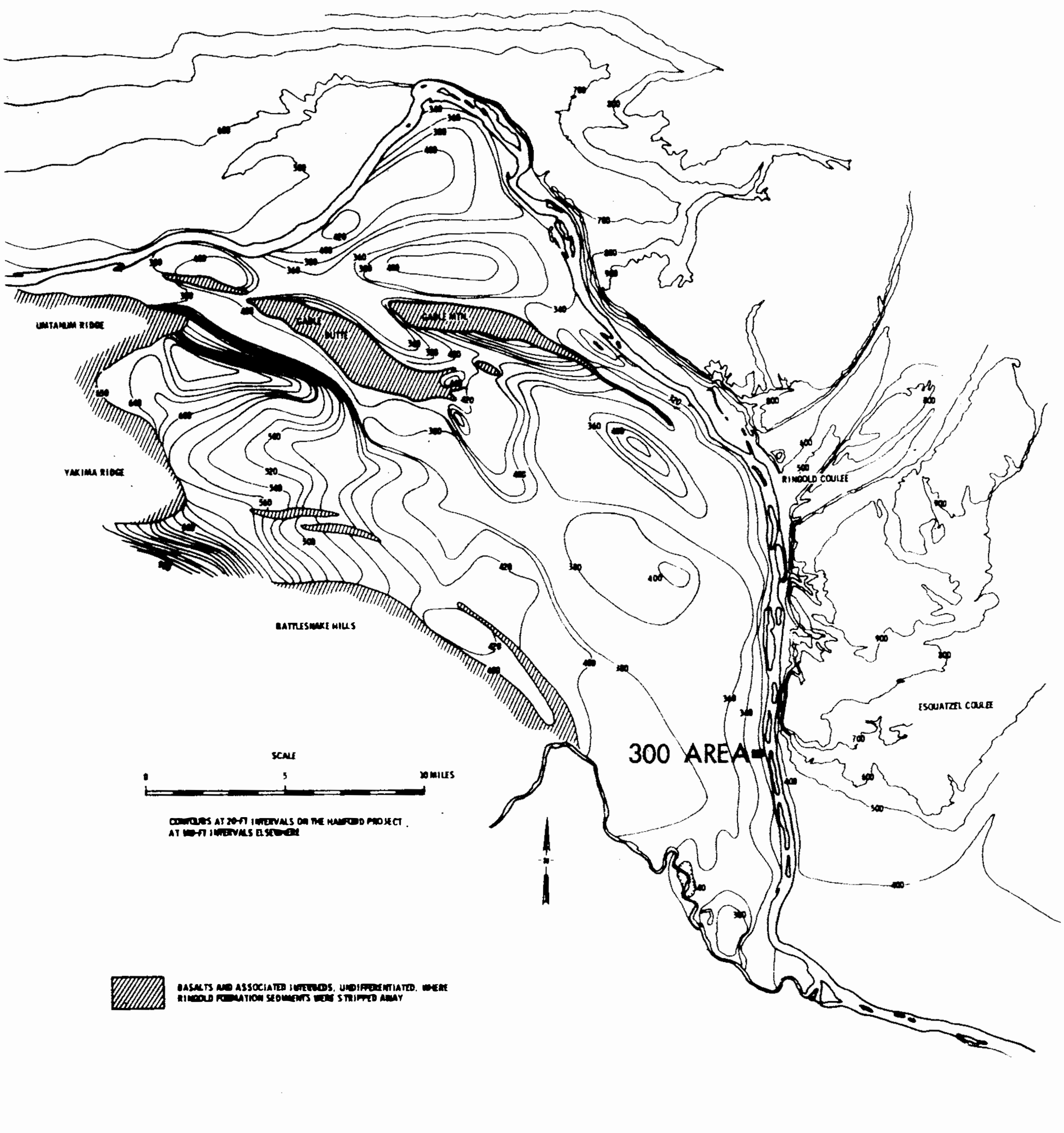


FIGURE A.1-3. The Surface of the Ringold Formation in the Pasco Basin.

A.1.1.3 Soils

Most of the Hanford Reservation is underlaid by sediments deposited by the glacial Lake Missoula floods, particularly of 18,000 to 20,000 years ago and about 12,000 years ago. The flood deposits, at or near the ground surface, range from: 1) coarse boulder and cobble gravel in the extreme northern reaches of the Hanford Reservation; 2) to sandy cobble to granule gravels in the central part of the Reservation; 3) to coarse sands in the southern part. Adjacent to the Yakima and Rattlesnake Hills the sediments grade into silts and fine sands. The distribution reflects the velocity of the flood waters depositing the sediments: greatest velocities where the floods debouched from the Columbia River gorge upstream from Hanford; less where the flood waters spread out in the Pasco Basin; and least in the lee of the ridges and with the shallow waters adjacent to the bordering masses.

As a result of the semiarid to arid environment that prevailed for at least 12,000 years, the entire Reservation was blanketed by at least a thin veneer of wind-blown (eolian) sediments. These sediments were largely derived locally from the flood deposits, but some were from as far as the lower Yakima and Columbia River Valleys, upwind (SW) of the Hanford Reservation. The eolian sediments thus range from very fine sands and silts, that in some places blanket coarse gravels and basalt bedrock, to coarse sands that were moved only short distances and can scarcely be distinguished from the parent material.

A.1.2 Seismology

Eastern Washington is in a region of low to moderate seismicity that lies between the western Washington and western Montana zones of considerably greater seismicity. On the basis of the damage that has occurred since 1840, the U. S. Coast and Geodetic Survey designated eastern Washington as Zone 2 seismic probability, implying the potential for moderate damage from earthquakes (Figure A.1-4). Periodic revisions since 1948, the date of the first issuance of the risk map, and up to 1969, resulted in no changes in the potential for eastern Washington; although other parts of the country were upgraded in the damage potential. Table A.1-2 gives the approximate relationships among ground acceleration, damage potential, and intensity scales.

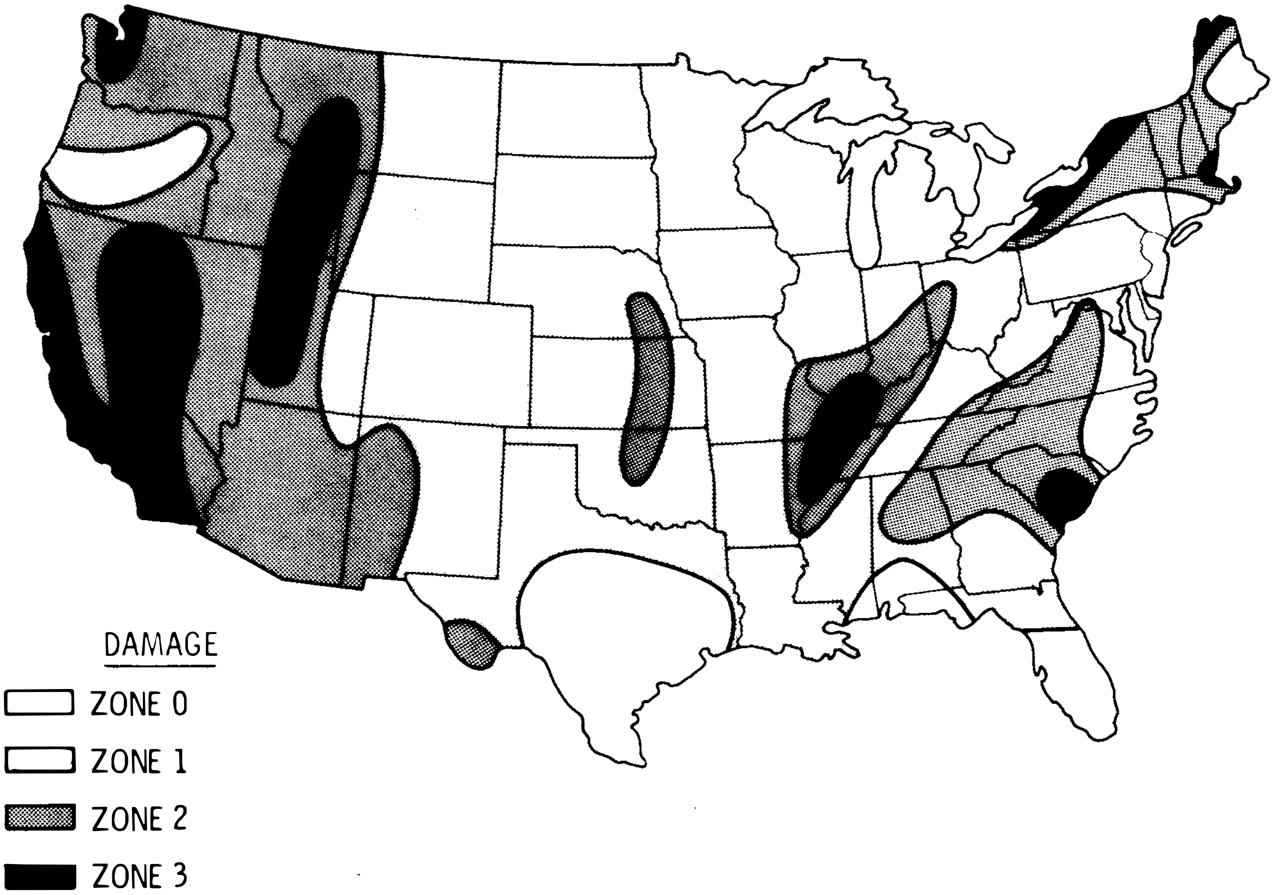
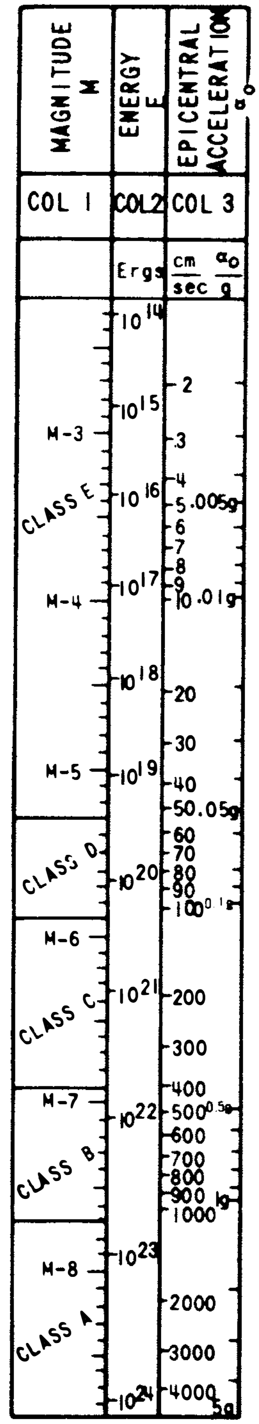


FIGURE A.1-4. Seismic Risk Map.

TABLE A.1-2

Approximate Relation Connecting Earthquake Intensity With Acceleration

ROSSI-FOREL INTENSITY SCALE (1883)	MODIFIED-MERCALLI INTENSITY SCALE (1931), WOOD AND NEUMANN	GROUND ACCELERATION a
COL 1	COL 2	COL 3
	I Detected only by sensitive instruments	$\frac{cm}{sec}$ $\frac{a}{g}$
I The shock felt only by experienced observer under very favorable conditions	II Felt by a few persons at rest, especially on upper floors; delicate suspended objects may swing	2, 3
II Felt by a few people at rest; recorded by several seismographs	III Felt noticeably indoors, but not always recognized as a quake; standing autos rock slightly, vibration like passing truck	4, 5 .005g, 6
III Felt by several people at rest; strong enough for the duration or direction to be appreciable IV Felt by several people in motion; disturbance of movable objects, cracking of floors	IV Felt indoors by many, outdoors by a few; at night some awaken; dishes, windows, doors disturbed; motor cars rock noticeably	7, 8, 9, 10 .01g
V Felt generally by everyone, disturbances of furniture, ringing of some bells	V Felt by most people; some breakage of dishes, windows, and plaster, disturbance of tall objects	20
VI General awakening of those asleep, ringing of bells, swinging chandeliers, startled people run outdoors	VI Felt by all; many frightened and run outdoors; falling plaster and chimneys; damage small	30, 40, 50 .05g, 60
VII Overthrow of movable objects, fall of plaster, ringing of bells, panic with great damage to buildings	VII Everybody runs outdoors; damage to buildings varies, depending on quality of construction; noticed by drivers of autos	70, 80, 90, 100 .1g
VIII Fall of chimneys; cracks in walls of buildings	VIII Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed	200
IX Partial or total destruction of some buildings	IX Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken	300, 400, 500 0.5g, 600
X Great disasters, ruins; disturbance of strato, fissures, rockfalls, landslides; etc.	X Most masonry and frame structures destroyed; ground cracked; rails bent; landslides	700, 800, 900 1g, 1000
	XI New structures remain standing; bridges destroyed; fissures in ground; pipes broken; landslides; rails bent	2000
	XII Damage total; waves seen on ground surface; lines of sight and level distorted; objects thrown up into air	3000, 4000, 5000 5g, 6000



RICHTER SCALE

Although the Hanford area has not experienced a damaging earthquake within historic time, the area is exposed to the possibility of earthquake damage from two sources: 1) the active seismic zones of western Washington and 2) earthquakes originating in the seismic zone that includes Walla Walla. The strongest earthquakes at Hanford within historic time have not been greater than four on the Modified Mercalli Scale (MM-IV), although intensities as high as MM-VII have been observed near surrounding towns.

Numerous earthquakes of magnitude MM-VI or greater have occurred in western Washington. The strongest shock of historic record to occur in western Washington was the 1949 Olympia-Steilacoom earthquake originating in the Puget Sound channel, about 150 miles from Hanford. The earthquake was rated MM-VIII, and intensities from MM-III to MM-VII were experienced at distances of 150 miles. In Richland and the Hanford area the shock was only slightly felt. The great Alaska earthquake of 1964 and recent shocks in western Washington and in Montana were not felt as strongly at Hanford as in surrounding localities. Eight shocks in western Washington between 1920 and 1965 were reported as having maximum intensities of MM-VII or greater.

Eastern Washington earthquakes occurring in historic times have not been as intense or as frequent as those in western Washington. In 1893 the Umatilla, Oregon area experienced an MM-VII, and in 1936 an MM-VII occurred in the area of Walla Walla and Milton-Freewater. In 1934 at Ellensburg and in 1957 near Othello a number of small shocks occurred. Some of these shocks reached MM-VI, but they were highly localized. The nearest earthquake to the 300 Area occurred in 1918 at Corfu, 30 miles to the north. The Corfu earthquake (MM-IV to V) or the Umatilla earthquake of 1893 probably caused the maximum historical ground motions in the Hanford area of three percent of gravity (0.03g).

Figure A.1-5 shows the active fault zones in Washington deduced from earthquake activity. No clear-cut relationships of epicenters to specific surface faults is recognized in eastern Washington. A low rate of tectonic deformation in eastern Washington is indicated for more than ten million years. The deformations are much less severe than in the active seismic zone of western Montana and in western Washington.

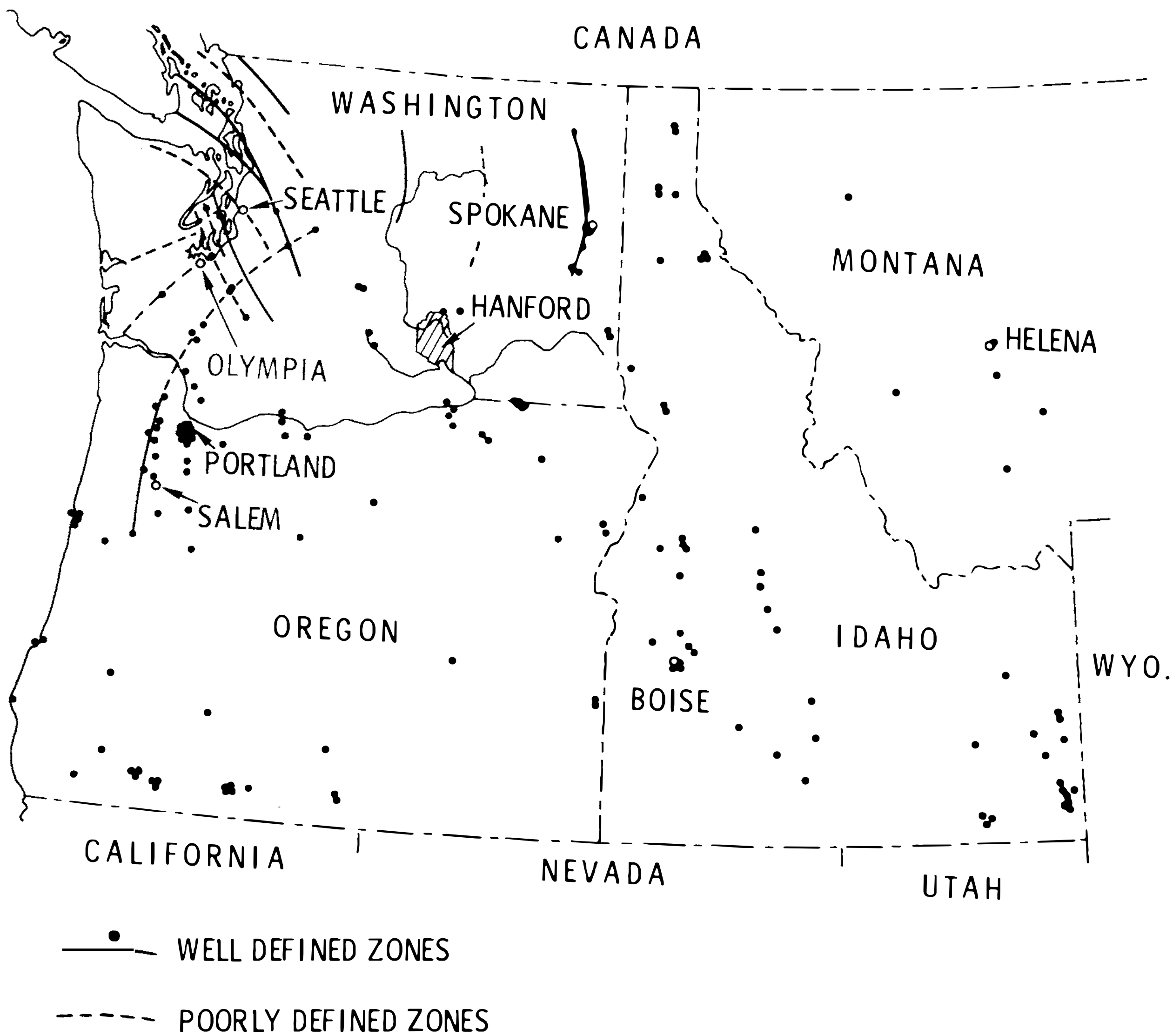


FIGURE A.1-5. Earthquake Zones of Washington.

Deformation certainty can be continuing since energy release occurs as stress accumulates. Because basalt flows contract significantly upon cooling to form the columnar jointing, or other more irregular fractures characteristic of massive basalt, the estimated 12,000 feet of basalt and interbeds in the Pasco Basin provide a large potential for low level stress release. Commonly, the stress is relieved by minor slippage on the many joints in the basalts and often in clay-rich interbeds between basalt flows.

Seismicity seems to be typified by swarms of small, shallow events. The Richter Magnitudes are generally less than 2.0 and the depths are unusually shallow (less than 2 km). A study of the focal mechanisms for these earthquakes has indicated that fracturing probably occurred on more than one fault surface but in response to general north-south horizontal compression. The medium in which these earthquakes occur is comprised of alternating horizontal layers of competent and weathered basalt. This indicates that only one or at most a few competent basalt layers were involved in any one event, and that large scale through-going fault zones are unlikely.

Sparse earthquake data and an inadequate understanding of the geologic features of the region preclude a comprehensive tectonic model of eastern Washington.

A model has been proposed that appears to explain the orientation of the gross tectonic features of the North American Cordillera (the main mountain region of the continent). Although oversimplified and idealized, it offers a potential for a better understanding of the tectonic features one to another. Once the nature of the features is better understood through regional studies, their relationships to each other can better be assessed through the Wise or updated and modified models for a more meaningful seismicity determination.

A.1.2.1 The Olympic-Wallowa Lineament

The Olympic-Wallowa Lineament is a topographic feature that has been cited as a possible major crustal rupture. Faults definitely are present at locations with potentially active surface faults in the Pasco Basin. Logically then, they are the locations for the maximum credible earthquake in the Pasco Basin.

The location considered to be the largest potential earthquake generator near Hanford is on the Rattlesnake-Wallula fault at the northwest zone of identified faulting at the southeast end of Rattlesnake Hills. Field investigations and a detailed literature review indicate that there are no significant faults closer to the site. If an earthquake comparable to the Umatilla quake (MM-VII) occurred at this location, which is about eight miles from the 300 Area, ground acceleration of about 0.13g at the 300 Area would be expected. A Safe Shutdown Earthquake (formerly called the Design Basis Earthquake) of 0.25g maximum horizontal ground acceleration accompanied by a vertical acceleration of two-thirds the horizontal is currently used at Hanford for designing nuclear reactors and facilities which contain plutonium. A design basis of 0.25g on the Hanford Reservation allows for an MM-VIII intensity quake epicentered at the same location, larger than any known in eastern Oregon or Washington. An MM-VIII quake is consistent with Zone 3 of the Seismic Probability Map, not the Zone 2 recommended by the map for this area.

A.1.2.2 Liquefaction

The likelihood of liquefaction of Hanford sediments from earthquake shocks is considered very remote. This conclusion is based on the type of subsurface materials, test results, and historic experience with similar soils.

A.1.2.3 Differential Compaction

Differential compaction from earthquake shocks is not uncommon in unconsolidated alluvium and was a major cause of damage in the Alaska earthquake of 1964. Sediments at Hanford, however, have a high degree of natural compaction. The Pasco Gravels which overlay the Ringold Formation have a high load-bearing capacity without undue settlement. Values are generally in excess of 6,000 lb/ft^2 even for materials directly at the ground surface, and 10,000 to 12,000 lb/ft^2 are commonly measured. Consequently, differential compaction would be negligible.

A.1.2.4 Slope Stability

The 300 Area is not affected by landslides as the immediate surrounding land is relatively flat. The closest slopes of significance are the White Bluffs located across the Columbia River and of sufficient distance to preclude concern.

A recent soil study determined the angle of internal friction of typical Hanford soils to be 39¼ at 80 percent relative density. Soils excavated at the FFTF site approximately six miles from the 300 Area would be expected to be similar to 300 Area soils and were found to exceed 80 percent relative density.

A.1.3 Hydrology

A.1.3.1 Regional Hydrology

As Figure A.1-6 (a map of the Columbia River Drainage Basin) shows, the Hanford Reservation lies along the Columbia River just north of (upstream from) the confluence with the Yakima River. The surface drainage in the Hanford Reservation is depicted in Figure A.1-7. Drainage in the northeastern two-thirds of the Reservation is directly to the Columbia River, while drainage of the southwestern third is into the Yakima River.

The Yakima River, a major tributary of the Columbia River, has an overall length of about 180 miles and a drainage area of about 6,000 square miles. The river heads in the rugged eastern slopes of the Cascade Mountains and flows southeastward into the semiarid region of central Washington. It joins the Columbia River only a few miles north of the confluence with the Snake River. Altitudes in the Yakima Basin range from 8,200 feet at Goat Rocks to 320 feet at the mouth of the Yakima River.

Examination of the geologic map of Washington reveals that the Columbia River Drainage Basin occupies two distinctly different geologic terrains. The western terrain encompasses the Cascade Mountains where relatively old sedimentary, volcanic, and intrusive rocks have been uplifted and dislocated by erosion into the rugged mountains. The eastern terrain derives from a thick sequence of basalt flows (the Columbia River Basalt Group) folded into numerous southeast to east trending anticlinal ridges and synclinal valleys. Clastic sedimentary rocks partly fill the synclinal valleys to depths exceeding 1,500 feet in some of the larger valleys. The Hanford Reservation lies almost entirely within the Pasco Basin, one of the larger synclinal valleys

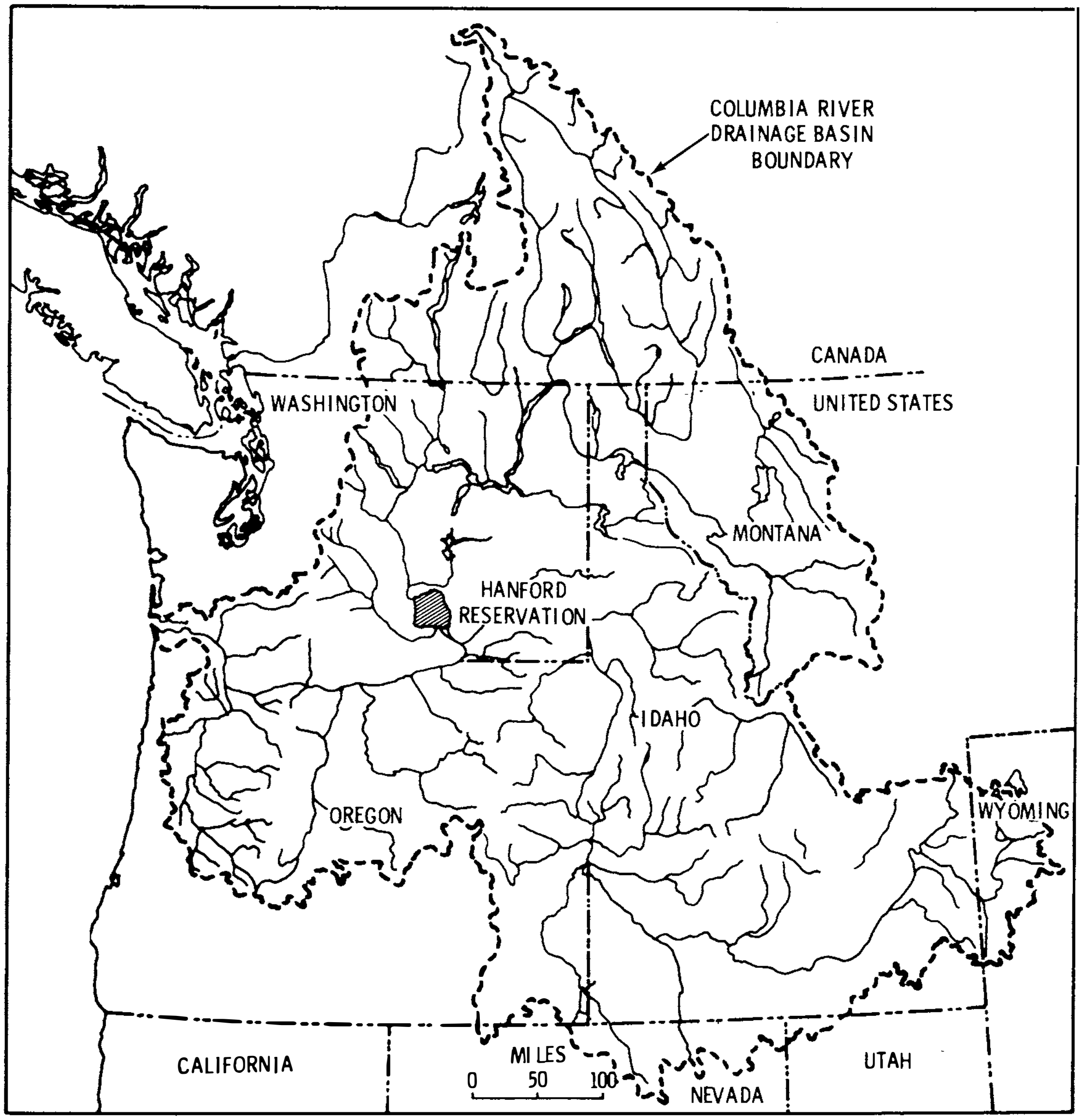


FIGURE A.1-6. The Columbia River Drainage Basin.

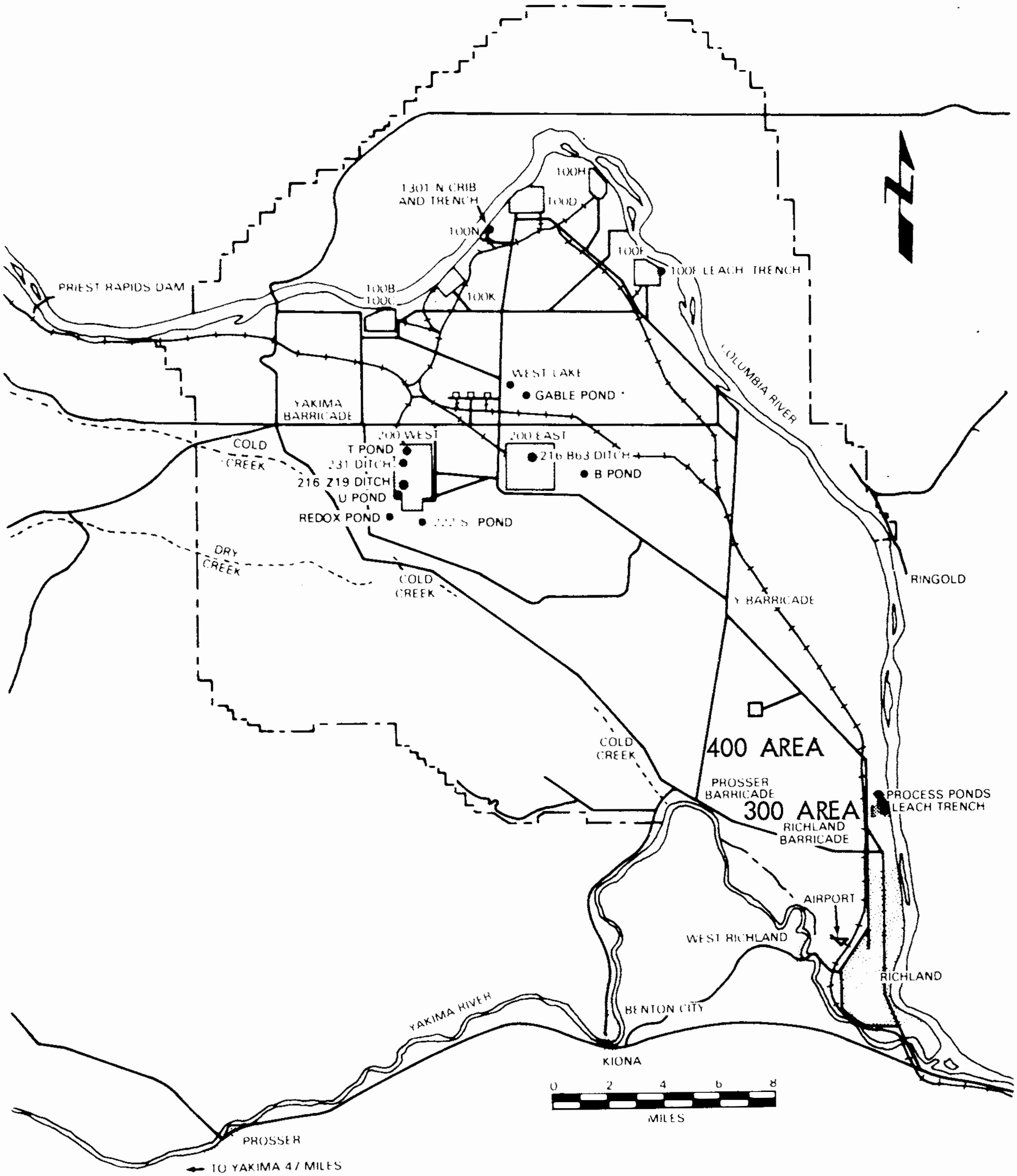


FIGURE A.1-7. Surface Water Drainage on Hanford Reservation.

in the eastern terrain. The 300 Area lies in the southeastern part of the Reservation at an elevation of about 400 feet above mean sea level (msl).

Direct precipitation over the Hanford Reservation mostly evaporates leaving a minimal amount of water as land runoff and for infiltration. The Yakima and the Columbia Rivers are the only two permanent streams in the area. Cold and Dry Creeks carry water only during the spring season.

The natural groundwater flow system underlying the Hanford Reservation has been modified by effluence from three areas: (1) the 200 West Area, (2) the 200 East Area, and (3) Gable Mountain Pond. Approximately one-third of the liquid disposed at Hanford is received by each of the flow systems through disposal to ponds, swamps and underground leach systems.

Figure A.1-8 is an isometric projection used in groundwater studies. The figure shows the Hanford groundwater table with exaggeration in the vertical dimension. Such a projection permits visual inspection of the changing groundwater gradients. The 200, 300 and 400 Areas are plotted.

The 300 Area lies near the Columbia River, and the Yakima River is 4-1/2 miles to the west. The Columbia River, with a long-term annual average flow of about 120,000 cubic feet per second (cfs), is extensively developed for hydroelectric power and irrigation supply (Figure A.1-9). The Yakima, with a mean flow of 3,240 cfs, is considerably smaller than the Columbia River.

A number of dams have been constructed on the Columbia River and on major upstream tributaries. The reservoirs provide an active storage of more than 37,000,000 acre-feet (a-f). The largest reservoirs are Mica (12,000,000 a-f) and Arrow (7,100,000 a-f) in Canada, and Libby (5,000,000 a-f) Hungry Horse (3,000,000 a-f) and Grand Coulee (5,200,000 a-f) in the United States. These dams provide improved regulation and have resulted in a decrease in flood levels.

A.1.3.2 Floods

The normal level of the McNary pool at the 300 Area is about 340 feet. (All levels in feet above mean sea level). During an average spring flood of 346,000 cfs peak flow (1960-1973), the level rises to about 350 feet.

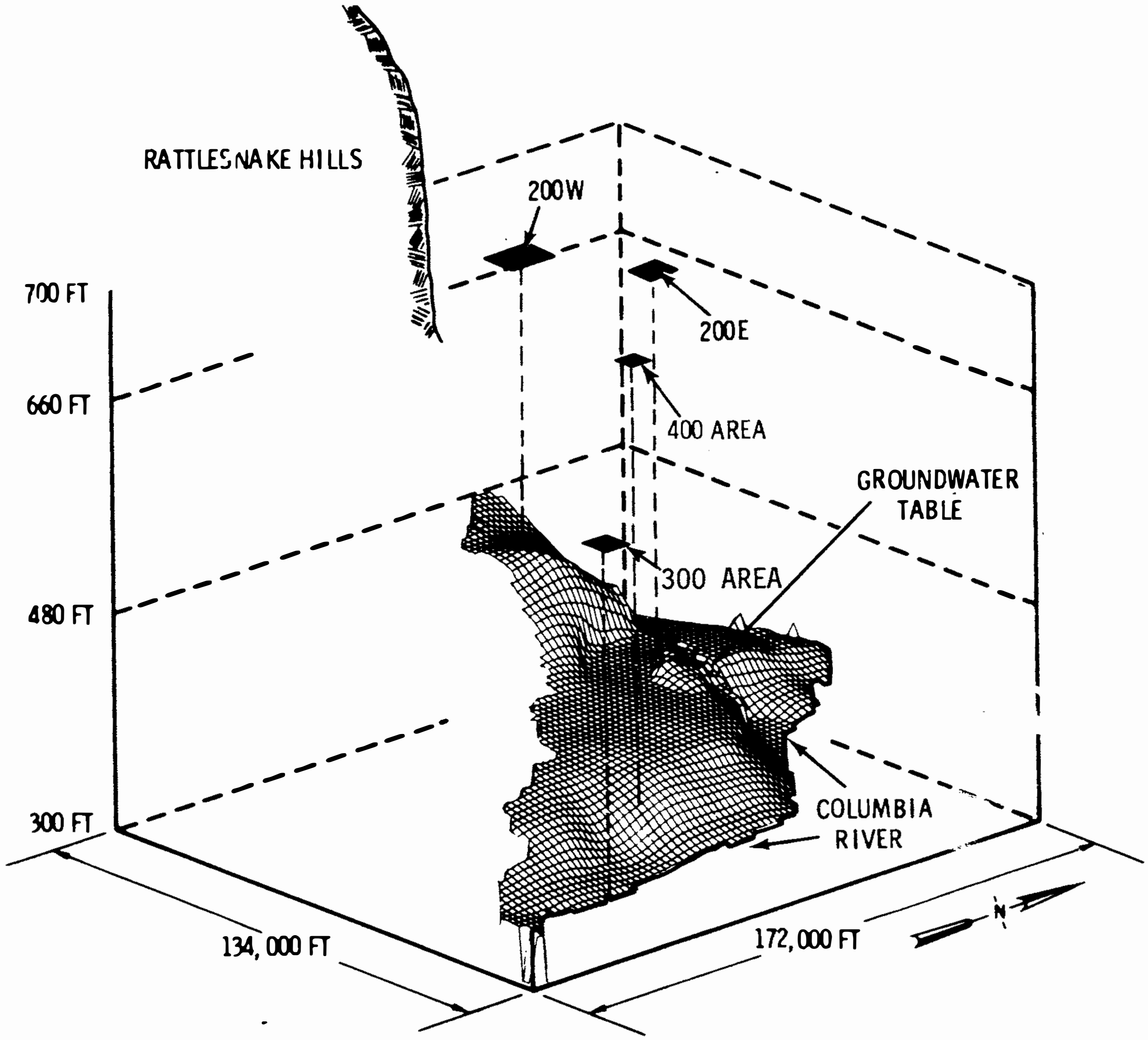


FIGURE A.1-8. Isometric Projection of the Groundwater Table Under the Hanford Reservation.

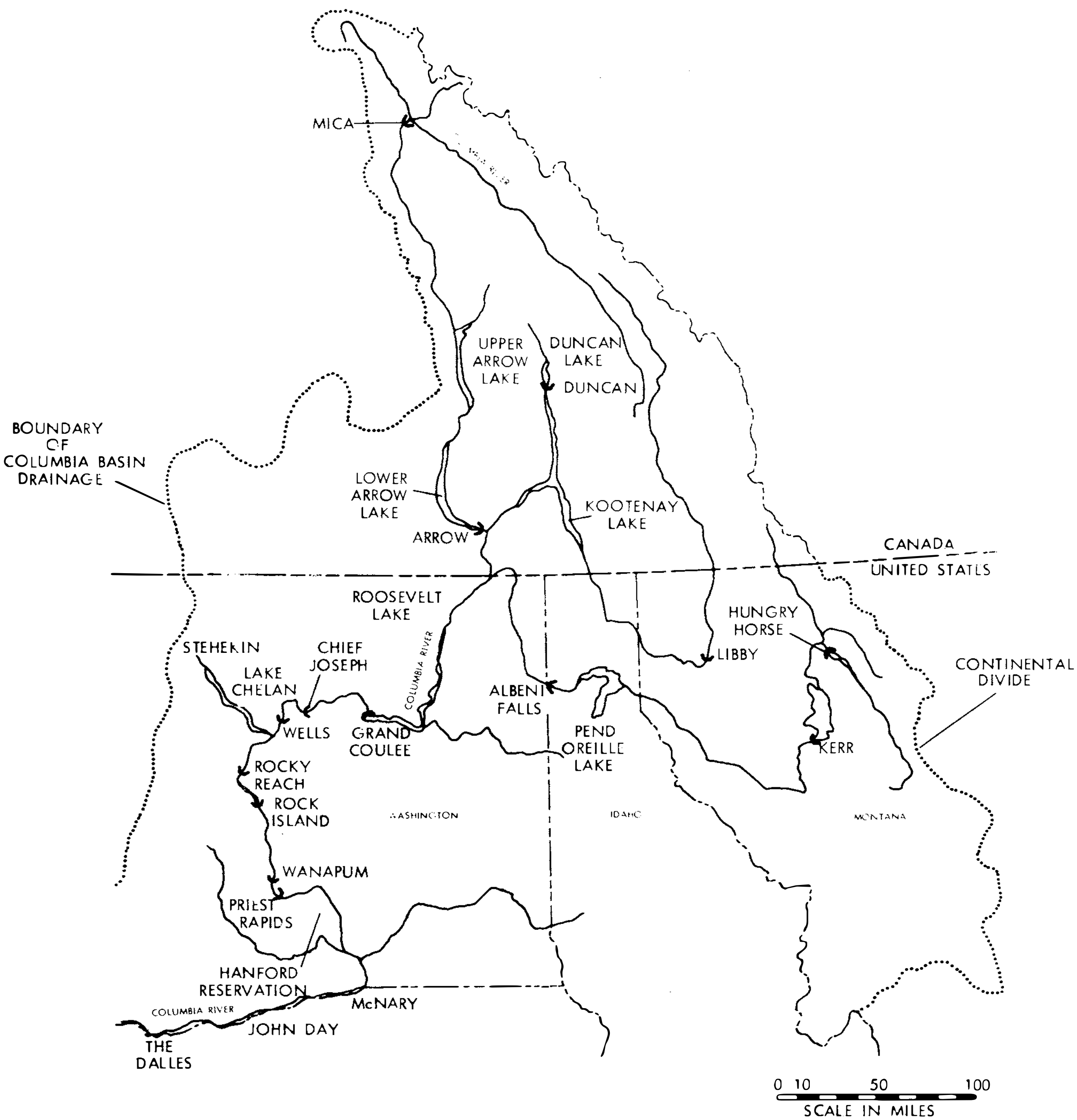


FIGURE A.1-9. Major Storage Dams Upstream of Hanford on the Columbia River and its Tributaries.

Figure A.1-10 shows plots of the Columbia River flow for an average year and for 1948, the largest flood of record in the near past. The 300 Area is nominally at an elevation of about 400 feet and has provided adequate protection from Columbia River floods.

Maximum discharge measurements for the Columbia River have been taken since 1859 (The Dalles, Oregon gauging station). The maximum flood of record is that of June 1894, which resulted in a peak discharge at Hanford which is estimated to be 740,000 cfs. The largest recent flood occurred in June 1948 and had an observed peak discharge of 693,000 cfs at Hanford. These floods resulted from melting of a large snowpack combined with spring rain. Construction of new dams along the Columbia River and its tributaries since 1948 has resulted in improved flow regulation and flood control capability.

The estimated 100-year maximum flood of 440,000 cfs would result in a river level of 356 ± 2 feet at the 300 Area based on U. S. Corps of Engineers projections. This projection is based on frequency analysis of actual flood records for the Columbia River as adjusted for 1975 flood control capability. The 100-year flood has a magnitude that may be equaled or exceeded once every hundred years, on the average. Peak elevations for the 25-year and 50-year floods are about two feet and one foot below the 100-year flood level, respectively.

The Probable Maximum Flood (PMF) has been evaluated by the U. S. Corps of Engineers for 1975 regulated flow conditions. According to the Corps of Engineers projections, the PMF would have a flow of 1,440,000 cfs and would result in a river level of 382 ± 4 feet at the 300 Area. (The river level reported by the Corps of Engineers is for river mile 348. Their reported river level was adjusted to the 300 Area, which lies between river miles 344 and 345. The correction applied was two ft for flow of 440,000 cfs and four feet for a flow of 1,440,000 cfs, as based on Corps of Engineers hydrographs.) The PMF assumes the most severe flood conditions considered reasonably possible. These conditions include winter snow accumulation, late and rapid spring melting, storm rainfall, and hydrologic conditions throughout the entire Columbia River drainage system.

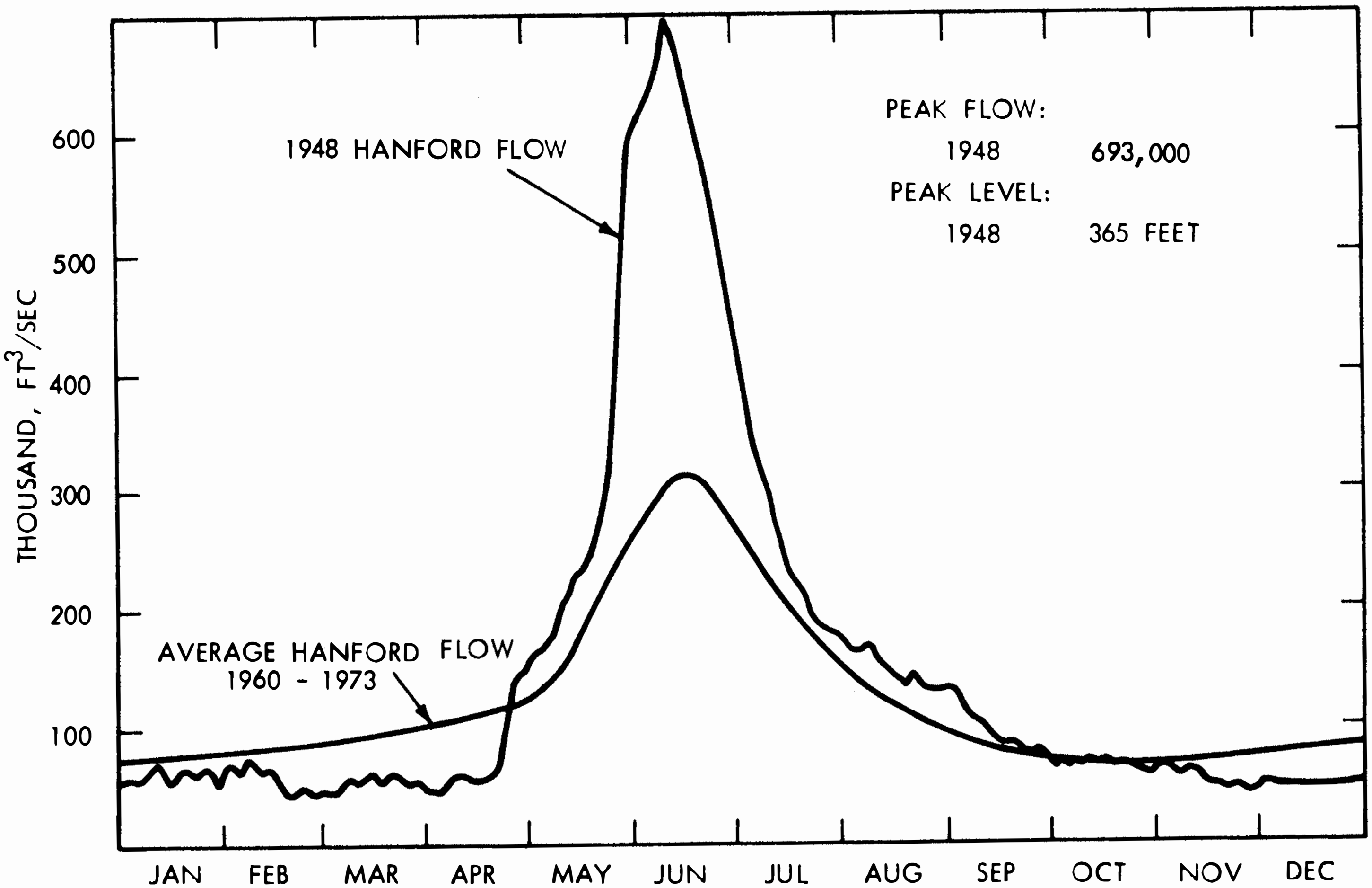


FIGURE A.1-10. Columbia River Flow at Hanford.

Landslides of more than a million cubic yards have occurred along the White Bluffs to the north within the last 12,000 years and more may occur. However, it is not anticipated that the river will be impounded.

Significant flooding resulting from freezing of the Columbia River is not considered a problem. The river has frozen completely over a number of times but has never experienced complete flow stoppage or significant flooding due to ice blockage. Sheet ice formation completely covering the river is very infrequent, having last occurred 40 years ago during the winter of 1936-1937. The erection of dams on the Columbia River has reduced the potential for ice blockage and flooding because of a significant increase in average winter flow rates.

Flooding on the Yakima River would not affect the 300 Area. The maximum recorded flow of the Yakima was 67,000 cfs measured in 1933.

Because of distance, failure of the 150-foot-high elevated water tanks (75,000 and 100,000 gallons) would not cause significant damage to any existing 300 Area facility which contains radioactive material. The probability of failure of the high tanks is believed to be acceptably low but has not been specifically analyzed.

Flooding by rainwater is not considered probable. The fluviatile and glaciofluviatile sediments (sands and gravels) which underlie the site to a depth of about 20 to 25 feet have very high permeability and are capable of storing vast quantities of water.

A.1.3.3 Groundwater

The 300 Area has a water table which varies from 350 feet at the west boundary to 340 feet (river level) on the east side. (Land surface elevation is 400 ft above sea level.) The groundwater communicates directly with the river, with the velocity of flow toward the river 15 to 80 ft/day,[3] depending on location. The water table on the east side rises to about 350 feet during high water of the Columbia River.

The unconfined aquifer underlying the Hanford Reservation is defined as the saturated sediment lying between the water table and the first thick, impermeable bed below the water table. The saturated interval lies partly in sediments of the Upper Ringold Formation and in other places in mostly fluviatile and glaciofluviatile sands and gravels. Tables A.1-3 and A.1-4 show the major geologic units in the Hanford region and their water-bearing properties.

The present elevation of the unconfined groundwater aquifer can be visualized by looking at the contour map of the water table and the isometric projection of the water table (Figure A.1-8). The map for January 1975 is shown in Figure A.1-12. The wells used in determining the water table are also shown. The accuracy of the contouring is directly related to the density of the measurement points, the local gradients and the accuracy of measuring water levels and well elevations. Data are normally taken to ± 0.01 feet.

A geologic cross section, Figure A.1-11, shows the water table elevations at three times during the history of the Reservation (a vertical to horizontal

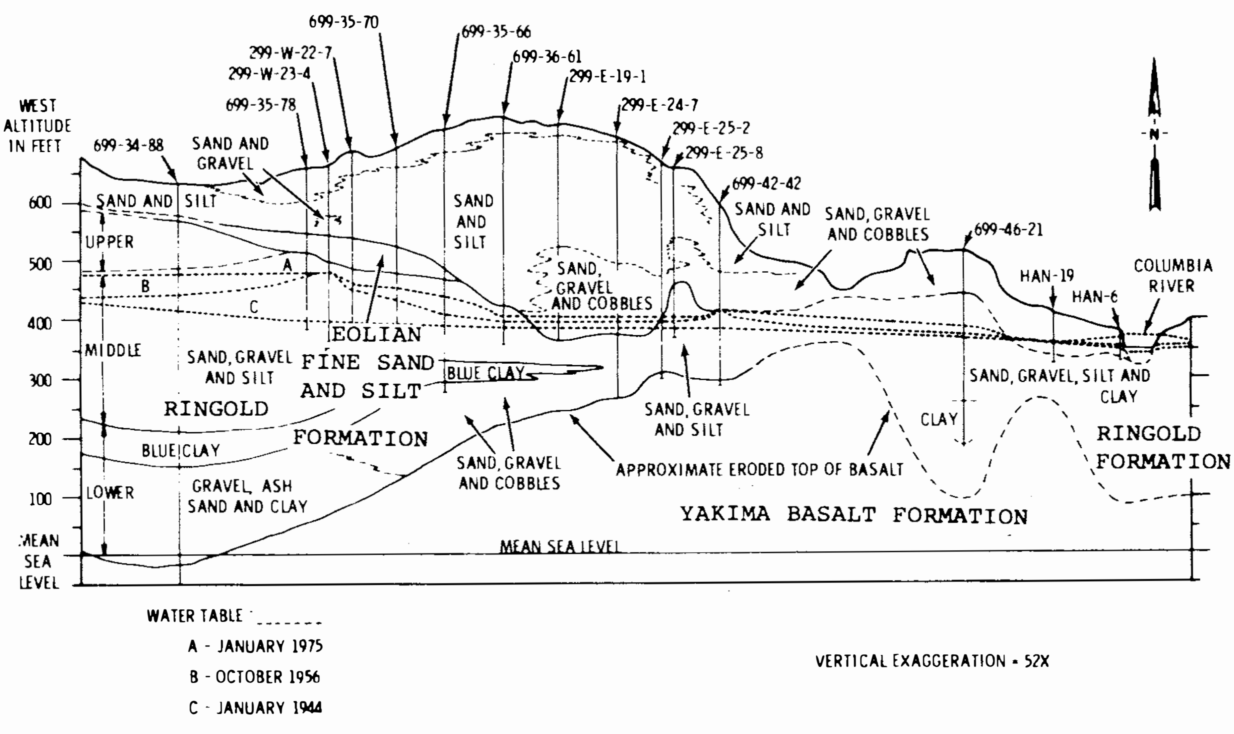


FIGURE A.1-11. Geologic Cross Section - Hanford Reservation.

Table A.1-3

MAJOR GEOLOGIC UNITS IN THE HANFORD REGION AND

THEIR WATER-BEARING PROPERTIES

System	Series	Geologic Unit	Material	Water-Bearing Properties
Quaternary	Pleistocene	Fluviatile and glaciofluviatile sediments and the Touchet formation. (0-200 ft thick)	Sands and gravels occurring chiefly as glacial outwash, Unconsolidated, tending toward coarseness and angularity of grains, essentially free of fines.	Where below the water table, such deposits have very high permeability and are capable of storing vast amounts of water. Highest permeability value determined was 12,000 ft/day.
Quaternary	Pleistocene	Palouse Soil (0-40 ft thick)	Wind deposited silt.	Occurs everywhere above the water table.
Quaternary	Pleistocene	Ringold formation (200-1,200 ft thick)	Well-bedded lacustrine silts and sands and local beds of clay and gravel. Poorly sorted, locally semi-consolidated or cemented. Generally divided into the lower "blue clay" portion which contains considerable sand and gravel, the middle conglomerate portion, and the upper silts and fine sand portion.	Has relatively low permeability; values range from 1 to 200 ft/day. Storage capacity correspondingly low. In very minor part, a few beds of gravel and sand are sufficiently clean that permeability is moderately large; on the other hand, some beds of silty clay or or clay are essentially impermeable.
Quaternary	Miocene and Pliocene	Columbia River basalt series (>10,000 ft thick)	Basaltic lavas with interbedded sedimentary rocks underlie the unconsolidated sediments.	Rocks are generally dense except for numerous shrinkage cracks, interflow scoria zones, and interbedded sediments. Permeability of rocks is small (e.g., 0.002 to 9 ft/day) but transmissivity of a thick section may be considerable (70 to 700 ft^2/day).
	?	Rocks of unknown age, type, and structure.	Probable metasediments and metavolcanics.	?

Table A.1-4

AVERAGE FIELD HYDRAULIC CONDUCTIVITY (FT/DAY) MEASUREMENTS

Tested	Pumping Tests	Specific Capacity Tests	Tracer Tests	Cyclid Fluctuations	Gradient Method
Glaciofluviatile	1,200-12,000	1,300-17,000	8,000	2,200-7,600	-
Glaciofluviatile and Ringold	120-670	130-530	-	130-800	-
Ringold (including clays)	1-200	8-40	-	20-60	13-40

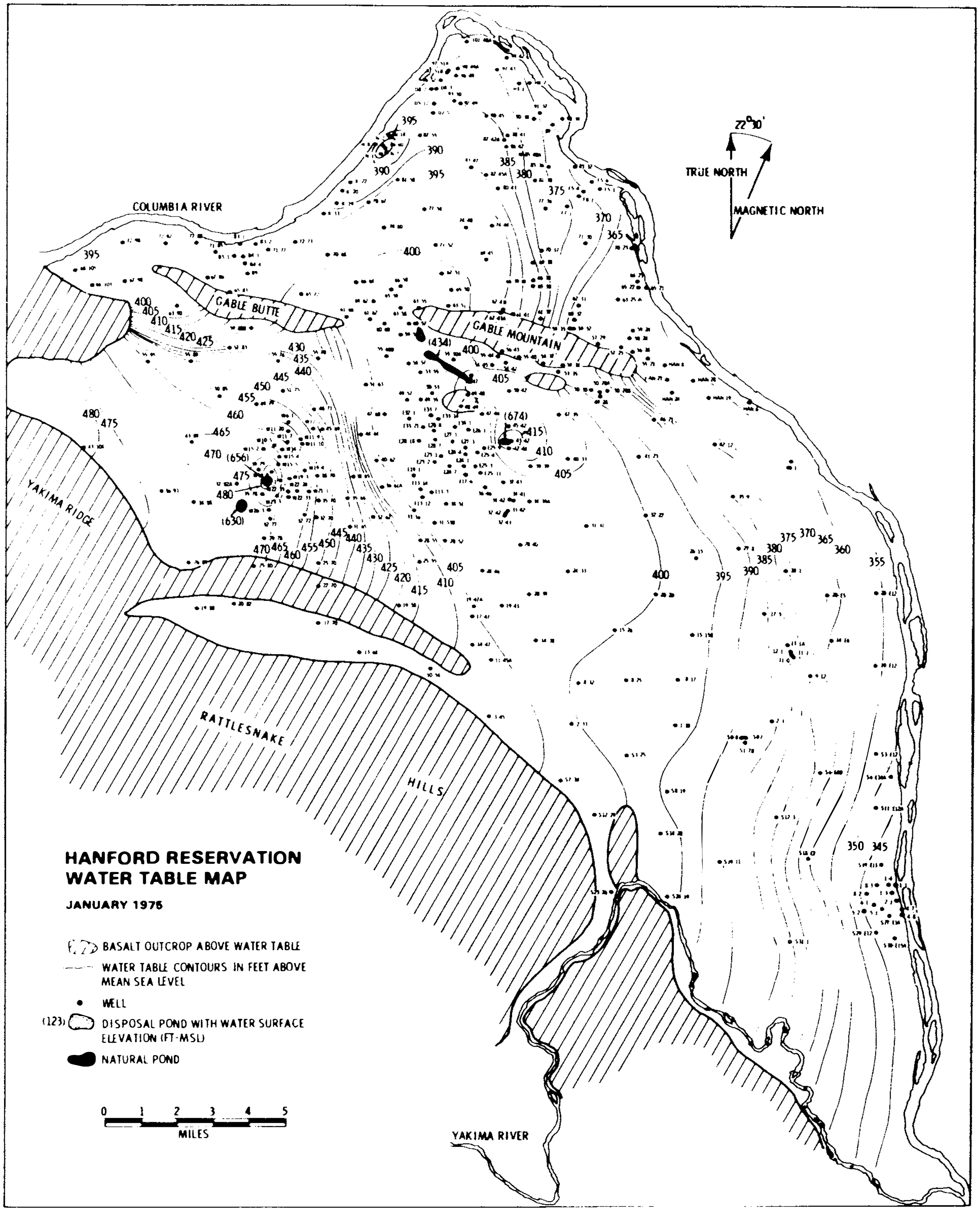


FIGURE A.1-12. Hanford Reservation Water Table Map.

distortion is noticeable). The depth to the water table varies greatly from place to place, depending chiefly on local topography, and ranges from less than one to more than 300 feet below the land surface. The current estimate of the maximum saturated thickness of the unconfined aquifer is about 230 feet. Depth to the water table at the 300 Area is approximately 160 feet.

From 1944 through 1973 (the last year for which data have been compiled), the chemical processing plants in the 200 Areas have discharged to ground over 132 billion gallons (4×10^5 a-f) of waste water and cooling water. Such a large volume of water has had a profound effect on the regional water table. Water table maps have been prepared over the years; a representative selection of water table maps for the 30 years of Hanford operation is available.

Constituents which are detectable over a significant area in the groundwater are gross beta emitters, tritium, and nitrate ion. Historically, since the gross beta emitter away from the disposal site has been primarily ^{106}Ru, the gross beta measurement concentrations are calculated as ^{106}Ru. Tritium and nitrate ion are also poorly absorbed on the soil and thus move primarily by convection with the groundwater. They have formed the plumes of contamination shown in Figures A.1-13, 14, and 15 drawn from the average concentrations measured July-December 1973 from the various sampled wells.

Concentrations of beta emitters and tritium in 300 Area groundwaters are both less than the most restrictive concentration guide as found in ERDAM 0524. Nitrate concentrations are approximately equal to or less than Public Health Service Drinking Water Standards (Revised 1962).

A.1.4 Meteorology

The Hanford Reservation lies east of the Cascade Mountains and, as a result, has a semi-arid climate reflecting the rain shadow effect that the mountains have in blocking most of the moisture carried in from the Pacific Ocean by the prevailing westerly winds. The summer season is characterized by hot, clear, dry weather with occasional strong winds and some clouds associated with mild disturbances moving in from the Pacific. In the wintertime, the intrusion of clouds and limited rainfall is associated with the relatively

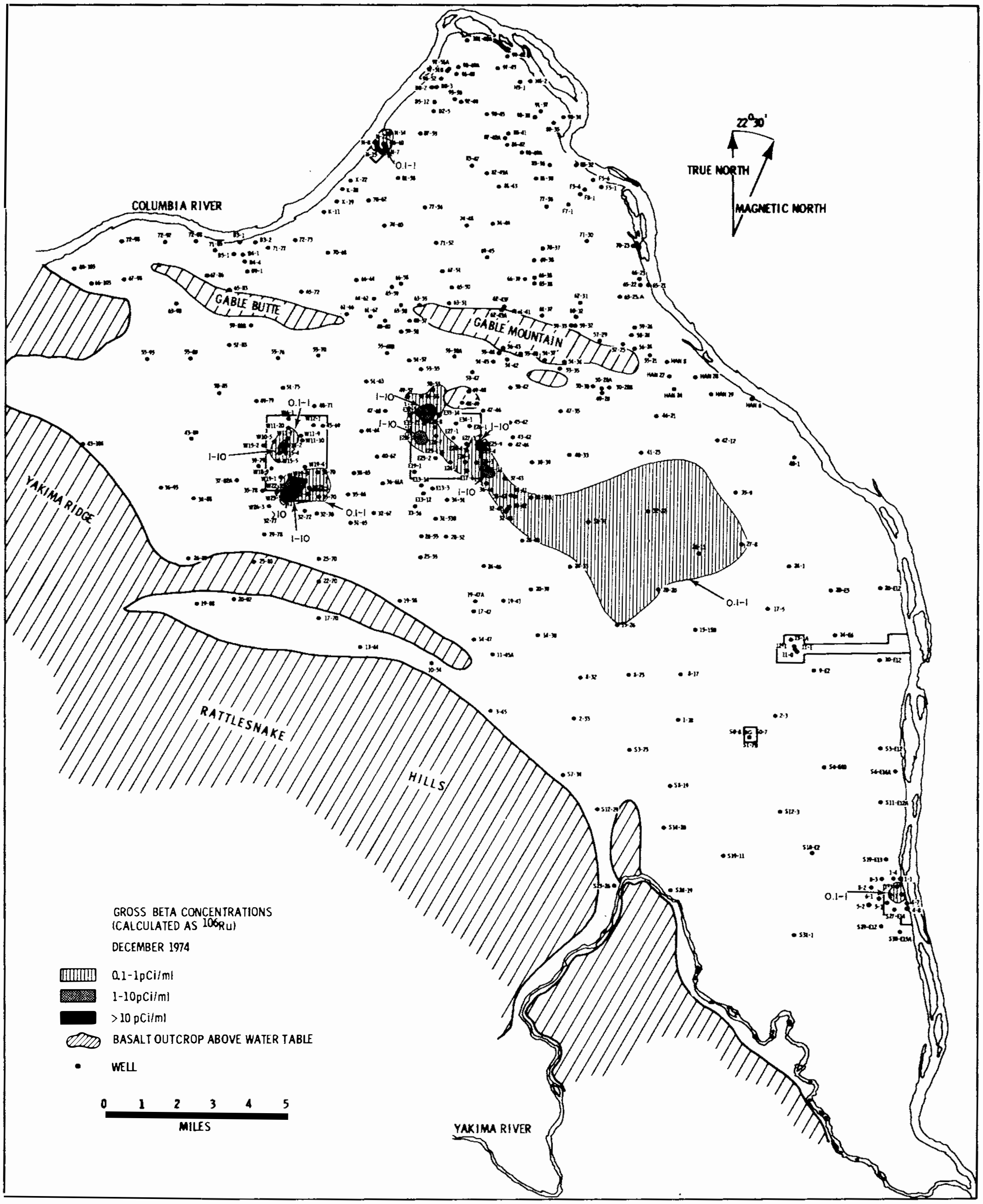


FIGURE A.1-13. Average Gross Beta (as ^{106}Ru) Concentrations for 1973 (Concentration Guide: 10 pCi/ml).

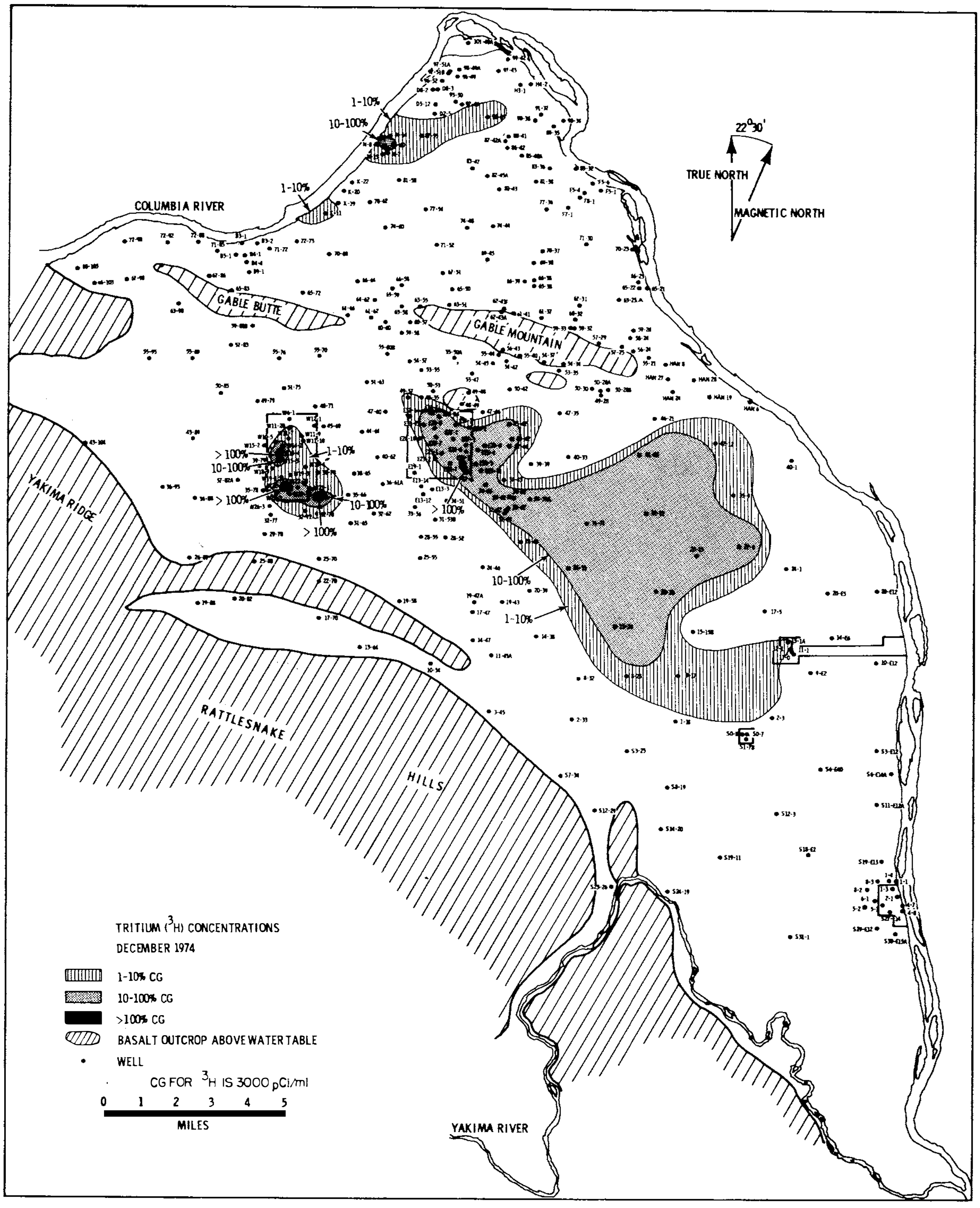


FIGURE A.1-14. Average Tritium (^3H) Concentrations for 1973 (Concentration Guide: 3000 pCi/ml).

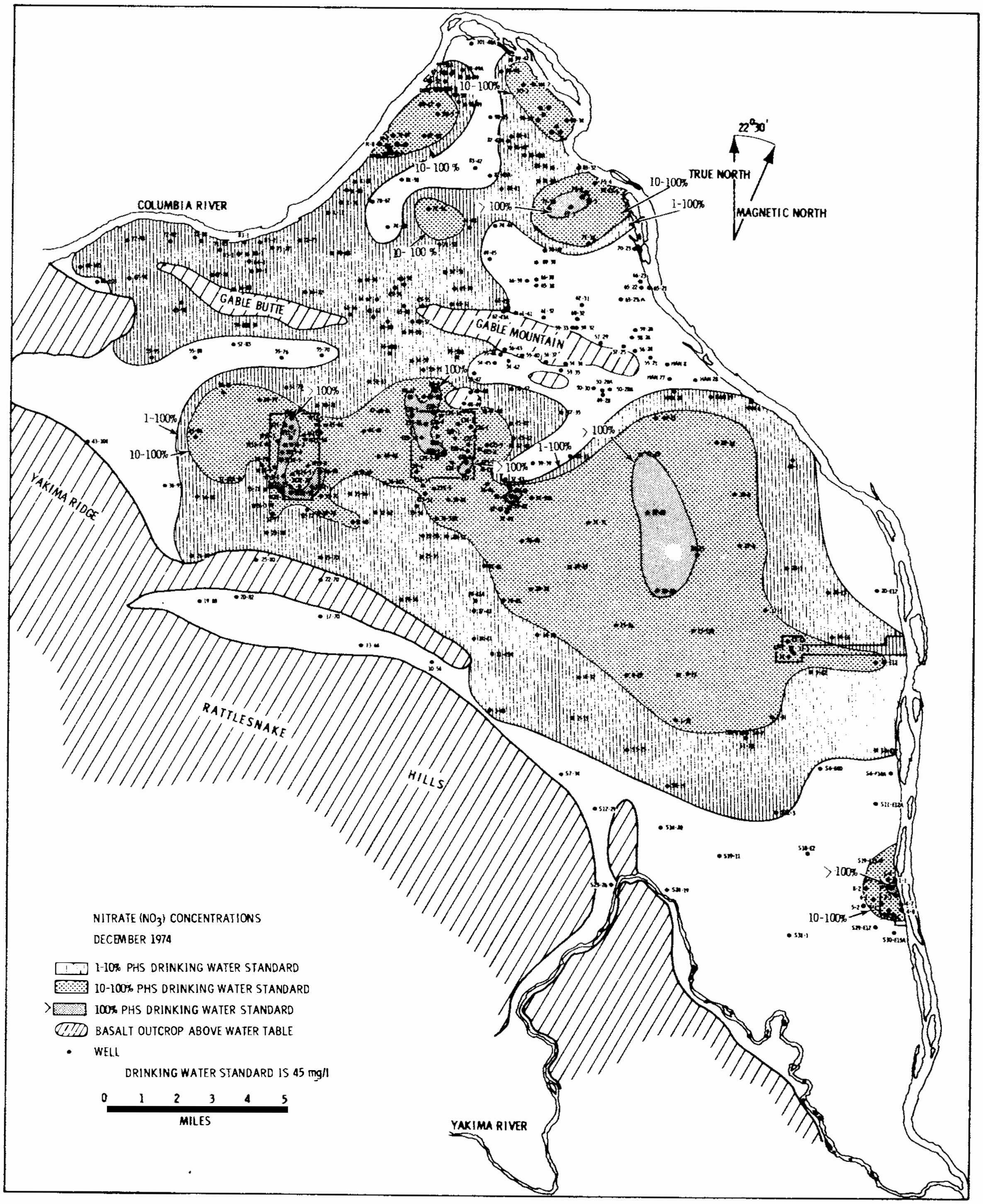


FIGURE A.1-15. Average Nitrate Ion (NO_3^-) Concentrations for 1973 (Drinking Water Standard: 45 mg/l).

intense weather disturbances moving eastward over the Pacific Northwest. These are occasionally interrupted by intrusions of continental polar air masses moving southward from Canada which bring colder, dryer air to the Hanford Reservation.

The local topography also affects the area's climate. Due to the distribution of hills, ridges, and the valleys lying between them feeding into the Reservation, the winds in various parts of the reservation have preferred directions. The topography not only channels light winds resulting from large-scale pressure patterns, but also funnels drainage winds flowing up or down the sloping valleys in response to differential ground heating and cooling.

A.1.4.1 The Meteorology of the 300 Area

Although very detailed meteorological measurements and observations have been made on a continuous basis since 1944 at the Hanford Meteorological Station (HMS) located near the center of the Hanford Reservation, relatively little meteorological data measured in the 300 Area are available. The HMS observations have been fully documented(1), but are not a completely accurate description of the 300 Area weather conditions, since the HMS is located 20 miles northwest of this Area. This is especially true of the meteorological parameters such as winds and temperature, which are known to be highly variant spacially on the Hanford Reservation. However, meteorological observations taken at the HMS can give extremes, trends, and ranges of winds, temperature, and other parameters closely approximating those prevalent in the 300 Area. Furthermore, weather phenomena with a horizontal length scale comparative with that of the Hanford Reservation, such as thunderstorms, or blowing dust, could accurately be described for the 300 Area by observations made at the HMS. Therefore, the following synopsis will discuss conditions observed at the HMS unless stated otherwise. Emphasis is placed on general trends, extremes and ranges of meteorological parameters which may be observed in the 300 Area.

A.1.4.2 Temperature

Temperatures observed on the Hanford Reservation can be discussed on the basis of local records from 1912 to 1970. On the average, January is the coldest month with an average temperature of 29.4°F. The average maximum and average minimum temperatures for January are 36.7°F and 22.1°F, for an average January temperature range of 14.6°F. The coldest January on record had an average temperature of 12.1°F, and the coldest recorded temperature since 1912 was -27°F. The greatest wintertime daily temperature was 42°F. The average number of days in a year with minimum temperatures of or below 32°F is 115, and the longest uninterrupted period of freezing temperatures was 23 days.

The warmest month of the year on the average is July, with an average temperature of 76.6°F. The average maximum and minimum temperatures for July are 91.8°F and 61.0°F, with an average July range of 30.8°F. The warmest July experienced on the Hanford Reservation had an average temperature of 81.8°F and the warmest temperature recorded was 115°F. The greatest summertime daily temperature range was 44°F, the average number of days with maximum temperatures at or in excess of 100°F is 13, and the longest string of consecutive days with maximum temperatures greater than or equal to 100°F was 11.

Several characteristics of this area result in allowing the temperature to change significantly over relatively short periods of time. First, the dryness of the air results in a much greater heat loss by the ground to space at night than areas with higher humidities. This causes surface temperatures to fall quite rapidly after sundown on clear nights, and results in comparatively low nighttime temperatures. Warm and cold fronts passing through the area can cause noticeable temperature changes, and quite severe temperature drops are experienced when the continental polar air masses make intrusions into the region. Finally, the location on the lee side of the mountains can often result in the chinook phenomenon, a warm wind resulting from downslope subsidence of air having a decreased water vapor content due to rain condensing and falling out of it on the west side of the mountains. In an extreme case of the chinook, the temperature has increased by 24°F in an hour.

A.1.4.3 Humidity

The relative humidity of the Hanford Reservations varies with the seasons, mostly because of temperature variation. The average January relative humidity is 75.7%, while the average July value is 31.8%. The wintertime frontal storms can bring in some moisture causing most of the fog and rain experienced in the winter months.

Because the 300 Area is located next to the Columbia River (unlike the HMS from which the above values are taken), it is likely to have slightly higher relative humidity values for the same air temperatures because of river water evaporation. Thus, it is possible that fog could form in the 300 Area and not form at the HMS, even though the two locations register the same temperature. The difference in the number of days in which fog is observed should be few, however, since both areas would normally have values below the near 100% relative humidity required for fog formation.

A.1.4.4 Wind

Surface wind observations have been recorded in the past at the 300 Area, and a time distribution study of their direction and speed show significant differences from the low-level winds recorded at the HMS. While the predominant wind direction at the HMS is northwesterly because of local topographic influences, the predominant direction in the 300 Area is southwesterly. In both cases, however, the predominant direction for the strongest winds is southwesterly. These wind directions are more often a result of large-scale pressure patterns (the Pacific storms) than from topographic influence. Joint wind speed and wind direction frequency distributions have been tabulated for both the HMS[1] and the 300 Area[2]. Also, wind roses have been plotted for many locations on the Hanford Reservation[3].

Although no vertical profile of winds have been measured in the 300 Area, those measured at the HMS show how the rate of change of wind velocity with height varies seasonally and diurnally. In the summertime, generally, very little direction shear occurs; but during the winter, with its disturbance-related temperature changes, the wind direction tends to vary with height much of the time. The variation of wind speed with height is always greatest under the most stable conditions, which on a diurnal scale occur at night. This variation is greatest during summer nights.

Strong winds have occurred on the Hanford Reservation, and are usually associated with the strong pressure gradients connected with the winter storms.

Although the average wind speed in June (measured at a height of 50 feet) is approximately 1.5 times that for December, December has had five times as many occurrences of wind speed greater than 31 mph as June. On the other hand, December has many more instances of calm and light winds than June normally has. Nevertheless, the odds are that the strong winds will come during the winter months. The highest wind speed ever recorded on the Hanford Reservation at a height of 50 feet was a gust of 80 mph associated with gale force winds. This occurred behind a wintertime occluded front.

One funnel cloud occurred on the Hanford Reservation in 1948 that has not been confirmed as a tornado. Thirteen tornados were confirmed within 100 miles of the HMS in the last 60 years. There is some evidence[4] that there may be preferred regions of Oregon, Washington, and Idaho for tornado formation. Even so, the probability of a tornado forming and then striking the Exxon Nuclear Company, Inc., for example, is estimated to be six chances in a million during a given year[5]. The maximum wind speed for the Hanford site is estimated in the <u>Fast Flux Test Facility Environmental Statement</u> (WASH-1510) as 175 mph. This agrees with the best estimate of 174 mph in the statistical tornado study made by Exxon Nuclear Company, Inc.[15] (formerly Jersey Nuclear Company.) The occurrance of a typhoon (Pacific hurricane), another source of strong winds, can be virtually ruled out in this region.

A.1.4.5 Precipitation

The average annual precipitation for the Hanford Reservation measured at the HMS is 6.25 inches. Forty-two percent of this amount falls from November through January, while only 10 percent falls from July through September. Precipitation falls on 132 days out of the average year, but only 24 of these days receive 0.10 inches or more. The largest number of consecutive days in which some precipitation fell is 15, and the longest period without measurable precipitation is 101 days. The greatest rainfall rate measured over a period of 12 hours or more was 1.88 inches in 12 hours.

About 40 percent of all precipitation falling from December through February is as snow. On the average, winters have only five days on which six or more inches of snow accumulates. The longest continuous period in which the snow cover was six inches or more was 32 days. The greatest recorded snowfall was 12.1 inches.

A.1.4.6 Miscellaneous Phenomena

Thunderstorms are recorded[1] in Hanford Reservation records as thunderstorm days. A thunderstorm day is a calendar day during which thunder is heard. Virtually all thunderstorms occur during the months of April through September, averaging 11 days per year. Though a severe thunderstorm is rarely experienced in this area, lightning strikes have set off grass fires on the Hanford Reservation burning thousands of acres of grass.

Hail has fallen in every month from February through October, although it is normally more closely associated with thunderstorms. Hail is a rare event, having occurred on only 14 days of a 25-year record. Hail seldom occurs because its formation requires an abundance of super-cooled water droplets in the clouds, a rarity in this dry region. Hailstones have ranged in size from 0.2 inches to 0.4 inches on the Hanford Reservation.

Fog has been observed in every month of the year at the HMS, but 95% of all fog occurrences were during the months from November through February. Fog is observed at the HMS on the average of 38 days per year. As mentioned earlier, this number could be slightly larger for the 300 Area due to its Columbia River proximity. Radiation fog, a result of nocturnal cooling near the ground, is by far the most common type. It occurs in conjunction with low surface wind speeds. When freezing temperatures occur during fog periods, the water droplets come in contact with objects and freeze on them, resulting in rime ice deposits. Occasionally such deposits have been heavy enough to break some local electric lines.

Blowing dust and suspended dust are events restricting visibility to six miles or less. While blowing dust usually occurs with wind speeds varying from 19 to 60 mph, suspended dust can occur in winds as light as 4 mph. Winds from any direction can cause blowing dust or suspended dust, but by far the most common direction source is southwesterly. It will be recalled that this is the "strong wind" direction for the Hanford Reservations.

A.1.4.7 Pollution Dispersion Characteristics

Light winds and inversions are the primary inhibitors of dispersion of gaseous or particulate pollution. Because of this area's dry, clear climate, nocturnal inversions occur regularly, but are most severe in the summer months. However, the low-level inversions are almost always eradicated during the day by strong surface heating. Thus, while foreign material may be trapped within the inversion layer adjacent to the ground on a clear night, it will almost always be dispersed by the low-level turbulence caused by daylight heating. Overall, June has the most unstable days (strongest decrease of temperature with height and dispersion of pollutants), while October has the most stable nights (strongest increase of temperature with height and trapping of pollutants).

Normally, light winds accompany the nocturnal inversions. However, these inversions can be sustained in the presence of winds up to 20 mph as long as the winds are steady and not gusty. In this case, pollutants would be transported horizontally, but would undergo very little vertical dispersion. Vertical dispersion can only occur when the inversion is dissipated. This happens during turbulent conditions such as gusty winds, the presence of local obstructions to flow, or vertical updrafts due to ground heating. Since combinations of the turbulent conditions are more efficient in the dispersion of pollutants than any single condition, windy days have better pollution dispersion characteristics than do windy nights.

Stagnation, the opposite of the windy conditions described above, can occur for extended periods of time. It is defined as the persistence of a given volume of air over a region characterized by a period of daily average wind speed five mph or less, with no gusts greater than 15 mph. The months of lightest average wind speed (November through February) studied over a 15-year period showed one case of 19 and 20 days' stagnation periods back to back. Although such extreme cases can only be expected about once in 20 years, a 10-day stagnation period can be expected every other season from probability considerations. These stagnation periods result from the interruption of the wintertime Pacific storms propagating eastward across the region bringing with them relatively strong winds and unstable conditions.

Although combined wind and stability measurements have never been conducted on a continuous basis in the 300 Area, such measurements have been undertaken over a period of one year at a meteorological tower located adjacent to the construction site of the Washington Public Power Supply Systems (WPPSS) No. 2 power plant. This tower is located about seven miles northwest of the 300 Area. Because of its proximity and similar surrounding topography, the WPPSS No. 2 tower data are considered to be generally representative of the conditions as they might be measured in the 300 Area. They are certainly more representative of average 300 Area meteorological conditions than those measured at the distant HMS.

Wind velocity and air temperature measurements made at the WPPSS No. 2 tower at heights of 33 feet and 245 feet have been analyzed to produce values of the average atmospheric dilution factor, $\bar{\chi}/Q$. This is a measure of the average efficiency of pollutants dispersion for a particular area based on that area's wind and stability characteristics. For a given distance and direction from the source, the smaller the value of $\bar{\chi}/Q$, the more efficient the dispersion of pollutants is at that point. Table A.1-5 shows the results of calculations which were made assuming a ground level release. These values are ultimately used for estimating radiation dose levels for a nuclear facility. The low values throughout the table indicate that, on the average, the area in question has good air pollution dispersion characteristics.

A.1.5 Ecology

The Hanford Reservation is an isolated, controlled access area and has been used for production and test reactor operations for over two decades. Plants and animals are, for the most part, naturally occurring species. Agricultural production is limited to the periphery of the Reservation, the closest point being nearly one-half mile due east of the HFNS site.

TABLE A.1-5

Atmospheric Dilution Factors for HFNS

RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	4.97E-06	7.55E-07	3.31E-07	1.99E-07	1.36E-07	6.50E-08	2.48E-08	1.26E-08	8.14E-09	5.89E-09	6.51E-06
NNE	4.24E-06	6.39E-07	2.79E-07	1.67E-07	1.14E-07	5.41E-08	2.05E-08	1.04E-08	6.75E-09	4.90E-09	5.53E-06
NE	3.80E-06	5.78E-07	2.54E-07	1.53E-07	1.04E-07	4.99E-08	1.91E-08	9.70E-09	6.31E-09	4.57E-09	4.98E-06
ENE	3.62E-06	5.52E-07	2.43E-07	1.46E-07	1.00E-07	4.80E-08	1.84E-08	9.32E-09	6.04E-09	4.37E-09	4.75E-06
E	3.34E-06	5.06E-07	2.22E-07	1.33E-07	9.07E-08	4.32E-08	1.64E-08	8.27E-09	5.35E-09	3.86E-09	4.37E-06
ESE	5.16E-06	7.85E-07	3.43E-07	2.05E-07	1.40E-07	6.62E-08	2.50E-08	1.25E-08	8.06E-09	5.82E-09	6.75E-06
SE	6.41E-06	9.81E-07	4.32E-07	2.60E-07	1.77E-07	8.49E-08	3.24E-08	1.64E-08	1.06E-08	7.69E-09	8.41E-06
SSE	6.34E-06	9.70E-07	4.27E-07	2.57E-07	1.76E-07	8.43E-08	3.23E-08	1.64E-08	1.07E-08	7.72E-09	8.32E-06
S	5.95E-06	9.12E-07	4.03E-07	2.44E-07	1.68E-07	8.07E-08	3.12E-08	1.60E-08	1.04E-08	7.54E-09	7.82E-06
SSW	4.95E-06	7.61E-07	3.38E-07	2.05E-07	1.41E-07	6.81E-08	2.65E-08	1.36E-08	8.84E-09	6.42E-09	6.52E-06
SW	4.93E-06	7.67E-07	3.42E-07	2.07E-07	1.43E-07	6.92E-08	2.70E-08	1.38E-08	9.02E-09	6.54E-09	6.51E-06
WSW	3.96E-06	6.15E-07	2.73E-07	1.65E-07	1.14E-07	5.50E-08	2.14E-08	1.10E-08	7.14E-09	5.18E-09	5.23E-06
W	3.53E-06	5.48E-07	2.44E-07	1.48E-07	1.02E-07	4.92E-08	1.92E-08	9.82E-09	6.40E-09	4.65E-09	4.66E-06
WNW	3.51E-06	5.40E-07	2.38E-07	1.44E-07	9.84E-08	4.72E-08	1.82E-08	9.28E-09	6.04E-09	4.38E-09	4.62E-06
NW	3.19E-06	4.84E-07	2.12E-07	1.27E-07	8.68E-08	4.14E-08	1.57E-08	7.99E-09	5.19E-09	3.76E-09	4.17E-06
NNW	4.44E-06	6.78E-07	2.98E-07	1.79E-07	1.22E-07	5.85E-08	2.23E-08	1.13E-08	7.32E-09	5.29E-09	5.82E-06
TOTALS	7.23E-05	1.11E-05	4.88E-06	2.94E-06	2.01E-06	9.65E-07	3.70E-07	1.88E-07	1.22E-07	8.86E-08	9.50E-05
CUM TOTL	7.23E-05	8.34E-05	8.83E-05	9.12E-05	9.32E-05	9.42E-05	9.46E-05	9.48E-05	9.49E-05	9.50E-05	9.50E-05

A.1.5.1 Soil

Soils of the Hanford Reservation formed from five kinds of parent material, including recent alluvium, old alluvium (glacial outwash), windblown sand, lacustrine (lake-laid) deposits, and loess (wind-laid) deposits. Basalt bedrock underlies all of these deposits. The mineralogy of the parent material is varied, resulting in part from weathering of local basalts and in part from weathering of igneous and metamorphic rocks to the north and east of the Hanford Reservation.

The soils of the Hanford Reservation have been mapped, described, and classed Physical and chemical characteristics of major soil series of the Hanford Reservation are also available. The soil in the vicinity of the 300 Area may be described as a dark-colored, coarse or medium textured soil underlaid by gravel. The surface soil is generally about 36 inches thick. Occasional dunes of coarse wind blown sand are present. The sparse vegetation supported by these soils can be used for grazing, but such use is severely limited by the shallow soil, eroded, rough, stony or very dry sandy conditions.

A.1.5.2 Vegetation

The vegetation mosaic of the Hanford Reservation consists of eight major kinds of plant communities identified by the most conspicuous or most abundant plant species:

- Sagebrush/bluebunch wheatgrass
- Sagebrush/cheatgrass or Sagebrush/Sandberg's bluegrass
- Sagebrush-bitterbrush/cheatgrass
- Greasewood/cheatgrass-saltgrass
- Winterfat/Sandberg's bluegrass
- Thyme buckwheat/Sandberg's bluegrass
- Cheatgrass-tumble mustard
- Willow

The most broadly distributed vegetation-type on the Hanford Reservation is the sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass association. This association is typical of the 300 Area except for the addition of bitterbrush intermingled among the sagebrush shrubs. Large range fires have occurred on the Hanford Reservation; the largest covered over 19,000 contiguous acres in 1970 but did not affect the 300 Area. The fire effectively removed much of the surface vegetation. The most efficient early invader of these burned areas was tumbleweed.

A.1.5.3 Mammals

The mule deer is the only big game mammal normally found on the Hanford Reservation, although a white-tail deer has been recorded. A single elk resided on the Reservation for a few months in 1971-72, probably a migrant from the Blue Mountains 70 miles to the east. Most of the mule deer on the Hanford Reservation occur along the Columbia River, with smaller concentrations near Gable Mountain in the 200 Area, at Rattlesnake Springs, and on the Snively Ranch area in the Rattlesnake Hills. Over the past years, 180 fawns (from near the Columbia River only) have been tagged and released. Tagged animals have been taken during the legal hunting season from as far away as Prosser, Washington; along the Yakima River, from Mattawa, in the Saddle Mountains, and near the Walla Walla River.

The cottontail rabbit is the only small game mammal, with small populations scattered throughout the Reservation Area. The raccoon is probably the most abundant fur bearing mammal on the Hanford Reservation, mostly confined to shoreline areas of the Columbia River and waste ponds in the 200 Areas. Beavers and muskrats occur in backwater areas of the Columbia River, while muskrats are found in waste ponds and ditches in the 200 Areas. Minks occur along the Columbia River, and weasels are scattered throughout the Hanford area. The coyote is abundant on the Hanford Reservation as compared with adjacent land areas, although no accurate estimate of population density has been made. The bobcat and badger are present on the Reservation but in low numbers.

The jackrabbit is widely distributed on the Hanford Reservation; however, it is less abundant in the sagebrush/bluebunch wheatgrass vegetation than in the sagebrush/cheatgrass and sagebrush-bitterbrush/cheatgrass vegetation-types. The jackrabbit is an important food item for coyotes and raptors. Porcupines are widely distributed over the Reservation area but are especially abundant along the Columbia River.

Small mammals are abundant on the Hanford Reservation. Their population dynamics have been studied by mark-and-recapture techniques. The great basin pocket mouse is the most abundant mammal on the Reservation. Deer mice and ground squirrels are locally abundant, as is the pocket gopher. Other small mammals are the harvest mouse, house mouse, Norway rat, mountain mole, sagebrush mole, grasshopper mouse, vagrant shrew, Merriman shrew, least chipmunk, and wood rat.

A.1.5.4 Birds

The chuckar partridge is the most important game bird on the Hanford Reservation. Most of the population is concentrated on the Arid Land Ecology (ALE) Reserve, especially in the Rattlesnake Hills, but local populations exist in the Gable Mountain and White Bluffs area. Although introduced to Washington from Eurasia, the chuckar is well adapted to the arid environment of the Hanford Reservation, feeding upon herbage, seeds and insects associated with dry rangeland.

Chinese ring-necked pheasants are present on the Hanford Reservation but in small number. Small groups are found along the Columbia River, generally upstream from the old Hanford townsite, Rattlesnake Springs and Snively Spring. The habitat is marginal for pheasants.

California quail are present as scattered local populations along the Columbia River, especially on abandoned farmstead sites with residual orchard and shade trees, and around the waste ponds in the 200 Areas.

Mourning doves are migratory birds that nest throughout the Hanford Reservation area during the spring months. Most birds have migrated by October.

Sage grouse are present on the Hanford Reservation in small numbers. In recent years most sightings occurred in the Rattlesnake Hills on the ALE Reserve. Over the years the sage grouse population declined in southeastern Washington as pristine habitat was converted to dryland wheat and irrigated agricultural fields.

The Canadian goose is the most important of the nesting waterfowl on the Hanford Reservation; the nesting habitat is confined to islands in the free-flowing reach of the Columbia River. The Columbia River also provides a resting sanctuary for migratory flocks of ducks and Canadian geese. At peak migratory periods, 70,000 birds or more, mostly mallards, use the Hanford reach of the Columbia River.

Raptorial birds use the Hanford Reservation as a refuge from human intrusions, especially during the nesting season. Trees around abandoned farms in the 100 Areas and around abandoned military installations provide nesting habitat for red-tailed hawks, Swainson's hawks, and great horned owls, while prairie falcon nests are located on Gable Butte and along Umtanum Ridge. The sparrow hawk is the most abundant of the raptorial birds, and the marsh hawk nests on the Hanford Reservation (as does the burrowing owl), but the osprey is only an occasional visitor along the Columbia River. The golden eagle and bald eagle are both winter visitors. The raptorial birds are of particular interest because their ancestral ranges are being steadily reduced by human encroachment. Relatively large areas of uninhabited land, such as the Hanford Reservation, provide a nesting and foraging ground for raptorial birds.

A.1.5.5 Snakes and Lizards

As compared with the southwestern United States desert areas, the herpetofauna of the Hanford Reservation, like south-central Washington in general, is sparse. The most abundant reptile of the low elevation steppe vegetation is the side-blotched lizard. The horned lizard is not common and the sagebrush lizard is scarce. The most abundant snake is the gopher snake, but the yellow-bellied racer and the Pacific rattlesnake are common. The coachwhip snake and the desert night snake are seldom observed.

Snakes are an important food item for the Swainson's hawk. Most reptiles are rather widely distributed over the Hanford Reservation in small numbers, generally decreasing in numbers as elevation increases. The side-blotched lizard apparently does not occur at all at elevations above 1,300 feet.

A.1.5.6 Insects

Leafhoppers (Cicadellidae), aphids (Aphilididae) and plant hoppers (Fulgoridae) are all present, but members of the superfamily Coccidea are the most abundant. The Coccidea are primarily mealybugs (Pseudococcidae), most of which occur in association with bluebunch wheatgrass. Cicadas may periodically be conspicuously present in this area, primarily due to the buzzing "song" produced by the males. The order Orthoptera contains the well known family Acrididae (grasshoppers) which are frequently very destructive members of grassland communities. The grasshopper possessing the greatest potential for outbreak in this area is the migratory grasshopper (*Melanoplus sanquinipes*). Localized concentrations have occurred at Hanford in the past and will probably continue to do so in the future. These concentrations appear to occur only in the cheatgrass-tumble mustard vegetation.

The order Coleoptera (beetles) constitutes the largest insect order and contains nearly 50% of all known insect species. They are a very diverse group, inhabiting nearly all conceivable types of habitat. Some important predacious beetle families in this area are the ground beetles (Carabidae), tiger beetles (Cicindelidae), checkered beetles (Cleridae) and ladybird beetles (Coccinellidae). The weevils (Curcultionidae) are probably the most important group of plant eaters in this order. Sixteen species of darkling beetles are known to occur in this area. Two species, *Philolithus densicollis* and *Stenomorpha puncticollis*, can be particularly abundant. *Philolithus* is much more abundant in native grasslands than in cheatgrass swards, while *Stenomorpha*, somewhat less abundant than *Philolithus*, is less sensitive to vegetation type. *Stenomorpha*, however, does not occur at low elevations.

The order Hymenoptera (ants, wasps, bees) contains a great number of species that are either predators or parasites, as well as the plant pollinators essential for ensuring fertilization of many flowering plant species. The ants (Formicidae) can be an important component of natural systems, but they are not abundant on the Reservation. Ants apparently occur in all vegetation types. Members of the family Specidae are solitary wasps. The Ichneumonidae, another Hymemopteran family, also attack a great variety of insect hosts. However, unlike the Sphecids (who paralyze and drag their prey to a burrow), the Ichnumonids are mostly internal parasites in immature stages of the host. Wasps are very mobile and occur in all vegetation types.

The collembola (springtails) play a dual role, some members feeding on decomposing plant material, others feeding directly on living plant tissue. Collembola are very common in any mulch layer but are frequently overlooked, due to their tiny size. The most abundant collembola species belongs to the family Sminthuridae, sometimes called the globular springtails.

A.1.5.7 Aquatic Ecology

The Columbia River is the dominant aquatic ecosystem on the Hanford Reservation. The fifth largest river in North America, it has a total length of 1,214 miles from its origin in British Columbia to its mouth at the Pacific Ocean. Numerous dams have been built on the river, with the only free-flowing U. S. section occurring between Priest Rapids Dam and McNary Reservoir. No significant tributaries enter the stream in this section, which is mostly contained within the Hanford Reservation. The entire Columbia River is exceptionally clean for a river of its size. The only other natural lotic ecosystem of any size on the Hanford Reservation is Rattlesnake Springs.

Several small lentic sites, that are a result of waste discharge effluents, are present within the Hanford Reservation. The largest of these is Gable Mountain Pond. Two trenches, totally about one acre, receive uncontaminated process waste generated in the 300 Area laboratories and reactor fuel canning complex.

No ecological studies have been conducted on the 300 Area trenches. Vascular plants grow down to the water's edge, but the trench proper is unsuitable for aquatic life. Ducks are occasionally observed on the trenches.

The Columbia River presents a very complex ecosystem in terms of tropic relationships due to its size, the number of man-made alterations, the diversity of the biota, and the size and diversity of its drainage basin. Streams in general, especially smaller ones, depend greatly upon allochthonous input or organic matter to drive the energetics of the system. Large rivers, particularly the Columbia with its series of lentic reservoirs, contain a significant population of autochthonous primary producers (phytoplankton and periphyton) which contribute the basic energy needs. The dependence of the free-flowing Columbia River in the Hanford stretch upon an autochthonous food base is reflected by the faunal constituents, particularly the herbivores in the second trophic level. Filter-feeding insect larvae such as caddis fly larvae, Hydropsyche, and periphyton grazers such as limpets and some mayfly nymphs are typical forms present. Shredders and large detrital feeders (such as the large stonefly nymphs) which are typical of smaller streams are absent. The presence of large numbers of the herbivorous suckers also attests to the presence of a significant periphytic population. Carnivorous species are numerous, as would be expected in a system of this size. Figure A.1-16 is a simplified diagram of the food-web relationships in selected Columbia River biota and represents probable major energy pathways.

A.1.5.8 Rare or Endangered Species

Currently there are no plant species occurring within Washington State which are officially listed as rare or endangered. The blue mountain onion Allium dictuon is the only plant species that has been proposed for consideration under the Endangered Species Act. The rocky soils on the ridge crests of the Rattlesnake Hills hold an endemic species of Balsamroot, Balsomorphiza rosea, but this species is locally abundant and not endangered at this time.

The Hanford Reservation provides a refugium for several rare, threatened or indeterminate species, all raptors. The prairie falcon (Falco mexicanus) nests in several regions on the Reservation, with the number of nesting pairs probably in the dozens. The American peregrine falcon (Falco peregrinatus anatum) apparently does not nest on the Reservation but does in neighboring regions, probably in small numbers. Species lacking specific data to attest to their status but considered to be possibly in some danger include the ferrugionous hawk (Buteo regalis), which nests in several sites

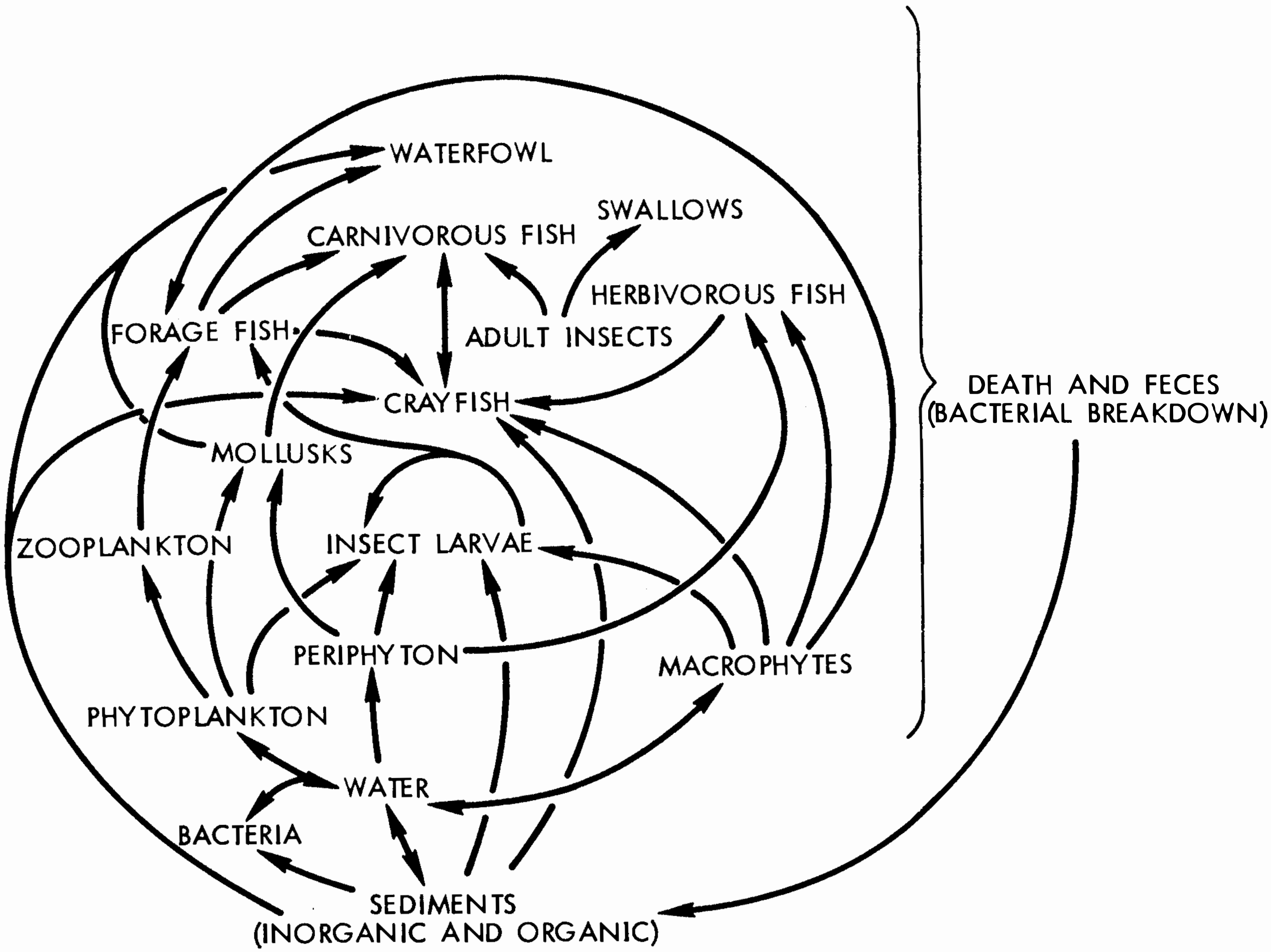


FIGURE A.1-16. Food Web of Columbia River.

on the Reservation but in small numbers; the American osprey (Pandion haliaetus carolinensis), only a visitor; and the western burrowing owl (Speotyto cunicularia hypugaea), which nest on the Reservation in small but significant numbers.

The proposed site for the HFNS facility in the 300 Area would have no effect on these rare or endangered species of plant and wildlife.

A.1.6 Radiological Condition

The radiological condition of the 300 Area, as part of the Hanford Reservation, has been studied since the beginning of operations at Hanford. Environmental data collected during 1975 showed continued compliance of Hanford operations with all applicable State and Federal regulations. Levels of radioactivity in the atmosphere from Hanford operations at all offsite sampling locations were indistinguishable from levels due to natural causes and world-wide fallout from the atmosphere. Routine radiological analyses of Columbia River water upstream and downstream of the Hanford Reservation did not show any identifiable effect due to Hanford operations. The majority of radioactivity measured in foodstuffs during 1975 was the result of naturally occurring potassium-40 and the fallout related nuclides strontium-90 and cesium-137. Other radionuclides detected occasionally were also attributed to worldwide fallout.

An extensive environmental surveillance and evaluations program provides measurement and interpretation of Hanford operations radiological impact upon its environs, both onsite and offsite. All significant potential pathways are evaluated, including particularly those resulting in direct exposure to the public and those wherein environmental reconcentration is likely to occur. Summaries and interpretation of the data are published in a series of annual reports. Groundwater data and evaluations are reported in the series, "Radiological status of the Groundwater Beneath Hanford Project for..." the latest issue being BNWL-1970 for 1974.[6] Environmental data from offsite locations are presented in the annual "Environmental Surveillance at Hanford..." series of reports, the latest being BNWL-1979 for 1975.[7] Environmental data from locations within the plant boundaries are presented in the annual "Environmental Status of the Hanford Reservation for..." report series, the latest being BNWL-B-477 for 1975.[8]

Radioactive materials are naturally present in the air we breathe, the food we eat, and the soil on which we live. Additional radioactive materials are present in the environment due to fallout of radioactive debris from past nuclear detonations in the atmosphere. The average total-body dose received by man in most parts of the world is approximately 0.1 rem per year.[9]

The lung and skeleton are selectively exposed to additional dose. Radon and its progeny are inhaled along with the air we breathe. Naturally occurring radium and strontium-90 from fallout (which are chemically similar to calcium) are ingested in our food. The average total-body dose received in the Hanford region is approximately 100 mrem per year[8] which is similar to the world average. Cosmic and terrestrial sources contribute approximately 75 mrem per year. The remaining 25 mrem per year is received from radioactivity present in our bodies, primarily potassium-40.

Past operations at Hanford have included the operation of nine plutonium producing reactors (eight with once-through cooling) along the Columbia River 100 Areas, fuel reprocessing and waste disposal activities at the 200 Area, and fuel fabrication and laboratory facilities at the 300 Area. The eight reactors with once-through cooling are no longer in operation. The remaining reactor, in the 100-N Area, may shut down during 1978, but the schedule is tentative. Fuel reprocessing activities have decreased from past years, with future operations difficult to predict. Fuel fabrication in the 300 Area is for the 100-N Reactor, and the future of this activity will parallel operation of N-Reactor. The research and development laboratories are in support of the Liquid Metal Fast Breeder Reactor program and therefore contain some plutonium. Presently, two 1100-MWE power reactor are under construction at the WPPSS site, approximately seven miles northwest of the HFNS site, and plans include the construction of one more power reactors. The FFTF, located within the 400 Area, will include a fast flux test reactor using sodium as a coolant. All of these operations have the potential to affect the radiological environment of the HFNS site.

A.2 The Surrounding Region

The Hanford Reservation is a restricted access area; land south of the Columbia River is under DOE control and land north of the Columbia River is controlled by the U. S. Fish and Wildlife Service as a game refuge. This region of the State of Washington has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the reservation have gradually been put under irrigation during the past few years. Most irrigated farms near the Hanford Reservation obtain water from the Yakima or Columbia Rivers.

A.2.1 Land Use On The Reservation

The present use of Reservation lands surrounding the 300 Area is indicated in Figure A.2-1. Many of the plutonium production reactors, shown along the Columbia River in the north part of the Hanford Reservation, have been deactivated by DOE. Fuel reprocessing and waste management activities are located at the 200 Areas, approximately 16 miles northwest of the 300 Area. The Fast Flux Test Facility (FFTF) and supporting facilities are located about six miles northwest in the 400 Area. Also shown in Figure A.2-1, is the site for the WPPSS Hanford Washington Nuclear Plant Number 2 (WNP-2) which is located about seven miles north of the 300 Area.

The 77,000-acre area in the southwest corner of the Hanford Reservation is set aside for long-term ecological studies. This large area is relatively undisturbed land of desert-steppe terrain ranging in elevation from about 350 feet to 3600 feet. Studies being conducted for DOE by Pacific-Northwest Laboratories (PNL), include effects of rainfall, shade and solar radiation with corresponding variations in soil, plant growth and wildlife.

With the exception of the Arid Lands Ecology (ALE) Reserve and the Columbia River Islands Reserve, other areas of ecological study shown on Figure A.2-1 are only temporarily restricted. Studies such as the investigation of sagebrush and grass regrowth following a lightning-originated fire in July 1970, (which destroyed approximately 19,000 acres) are being conducted.

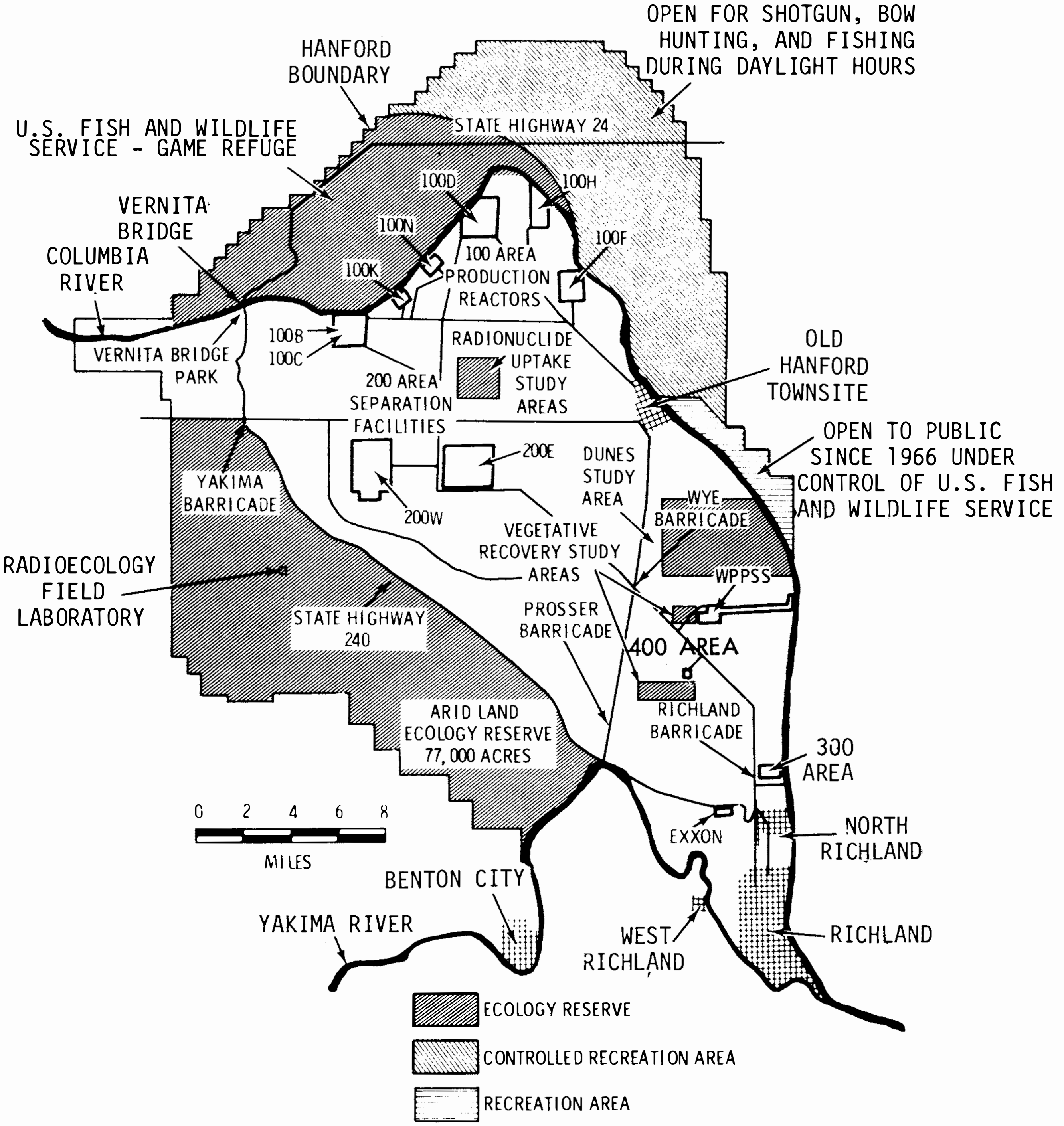


FIGURE A.2-1. Land Use on the Hanford Reservation.

Islands in the upper portion of the Columbia River adjacent to the Hanford Reservation are excluded from public use by the DOE and are used for wildlife refuge and DOE environmental research.

Also to the north of the Columbia River is a 54,000-acre area where hunting (shotgun and archery) will be permitted during daylight hours. Fishing and other recreational activities will be determined by the Washington State Department of Game at a later date. In addition, a 4000-acre area, located on the east side of the Columbia River opposite the original townsite of Hanford is presently used by the Washington State Department of Game for controlled hunting. All the above areas are shown in Figure A.2-1.

The 300 Area is bounded on the west by an DOE-constructed four-lane highway connecting to the public highway system at Richland, Washington. This four-lane highway is part of a network of approximately 270 miles of DOE-constructed two- and four-lane primary roads, 175 miles of secondary gravel roads and 225 miles of gravel and unimproved roads on the reservation.[10]

The DOE-owned railroad system has a capability of moving approximately 12,000 cars per year over 150 miles of Reservation track. The system includes five main lines, 195 subsidiary lines, and two classification yards.

Barges with capacities up to 3000 tons can navigate the Columbia River from the point adjacent to the site to the point of entry into the Pacific Ocean.

The 300 Area is about four miles north of the Richland Airport and 11 miles southeast of Vista Field near Kennewick and the Tri-Cities Airport near Pasco.

A.2.2 Land Use Adjacent to the Reservation

Land use within a 30-mile radius of the site (illustrated by Figure A.2.2) includes residential, suburban, corporate city, agricultural, industrial and commercial, scenic, recreational, and general use land areas. The region within 30 miles of the site includes areas of Adams, Benton, Franklin, Grant, Walla Walla and Yakima Counties.

The predominant use of lands within the 30-mile radius of the 300 Area is agricultural, with the nearest farms located along the east bank of the Columbia River in Franklin County. Principal crops are alfalfa, hay, wheat, potatoes, and sugar beets.[10]

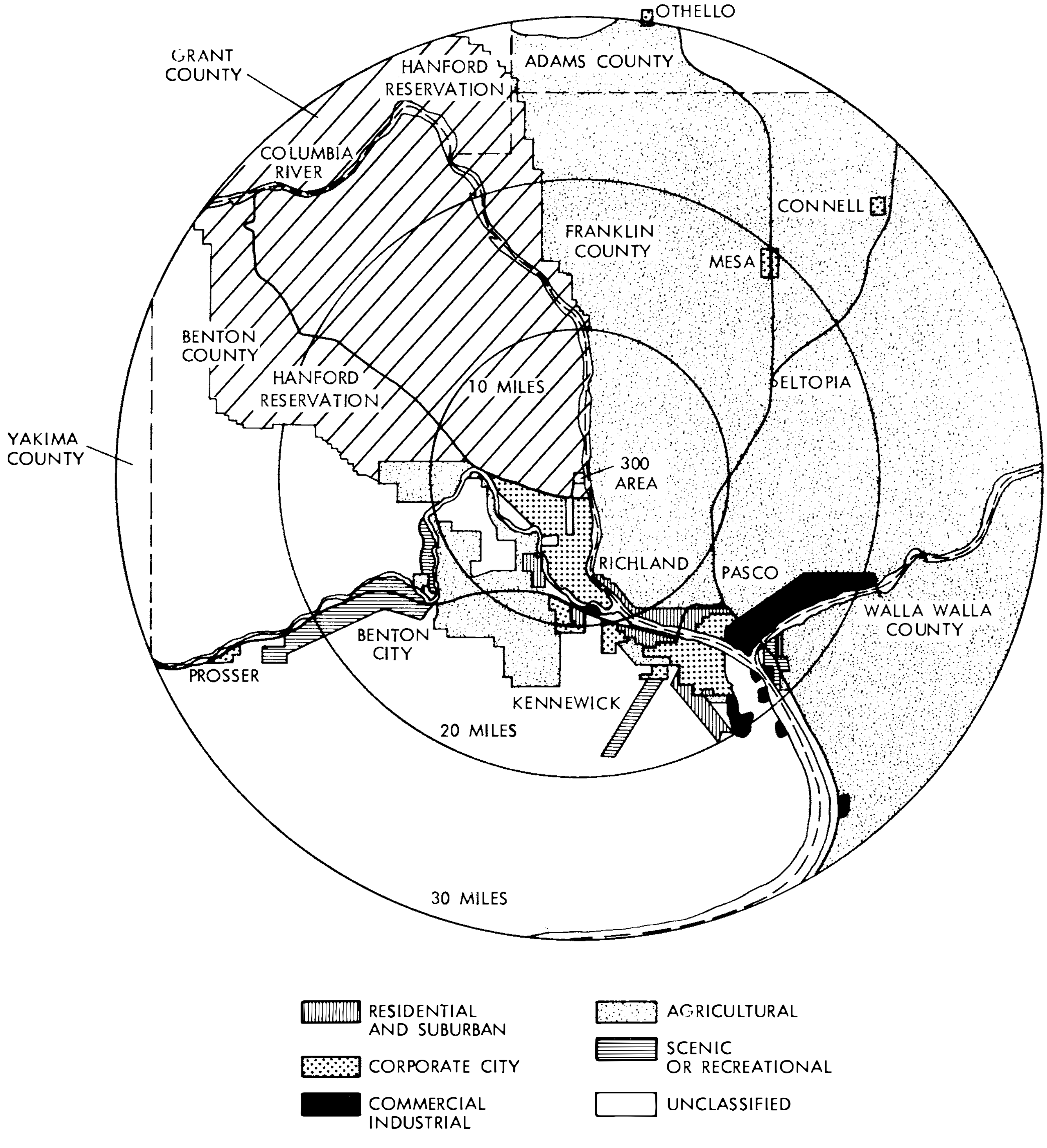


FIGURE A.2-2. Zoning Status of Area Surrounding the 300 Area

Industrial plants and laboratories located just south of the Hanford Reservation in north Richland include: Pacific Northwest Laboratories, Exxon Nuclear, U.S. Testing Corporation, Washington Public Power Supply System, J. A. Jones shops and offices, Western Sintering Corporation Plant, and NORTEC.

A.2.3 Regional Demography

Population in the area surrounding the Hanford Reservation is sparse, consisting primarily of farms and farming communities to the north, east, and west of the Reservation. The Tri-Cities, located to the south and southeast of the Reservation, represent the major population concentrations in the area.

Figures A.2-3 and A.-4 show the projected year 2000 census of the surrounding region within a 10-mile and 50-mile radius of the 300 Area. The projections were based on 1970 U.S. Census populations[11] adjusted for growth trends published by the State of Washington.[12] Pacific Northwest Bell Telephone Company, and Bonneville Power Administration, plus a special Tri-City regional economic study (April 1975).[13] The forecast does not reflect population expansion which would result from the erection of a nuclear park or a more intensive use of nuclear energy for nuclear power. Basic assumptions used in the forecast were:

- The Hanford Reservation will remain controlled with no permanent residents.
- There is an even distribution of residents throughout the unincorporated portions of each census district.
- The rate of population growth in urban and adjoining rural areas was related to projected economic developments.

Fpr CY-2000, an estimated 67,000 people will be living within a 10-mile radius of HFNS; and 256,000 people within a 50-mile radius.

A.2.4 Historic and National Landmarks

Review of the National Register of Historic Places[14] and the Washington State Register of Historic Places[15] indicates that there are no historical structures or archaeological sites in the immediate vicinity of the HFNS.

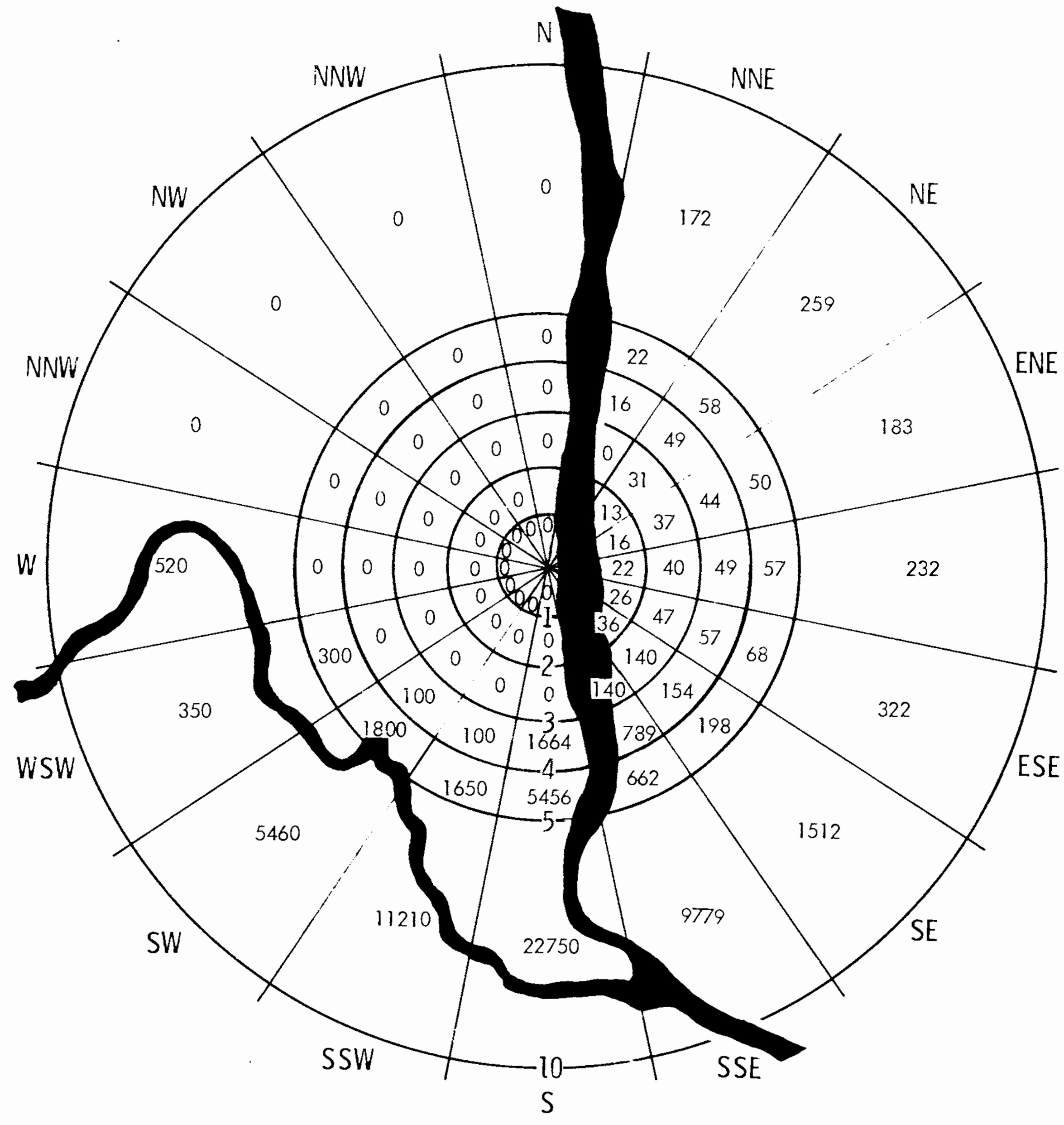


FIGURE A.2-3. Estimated Geographic Distribution of the 2000 Population Within a 10-Mile Radius of the 300 Area.

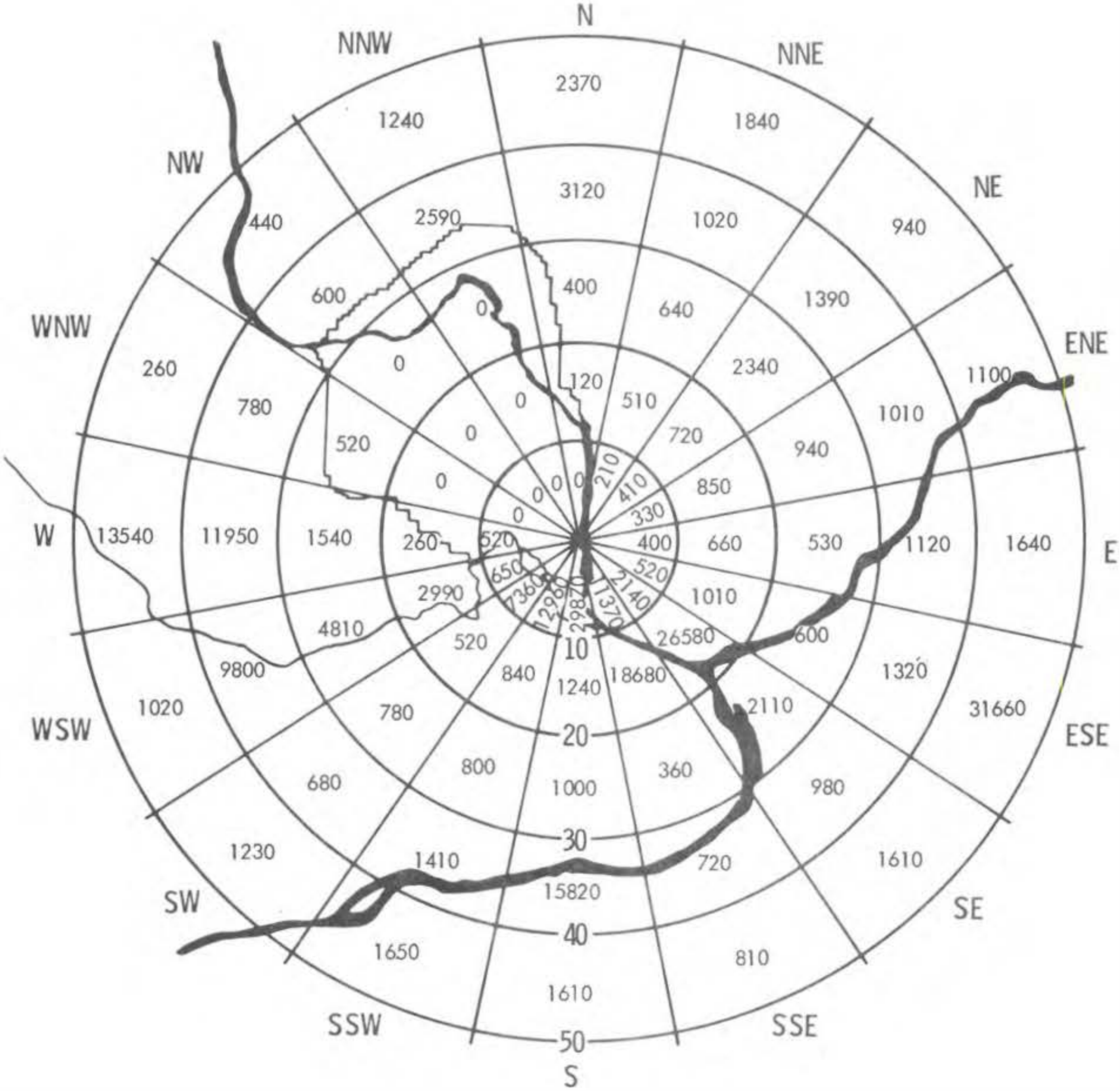


FIGURE A.2-4. Estimated Geographic Distribution of the 2000 Population Within a 50-Mile Radius of the 300 Area.

The nearest historical site to the HFNS is the Wooded Island Archaeological District which is located approximately 4-1/2 miles north. Wooded Island is an island in the Columbia River that contains six archaeological sites related to the Wanapum Indian peoples. The construction and operation of the HFNS is not expected to have any positive or negative impact on any of the existing or potential historic sites or districts.

Historic sites entered on the Washington State and/or National Registers of Historic Places or National Register of Historic Landmarks that are within approximately 50 miles of the HFNS site are as follows:

Benton County

- Columbia Park Island - Columbia River, west of Kennewick.
- Rattlesnake Springs Archaeological District - 25 miles northwest of Richland, DOE Arid Lands Ecology Reserve.
- Ryegrass Archaeological District - right bank of Columbia River, DOE Hanford Works Reservation.
- Telegraph Island Petroglyphs - Telegraph Island, Columbia River, vicinity of Patterson.
- Wooded Island Archaeological District - seven miles north of Richland, Columbia River.
- Locke Island Archaeological District - Columbia River, approximately 28 miles north-northwest of Richland.
- Snively Canyon Archaeological District - Rattlesnake Hills, approximately 25 miles northwest of Richland.
- Hanford Island Archaeological District - Columbia River, north of Richland.
- Hanford North Archaeological District - Richland vicinity
- Benton County Courthouse - Prosser

Franklin County

- Ainsworth - 5 miles southeast of Pasco near junction of Snake and Columbia Rivers.

- Lyons Ferry Boat - 5 miles northwest of Starbuck, Palouse River near confluence of Palouse and Snake Rivers.
- Marmes Rock Shelter - confluence of Palouse and Snake Rivers.
- Savage Island Archaeological District - thirteen miles north of Richland, Columbia River.

Walla Walla County

- Whitman Mission - Seven miles west of Walla Walla

Grant County

- Lind Coulee Archaeological Site - located within a 2.4 mile radius 3 miles northeast of Warden.

Kittitas County

- Ginkgo Petrified Forest - 29 miles east of Ellensburg

While further[16,17] archeological sites are not of national significance, many less unique sites are in the area. The Columbia River shoreline, from Vantage in the north downstream to Umatilla, is rich with Indian artifacts. Many campsites and fishing grounds within the Reservation boundary were traditionally used as wintering areas from prehistoric times until the area was evacuated in 1943.

A.3 REFERENCES

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2. Hale, J. P., Site Safety Analysis, Fast Flux Test Facility, BNWL-1350, Battelle, Pacific Northwest Laboratories, Richland, WA, April 1970.

3. Waste Management Operations Environmental Statement, WASH-1538, United States Atomic Energy Commission, Richland, WA, September 1974.

4. Fujita, T., Estimate of Maximum Wind Speed of Tornadoes in Three Northwestern States, SMRP Research Paper No. 92, University of Chicago, IL, December 1970, COM-71-00731.

5. Jaech, J. L. Statistical Analysis of Tornado Data for the Three Northwestern States, Jersey Nuclear Company, Richland, WA, December 1970.

6. J. R. Raymond, et al., Environmental Monitoring Report on Radiological Status of the Groundwater Beneath the Hanford Site, January-December 1974, BNWL-1970, Battelle, Pacific Northwest Laboratories, Richland, WA, 1976.

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8. J. J. Fix, Environmental Status of the Hanford Reservation for CY-1975, BNWL-B477, Battelle, Pacific Northwest Laboratories, Richland, WA, 1976.

9. L. A. Sagan, editor, Human and Ecological Effects of Nuclear Power Plants, Charles C. Thomas, Springfield, IL, 1974.

10. U.S. Atomic Energy Commission, Environmental Statement Hanford Number Two Power Plant, Washington Public Power Supply System, Richland, WA, 1972.

11. 1970 Census of Population, U.S. Department of Commerce/ Bureau of the Census for Washington State.

12. State of Washington, Population Trends, 1975, Information Systems Division, Office of Program Planning and Fiscal Managements, Olympia, WA, July 1975.

13. A Socioeconomic Study, Woodward-Clide Consultants, April 1975.

14. National Register of Historic Places, Department of the Interior, National Park Service, February 1973, and monthly supplements through November 1973.

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16. D. G. Rice, "Archeological Reconnaissance - Ben Franklin Reservoir, 1968", Laboratory of Anthropoligy, Washington State University, Pullman, WA, 1968.

17. D. G. Rice, "Archeological Reconnaissance - Hanford Atomic Works" Washington State University, 1968.

APPENDIX B

COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 4 1977

Mr. W. H. Pennington, Director
Office of NEPA Coordination
U. S. Energy Research and Development
Administration
Washington, D. C. 20545

Dear Mr. Pennington:

This is in response to your request for comments on the Draft Environmental Impact Statement for the High Flux Neutron Source Facility at the Hanford Reservation in Richland, Washington (ERDA-1556-D).

We have reviewed the statement and determined that the proposed action has no significant radiological health and safety impacts nor will it adversely affect any activities subject to regulation by the Nuclear Regulatory Commission. Accordingly, we have no substantive comments to make.

Thank you for providing us with the opportunity to review the High Flux Neutron Source Facility Draft Environmental Impact Statement.

Sincerely,

Voss A. Moore

Voss A. Moore, Assistant Director
for Environmental Projects
Division of Site Safety and
Environmental Analysis

cc: CEQ (5)

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

August 19, 1977

Mr. W.H. Pennington, Director
Office of NEPA Coordination
Energy Research & Development
Administration
Washington, D.C. 20545

Dear Mr. Pennington:

I am replying to your request of July 26, 1977 to the Federal Power Commission for comments on the Draft Environmental Impact Statement for the ERDA 1556-D High Flux Neutron Source Facility, Hanford, Washington. This Draft EIS has been reviewed by appropriate FPC staff components upon whose evaluation this response is based.

The staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power and natural gas industries for which the Federal Power Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involved with the proposed action. It does not appear that there would be any signficant impacts in these areas of concern nor serious conflicts with this agency's responsibilities should this action be undertaken.

Thank you for the opportunity to review this statement.

Sincerely,

Jack M. Heinemann
Advisor on Environmental
Quality

Advisory Council on
Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

August 17, 1977

Mr. W. H. Pennington, Director
Office of NEPA Coordination
Energy Research and Development Administration
Washington, D.C. 20545

Dear Mr. Pennington:

This is in response to your request of July 26, 1977, for comments on the Energy Research and Development Administration's draft environmental statement (DES) ERDA-1556lD, High Flux Neutron Source Facility, Hanford Reservation, Richland, Washington.

We have reviewed the DES and note that while cultural resource studies to date indicate no properties included in or eligible for inclusion in the National Register of Historic Places will be affected by the proposed undertaking, the possibility exists for previously unknown cultural resources to be encountered during construction. ERDA is reminded that should previously unknown cultural resources be identified during construction, which are eligible for inclusion in the National Register, it must afford the Council an opportunity to comment in accordance with the "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R. Part 800), as appropriate.

Should you have questions or require additional assistance in this matter, please contact Brit Allan Storey of the Council staff at P. O. Box 25085, Denver, Colorado 80225, telephone (303) 234-4946.

Sincerely yours,

Michael H. Bureau
for Louis S. Wall
Assistant Director, Office of
Review and Compliance

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

Room 360 U.S. Courthouse, Spokane, Washington 99201

August 18, 1977

W. H. Pennington, Director
Office of NEPA Coordination
U.S. Energy Research and Development Administration
Washington, D.C. 20545

Dear Sir:

The SCS has reviewed the draft environmental impact statement on the High Flux Neutron Source Facility, Hanford Reservation, Richland, Washington.

Those portions of the draft environmental impact statement of interest and concern to us appear to be adequately treated and we have no comments to make at this time.

Thank you for the opportunity to review the above statment.

Sincerely,

Richard P. Porter, Acting

Galen S. Bridge
State Conservationist

UNITED STATES DEPARTMENT OF AGRICULTURE
EXTENSION SERVICE
WASHINGTON, D.C. 20250

Cooperating with Land Grant Colleges and Universities

August 25, 1977

SUBJECT: Draft Environmental Impact Statement - High Flux Neutron Source Facility, Hanford Reservation, Richland, Washington

TO: W. H. Pennington, Director
Office of NEPA Coordination

The subject document has been reviewed by members of our staff.

We have neither negative or positive comments to offer.

H G Geyer

H. G. GEYER, D.V.M.
Director, Environmental Programs

Attachment

STATE OF WASHINGTON

OFFICE OF THE GOVERNOR

OFFICE OF PROGRAM PLANNING AND FISCAL MANAGEMENT

Dixy Lee Ray
GOVERNOR

HOUSE OFFICE BUILDING
OLYMPIA, WASHINGTON 98504

Orin Smith
DIRECTOR
206-753-5450

September 13, 1977

Mr. James L. Liverman
Assistant Director for
Environment and Safety
U.S. Energy Research and
Development Administration
Washington, D.C. 20545

Dear Mr. Liverman:

Review of the draft environmental impact statement for the High Flux Neutron Source Facility at Hanford Reservation has been completed by agencies of the State of Washington. The review process was coordinated by the Office of Program Planning and Fiscal Management, as the designated state clearinghouse, pursuant to the provisions of OMB Circular A-95.

Comments were received from the Department of Ecology and the Department of Game. While it is understood that ERDA will respond directly to the Game Department's comments relating to the content of the statement, the following is highlighted here for your consideration.

The Game Department recommends the installation of covering and fencing around evaporation ponds, leaching trenches, waste water trenches, etc. to stop wildlife, especially game birds, from entering such areas.

Thank you for the opportunity to review this document. I hope you will find these comments useful in preparing the final document.

Sincerely,

NICHOLAS D. LEWIS
ASSISTANT DIRECTOR

by: Michael E. Mills
Administrative Assistant

NDL:MEM:de

DEPARTMENT OF GAME

600 North Capitol Way / Olympia, Washington 98504

September 7, 1977

Mr. Mike Mills
State Planning Division
Office of Program Planning &
Fiscal Management
House Office Building
Olympia, Washington 98504

DRAFT EIS: High Flux Neutron Source Facility

Mr. Mills,

Your document was reviewed by our staff as requested; comments follow.

We strongly recommend the use of netting and other such devices to protect wildlife. Covering and fencing should be installed around evaporation ponds, leaching trenches, wastewater trenches, etc. These precautions are necessary to stop wildlife, especially game birds, from entering such areas.

Thank you for the opportunity to comment on your document. We hope you find our comments helpful.

Sincerely,

THE DEPARTMENT OF GAME

Fred H. Maybee

Fred H. Maybee, Applied Ecologist
Environmental Management Division

FHM:cv
cc: Agencies
Regional Manager

STATE OF
WASHINGTON

Dixy Lee Ray
Governor

DEPARTMENT OF ECOLOGY
Olympia, Washington 98504 206/753-2800

MEMORANDUM

TO: Mike Mills, State Planning Division
Office of Financial Management
House Office Building
Olympia, Washington

FROM: Rosemary Walrod, Environmental Review Section

SUBJECT: Draft Environmental Impact Statement --
ERDA - High Flux Neutron Source Facility

DATE: September 12, 1977

We appreciate receiving a copy of this draft environmental impact statement, however, we have no comments to offer at this time.

RW:bjw

LAUT R. WADE
Financial Consulting
750 WELCH ROAD • PALO ALTO, CALIFORNIA 94304

September 20, 1977

Mr. W.H. Pennington, Director
Office of NEPA Coordination
Energy Research and Development Administration
Washington, D.C. 20545

Dear Mr. Pennington:

This letter is with reference to the July 1977

Draft Environmental Impact Statement
High Flux Neutron Source Facility
Hanford Reservation - Richland, Washington

This proposed project is described as " one of the first major steps in the fusion reactor development program which will lead to commercial fusion plants by the year 2000." The stated electrical load is 9,000 KW with "250,000 KWH of electrical energy per day of operation to be drawn from the Bonneville power pool".

Approximately half of the total energy used in the Pacific Northwest is hydroelectric power. Around 90% of the electricity is generated by hydro power. Because of the worst drought in a century sundry essential industries have had to shut down facilities because of a shortage of electric power. The Bonneville Power Administration has advised its preference customers that it will be unable to supply their future growth requirements after 1983. November 1, 1976 BPA discontinued direct deliveries of non-firm energy to its industrial customers and also terminated secondary sales to private utilities. In BPA's August 1977 " Power Outlook through 1987-88 " power shortages are forecast for every year on all three assumptionsfor the next ten years under critical water conditions.

The stream flow of the Columbia River is the lowest in a century. The drought in California is the worst in modern times; Secretary Bergland has accurately forecast the state could be a desert with another year of drought. California experienced a 6 year drought from 1928 through 1934 so another year of drought would be nothing new. The Northwest Power Pool is part of the interconnected FPC Western States Coordinating Council - WSCC. Complete information is available in the public domain on the water and electric power crisis in WSCC, the Pacific Northwest, the Northwest Power Pool and the state of Washington. Hopefully we may see a return to normal water and power conditions by 1980 but no means exist for forecasting the weather for this region where 40 million Americans live. Those who set public policy must assume the worst.

The regional situation is just one facet of the more critical national situation for which all the necessary information is also readily available. A $61.3 billion federal deficit is being forecast for fiscal 1978. A trade deficit of $25 billion is being forecast because of our costly imports of energy, with an even higher balance of payments deficit which threatens the value of the dollar. Currently we are importing daily, directly and indirectly, over 4,000,000 barrels of crude oil and petroleum products from nations which in the past have embargoed exports to the United States, which embargo could be reimposed any day if the oil exporters' once again feel U.S. foreign policy is adverse to their interests. So long as we hover on this brink of chaos there is obviously not a single BTU of energy available for any non-essential federal project, nor for any federal project with some essentiality whose deferral at this point would not immediately jeopardize the national welfare and security.

We have been going through a very difficult period for decision makers due to the lack of a National Energy Policy within which framework new proposals could be judged. In the west this has been compounded by what we hope have been abnormal weather patterns, but may well not be. I see no reason why ERDA should risk making more bad decisions when the Department of Energy is due to be open for business October 1 and presumably some outline of our future National Energy Policy should be available within a reasonable time frame. In my judgment all factors combined dictate that the High Flux Neutron Source Facility project should be deferred until such time as there is a basis for making an intelligent decision.

As one who has been intimately involved in the energy field for over a quarter of a century I must dissent strongly from any assertion that there will be commercial fusion plants in operation in the United States in 2000. Fortunately for the United States North America is a continent of energy so we face no shortage of energy for many generations to come; what is needed is merely a schedule for phasing in substitute forms of energy as existing sources of energy are gradually depleted. Most of the rest of the world does not enjoy our favorable position. Japan, and some of the industrial nations of Europe, may well have to resort to fusion power in a quarter of a century, but surely not the United States! The cost and risk in developing this form of energy should be left to those nations with the first need for it. Our $680 billion national debt represents to a large degree bills the American taxpayers have paid for these nations; now is the time to let these nations use their own resources to develop such new sources of energy as they may require, the benefits of which U.S. taxpayers can later enjoy.

I am strongly opposed to any sizeable expenditures on fusion power while the federal government is running unacceptable deficits and U.S. need for such energy is so remote.

Sincerely yours,

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

SEP 21 1977

Mr. W.H. Pennington
Director, Office of NEPA Coordination
United States Energy Research and Development Administration
Washington, D.C. 20545

Dear Sir:

Thank you for the opportunity to review the draft Environmental Impact Statement for the High Flux Neutron Source Facility (ERDA-1556-D) located at the Hanford Reservation, Richland, Washington.

We believe the draft report to be complete from the standpoint of HEW concerns and have only a few comments to make concerning its improvement.

In Table 5.3-1 titled "Estimated First Year Whole-Body Dose Commitment from HFNS Operations," appearing on page 5-6 of the statement, doses are expressed in rem. Usually these doses are expressed in mrem which, of course, result in higher numbers although actually no higher doses. However, for the average person familiar with this usual system, the numbers may appear misleadingly low. The same approach is used in paragraph 5.3.2.1 in describing the dose to the maximum individual at the site boundary which appears on page 5-8. The same nomenclature is used in describing the dose to the nearest resident which also appears on page 5-8. Also in paragraph 5.3.2.3 on page 5-9 discussing onsite exposures the same nomenclature is used. It is my recommendation that these all be changed to mrem per year, week, or other appropriate time period. The same is applicable to Table 5.3-3 on page 5-10 and Table 5.3-4 on page 5-11. In this instance specific organ doses are given due to various vectors such as air submersion, air inhalation, ground exposure, food crops, including milk, etc. The same is also true of Table 5.3-5 on page 5-12 where the average annual dose is given in rem as opposed to mrem.

With regard to analysis of accidents, the program which has been designed for this purpose is described and appears to be quite adequate and as conceived and as proposed to be conducted. It will be subject to continuous review and modifications as further experience is gained. Additionally, a special study was made with regard to the hazards involved with the operation of HFNS. Proposed methods or plans for controlling the types of accidents have been described in the draft statement.

Sincerely,

Charles Custard
Director
Office of Environmental Affairs

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

TRENTON 08625

OFFICE OF THE COMMISSIONER

September 23, 1977

Mr. W. H. Pennington, Director
Office of NEPA Coordination
Mail Station E-201
Energy Research and
Development Administration
Washington, D.C. 20545

Dear Mr. Pennington:

The New Jersey Department of Environmental Protection has reviewed the Draft Environmental Impact Statement for the High Flux Neutron Source Facility at the Hanford Reservation, Richland, Washington. Based on the review, we find no environmental objections to the project being implemented as proposed.

The selection of the Hanford Reservation for the site of the proposed Facility appears to be proper. In addition to the monitoring inherent with the new installation, Hanford has an installed, operating system for monitoring and evaluating air, water, groundwater and several other planned evaluation programs, such programs to be revised as required.

Also favorable from an environmental point of view is the fact that, because the proposed facility will be built within the confines of the Reservation, there will be, except for temporary construction activities, no significant effect on the surrounding ecology.

In a more general vein, if the goal of significant commercial fusion power by the year 2000 is to be realized, a facility, such as the one proposed, is needed as soon as possible.

Sincerely,

Glenn Paulson

Glenn Paulson, Ph.D.
Assistant Commissioner for Science

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

SEP 26 1977

Mr. W. H. Pennington
Office of NEPA Coordination
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Pennington:

Enclosed are the EPA comments from the review of the Draft Environmental Statement ERDA-1556-D, the High Flux Neutron Source Facility, on the Hanford Reservation, Richland, Washington.

As a result of our review, we have no objection to the action in general. However, there are areas, enumerated in the attached comments, where it is felt that more information is required both to assure that necessary precautions will be taken and to allow a more complete understanding of possible public health and environmental impacts. In accordance with EPA procedure and in light of this review, this statement is rated Category 2 (Insufficient Information) and the proposed action is rated LO (Lack of Objections).

Should you or your staff have any questions concerning our classification or comments, please do not hesitate to call on us.

Sincerely yours,

Rebecca Hanmer

Rebecca W. Hanmer
Director
Office of Federal Activities (A-104)

Enclosure

EPA Comments on ERDA-1556-D
The High Flux Neutron Source Facility

Environmental Impact

1. p. 1-1 Please expand the third paragraph to make its meaning clearer. Why will these factors result in minimal impact on the Columbia River?

2. p. 3-23 Please provide the estimated total water requirements for the facility, including that for sanitary use and accelerator cooling makeup.

   In designing demineralizers for purposes of decontamination, it is necessary to know what radionuclides and their chemical forms and amounts are expected. This information should be available and included in the EIS.

3. p. 3-29 The disposal of cold traps from the lithium system may pose an interesting radiation protection problem. What engineered safeguards have been taken? How long will they be stored prior to construction of the alkali metals facility? What and where will the alkali metals facility be and how will the tritium be processed from the lithium? What will be the final form, quantity, and activity content of ^{3}H wastes? The estimated activities of ^{3}H + ^{7}Be released during accidents are large; can equivalent amounts be expected for disposal?

4. p. 5-2 Even though environmental data collected during 1975 shows atmospheric levels of radioactivity to be indistinguishable from background, is there a soil sampling effort being made to confirm that no radionuclide from any source nearby may be resuspended during the construction process? Are there any designated contaminated surface areas on the Hanford reservation?

Economic Considerations

1. General: The draft EIS presents a very vague, comparative evaluation of options. There is little information on costs for alternative designs, alternative sites, and modifications of existing facilities. Specific cost estimates for these alternatives would provide a useful basis for comparison.

2. Section 3.5. There is a brief discussion of decommissioning of the proposed facility in Section 3.5 of the draft EIS. This section discusses the need for decommissioning and states that "...procedures for decommissioning of HFNS will be subject to specific ERDA approval and will be required to meet the standards for protection of workers and general public," and also states that "...dismantling of the facility is the most probable decommissioning approach," but the EIS provides no information on costs of decommissioning. Monetary costs, environmental costs and radiation exposure associated with decommissioning are not considered. The lack of cost estimates renders this section ineffectual. For decommissioning procedures that use existing technology, specific cost estimates should be included in the final EIS. For procedures that are currently being developed, an explanation of the possible range of costs should be provided.

3. Section 7.4.1. An estimate of construction costs for the proposed facility is presented in Section 7.4.1 of the draft EIS, but there is no explanation of the assumptions and methodology used to estimate costs. The draft EIS simply states that "the projected dollar cost of construction is estimated to be approximately $70 million (including escalation)." This brief statement is insufficient as there is no basis for evaluating the estimate. The section on construction costs should include explanations of: (1) assumptions on escalation rates, (2) timing of costs, (3) methodology used to estimate costs, (4) specific categories of costs (e.g., materials and labor).

Dose Analysis

1. Section 3.4.10. What neutron activation products were considered when computing the dose rates in both controlled and uncontrolled areas?

2. Section 5.3.2.1. It seems unlikely that the χ/Q could be 1.5×10^5 sec/m^3. Please rectify this problem.

3. Section 5.3.2.3. If it is not a typographical error, EPA requests an explanation of the 2×10^{-2} rem/hour dose rate to the maximally exposed worker. This dose rate, taken on an annual basis, clearly exceeds existing Federal radiation protection guidance.

4. Section 5.3.3. The analysis presented in EPA's report Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry, was intended to be neither exhaustive nor to be seen as an analysis of the only nuclides which EPA considers to be important. Those nuclides analyzed were merely examples, such analyses should be completed for all nuclides pertinent in any particular situation.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION X
1200 SIXTH AVENUE
SEATTLE, WASHINGTON 98101

REPLY TO ATTN OF: M/S 623

SEP 26 1977

W. H. Pennington, Director
Office of NEPA Coordination
U.S. Energy Research & Development
Administration
Washington, D. C. 20545

Dear Mr. Pennington:

We have completed our review of ERDA's Draft Environmental Impact Statement on the proposed High Flux Neutron Source Facility (HFNS) at the Hanford Reservation in Richland, Washington. The environmental statement is basically a thorough analysis of the expected environmental effects of the proposed facility. Consequently we have only a few comments and suggestions for your consideration.

1. The calculation of the on-site dose estimate may need to be expanded. The current estimate of 2×10^{-2} rem/hr is for a hypothetical worker in a building 800 feet north of the HFNS site. It appears that the intervening area is a parking lot and it would seem reasonable to assume that personnel would be going in and out of the parking lot throughout the workday. Thus a dose estimate for the parking lot (people therein) would seem appropriate. It also appears that the parking lot meets the criteria for a Zone II or Zone I area for radiation shielding, depending on how one defines "controlled access."

2. It would be helpful if the figure on page 3-21 could be expanded to show the origins of the various waste streams. Although this figure shows that all radioactive liquid wastes would be processed through the 300 Area facility, the text limits its waste treatment discussion to wastewater from the primary loop of the accelerator cooling facility. Similarly the figure indicates that organic fluids will be used for dust control, while the text mentions only the application of water for dust control. The specific fluids

likely to be used and the frequency and intensity of their application should be discussed in the FEIS.

3. The statement should discuss the potential environmental consequences of a radioactive leak from the primary loop to the non-radioactive secondary loop of the accelerator cooling system.

4. The statement should discuss what monitoring will be done to confirm the adequacy of the treatment of radioactive waste waters.

The Environmental Protection Agency has rated this draft environmental impact statement LO-2, LO (Lack of Objections), 2 (Insufficient Information). The rating will be published in the Federal Register in accordance with our responsibility to inform the public of our views on proposed Federal actions under Section 309 of the Clean Air Act, as amended.

We appreciate the opportunity to review your environmental statements and would be glad to answer any questions which you may have about our comments. I can be reached by telephone at (FTS) 399-1595.

Sincerely,

Alexandra B. Smith

Alexandra B. Smith, Chief
Environmental Evaluation Branch

October 4, 1977

Mr. W. H. Pennington, Director
Office of NEPA Coordination
ENERGY RESEARCH AND DEVELOPMENT
ADMINISTRATION
WASHINGTON, D. C. 20545

RE: Draft EIS - ERDA - 1556-D
High Flux Neutron Source Facility

Dear Mr. Pennington:

As a result of City Council's review and action at its October 3, 1977 meeting, I am herewith forwarding to you the comments and recommendations of the City of Richland relative to the above referenced Draft Environmental Impact Statement. These may be considered the official comments and recommendations of the City.

Overall, the City concurs with the Draft Enviornmental Impact Statements finding that the High Flux Neutron Source (HFNS) facility is not expected to have a significant environmental or socioeconomic impact. The facility does not appear to adversly impact the City of Richland and, in fact, appears to add stability to the Tri-Cities by providing a relatively small source of employment during a period when major construction projects in the area will be decreasing their manpower requirements.

The only deficiency in the Draft Environmental Impact Statement is the lack of identification and quantification of non-radiological, noxious chemicals to be released on site. The following questions need to be addressed in the final Environmental Impact Statement:

A. What are the noxious chemicals referenced on pages 1-2 and 5-14 which will be released in small quantities?
What quantities will be released?
What is the expected maximum off-site concentration?

B. According to figure 3.4-1, organic fluids waste will be used for dust control. What fluids will be used?
How will they be applied?
What will be their off-site impact?

In conclusion, the City of Richland concurs with the information supplied in the Draft and looks forward to your responses to these questions in the Final Environmental Impact Statement.

Thank you for the opportunity to review and comment on the proposed action and if you have any questions please contact me at this office.

Yours truly,

CITY OF RICHLAND

NEAL J. SHULMAN
Acting City Manager

NJS:BD:wmc

cc: Richland Ecology Commission

L. A. Pasquini
Department of Ecology

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 77/713

OCT 12 1977

Mr. W. H. Pennington, Director
Office of NEPA Coordination
U.S. Energy Research and
Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

Thank you for your letter of July 26, 1977, transmitting copies of the Energy Research and Development Administration's draft environmental impact statement on the High-Flux Neutron Source Facility, Hanford Reservation, Richland, Washington.

Our comments are presented according to the format of the statement or by subject.

Fish and Wildlife

We are generally satisfied with the draft statement's identification of impacts to fish and wildlife resources from the proposed facility, with the exception of the environmental impacts from radioactive waste management practices. The draft statement presumes that radioactive waste management practices on the Hanford Reservation are adequate to protect fish and wildlife resources. We have questioned such assumptions previously in our comments of November 4, 1976, on the Nuclear Regulatory Commission's draft statement, and of December 13, 1974, on ERDA's draft statement (attached) for Waste Management Operations at the Hanford Reservation. We believe that the final statement should include a discussion of the potential adverse impacts to biota that can occur as a secondary impact associated with the overall management operations of this proposed project. The impacts of radioactive waste management practices at the Hanford Reservation are of recent concern due to the August 29, 1977, announcement by the Corps of Engineers of a permit request by United Nuclear Industries, Inc. on behalf of ERDA for placing of fill to cover-up potential radioactive contaminated riverbank springs which feed into the Columbia River.

Mineral Resources

The statement is adequate in regard to its treatment of mineral resources. The Hanford reservation was withdrawn from entry under the general mining laws and from the applicability of the mineral leasing acts by various public land orders beginning in September 1943. Some 70,432 acres still remain withdrawn from mineral entry. Construction of this facility on the reservation will not dedicate any additional land to single purpose use.

Groundwater

The ground-water velocities given on page A-23 of the draft statement (15 to 80 ft/day) appear extremely high for the types of aquifer materials involved, the permeabilities reported and the hydraulic gradients indicated on page A-26. Our information suggests that the reported velocities may be 10 times or more too high--unless very unusual conditions exist. The reported ground-water velocities should be checked and corrected or explained in the final statement.

Wild and Scenic Rivers

The stretch of the Columbia River from the headwaters of McNary Reservoir upstream to Priest Rapids Dam, which flows through the Hanford Reservation, has been named under the provisions of Section 5(d) of the Wild and Scenic Rivers Act as amended through Public Law 94-486 (October 12, 1976). This fact should be recognized in the final statement, and any probable impact of the project on scenic and recreational values of this stretch of river should also be fully assessed.

Specific Comments

Page A-45, Rare or Endangered Species. Currently there are no plants occuring within Washington State which are officially listed as rare or endangered. The blue mountain onion *Allium dictuon* has been proposed for consideration under the Endangered Species Act. *Allium robinsonii* has not been listed as being considered for such classification as reported. The final statement should correct this error.

Page A-50, Figure A.2-1. The U.S. Fish and Wildlife Service is incorrectly identified as Bureau of Sport Fisheries and Wildlife. This should be corrected in the final statement.

We hope that these comments will be helpful to you in the preparation of the final statement.

Sincerely yours,

Larry E. Meierotto
Deputy Assistant SECRETARY

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

SEP 2[illegible] 1977

OFFICE OF THE
ASSISTANT DIRECTOR
FOR ASTRONOMICAL,
ATMOSPHERIC, EARTH,
AND OCEAN SCIENCES

Mr. W. H. Pennington
U.S. Energy Research and
Development Administration
Washington, D. C. 20545

Dear Mr. Pennington:

We have reviewed the DEIS - ERDA-1556-D, High Flux Neutron Source Facility, and have no comments to offer.

Sincerely yours,

Edward P. Todd
Acting Assistant Director

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—261-324/50