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ENVIRONMENTAL STATEMENT

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FAST FLUX TEST FACILITY
Richland, Washington

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MAY 1972

UNITED STATES ATOMIC ENERGY COMMISSION

RESPONSIBLE OFFICIAL:

R. E. Hollingsworth

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GENERAL MANAGER

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Preface

On September 26, 1971, during a visit to the Hanford site for the Fast Flux Test Facility (FFTF), President Nixon stated:

> "The Hanford fast flux test facility now under construction is a major advance in this program (national energy program). This technology will develop into the liquid metal fast breeder reactor, a process that will yield abundant energy that is clean and inexpensive."

As the President stated in his June 4, 1971 Message on Energy to the Congress of the United States:

> "Our best hope today for meeting the Nation's growing demand for economical clean energy lies with the fast breeder reactor. Because of its highly efficient use of nuclear fuel, the breeder reactor could extend the life of our natural uranium fuel supply from decades to centuries, with far less impact on the environment than the power plants which are operating today."

To achieve this objective necessitates a broad based fast breeder program incorporating a series of research and development activities specifically planned to advance the state-of-the-art of breeder technology to the point where this technology can be used to introduce breeders beginning in the 1980's.

A program of this type ranges from investigative theoretical work through the applied research phases. If successful, it passes through periods of exploratory development, laboratory experiment and conceptual engineering into those stages involving in-depth engineering, manufacturing and proof-testing of first-of-a-kind components, equipment and systems. These are incorporated into experimental installations and supporting test facilities, in this case the FFTF, to assure adequate understanding of design and performance characteristics, as well as to gain experience associated with other major operational, economic and environmental parameters.

Research and development on the Liquid Metal Fast Breeder Reactor (LMFBR) concept has been underway for over a quarter of a century. The reason for this continued interest in the breeder concept can be appreciated when one considers that if only Light Water Reactors (LWRs) were to be constructed, they would consume the estimated low-cost uranium reserves in the United States within the next 25-50 years. This is because LWRs utilize less than 2% of the available energy from the uranium fuel which they burn. The LMFBR, on the other hand, could utilize 60% or more of the total energy from uranium and could use our more extensive reserves of higher cost uranium without significant economic penalty. The breeder could thus extend this energy resource for centuries; be of major importance in providing clean electric energy; and provide other important advantages.

The history of the LMFBR program and a description of its present scope are set forth in Sections II.A and B of this statement. The success of the program to date has led to the conclusion that commercial size plants can be introduced on a large scale into the utility arena safely, reliably, and economically. The Environmental Statement - Liquid Metal Fast Breeder Reactor Demonstration Plant, WASH 1509, was issued in April 1972.

The FFTF is a much needed and logical research and development step in the LMFBR program to help assure the orderly and timely introduction of the LMFBR into the commercial arena. Operation of the FFTF will provide this country with the most powerful tool in the world for exploring the complex behavior of fuels and materials in a controlled fast neutron flux of high intensity and in a high-temperature sodium environment. Its size permits practical extrapolations of components to demonstration plants. It represents a reasonable financial investment at this stage, and is large enough to test the performance of fuels and materials on a statistical scale and at the high performance levels necessary for advanced demonstration plant cores and for commercial LMFBRs. The FFTF, through actual experience, will show how all the essential components of such a facility function individually and as a coherent system, and thus advance the state of LMFBR art. In addition, information would be obtained on the complex interaction of the system with its associated supporting facilities and with the local environment under actual operating conditions.

A firmer grasp would be obtained on the range of fuel and fuel cycle costs and technological factors. Such information is needed for input into the continued planning of research and development programs for the LMFBR and other advanced reactors. It also would be used for guidance in designing other test facilities and future experimental plants. The FFTF design, development, fabrication, test, construction and operating experience will be used widely in the construction and operation of other LMFBR plants. This experience will greatly reduce any uncertainties associated with the development of the design of subsequent plants and will help assure low radioactivity release rates and safe plant operation.

The AEC has prepared the FFTF Environmental Statement in accordance with Section 102 of NEPA. A draft statement was issued in July 1971[1] to the following agencies:

Department of Agriculture

Department of Commerce

Department of Defense

Department of Interior

Department of Transportation

Environmental Protection Agency

Federal Power Commission

Department of Health, Education and Welfare

State of Washington, Office of the Governor

The statement has been revised and expanded to reflect the comments received and other guidance obtained since July 1971, and to reflect the fact that the Washington Public Power Supply System environmental report for the Hanford No. 2 Nuclear Power Plant, located two miles from the FFTF.

The FFTF Environmental Statement provides information on all aspects of the environmental effects of the FFTF. The technology and facilities required for FFTF fuel fabrication, irradiated fuel reprocessing, waste management and transportation activities for the mixed plutonium-uranium oxide fuel cycle do not differ significantly from those used in support of current nuclear power plants operating on the uranium-plutonium fuel cycle. Adequate precautions have been developed to assure the safe handling of plutonium and to avoid its release to the environment. This applies to reactor operations and to postulated credible accidents and includes all phases of fuel fabrication, handling, storage, transportation and reprocessing. The FFTF and its supporting activities will be able to meet existing and planned environmental quality and safety standards and requirements. It should be noted that the low radioactivity release rates and the detailed care being taken to safeguard the plant from any accidental releases are in line with the President's directive in his June 4 message.

"We have very high hopes that the breeder reactor will soon become a key element in the national fight against air and water pollution.

"In a related area, it is also pertinent to observe that the safety record of civilian power reactors in this country is extraordinary in the history of technological advances. For more than a quarter century -- since the first nuclear chain reaction took place -- no member of the public has been injured by the failure of a reactor or by an accidental release of radioactivity. I am confident that this record can be maintained. The Atomic Energy Commission is giving top priority to safety considerations in the basic design of the breeder reactor and this design will also be subject to a thorough review by the independent Advisory Committee on Reactor Safeguards, which will publish the results of its investigation."

No significant adverse environmental impact is expected from construction and operation of the FFTF. During the construction period, disturbances of the ecological systems will be limited to the area immediately surrounding the site. The construction area will be restored to maintain the indigenous vegetation to the maximum extent possible. During operation, the impact of the facility on the surrounding environment will not be significant. Dry waste heat from the facility will be discharged directly to the atmosphere using sodium-air dump heat exchangers; therefore, there will be no waste heat rejected to local water supplies. The environmental impact of direct discharge of this heat to the atmosphere is not expected to be significant.

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Environmental Statement for Fast Flux Test Facility

I. Summary

This environmental statement has been prepared in accordance with the National Environmental Policy Act and in support of the U.S. Atomic Energy Commission's (AEC) design, fabrication, construction and operation of the Fast Flux Test Facility (FFTF) to be located at the AEC's Hanford Reservation in Benton County, Washington, an isolated, controlled access site used for production and test reactor operations for over two decades. The FFTF is a nuclear reactor complex designed for irradiation testing of fuels and materials to be used in future sodium-cooled fast breeder power reactors.

This facility is a major research and development test vehicle in the AEC's overall Liquid Metal Fast Breeder Reactor (LMFBR) program. The design and construction of the FFTF was statutorily authorized in 1966 (Public Law 89-428) and 1967 (Public Law 90-56). Site preparation was initiated during the summer of 1970 and construction began in November 1971. The reactor is scheduled to go critical in mid-1974 and should be in operation in 1975. The design is virtually completed. Most of the component fabrication is underway, and on-site construction is in process.

The heart of the complex is a 400 megawatt-thermal (MWt) nuclear reactor fueled with a mixture of plutonium-uranium dioxide (PuO_2-UO_2). It will provide for testing purposes a fast neutron flux irradiation environment similar to that of an LMFBR. Radioactive waste material will be generated at the FFTF site as a result of operation and maintenance of the reactor and reactor systems. These wastes will be in the form of liquids, solids and gases and will be produced through fission within the fuel, and activation of reactor structural materials, primary sodium coolant, and the reactor cover gas. The plutonium present (20 to 30 weight percent of the plutonium-uranium oxide) in the fuel will also be a source of radioactivity.

FFTF design guidelines stress maximum use of existing technology. The facility is designed to operate reliably, safely, and with minimum environmental effects in compliance with these guidelines. The design effort has been and continues to be supported by a strong research and development program with significant emphasis on prooftesting. Major safety features of the FFTF will include duplicate and independent shut down systems, a plant monitoring system that senses any abnormalities and shuts the plant down, a low pressure coolant system, a guard vessel surrounding the reactor vessel so that the reactor core will be immersed in sodium coolant even if there should be a leak in the reactor vessel or main coolant system, and a separate plant containment structure.

The FFTF will reject its waste heat only to the air. The FFTF is designed so that there will be no planned, continuous or intermittent releases of radioactive effluents to the environment, other than radioactive gas leakages which may occur through seals or by diffusion through structural materials, or during accident conditions discussed in Section IV.A.7. Radioactive wastes will be collected and shipped to a remote processing and storage site (200 Area) within the Hanford complex or to another AEC-approved location. Shipment of radioactive material within the Hanford reservation will be in accordance with AEC on-site procedures and regulations. See Section IV.A.8. Any off-site shipments of radioactive material (principally fuel for reprocessing) from the plant will be in compliance with regulations established by the AEC and the U.S. Department of Transportation (See Section IV.A.8)

With regard to radiological exposure of the public in the area of the FFTF, it is estimated that with postulated fuel failure and tritium release rates, the total exposure of the entire population in a 100 mile radius of the FFTF site (about 500,000 people) would be about 0.006 man-rem per year contrasted to 70,000 man-rems background radiation. The 0.006 man-rem number should also be compared to guidelines in 10 CFR 50 and AEC Manual Chapter 0524 which state that for power reactors the resultant whole body dose to the total population exposed should be less than 400 man-rems per year per 1000 MWe.

To meet environmental needs, the AEC has drawn upon the extensive operational experience gained in more than 25 years in nuclear product processing activities. Technology and the industrial capability are available to handle, transport, process and store these materials without endangering the public health or safety.

The FFTF is being built in accordance with the "defense-in-depth" safety concept to minimize the possibility and consequences of potential accidents. As part of this concept, the possibility of accidents occurring is recognized and has been addressed as an integral part of the plant design process. Multiple barriers to the release of fission products, conservatism in design and in the establishment of safety margins, and inherent characteristics of the concept such as the Doppler coefficient and the heat transfer properties of the sodium coolant are being used to assure safe operation. In addition, an extensive safety research and development program is being conducted to resolve any technical uncertainties and to provide a realistic basis for design decisions. Finally, the consequences of various hypothetical accidents have been evaluated under conservative assumptions in the Preliminary Safety Analysis Report that has been prepared as part of the safety review process.

A similar spectrum of postulated accidents is being examined under more realistic conditions in this Environmental Statement to assess the potential environmental effects of various malfunctions. The goal of these analyses of a spectrum of accidents under both conservative and realistic conditions is to assure that the FFTF will be operated safely, reliably and with minimal environmental impact.

As with steam-electric plant types of this size, the disturbances associated with construction and operation of the FFTF alter the local environment. These disturbances are comparable to those encountered in other heavy construction efforts of similar magnitude. Preventive measures are being taken to assure that the quality of the air and water resources at and near the FFTF will be maintained so as to satisfy applicable Federal, State, and local standards. The specific effects on the animal and plant life in the environs of the selected site have been addressed in the Environmental Statement - Sections IV.A.7.c-d-e.

The construction and operation of the FFTF are not expected to have adverse effects on the short- and long-term productive uses of the site and its environs. Eventual decommissioning of the plant (about 1995) will not introduce any technical problems that differ significantly from those encountered during refueling and maintenance of the reactor. Procedures for decommissioning of the plant will be subject to specific AEC approval and will be required to meet Federal, State and local standards for protection of workers and the general public.

With the exception of the relatively minor amount of fuel consumed during the lifetime operation of the demonstration plant, there will be no irreversible and irretrievable commitment of fuel resources by this plant.

In regard to the long-term use of available national energy resources, the FFTF project represents an important step in the development of the LMFBR nuclear power concept which can extend the energy obtainable from our uranium reserves by a factor of at least 30.[2] Since supplies of economically recoverable liquid fossil fuels are dwindling fairly rapidly, the fulfillment of the need for alternate sources of energy is of high priority.[3] Breeder reactors would aid in fulfilling this need. They would also contribute to reducing the thermal impact on the environment associated with present day nuclear steam-electric power generation.[4,5,6,7]

The use of existing fast flux reactors in this country for fast reactor fuels and materials irradiation testing and other programmatic needs was evaluated, and it was determined by the AEC that existing facilities would inadequately meet the objectives of the LMFBR program. The Experimental Breeder Reactor No. II (EBR-II), a priority project in the LMFBR program, while providing fast flux irradiation test space for the FFTF and the first demonstration plant cores, must be measurably augmented by other facilities such as the FFTF, to provide for fast flux testing requirements of future LMFBRs. The EBR-II does not have fully prototypic LMFBR environmental conditions, instrumented closed-loop space for controlled environment testing and a sufficiently high fast flux. Use of the Fermi Reactor, the Southwest Experimental Fast Oxide Reactor (SEFOR) and other reactors for irradiation testing has been considered, but inherent features in these reactors are even more restrictive than EBR-II in meeting LMFBR irradiation program needs beyond the FFTF and the first demonstration plant cores. In particular, the existing thermal neutron spectrum, water cooled test reactors cannot provide the required environment for fast flux irradiation testing. Extensive reviews by AEC and the nuclear industry have resulted in the conclusion that only the construction of the FFTF, specifically designed for testing purposes, can meet the fuels and materials fast flux irradiation needs of the LMFBR program.

The principal locations considered for the FFTF were the National Reactor Testing Station (NRTS) in Idaho and the Hanford Reservation. Both of these are isolated controlled access sites and, because of their characteristics, have been used for decades for reactor experiments and test operations. The Hanford site was selected because of:

a. Proximity to project and design resources.
b. Availability of qualified management and technical personnel.
c. Availability of improved communications and travel facilities.
d. Extensive experience in the development of plutonium fuels.
e. Experience in the design, construction, and operation of large power reactors such as the Hanford N-reactor.

The conclusion reached in 1965 was reviewed in 1970-1971. Based on this review, and after assessing and weighing the anticipated benefits of the proposed action against the environmental and other costs associated with it, and after considering the range of alternatives and their anticipated environmental impact, the AEC has concluded that the FFTF should be developed, constructed, and operated.

II. Backaround

A. Relationship of FFTF to LMFBR Program

1. Early Breeder Activities

The U.S. interest in breeder reactors dates back to the Manhattan Project days in the early 1940s when the possibility of breeding was first recognized by pioneers in the nuclear field. To obtain the advantage of breeder reactors, the AEC has been working for over 25 years on the sodium-cooled breeder reactor. The fast breeder research and development program has been continuous since 1945, although it has experienced variations in its priority for development. Much of the essential effort on the breeder has been conducted in the AEC national laboratories. One of the earliest steps in this program was the construction of the experimental Clementine fast neutron flux reactor at Los Alamos which, from March 1946 to December 1953, was used to explore the possibility of operating with a fast neutron flux, plutonium fuel and a liquid metal coolant -- in this case, mercury.

The Experimental Breeder Reactor I (EBR-I), pioneering in nature, operable in 1951, was the first reactor to prove the feasibility of breeding. Further, it was the first reactor to establish the engineering feasibility and technology of liquid-metal coolants and of small-scale liquid-metal components and instrumentation and control. Experience gained from the design, construction and operation of EBR-I contributed important information to LMFBR engineering and technology. Importantly, it made a noteworthy contribution to analyses of reactor stability and demonstrated that fast breeder reactors are inherently stable.

Further fast breeder reactor developments led to the construction in the U.S. in the mid-1950s of two fast reactors, the 62.5-MWt EBR-II and the 200-MWt Fermi Reactor. In the mid-1960s, construction was initiated on the 20 MWt SEFOR facility directed at providing a facility to conduct

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research bearing on the safety of LMFBRs. Fast breeder reactor efforts were also initiated in the United Kingdom, USSR and France. Experience gained from these reactors has contributed to the overall experience in the area of fast breeder technology.[8]

2. Establishment of a Priority Breeder Program

In 1962 the AEC issued its Report to the President on Civilian Nuclear Power.[9] This report pointed out that the use of breeders could solve the problem of an adequate and economic energy supply for the foreseeable future. The report concluded that nuclear energy can and should make an important, and eventually a vital, contribution toward meeting our long-term energy requirements and that economic breeders were essential to any long-range, major use of nuclear energy. The report included a detailed discussion of the role of breeders in the overall program and established the development of breeder reactors as a specific objective.

In evaluating the future course to be taken by the U.S. advanced reactor development program, the AEC, in early 1965, initiated a series of technical reviews.[10,11] These reviews of the reactor program indicated that additional important engineering information was required, and that additional facilities and other resources were necessary to obtain that information. There was clear evidence of the need to strengthen the engineering capabilities of the laboratories and industry, and to assemble necessary and adequate resources if the development of safe, reliable and economical breeder power plants suitable for operation in the utility environment was to be achieved. These early reviews further indicated a requirement for in-depth review of each of the technical elements of the breeder program. Concurrently, it was necessary to initiate detailed plans for each of these elements.[12]

During the early and mid-1960s remarkable advances were taking place in the development of light water reactor power plants and nuclear power moved toward widespread acceptance as a new source of electrical energy. It was recognized that the plutonium produced in light water reactors could be most efficiently used in fast breeder reactors, and that the breeder would measurably reduce uranium ore requirements. The breeder development program was thus invested with a sense of urgency which had been lacking.

In early 1967, the AEC issued the 1967 Supplement to the 1962 Report to the President on Civilian Nuclear Power.[11] The Supplement set forth the changes that had occurred since 1962, and considered the ongoing AEC reactor programs in relation to the recommendations of the 1962 report.[9] The Supplement reaffirmed the promise of the breeder for meeting our long-term energy needs and established the LMFBR program as the AEC's highest priority civilian reactor development effort. This decision was arrived at after considering the results of research pursued from 1948 onward.

It should also be noted that the Joint Committee on Atomic Energy (JCAE) and the House and Senate Appropriation Committees in their many published prints of hearings and reports,[13,14,15] have clearly indicated their conviction that the LMFBR program will make a major long-term contribution to the general welfare of this country. The Joint Committee and the Appropriations Committees have expressed their belief that this program may well be essential to satisfying the need for safe, reliable, and economic clean energy.

Based upon an evaluation of many potential coolants which could be used in breeder reactors, sodium was selected as the primary system coolant. Sodium has disadvantages, such as its chemical reactions with air and water, activation under irradiation, opacity, and relatively high melting point. However, it offers the best combination of characteristics including: excellent heat transfer properties; low pumping power requirements; low system pressure requirements; the ability to absorb considerable energy under emergency conditions (due to its operation well below the boiling point); a tendency to react with or dissolve many fission products and retain them within the sodium in the event that a release of fission products to the coolant system if fuel element failure were to occur; and excellent neutronic properties. In addition, U.S. industry has a well established capability for producing inexpensive high-grade sodium in large quantities and the technology and related experience in its use is substantial.

The LMFBR was chosen over the other breeder concepts principally because of predicted performance, industrial support, a broad base of technological experience and proven basic feasibility. These advantages offer the best prospect that this concept can be brought to commercial usefulness in a relatively short time period.

Subsequent to the large-scale commitments of the electric utility industry in 1967 to construct nuclear power plants, a number of projections were made which indicated the important role that nuclear power could play in providing power for the future.[16] These studies projected greatly increased consumption of electric power but did not anticipate the problems in meeting the demand for electric power that became very evident during 1969 and the summer of 1970. During the summer of 1970 the occurrence of brownouts in some of the major cities, sharply rising prices of coal and residual fuel oil, low level of fuel reserves at some of the major electric utilities and a shortage of natural gas in some markets led the President to direct that a special study be undertaken of the national energy situation. The purpose of the study was to develop, for the President's consideration, Federal actions that might be taken to alleviate potential shortages of fuel and to assure adequate supplies of clean fuels for the future. The Domestic Affairs Council Subcommitee on the National Energy Situation was formed, chaired by Mr. Paul W. McCracken, Chairman of the Council of Economic Advisers.[17] The members of the Subcommittee included the heads of those Federal agencies with significant involvement in energy matters. The activities of this Subcommittee culminated in a plan of action that was recommended to the President. This plan was reflected in the President's Energy Message to Congress of June 4, 1971.[18]

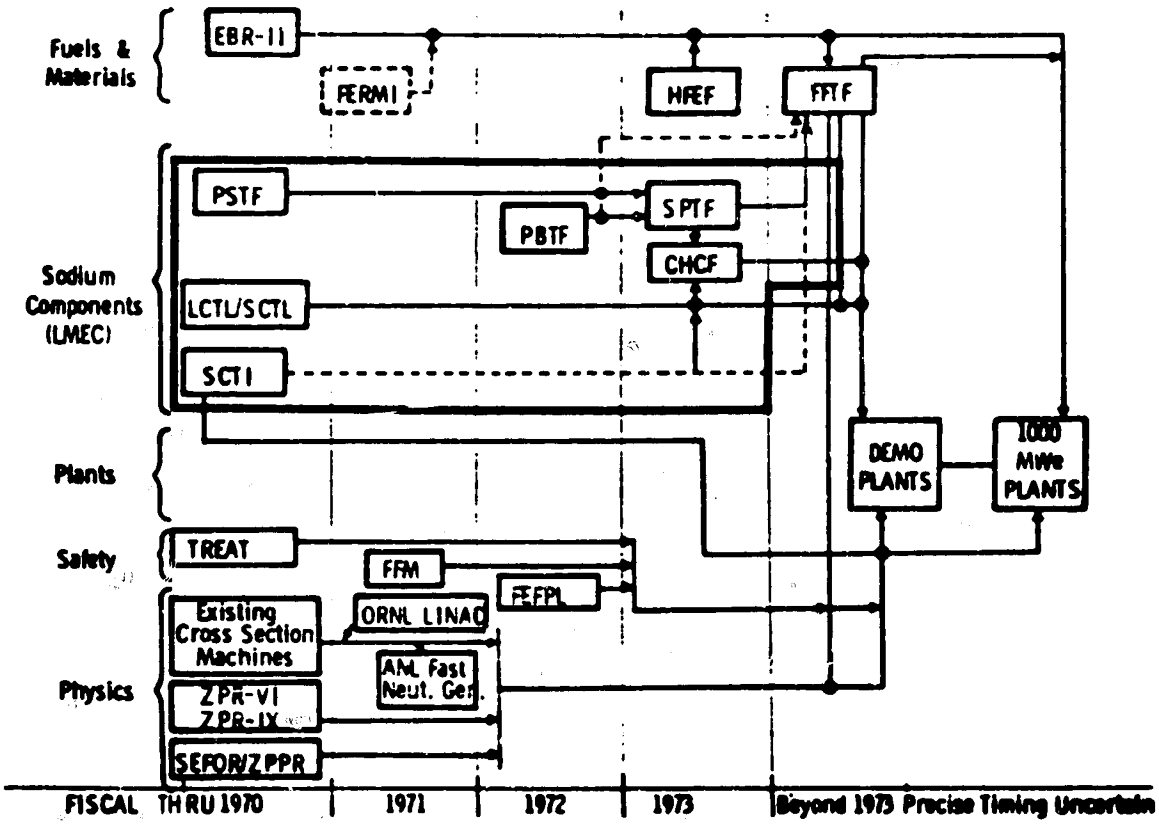
3. Current and Planned LMFBR Program

In view of the priority established as the result of the civilian power program review that culminated in the 1967 Supplement to the 1962 Report to the President[11], the level of activity on the LMFBR was considerably increased. The buildup to bring together the required resources, including manpower, facilities and funds, for an effective overall R&D program continued within the AEC, the AEC laboratories, and in other sectors of the nuclear community. New major test facilities were planned and existing facilities were upgraded (Fig. II.A.3.1).

The most important of these facilities are the EBR-II and the FFTF. The continued operation of EBR-II and the expeditious completion of the FFTF are essential to the success of the LMFBR program. The LMFBR program as indicated in the LMFBR Program Plans[12] not only needs the fast neutron flux and testing capabilities which EBR-II now provides, but also the even higher fast flux and greater testing capabilities, particularly testing in closed loops, which the FFTF will provide. Operation of the FFTF will permit vitally important irradiation testing of a variety of fuels, reactor control materials and structural materials in a controlled and instrumented fast neutron flux which approximates that required in future fast breeder reactors. In addition to the testing capability of the EBR-II and FFTF, the SEFOR facility has provided important information on LMFBR safety. The design, construction, operating and maintenance experience obtained from these LMFBR plants, as well as the Fermi plant, is particularly important to the LMFBR research and development program.

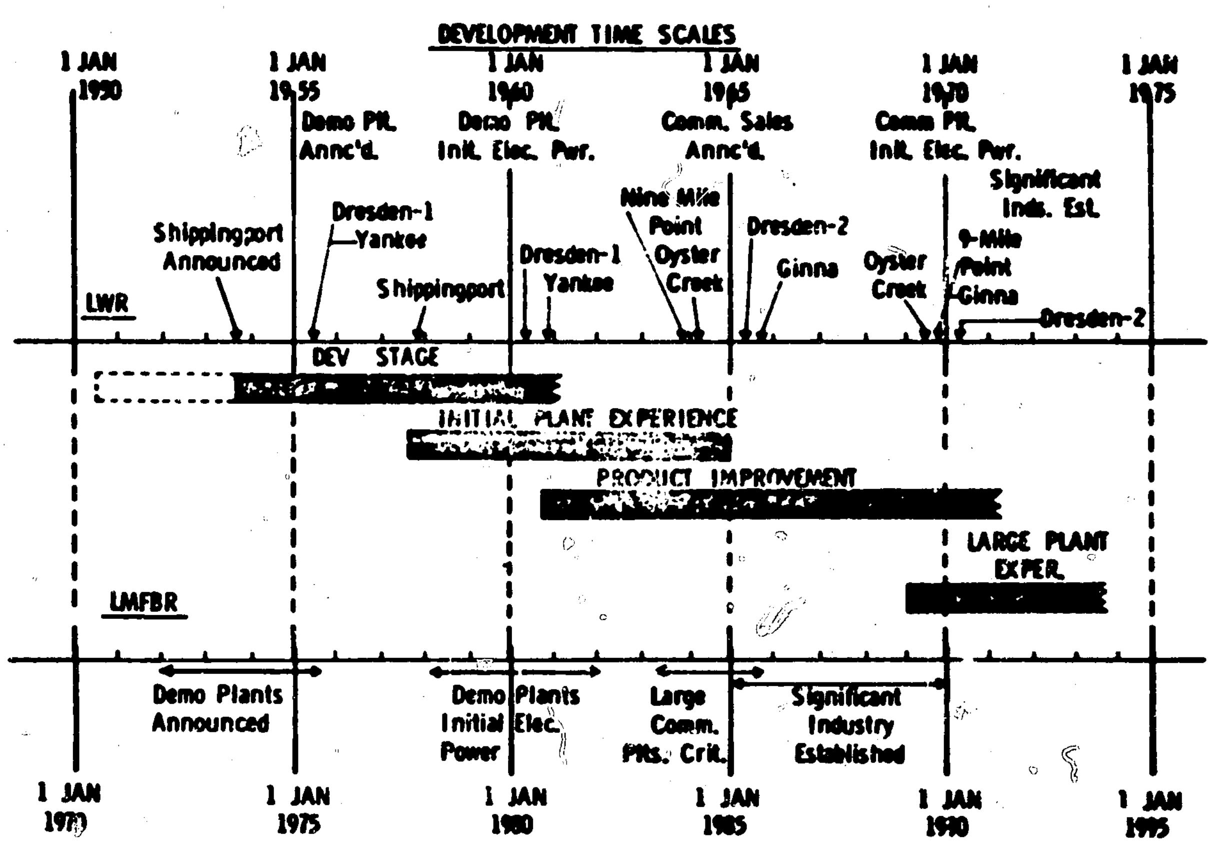
Breeder reactor development is being conducted along lines similar to that followed in the past for the development of LWRs, as shown in Figure II.A.3.2. In addition to LMFBR base research and development program activities, the AEC's current plans call for government participation in and support for the construction of a limited number of LMFBR demonstration plants, each of which would be a cooperative effort as previously described. The AEC contemplates that these plants would become operational at about two-year intervals beginning about 1978.

Encouraged by the increased attention and efforts of the Government, and their own independent evaluations, major reactor manufacturers and utilities began making substantial investments in the early 1970s with a view to making large-scale commitments to a cooperative arrangement for the first LMFBR demonstration plant. These investments are wholly apart from their other heavy commitments to nuclear power, particularly in the LWR reactor plants.



LMFBR PROGRAM FACILITIES (INITIAL AVAILABILITY AND ROLE)

FIGURE II.A.3.1



DEVELOPMENT TIME SCALES OF DEMONSTRATION PLANTS

FIGURE II.A.3.2

The most recent developments are that the AEC has accepted as a basis for negotiation a joint proposal of the Commonwealth Edison Company of Chicago and the Tennessee Valley Authority (TVA) for the design, development, construction and operation of the first LMFBR demonstration plant. Negotiations are in progress. If an arrangement with these proposers is entered into, the plant would be located on the TVA system and would be operated by TVA. Related studies are underway to help determine the plant site as well as the design characteristics of the plant. In April 1972, the AEC issued Environmental Statement - Liquid Metal Fast Breeder Demonstration Plant - USAEC Report WASH-1059.

4. Foreign LMFBR Activities

Essentially all of the major industrial countries of the world are developing liquid metal-cooled fast breeder reactors on a national priority basis because they also foresee significant economic and fuel supply advantages in this form of energy production. Each of these nations has committed significant resources to test facilities and demonstration plants. The USSR is well along in construction of the world's largest LMFBR of 600 megawatts electric (MWe) capacity; it also completed construction in late 1971 of a dual-purpose 150 MWe demonstration LMFBR, the BN-350. The United Kingdom and France are scheduled to begin operation of 250 MWe demonstration plants in 1973. Japan has announced plans to construct a commercial size demonstration plant for operation in this decade. French, Italian and West German utilities stated in May 1971 their joint plans to purchase two LMFBRs, the first, a 1000 MWe LMFBR, to be located in France and the second, a 2000 MWe LMFBR, to be located in West Germany. More recent information indicates that West Germany and the BENELUX countries have organized to assume a key role in building and operating the SNR-300. Table II.A.4.1 provides more details on the foreign LMFBR schedules and the world-wide LMFBR projects.

NAME	COUNTRY	POWER MWt	POWER MWe	INITIAL OPERATION
Operable				
BR-5	USSR	5[1/]	---	1959
DFR	United Kingdom	60	14	1959
EBR-II	United States	62.5	16	1963
FERMI	United States	200	60.9	1963
RAPSODIE	France	40	---	1967
SEFOR	United States	20	---	1969
BR-60 (BOR)	USSR	60	12	1970
Under Constr.				
BN-350	USSR	1000[2/]	150	1972
PFR	United Kingdom	600	250	1973
PHENIX	France	600	250	1973
FFTF	United States	400	---	1974
JOYO	Japan	100[3/]	---	1974
BN-600	USSR	1500	600	1976
Planned				
KNK-II	W. Germany	58	20	1973
PEC	Italy	140	---	1976
SNR	W. Germany[4/]	730	300	1977
DEMO #1	United States	750-1250	300-500	1978
MONJU	Japan	750	300	1978
DEMO #2	United States	750-1250	300-500	1980
CFR	United Kingdom	3125	1320	1979
PHENIX 1000	France[5/]	2500	1000	1979
SNR 2000	Germany[5/]	5000	2000	1983
Decommissioned				
CLEMENTINE	United States	.025	---	1946
EBR-I	United States	1	0.2	1951
BR-2	USSR	0.1	---	1956
LAMPRE	United States	1	---	1961

1/ To be increased to 10 MWt in 1972.
2/ Dual purpose: 150 MWe for electric power and 200 MWe equivalent for desalination.
3/ To be operated at 50 MWt initially.
4/ In cooperation with the BENELUX countries.
5/ Tripartite effort, France, German and Italian Electric Utilities.

LIQUID METAL-COOLED FAST REACTOR PROJECTS

TABLE II.A.4.1

5. Fuels and Materials Irradiation Test Facility Needs

Fast neutron flux irradiation test facilities are necessary to provide for the development of safe, reliable, and economical fuels and materials for use in advanced cores of LMFBR demonstration plants and in commercial LMFBRs.

Fast breeder reactor fuels and materials require a test environment of high temperature flowing sodium, a fast neutron flux environment and high sodium temperature differentials necessary to adequately duplicate the behavior of LMFBR fuels and materials. Such an environment has been shown to be significantly different than a thermal flux reactor environment. For example, fuel and structural materials in future fast breeder reactor cores may be exposed to sodium temperatures of 1,300° to 1,400°F (associated with sodium bulk outlet temperatures of up to 1,200°F), fast neutron fluxes of up to 10^{16} n/cm^2-sec, fast neutron fluences of up to 10^{24} n/cm^2 and sodium temperature differentials up to 400°F. It has been determined that thermal reactors cannot be economically altered to simulate LMFBR conditions. There is a general consensus that experimental results obtained in an unaltered thermal neutron flux environment cannot be reliably extrapolated to LMFBR conditions.

Based on these considerations, present water-cooled test reactors, such as the Engineering Test Reactor and the Advanced Test Reactor, utilizing a thermal neutron flux environment and containing closed loops, though playing a major role in the successful development of light water reactors, are inadequate for fast flux testing.

Existing fast flux reactors, EBR-II and Fermi, not designed originally as fuels and materials test facilities, could provide an interim measure of fast flux tests, but are inadequate to accomplish the in-depth testing needed for demonstration LMFBR plants and commercial LMFBR plants. The U.S. has been fortunate to have EBR-II which is the only currently available U.S. facility performing fast neutron flux irradiation of LMFBR fuels and materials.

This facility has been modified and upgraded sufficiently to provide for the development of the first cores of the FFTF and the LMFBR demonstration plants. Both EBR-II and Fermi lack neutron flux spectrum and sodium coolant conditions prototypic of the future LMFBRs, and the testing capability for highly instrumented and controlled fast flux environment tests, which can be provided for only in closed and open loops obtainable in the FFTF.

The AEC decided in 1965, based on a national consensus, that construction of a Fast Flux Test Facility (FFTF) must be undertaken if the national objectives of the liquid metal-cooled fast reactor development program were to be achieved. The FFTF was initiated by the AEC in 1966.

5. <u>Fast Flux Test Facility</u>

The FFTF will be a nuclear complex consisting of a fast flux test reactor and associated heat removal systems, coolant servicing systems, fuel handling systems, control systems, waste disposal and facilities, post-irradiation examination facilities, maintenance facilities and administrative offices. These facilities will provide an advanced high-level fast neutron flux reactor facility for carrying out a comprehensive fuels and materials testing program to develop and demonstrate economical fuels and satisfactory materials for the LMFBR program. The FFTF will incorporate closed loops in a fast flux environment, representative of LMFBR conditions, complete with coolant instrumentation and control (flow, temperature and impurities) and fuels and materials instrumentation. Also, the FFTF will provide other in-core space, with an environment representative of LMFBR conditions, which is required to test statistically larger quantities of candidate fuels and materials specimens.

To provide a comprehensive and controlled approach to the engineering of the FFTF and to ensure that the design objectives are met, all system designs have been developed in System Design Descriptions (SDD) as the designs progressed. The SDD's are prepared in accordance with RDT Standard F 1-2, Preparation of System Design Descriptions. They provide identification of system design requirements and provide ready means for ensuring the resultant system and component designs meet these requirements. The technical design information contained in an SDD provides for effective project communication on and control of the design by establishing the status of the system and component designs at any time during the project. In addition, the SDD's include in reasonable detail the step by step procedures for operating and maintaining the systems, components, and equipment, taking into account supplementary information which will be specified and set forth in Components Manuals, per RDT Standard F 4-20T, Operation and Maintenance Manuals.

The FFTF has been designed and constructed in accordance with standards compiled by the AEC's Division of Reactor Development and Technology together with those required for licensing approvals and other applicable nationally recognized codes and standards, such as those issued by ANSI, ASME, and IEEE. The SDD provides

* ANSI - American National Standards Institute
* ASME - American Society of Mechanical Engineers
* IEEE - Institute of Electrical and Electronic Engineers

identification of these and how they are implemented in the design. Only project management has the authority to grant modifications and deviations to the standards.

To help ensure success in achieving the objectives of the FFTF development, RDT Standard F 2-2T, Quality Assurance Program Requirements,[19] is used in the design, fabrication, construction and testing of the FFTF and will be used in its operation and maintenance. This comprehensive standard sets forth policies and contains the basic requirements for the establishment and implementation of effective quality assurance throughout all phases of the FFTF work. This standard is broadly applied, rigorously pursued and complied with in a disciplined fashion; compliance is monitored.

The FFTF, which is typical of many of the components and systems which will be in LMFBR demonstration plants, has become a center for the application of disciplined LMFBR engineering to the design, construction, testing, operation and maintenance of first-of-a-kind nuclear plant projects. The FFTF provides a focus for management, design and development activities for much of the LMFBR program.

The major objectives of the FFTF are:

1. To provide a strong, disciplined engineering base for the LMFBR program, principally in the following areas:

a. Fast flux irradiation of LMFBR fuels and materials,

b. Design, construction, operation and maintenance of LMFBRs, including:

(1) Statistically significant experimental data for the LMFBR program,

(2) Verification of LMFBR design,

(3) Verification of LMFBR analytical procedures,

(4) Identification of needs for, and preparation of criteria, codes, standards and guides,

(5) Physics,

(6) Fuels and materials,

(7) Safety,

(8) Sodium technology,

(9) Sodium components and systems,

(10) Instrumentation and control,

(11) Fuel cycle and

(12) Plant design and overall planning and

c. Training ground for personnel from industrial organizations, utilities and national laboratories.

2. Provide fast flux testing for other AEC and U.S. programs.

3. Contribute to the development of a viable self-sustaining competitive U.S. LMFBR industry.

All FFTF design and testing efforts include significant amounts of the first-of-a-kind engineering application of previously developed technology and development and application of new standards, stress analysis techniques and quality assurance practices. Design and testing efforts require education and training of personnel in both the laboratories and industry in these new techniques and practices. Direct and indirect benefit results from all aspects of this effort to help develop a reliable liquid metal-cooled fast reactor system. In particular, the engineering developments will benefit the demonstration plant program.

The FFTF will provide an adequately controlled and instrumented environment in a fast neutron flux for testing instrumented fuel specimens, fuel rods, fuel subassemblies and clad and structural materials with capabilities to test up to failure in dynamic sodium. Closed loops will be used in order that sample materials or fuel elements can be tested under carefully controlled conditions. From the testing to be conducted in the FFTF, the variables affecting fuel performance can be separated for better understanding of fuel behavior and a program can be formulated to focus on those problem areas that are critical to economic and efficient fuel performance.

The AEC's contractors have submitted and continue to submit design and safety evaluation documentation such as SDDs, the FFTF Preliminary Safety Analysis Report, and work plans. These are reviewed by the Division of Reactor Development and Technology (RDT). RDT also obtains, in the area of safety, the independent review of the Division of Reactor Licensing (DRL) and the Advisory Committee on Reactor Safeguards (ACRS). Results of these reviews continue to confirm that the proposed construction of the FFTF can be carried out safely. Similar procedures will be followed prior to start of FFTF operation. Based on initial findings, approval by the AEC was obtained to proceed with the FFTF in 1968.

7. Organization and Management

The United States Government, acting through the AEC, will be the owner of the FFTF. Programmatic direction for the project is provided by the AEC Division of Reactor Development and Technology.

The project is managed by Westinghouse Hanford Company, a wholly-owned subsidiary of the Westinghouse Electric Corporation, under Contract AT(45-1)-2170 with the AEC. This contract is administered by the AEC's Richland Operations Office.

Under the project management of the Hanford Engineering Development Laboratory (HEDL) operated by the Westinghouse Hanford Company, there are two major contractors for FFTF design engineering and construction. The Bechtel Corporation is the Architect-Engineer and Construction Manager. The Advanced Reactors Division of the Westinghouse Electric Corporation is the Reactor Plant Designer.

8. Schedule and Status

Advanced architect engineering funds were authorized in FY 1967; the project was fully authorized in FY 1968.[13,14,15] Site preparation was begun during the summer of 1970 and construction began in November 1971. The reactor is scheduled to go critical in mid-1974 and should be in operation by 1975.

B. Detailed Description

1. Location of Facility

The FFTF site is located approximately 12 miles north of the center of Richland in Benton County, Washington. This remote site is within the confines of the 559-square-mile Federally-owned Hanford Reservation to which access is controlled for reasons of national security and health and safety considerations. Figure II.B.1.1 shows the location of the Hanford Reservation in the State of Washington. Figure II.B.1.2 shows the surrounding site area and the FFTF site within the Hanford Complex.

The site is 175 miles south of the Canadian border, 110 miles west of the Idaho-Washington border, and 225 miles east of the Pacific Ocean. Approximate airline distances from the site to major cities in the Pacific Northwest are listed in the following table.

City	Direction from Site	Distance from Site
Richland, Washington	South	12 miles
Kennewick, Washington	Southeast	18 "
Pasco, Washington	Southeast	19 "
Spokane, Washington	Northeast	120 "
Butte, Montana	East	330 "
Walla Walla, Washington	East-southeast	55 "
Boise, Idaho	Southeast	260 "
Portland, Oregon	West-southwest	180 "
Yakima, Washington	West	55 "
Seattle, Washington	West-northwest	160 "
Vancouver, British Columbia	Northwest	260 "

The FFTF site, is about two miles southwest of Washington Public Power Supply System's proposed Hanford No. 2 nuclear plant[20] and about six miles from the

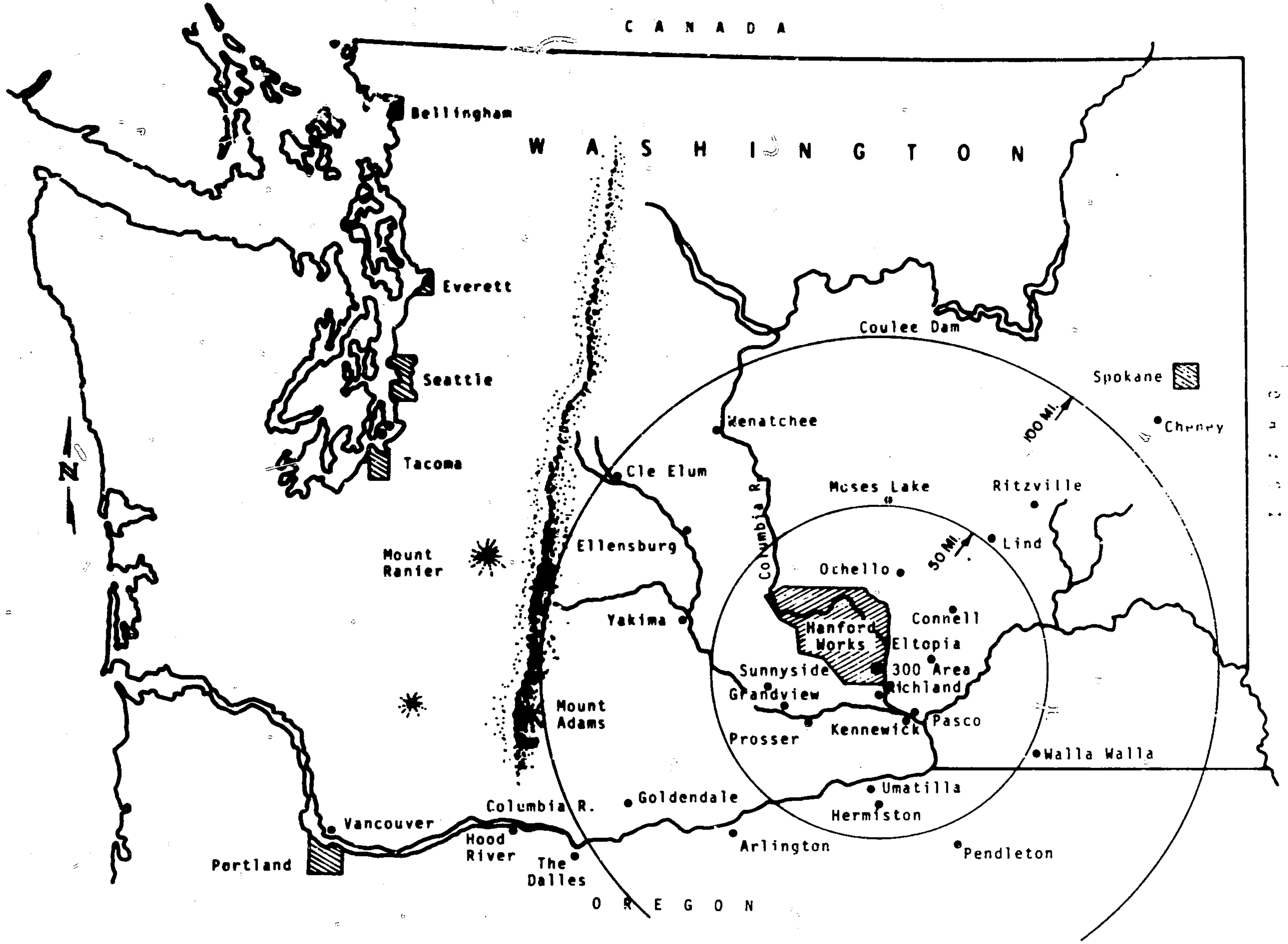


Figure II.B.1.1 Location of The Hanford Reservation

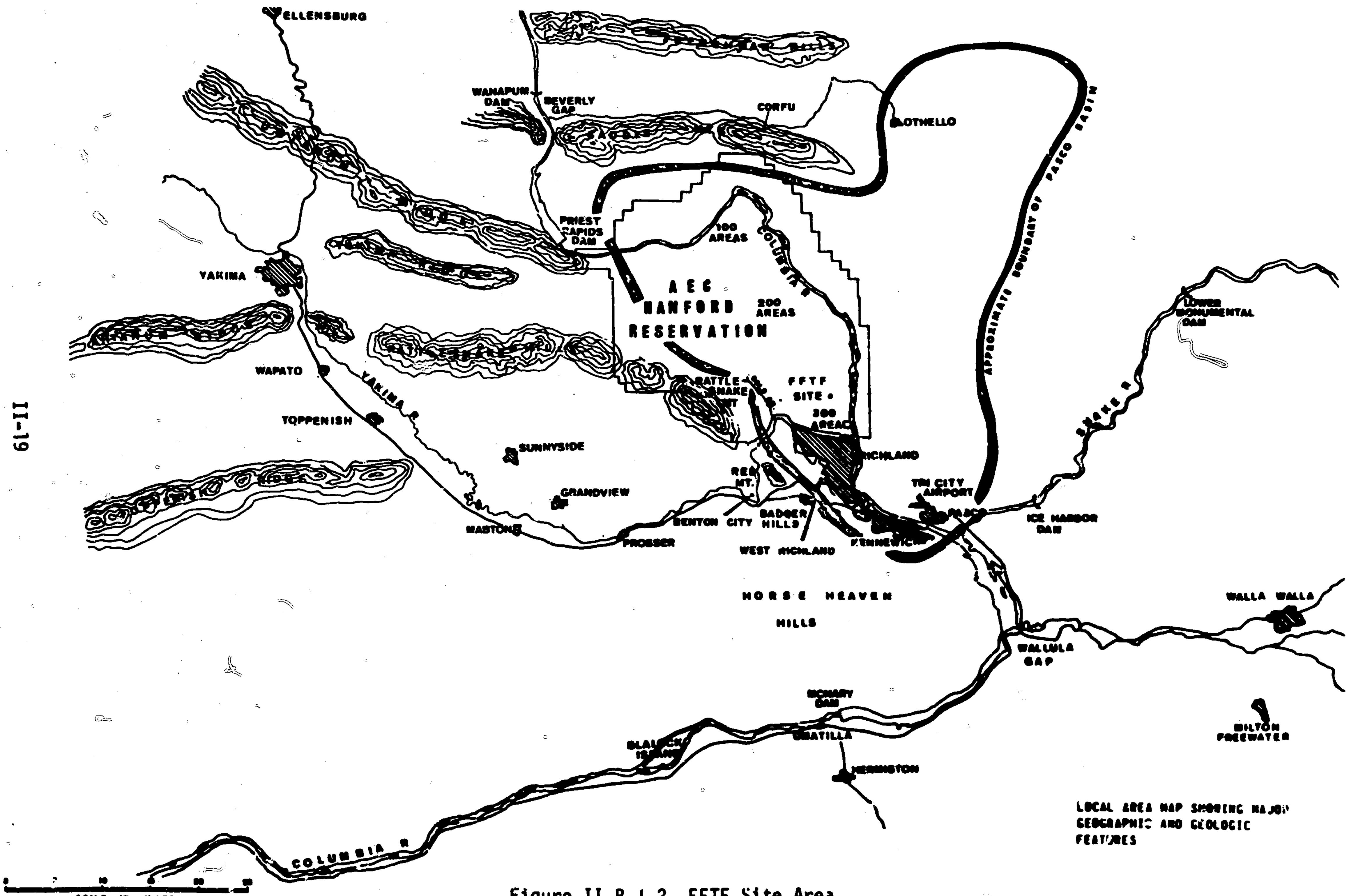


Figure II.B.1.2 FFTF Site Area

300 area facilities which are devoted primarily to R&D work in support of AEC nuclear programs. The site is about 4-1/2 miles from the west bank of the Columbia River which flows south and forms the east boundary of the Hanford Reservation. The site area consists of undeveloped, relatively level ground covered with desert vegetation and is at an elevation of about 555 feet above mean sea level. Two views of the site, one when construction began, the other at present, are shown in Figure II.B.1.3 and II.B.1.4. These views depict the character of the site environment and show the remote surroundings of the site.

The site is about 7 miles north of the Richland Airport and 15 miles northwest of either Vista Airport near Kennewick or the Tri-Cities Airport near Pasco. Only the Tri-Cities Airport has regularly scheduled commercial airline service. The Hanford Reservation comprises FAA Restricted Area R-6715 over which air travel is restricted at altitudes below 10,000 feet. The Richland Office of the Atomic Energy Commission authorizes occasional flights over the Reservation at altitudes below 10,000 feet for special purposes.

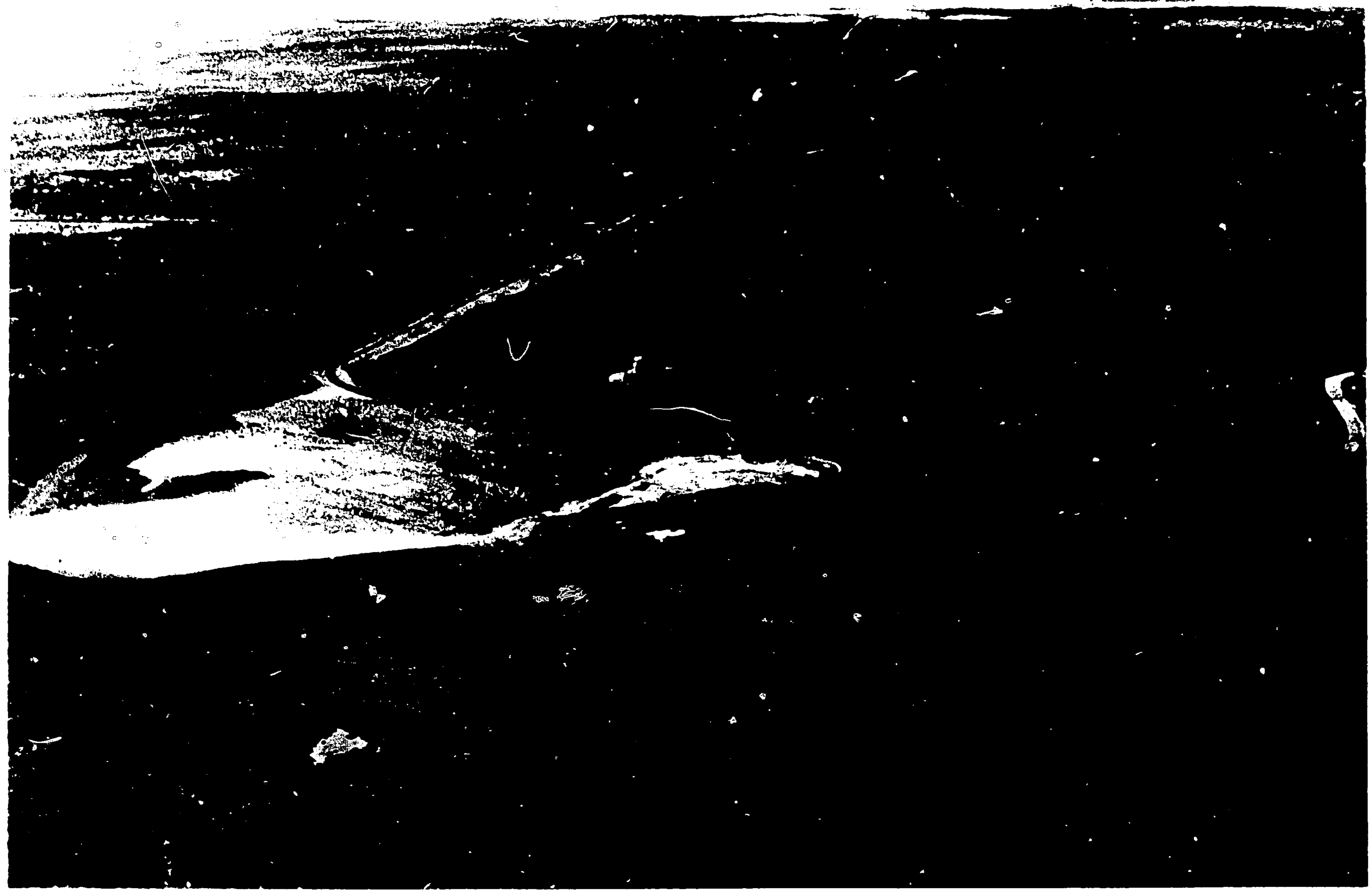


Figure II.B.1.3 Site Looking Northeast at the Start of Construction

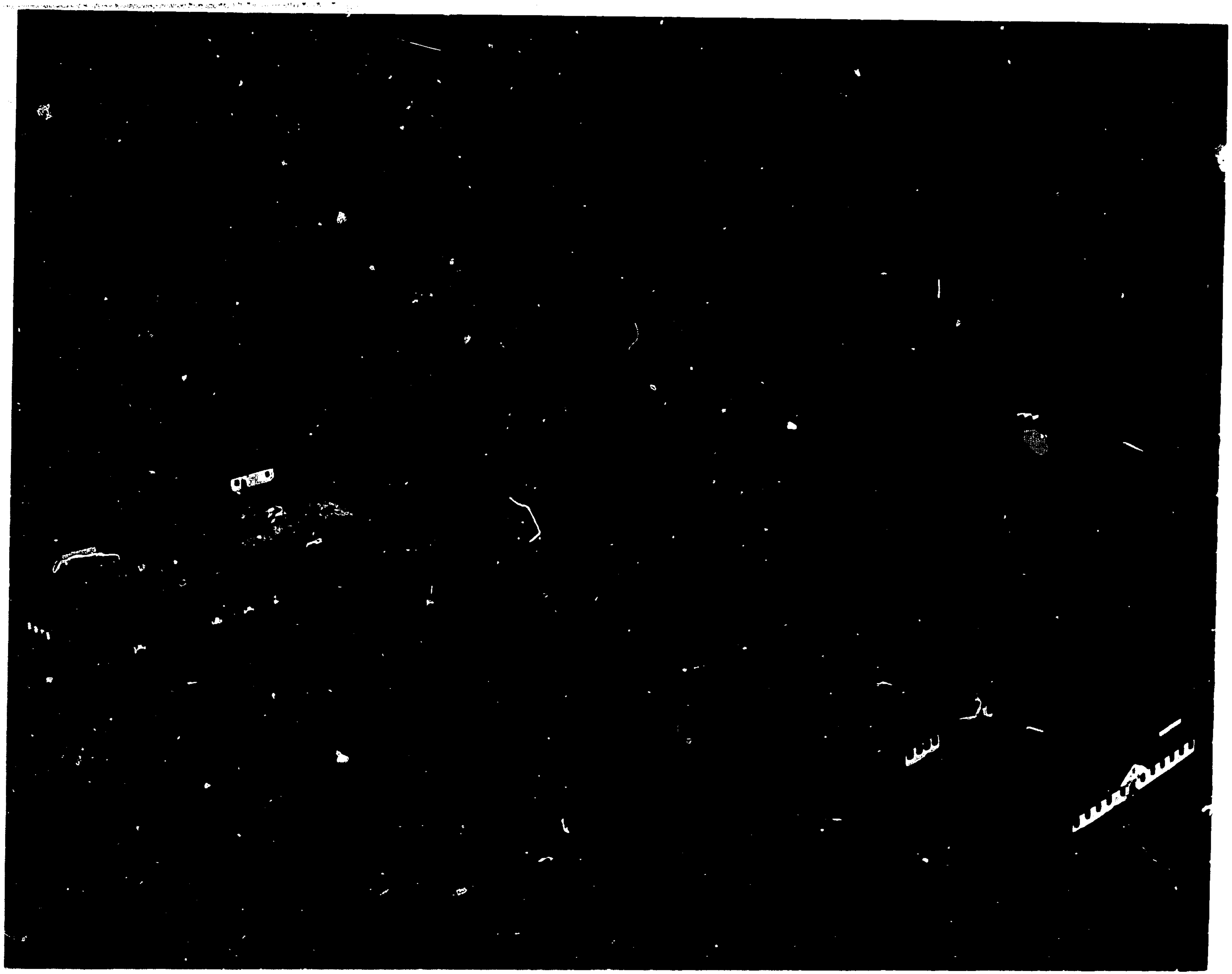


Figure II.B.1.4 S[illegible] Looking Northwest Summer 1971

2. Physical Characteristics of the Facility

The FFTF comprises all the facilities to be constructed at the site including the reactor, containment building, service and control buildings and utility services. A site plan is shown in Figure II.B.2.1. The central feature of the FFTF is the reactor containment building, an all welded cylindrical steel structure 135 feet in diameter and 187 feet high (115 feet above grade). The reactor containment building houses the reactor complex consisting of the reactor core, closed test loops, control and safety rod system, the fuel handling system and the in-vessel fuel storage system; the three main primary coolant loops with intermediate heat exchangers, piping, valves and pumps; the closed loop primary systems; the secondary pumps (main and closed loops), with some of the secondary piping; and the primary system sodium storage tank. The general building arrangement is shown in Figure II.B.2.2.

a. Reactor

The Fast Test Reactor (FTR) is a sodium-cooled fast neutron flux reactor with a peak fast neutron flux of 7×10^{15} n/cm^2-sec. The FTR will provide a controlled and instrumented environment prototypical of proposed LMFBR's, in which reactor materials and nuclear fuels can be tested. The reactor consists of a central core with fuel, control and safety rods and closed loops; core support structure, radial reflector and shield, reactor vessel,[21] sodium inlet and outlet piping instrument trees, in-vessel refueling machines, core-restraint mechanisms, closure head with rotating plugs and drives and other parts and plugs, control and safety rod drives, liquid level and neutron instrumentation and the reactor guard vessel. During normal operation, the reactor is essentially hermetically sealed.

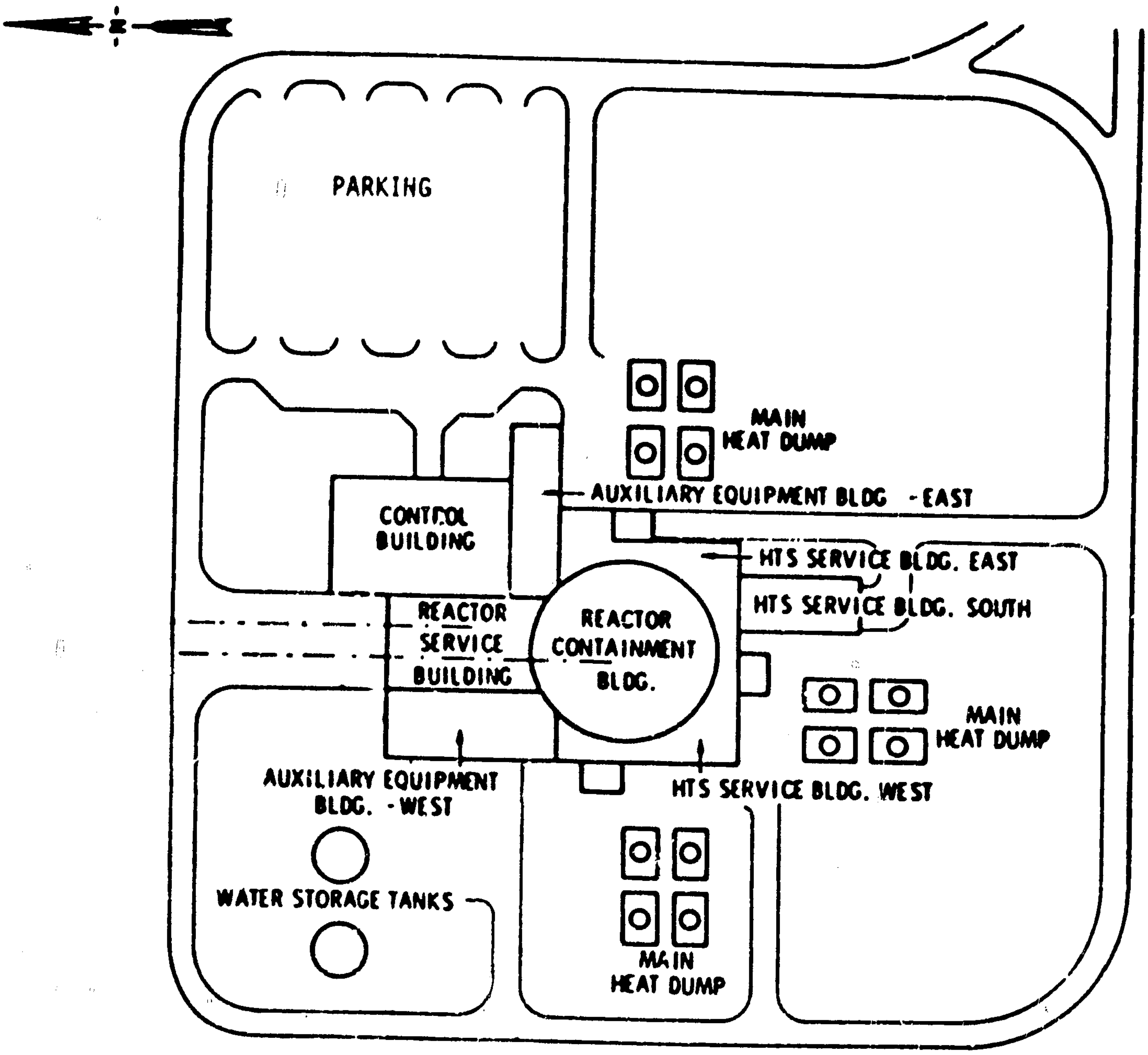


Figure II.B.2.1 FFTF Site Plan

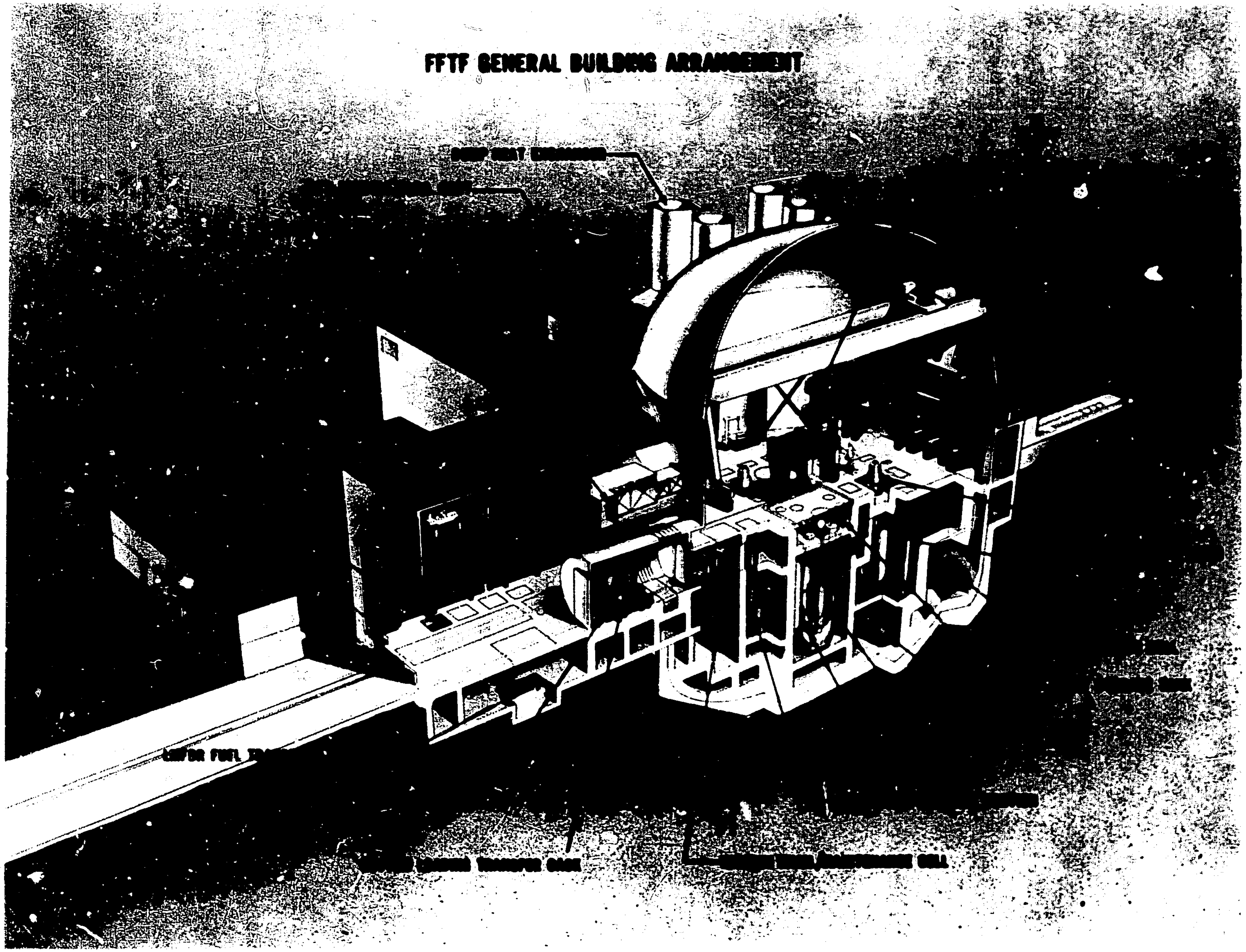


Figure II.B.2.2 FFTF General Building Arrangement

(1) Reactor Core

The reactor core (Figure II.B.2.3) is comprised of an array of 100 vertical hexagonal subassemblies, 73 of which contain driver fuel, 18 are control and safety rods and 9 are test positions which can be used for irradiation testing of prototypical LMFBR fuel pins and experimental fuel and material specimens. Provisions are made to incorporate closed loops into six of these test positions. In a closed loop, the loop coolant is separated from the reactor coolant. To provide for the six closed loops whose inlet and outlet piping traverses the area above the reactor vessel closure, it is necessary to trisect the reactor core, with each sector served by its own internal refueling machine, rotating plug instrument leads, internal fuel storage position and transfer port.

Power output of the reactor is 400 megawatts (thermal). Heat will be rejected to the atmosphere via sodium-air dump heat exchangers. A cross section of the reactor is shown in Figure II.B.2.4. Table II.B.2.1 lists the basic facility design characteristics.

General design criteria[22] have been used to guide reactor system design so that the potential for damage to the reactor is low. Specific criteria[23] for fuel melting, clad strain and embrittlement limits have been established on the fuel design to insure integrity under specified accident conditions. Extensive development programs (Section IV.B.1.b) provide supporting data regarding these damage criteria and limits and establish the adequacy of reactor design for normal operation.

(2) Reactor Driver Fuel

Driver fuel subassemblies (Figures II.B.2.5 and II.B.2.6) are hexagonal stainless steel cans 12 feet long and 4.575 inches across flats. Each contains an array

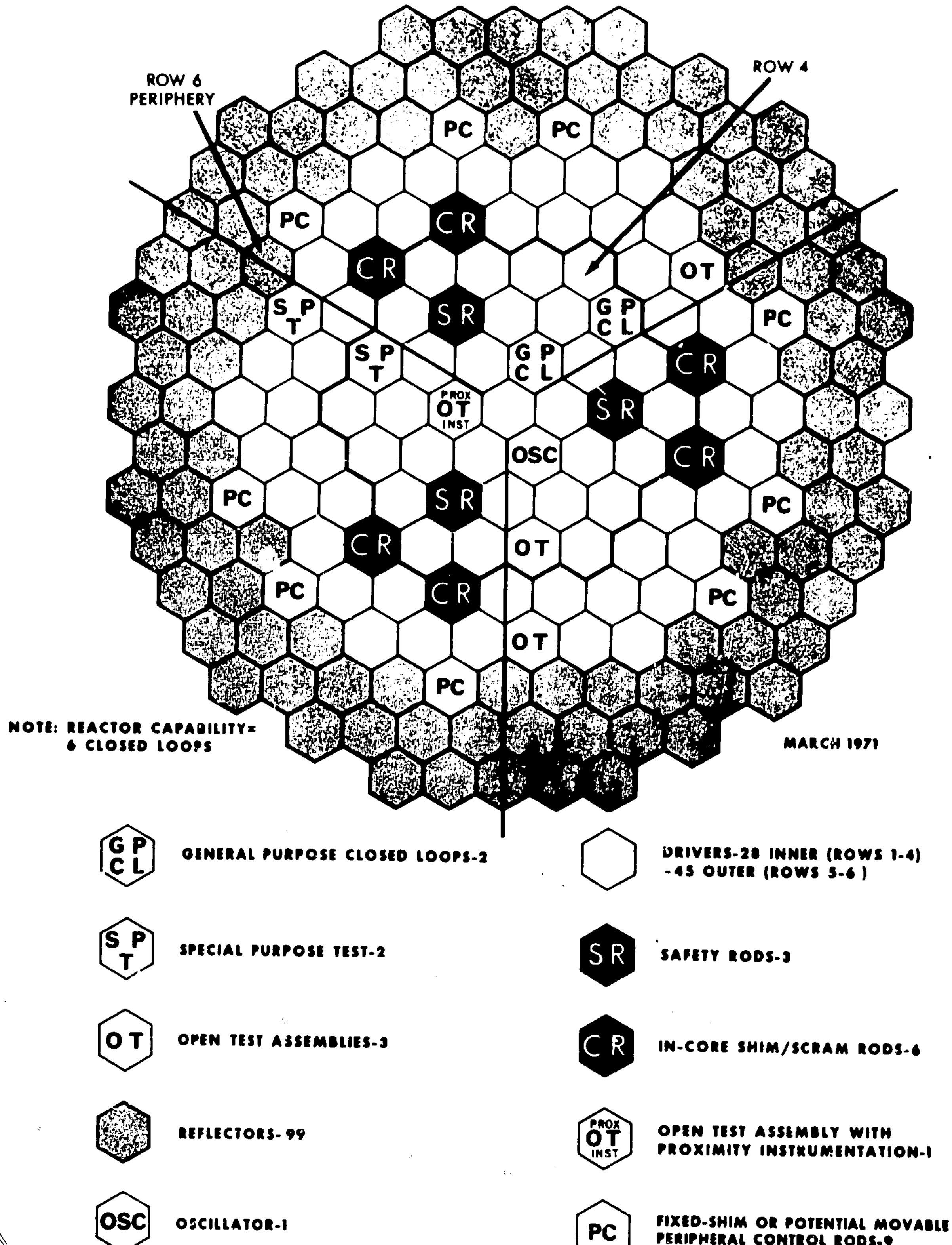


Figure II.B.2.3 FFTF Core Map

FFTF REACTOR

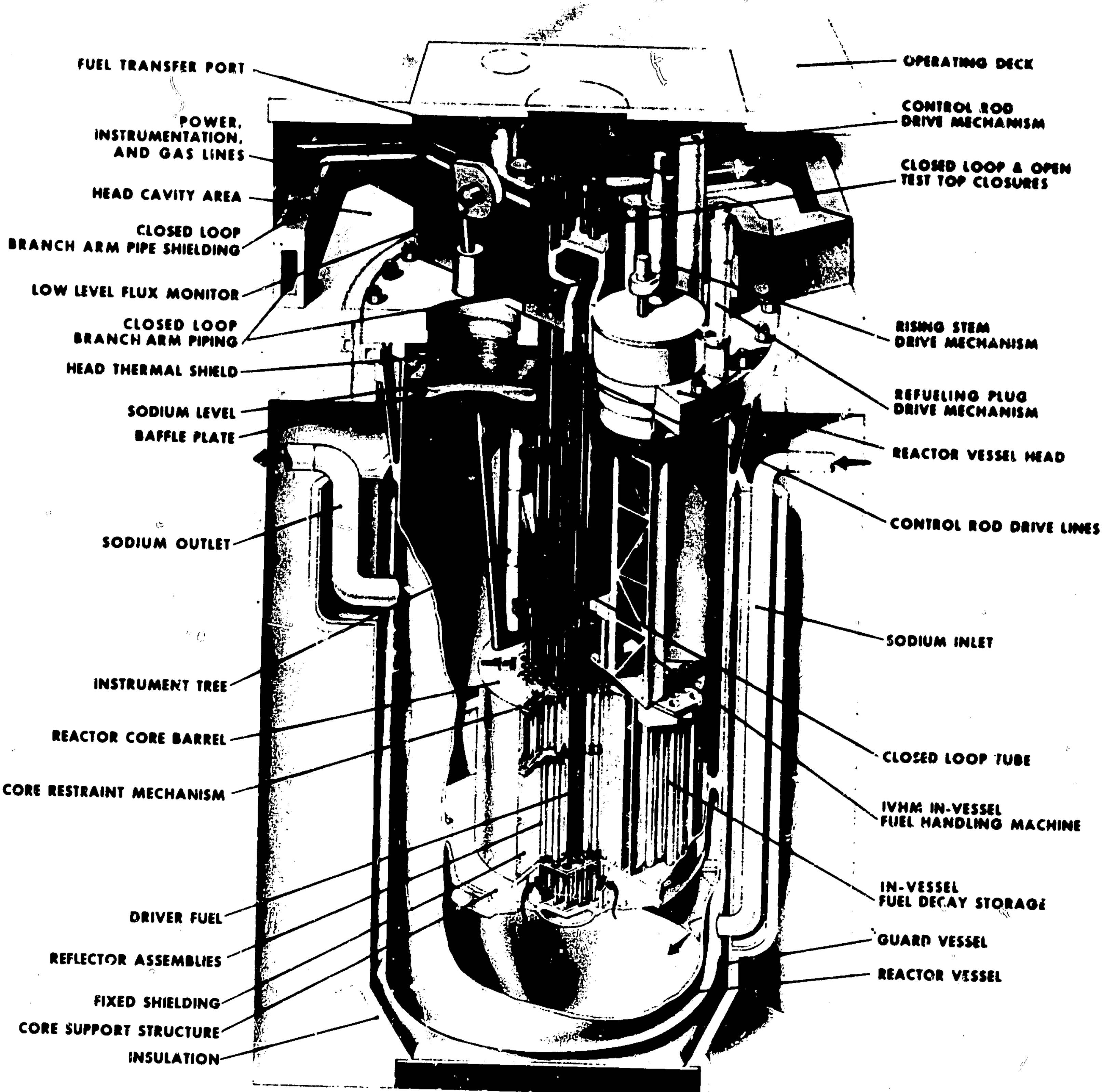


Figure II.B.2.4 FFTF Reactor Assembly

AEC-RL RICHLAND, WASH

TABLE II.B.2.1

FFTF BASIC FACILITY DESIGN CHARACTERISTICS

Heat Transport System (3 Primary Loops)	Initial Capability	Maximum Capability
Reactor Power	400 MW	400 MW
Reactor Outlet Temp	860°F	1050°F
Core Outlet Temp.	900°F	1100°F
ΔT - Core	300°F	400°F
ΔP - System	500 ft - Na	500 ft - Na
IHX - LMTD	85°F	100°F
DHX Modules	12 @ 33 MW	12 @ 33 MW
Total Coolant Flow	43,500 GPM	43,500 GPM
Sodium Systems Cover Gas	Argon	

Containment Building

Vessel Material, Shape	SA-516, Grade 60 Steel Cylinder, Elliptical Head
Vessel Size	135 ft. Diameter x 187 ft. High
Design Pressure	10 psig

Core Arrangement

Vertical, 91 lattice positions with 75 driver fuel subassemblies in hexagonal array

Subassembly Length

12 ft. Overall, 3 ft. Fuel, 4 ft. maximum Gas Plenum (Advanced Cores)

Fuel Composition

20-30 Weight % PuO_2
70-80 Weight % UO_2

Fuel Target Burnup

45,000 MWd/TONNE

TABLE II.B.2.1 (Cont.)

FFTF BASIC FACILITY DESIGN CHARACTERISTICS

Capability for Instrumented In-Core Open Test Positions	3-9
Peak Flux	Initial Flux 0.7 to Advanced Cores of 1.3 x 10^{16} nv Installation Planned
Closed Loops	
Initial Number	2 General Purpose - 2 MW 2 Special Purpose - User Supplied
Ultimate Number	6-4 MW Each
Outlet Temperature	1400°F (Bypass Flow Permitted)
Number of Cells Provided	4 Cells - (with capability to add 2 more)
Fuel Examination	Interim Examination of Irradiated Fuel
Interim Irradiated Fuel Storage	Capability for storage in sodium
Fuel Handling Machines	In-Vessel Handling Machine; Single Gas-Cooled Ex-Vessel Handling for Driver Fuel and Experiments in Open and Closed Loops
Plant Design Life	20 Years
Plant Control Scheme	Analog-Manual and Analog-Automatic
Engineering and Operations Building	Office space to house Control Room, operational and support personnel and services

TABLE II.B.2.1 (Cont.)

FFTF BASIC FACILITY DESIGN CHARACTERISTICS

R/A Waste Tankage	Temporary Onsite Storage with Provision for Transfer to Hanford R/A Waste Facilities
Sodium System Cells	Steel-lined, nitrogen atmosphere
Assembly, Testing and Qualification of Core Components	Performed elsewhere onsite and offsite
Short-Term Irradiation Facility	Future capability for installation of the closed or open loop core positions, using spare closed loop cell
Maintenance Facility and Component Transport	Simple maintenance facility including space for decontamination and cleaning of R/A Component

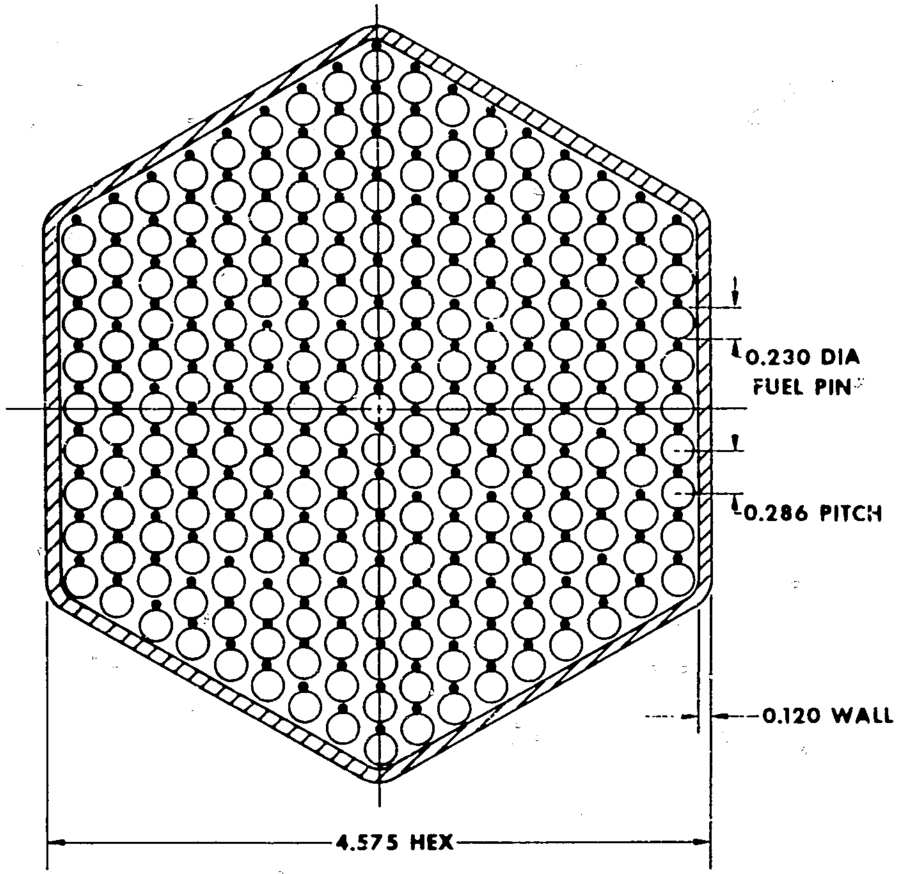


Figure II.B.2.5 Fuel Assembly Cross Section Thru Core

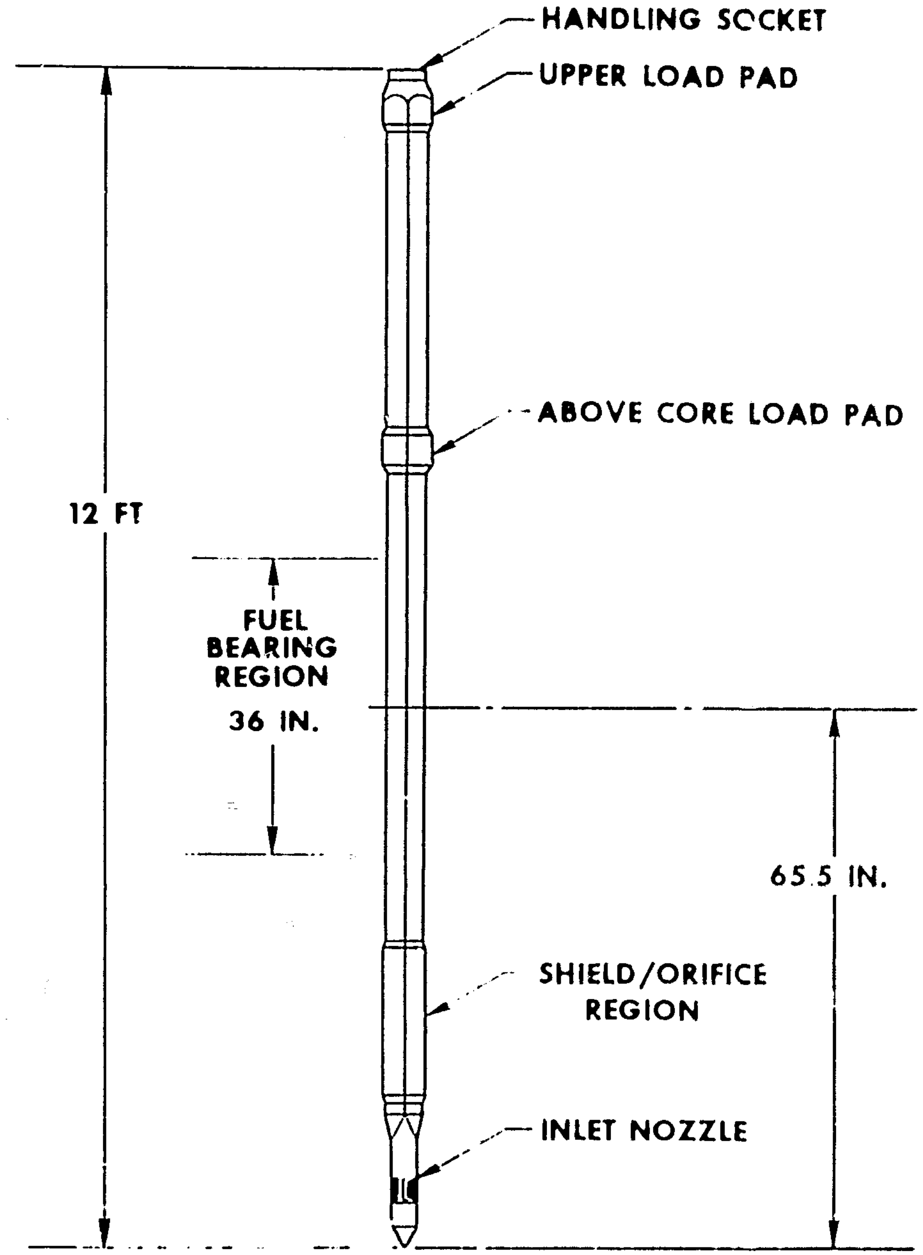


Figure II.B.2.6 Fuel Assembly

of fuel pins (Figure II.B.2.7) containing pellets of a mixture of plutonium uranium dioxide (PuO_2-UO_2). Surrounding the reactor core are 99 radial reflector subassemblies serving as a shield and as a neutron reflector.

Fuel pins are clad in a sealed stainless steel jacket to prevent the release of radioactive fission products from the fuel to the coolant. Maximum cladding temperatures are in a range below 1200°F where the properties of stainless steel are better understood. The fuel pins will be operated below central fuel melting. The fuel and the clad can withstand transient higher temperatures without failure or hazard, as determined by transient testing in the experimental TREAT facility.

The reactor core subassemblies and the surrounding reflector subassemblies are supported by a bottom grid structure. This grid structure is rigidly welded to the reactor vessel walls.

Sodium flows upwards through the core subassemblies. Hydraulic holddown is utilized in the inlet nozzle of the subassemblies to prevent upward movement of the subassemblies during flow.

Core monitoring instrumentation, in addition to neutron flux and bulk sodium flow and temperature instrumentation, is provided to monitor flow and outlet temperatures for each fuel element, control and safety rod and test position.

(3) Reactor Vessel

The reactor core is housed in a 304 **stainless steel** vessel (Figure II.B.2.4) about 270 inches in diameter and about 520 inches in height.[24] The vessel is suspended from a building support structure and is contained in a reinforced

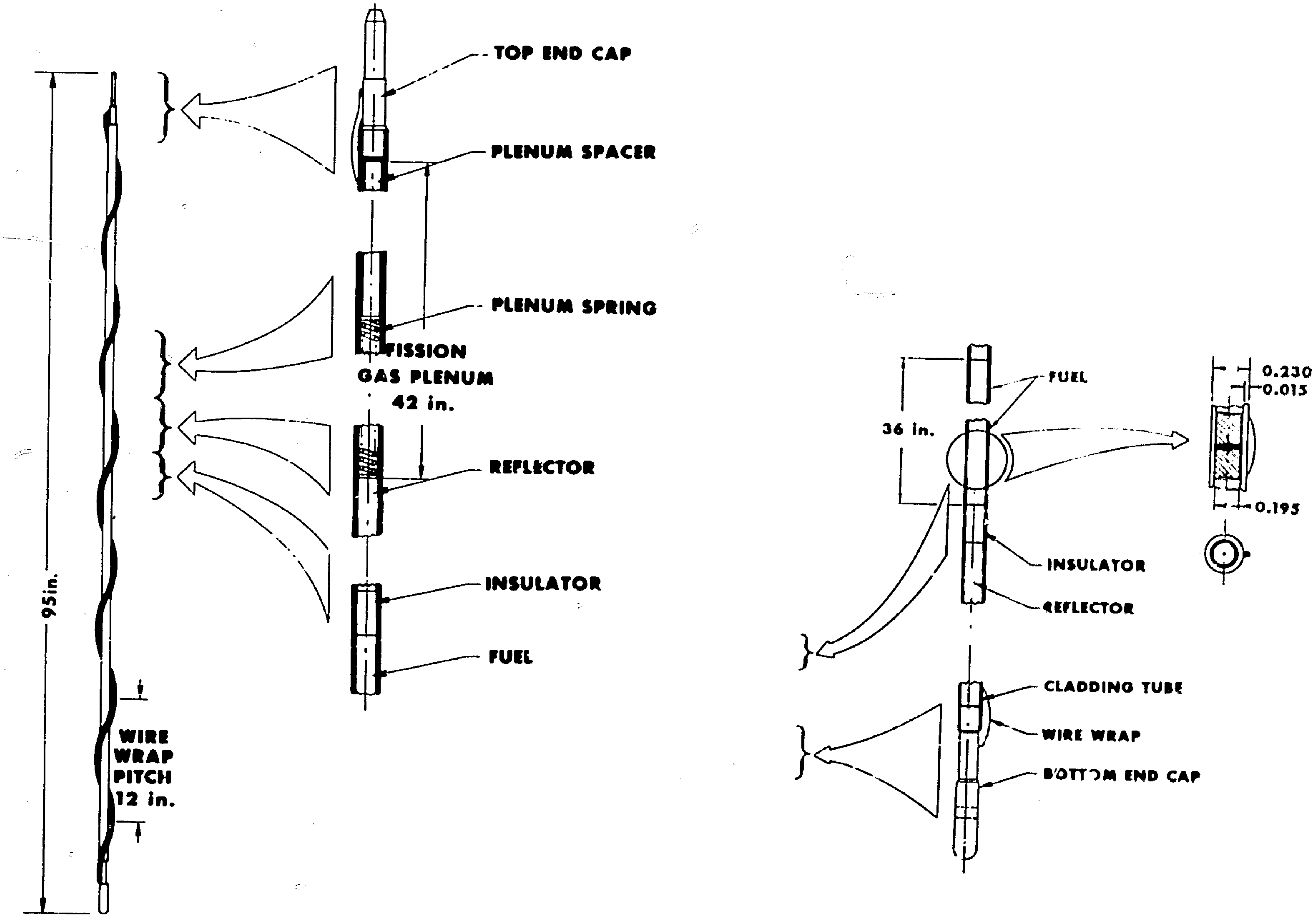


Figure II.B.2.7 Fuel Pin

concrete enclosure below the floor level. The floor level is at grade or nominally 550 feet above mean sea level. The reactor vessel contains internal structures which provide support for the reactor core and sodium coolant inlet and outlet plenums. The vessel and its closure head (described below) are heavy-walled structures designed to contain the coolant and are able to withstand hypothesized large releases of energy. In addition, a guard tank surrounds the vessel to protect against loss of coolant from the reactor. Sodium leak detection is provided between the reactor vessel and guard vessel. The guard vessel is sized so as to limit the volume between the guard vessel and the reactor vessel such that any leak from the reactor will be confined, assuring a sodium level well above the sodium inlet and outlet. The large pool of sodium above the reactor core outlet is effective in mitigating thermal transients.

The reactor vessel is capped with a flat head (Figure II.B.2.4) supported from the building support structure. The head is a forging 21 inches thick and 25 feet in diameter, with penetrations for rotating plugs, instrument trees, control and safety rod drive shafts, open and closed loops, in-vessel handling machine, core restraint drive shafts, fuel transfer posts, liquid level instrumentation and neutron flux instrumentation. The bottom of the plug supports about 25 inches of shield plates, used for thermal and radiation shielding.

(4) <u>Closed Loops</u>

To provide for fast neutron flux testing in a controlled sodium environment, with contact instrumentation and independent of the reactor primary coolant system, provisions are being made for up to six (6) closed loops (Figure II.B.2.3) each with its own primary and secondary sodium systems including a sodium-air dump heat exchanger and independent sodium service systems. 25

The closed loop consists of a 38.5 foot long re-entrant tube with sodium inlet and outlet above the reactor vessel. The sodium systems for the closed loops, excluding the sodium-air dump heat exchangers, are located in individual cells within the containment building.

The closed loop can be separated above the reactor for insertion and removal of test subassemblies or test trains of fuel and materials specimens. A minimum 2.5-in.-diameter section is available in the reactor core area for insertion of tests. Up to 20 electrical leads, a flux thimble and a small tube for pressure measurement can be inserted for measurement purposes. The in-reactor closed loop is insulated from the primary reactor coolant. The closed loop itself is removable from the reactor.

Initially, only 4 of the 6 loops, rated up to 2 MWt, will be equipped with necessary components. Though operating characteristics of each closed loop will depend on the test undertaken, one possible set of characteristics are shown in Table II.B.2.2.

(5) Open Test Positions

Certain positions in the core (Figure II.B.2.3) are designated as "open test assembly with proximity instrumentation." These core positions can be used interchangeably with driver fuel. They have the capability of greater instrumentation than the normal driver fuel positions.

Tests in open test positions will be limited, at least initially, to specimens whose performance and potential failure characteristics are understood to a

TABLE II.B.3.2

2MW(t) CLOSED LOOP TESTING CHARACTERISTICS

Testing Conditions	Values	Remarks
Maximum Na Temperature from test section	1400°F (760°C)	Achieved by internal by-passing and reducing total heat generation of test compatible with maximum flow capability.
Maximum Na hot leg temperature-primary piping	1200°F (649°C)	
Maximum Na cold leg temperature-primary piping	1000°F (538°C)	Nearly isothermal test. Includes maintaining temperature during shutdown.
Maximum Na flow rate	1.14×10^5 lb/h (5.17×10^4 kg/h)	Determined by 200°F ΔT 2MW.
Maximum ΔT in primary	400°F at 2 MW (204°C)	
ΔP across test section	100 psi (7 kg/cm^2)	
Minimum Na cold leg temperature-primary piping	600°F at 2 MW (316°C)	For lower temperature accept lower power.
Maximum heat generation of test section	2 MW	
Minimum cold leg temperature-secondary piping	500°F at 200°F ΔT & 2MW (260°C at 93°C ΔT)	For IHX LMTD of 100°F.
Minimum Test Diameter in CLIRA	2.5 in (64 mm)	Diameter of hole for test element.
Active Length Test Element	3 ft (914 mm)	Corresponds to active core.
Test Train Length	Capable of shortening	For transfers out of containment.

degree approaching that of the fuel. Other tests will be carried out in the closed loops described in the previous section.

b. Reactor Control and Safety System

The function of the Reactor Control and Safety System is to provide operational control of the reactor for all predictable conditions of operation, normal and abnormal. The reactor core contains 9 peripheral vertical shim control rods, 6 in-core vertical shim/scram rods and 3 vertical safety rods (Figure II.B.2.3). These rods[21,26] provide for reactor primary safety, operational control and secondary safety. Vertical movement of boron carbide (used as the neutron absorber) in these rods controls the neutron flux of the reactor and, thereby, its power. The 3 primary safety rods are used for rapid shutdown, while the control rods regulate power level. The control rods in addition to regulating power level, are used as secondary safety rods to back up the 3 primaries. All movable rods scram (rapid shutdown) in the direction of gravity. The rate of reactivity increase is limited by design to predetermined values.

Each control and safety rod is driven by control and safety rod drive shafts connected to rod drive mechanisms located above the reactor. In-reactor guide tubes provide necessary guidance for the rods.

The FFTF control and protective systems provide a high degree of separation of control and protective functions to assure that inadvertent control errors or malfunctions will not interfere with prescribed protective functions. The protective functions are limited to the initiation of the protective actions of reactor scram, containment isolation and shutdown core cooling mode; i.e., initiation of pony motor operation. Redundancy in instrumentation and control circuitry and equipment is provided to the degree necessary to maintain control and safety during operation and refueling. For example, either of the two independent protective systems can safely shut down the reactor.

c. Instrumentation and Control

The FFTF has extensive instrumentation and controls consisting of three parts--Protection system, Data System and Control System. The Protection System[27] provides for the measurement of coolant and component temperatures, core and pipe sodium flow, neutron flux density from startup to full power, system pressures, sodium levels, gamma radiation, radioactive gases and particulates and other parameters of interest or necessity. The Protection System provides for safe reactor shutdown and containment isolation.

The Data System[28] monitors many of the above mentioned parameters independent of the Protection System and performs various calculations and provides display information. Also included is a fuel cladding detection and location system.

The Control System[29] provides both direct operator and automatic control of the reactor and includes alarm functions from remote or local stations to the central control system. Redundant instrument sensors are provided throughout the plant for separation of protection and control functions.

d. Reactor Refueling

The FFTF fuel handling system when in operation is a closed system[30]; i.e., it operated in an inert atmosphere at all times and maintains a continuous seal between components containing sodium and any external refueling devices. The system consists of:

- Handling entirely internal to the reactor vessel.

- Removal and insertion of driver fuel from and into the in-reactor fuel storage.
- Removal and insertion of closed loop tests or loops
- Transfer to or from the reactor from or to the interim decay storage or the interim examination cell.
- Transfer to or from the transfer cask
- Transfer to or from the shipping cask.

To remove and insert fuel into the core of the reactor, three refueling machines, one located in each of the three sectors of the reactor, are located in-vessel above each core sector (Figure II.B.2.8). Their drive mechanisms are above the reactor located in rotating plugs. Remotely, each machine in conjunction with the rotation of the rotating plug and rotation of the machine's offset arm can transfer fuel to or from the core into and out of storage positions located in the reactor vessel outside of the core. The same in-vessel machine can insert fuel into or remove fuel from a transfer pot located in the fuel storage area. The transfer pot is located under a fuel transfer port, which serves as the transition between the reactor and the ex-vessel (Figure II.B.2.9) fuel handling system. The ex-vessel refueling machine can be positioned above the fuel transfer port (one port for each reactor sector) and can remove or insert fuel from the transfer pot.

During refueling, the ex-vessel refueling machine maintains a seal between the internal reactor cover gas and the external containment building atmosphere.

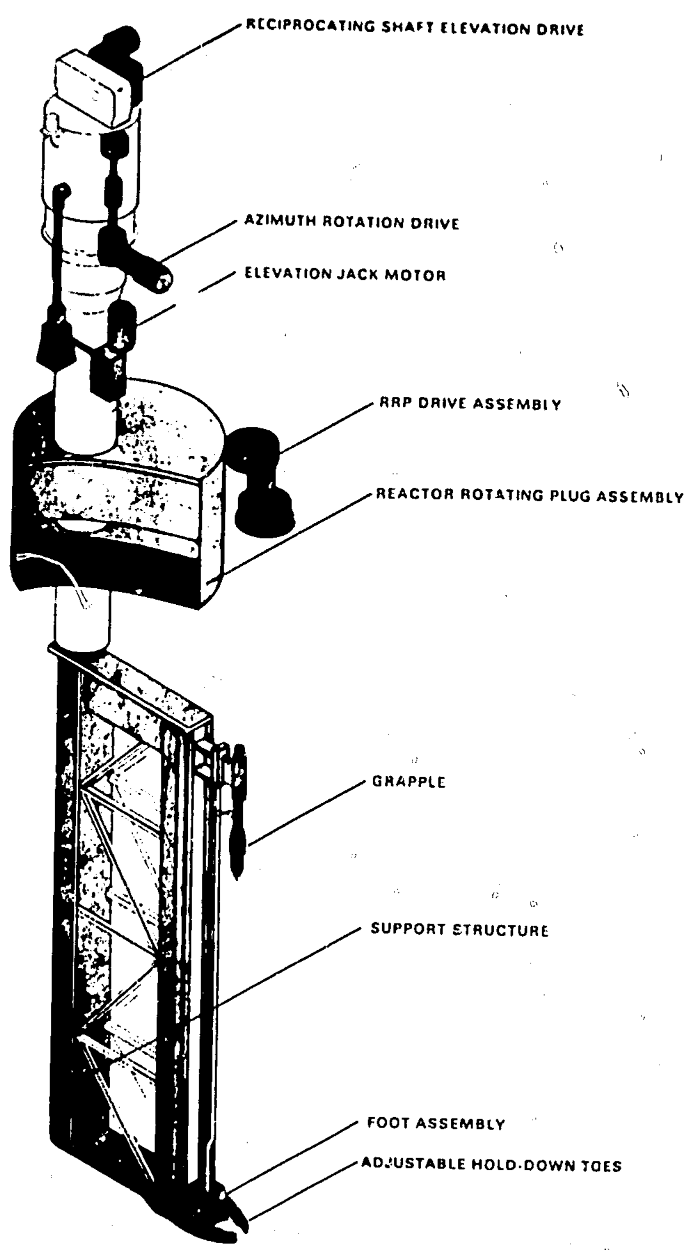


Figure II.B.2.8 In-Vessel Handling Machine

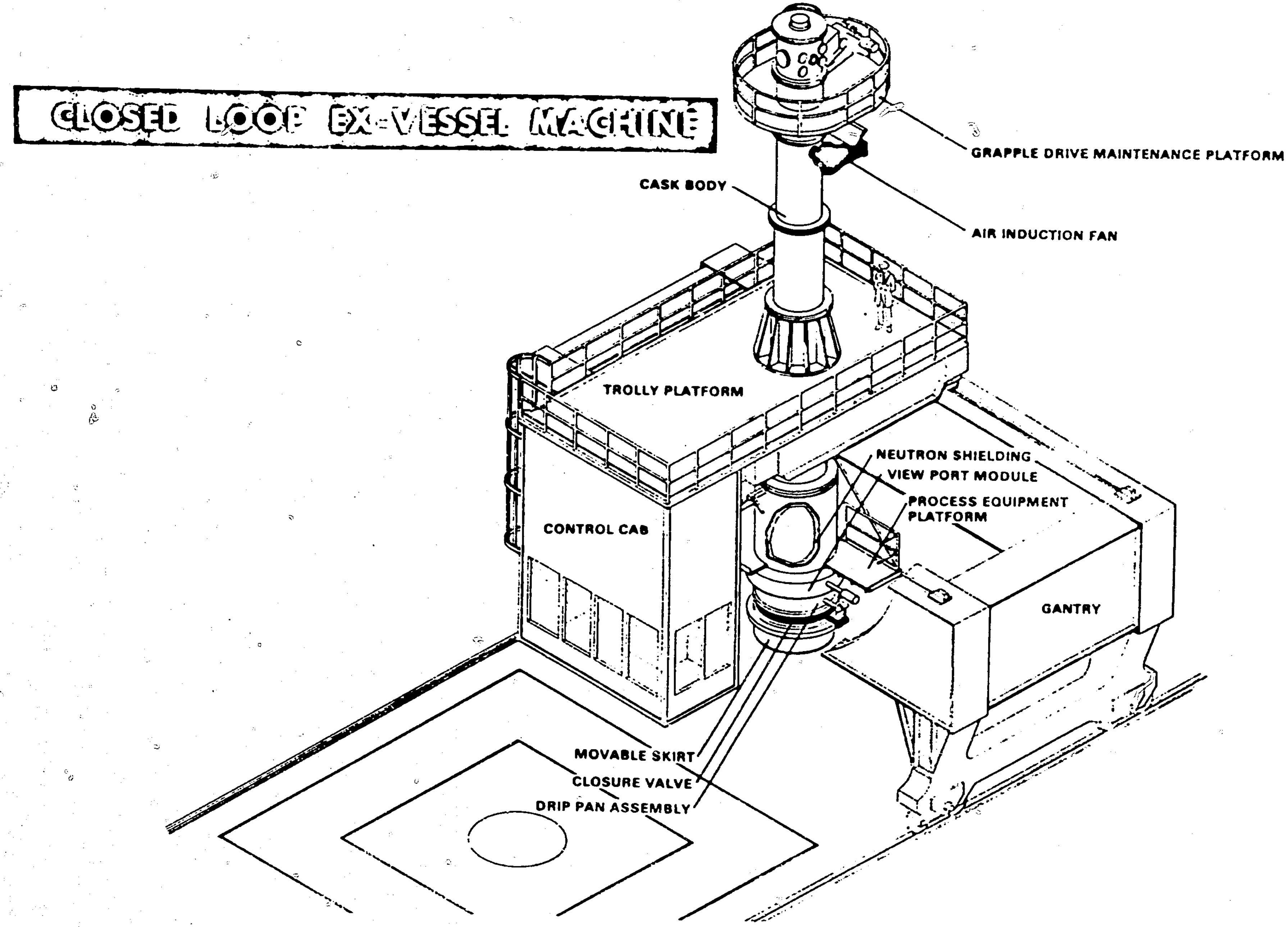


FIGURE II.B.2.9

The ex-vessel handling machine transfers driver fuel, test fuel or test trains, and closed loops to or from the reactor to the interim decay storage or to the interim examination all located in the floor of the containment building. A bottom loading cask car removes fuel from either of these in-floor cells, through an equipment air lock and into a shipping zone where fuel or test trains are transferred into shipping casks.

e. Heat Transport System

Reactor heat removal (Figure II.B.2.10) is accomplished by means of sodium transport, utilizing three parallel, independent heat transport circuits [31]. Each circuit has a primary and secondary loop with ultimate heat rejection to the atmosphere utilizing sodium-air dump heat exchangers in the secondary loop. The primary loops contain sodium which becomes radioactive under neutron irradiation as it passes through the reactor.

An inert gas (argon) is provided over the primary sodium system. As a result of operation of the reactor, radioactive materials may be produced through fission within the fuel, through activation of reactor structural materials, through activation of the reactor cover gas and through activation of the sodium in the primary loop as it passes through the core. A secondary sodium system is provided to effectively isolate the atmosphere from this activity. Accidental contamination of the secondary loops is prevented by maintaining a higher relative pressure on the secondary side so that any leakage that might result from failures of tubing within the primary to secondary heat exchangers is into the primary sodium. The FFTF will contain approximately 1.6 million

FFTF REACTOR HEAT TRANSPORT SYSTEM

ONE OF THREE PARALLEL COOLANT CIRCUITS

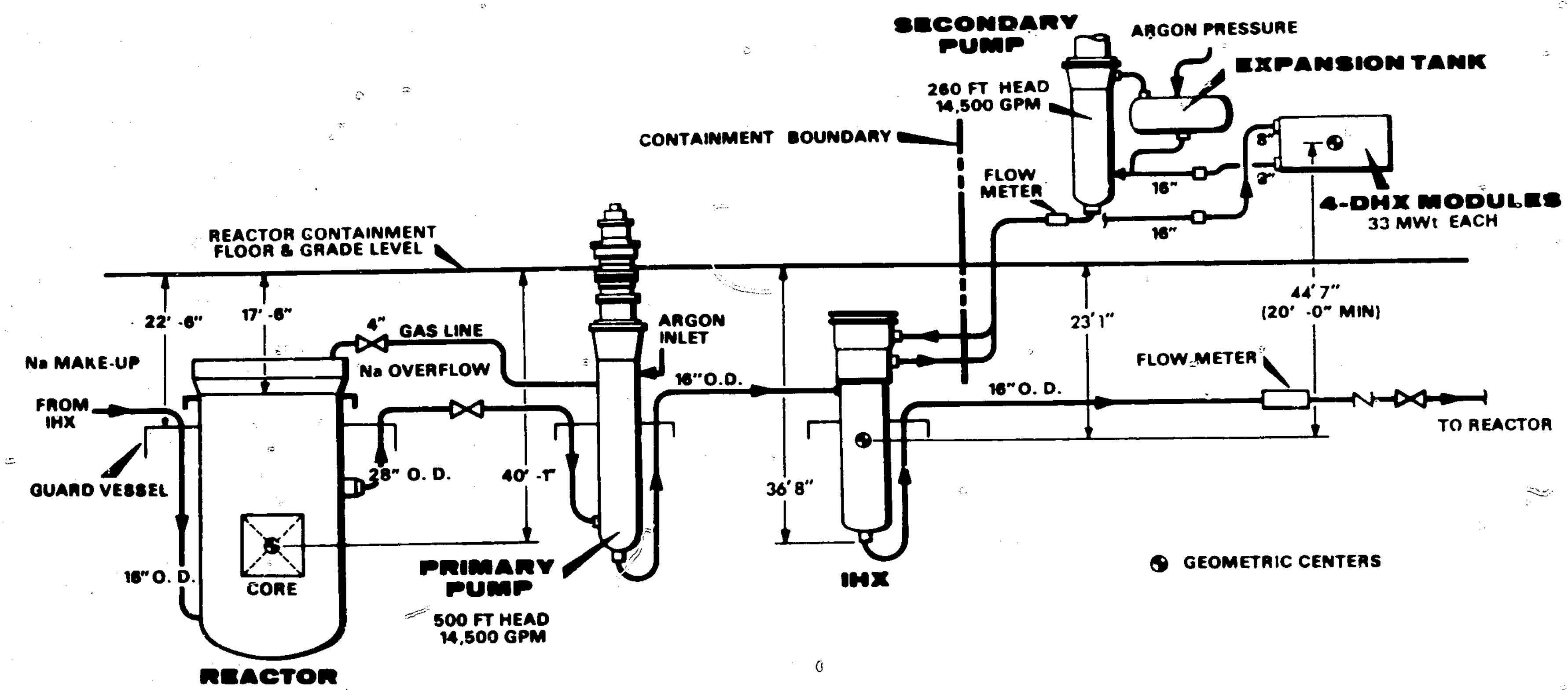


Figure II.B.2.10

REACTOR THERMAL DATA	
POWER	400 MWt
INITIAL PEAK FLUX	7.0×10^{15}
CORE OUTLET, INITIAL	900°F
MAX DESIGN	1100°F
CORE INLET, INITIAL	600°F
MAX DESIGN	800°F

HEAT EXCHANGER THERMAL DATA	
HEAT REMOVAL/CIRCUIT 133 MWt @ 85°F LMTD	
HOT LEG PRIMARY SODIUM,	
INITIAL	858°F
(ULTIMATE)	~1035°F
DHX AIR INLET, DESIGN	90°F
DHX AIR OUTLET	~600°F

pounds of radioactive sodium and approximately 3.2 million pounds of non-radioactive sodium. Included in each primary loop are a circulating pump, two isolation valves, a check valve and the shell side of an intermediate heat exchanger (IHX), Figure II.B.2.10.

Each of the pumps is a free-surface, centrifugal type circulating pump which draws sodium from one of the reactor vessel outlet nozzles and then forces it through an IHX and the rest of the loop back into the vessel through one of the reactor vessel inlet nozzles.

Each secondary loop comprises the tube side of an IHX, a circulating pump, valves, connecting piping and a set of sodium-air dump heat exchanger modules. The reactor coolant system will remove the heat generated in the reactor, except that of the closed loops, for all modes of reactor operation, including emergency cooling and shutdown. Heat generated in closed loop experiments will be removed by primary and secondary heat transport systems independent from the main heat transport system. The closed loops will reject their heat to the atmosphere by means of sodium-air dump heat exchangers during normal operation.

For all circuits, the secondary sodium pumps and sodium-air dump heat exchangers are located outside the containment structure.

The Heat Transport System is designed to maintain reactor heat removal in the event of loss of normal electrical power or pipe breaks. Pony motors, supplied with emergency power, located on the same shafts as the normally operated motors operate automatically upon reactor scram or shutdown and provide forced coolant circulation under loss of normal power conditions. In addition, natural convection cooling of the core is available to remove reactor decay heat for complete loss of electrical power to pump motors.

Guard vessels surrounding the reactor vessel, IHXs and primary pumps, together with elevated piping outside of the guard vessels, are designed in a manner to provide for sodium coverage of the core and for coolant circulation paths following any failure of the coolant boundary (pipes, vessels and valves).

The reactor and primary system cover gas is argon. The effluent cover gas from these systems will be recirculated after being cleaned up. The effluent gas is passed to the Radioactive Argon Processing System. This system purifies the cover gases of stable and radioactive species of xenon and krypton which may be released to the cover gases from reactor fuels. The purified gas is reused as cover gas for the reactor system. Thus, there is no routine release of radioactivity from the cover gas system except for minor amounts of leakage.

f. Containment Building

The containment vessel is a pressure-tight, cylindrical, welded steel vessel[32] 135 feet in diameter and 187 feet high and is designed, constructed and tested in conformance with the ASME Boiler & Pressure Vessel Code, Section III, Subsection B. The bottom of the vessel is located approximately 78 feet below grade and is supported on a reinforced concrete pad. Above-grade penetrations through the containment vessel include the personnel airlock, emergency airlock, an equipment transfer lock 25 feet in diameter and 40 feet long, ducts for the supply and exhaust ventilation and penetrations for piping and wiring. All penetrations are leak tight. The entire containment building and penetrations will be leak tested periodically in accordance with nuclear codes and standards. Design pressure of the building is 10 psig.

The operating floor inside the containment vessel is at ground level. All cells containing primary systems sodium equipment are sealed and inerted with a nitrogen atmosphere below grade to preclude fires in case of a sodium leak. Normal air atmosphere is maintained in the space above the operating floor. Facilities in this space include a gantry crane which services the area, heating and ventilating equipment, refueling equipment, miscellaneous accessories, utilities and control stations. This above-grade work area is shielded from the reactor and primary coolant and will permit continuous occupancy during full-power operation.

All facility buildings are divided into ventilation control zones, balanced to cause air flow from areas of lesser contamination potential to areas of greater potential[33]. The containment building is maintained at a slight negative pressure relative to the atmosphere so that any leakage will be from outside to inside.

During normal operations, as noted earlier, the effluent from primary cover gas systems will be recirculated after being cleaned up; the gas processing system is designed so that there will be no deliberate release of radioactivity to the environment. However, in spite of the design precautions taken to clean up and retain radioactive contaminants, some leakage may occur through seals in the reactor vessel head and in other primary system components into the outer containment building. The possibility also exists for minor leakage during other operations such as refueling.

To further minimize the impact from these potential sources, exhaust ventilation air passes through high efficiency particulate and halogen filters prior to release to the atmosphere. Under operating conditions, the activity level of the exhaust ventilation air is expected to be essentially that of background.

The containment design (leak tightness and pressure containment) reflects recognition of the possibility of more severe releases of radioactivity due to accident conditions. Monitors are provided in the exhaust ventilation system to provide for isolation of containment building ventilation in the event of abnormal radioactivity levels. The containment building is designed to leak no more than 0.1 percent per day at 10 psig internal pressure and at a temperature of 250°F. This will provide the capability to safely accommodate the full range of hypothesized accident conditions (including radionuclide releases from the reactor and major sodium spills and fires).

g. Auxiliary Systems and Structures

Surrounding the containment building are the control building, auxiliary equipment buildings (east and west), reactor service building, HTS service buildings (east, west and south) and the sodium-air dump heat exchangers[34]. Other auxiliary structures at the site include:

- Electrical Substations
- Water Supply Wells
- Water Pump House
- Raw Water Storage Tanks
- Ventilation Cooling Towers
- Process and Sanitary Sewer
- Material Storage Building
- Materials Storage Yard
- Flammable Material Storage Building
- Inert Gas Receiving and Storage
- Fuel Oil Storage Tanks
- Sewage Treatment Plant

- Percolation Ponds for Process and Sanitary Sewer Systems
- Railroad
- Roads, Parking, Sidewalks and Fencing

The reactor support buildings and yard structures provide the necessary shelter, space, structural support, physical barriers, biological shielding and general facility arrangement to support the operation, maintenance and safety requirements of the FFTF.

Activities in support of routine reactor operations and experiments are performed in the Reactor Service Building. Certain of these, such as the Fuel and Radioactive Wastes Handling Area and Sodium Cleaning Facility involve radioactive or toxic materials. All such activities are housed in specially designed enclosures, and waste treatment facilities, such as the heating and ventilation systems, are provided to exercise the necessary control over routine operations and accident events. Spent fuel elements and non-fuel core components are cleaned in the Sodium Cleaning Facility before leaving the plant. This facility reacts residual sodium on the components and is housed in a subgrade vault. Waste solutions from this facility are flushed to the Radioactive Waste System, described in Section IV.A.7.

The Reactor Service Building serves as a receiving and shipping point for reactor sodium. Sodium is received and piped to the reactor sodium system where it is contained under inerted gas in enclosed systems. A sodium impurity monitoring and cleanup system is provided for cleanup and purification so that very little makeup or waste sodium will be handled after the start of operation.

Sodium systems in the plant are provided with leak detection systems so that any leakage can be detected promptly and stopped before a hazard exists.

The Control Building is a conventional, steel-reinforced, concrete structure housing the control room, computer room, the cable spreading room and related equipment. It is designed to protect the occupants and equipment from radiation exposure and to achieve safe reactor shutdown and standby, even in the event of an accident.

A personnel decontamination area is provided adjacent to the work area for removal of outer garments and body cleansing. Personnel airlocks and barriers are provided so that the heating and ventilation system can control the spread of potential airborne activity.

Switchgear and battery rooms are separated to prevent damage to both systems from a single accident.

The electrical substation is located near the perimeter of the FFTF site. Electrical distribution systems within the site are buried to provide maximum reliability in event of an accident.

A fire protection system is provided for the reactor plant and facilities to assure that fires will not result in major damage to the plant or to the environs. Sodium-air dump heat exchangers have self-extinguishing fire protection capability which is actuated automatically on receipt of a fire detection signal. In addition, capability is provided to flood each module with inert nitrogen gas. All radioactive sodium areas are contained in inert gas cells to preclude fires. Potential alkali metal fire areas are provided with portable fire extinguisher equipment. Conventional fire fighting equipment or systems such as sprinklers are provided in the areas not containing sodium.

h. Control Taken to Assure Adequate Facility Design and Function and Minimum Environmental Impact

The following actions have been taken to assure a safe and reliable FFTF design which should assure minimum adverse environmental impact. These have been overriding concerns that have set the pace for all other FFTF activities. Overall and detailed plans to design, fabricate, erect, test, operate and maintain the FFTF were established in 1966. These plans were based on an approach to FFTF safety which provides three levels of assurance.

The first level concerns the intrinsic features of the design and the quality, redundancy, inspectability, and fail-safe features of the components of the reactor and plant. The design of the FFTF is such that the plant will be safe during normal operation and will have a large tolerance for abnormal operation and component malfunction. Those malfunctions or faults that could affect safety are guarded against by design, quality control, or fail-safe features as appropriate.

The second level concerns such incidents as partial loss of flow, reactivity insertions, failure of parts of the safety system, or fuel handling problems, which are assumed to occur in spite of the care taken in design, construction, and operation. Safety systems (including detection instrumentation) and protective devices have been employed in the FFTF to minimize or prevent core damage despite such failures. Safety margins and redundancy have been used in the design of the safety systems and protective features to guarantee their adequacy and reliability.

The third level concerns the postulated failure of protective safety systems simultaneously with the accident they are intended to control. The consequences of such hypothetical accidents have been evaluated and understood. Practical design means provide additional measures of safety to mitigate the accident or accommodate the consequences.

The FFTF program plans included provisions for adequate resources in terms of money, personnel and facilities; top level competent technical and managerial talent to effectively implement the plans; effective centralized coordinated organization and management; and establishment of priorities and schedules needed to do the job. Systematic disciplined engineering design and analyses have been applied to the task of implementing these plans. Use of strong quality assurance practices including the development of standards, codes and criteria; maximum use of component, instrumentation and control and system proof tests; and quality assurance tests, preoperational tests and model tests were instituted early in the FFTF program. Implementation of the program includes aggressive prosecution of the required research and development effort and continual reviews, assessments and redirections as needed, identifying problem areas and resolving them. As part of this area, provision has been made for sodium, fuels and materials, component, instrumentation and control and system proof tests and model tests. Examples are 1) at the Liquid Metals Engineering Center (LMEC) a prototype pump will be tested in sodium at FFTF operating conditions, 2) also at LMEC, prototypic heat exchangers will be tested in sodium and exposed to thermal transients, 3) at HEDL a 1/3 segment of the reactor core will be mocked up and tested in sodium in the Composite Reactor Component Test Activity (CRCTA) Facility, 4) at HEDL the core mechanism will be mocked up and tested in the Core Mechanical Mockup Facility (CMM), 5) a 1/4-scale model of the reactor vessel will be hydraulically tested with water, and 6) irradiations of in-core materials are being completed at the EBR-II reactor. There are hundreds of other tests underway and planned at various test locations throughout the country. Important to the FFTF program was the establishment of an industrial base to provide the necessary competent engineering, design, fabrication, erection, test operation, and maintenance capability needed for this and other LMFBR projects.

The use of strong quality assurance practices has assured high quality workmanship during preparation of material for, and fabrication, erection, test operation and maintenance of the FFTF -- a basic necessity in any enterprise of this nature.

It was determined early that the success of the FFTF program required focusing of the LMFBR base program on the FFTF, using the FFTF as a unifying central LMFBR project. The experience gained through the Navy propulsion reactor programs; the light water reactor program; the EBR-II, Fermi, SEFOR projects, the national laboratories; and from other reactor programs are being factored into the FFTF program.

A major effort has been underway to train operating and maintenance personnel for the FFTF. Design, operating and maintenance personnel will be increasingly utilized to prepare and issue detailed well-planned and coordinated operating and maintenance procedures. Steps are also being taken to assure that these procedures are applied in a well organized and planned set of operations and maintenance practices.

Important to minimizing and adverse impacts of the FFTF on the environment have been the systematic development, design, fabrication, test, installation, operation and maintenance of large numbers of safety features. Painstaking detailed attention has been paid to each aspect of the FFTF, no matter how small or apparently trivial, to assure that the safety of the FFTF will not be compromised, and if inadvertently compromised, to minimize the consequences. A brief description of these safety features follows:

For the containment building: A gas-tight steel shell; sealed and monitored containment building penetrations; fast acting containment building isolated valves; nitrogen atmosphere for cells containing sodium equipment including reactor cavity; airlocks for personnel and equipment; a foundation design for all normal and abnormal loadings including seismic effects; and a biological shield completely surrounding all radioactive components.

For the reactor vessel, reactor vessel head, and reactor vessel and internal structures: A reactor vessel and reactor vessel head capable of withstanding the hypothetical core disruptive accident; a guard vessel; location of inlet and outlet pipes and stand pipe around reactor inlet piping; a sodium reservoir above outlet nozzles, all of which are designed to preclude loss of sodium in the event of reactor vessel and piping leak; a reactor vessel support system designed to adequately restrain the reactor vessel for all conditions including the hypothetical core disruptive accident; a core restraint system which prevents any excessive movement of the reactor fuel; control and safety rods capable of maintaining the power level below safe limits; instrumentation - thermocouples for detecting temperature deviations from normal; flow meters which can detect abnormal flow conditions; a FEDAL (Fuel Element Failure Detection and Location) system[35] capable of detecting and signaling even minute leaks of fission products escaping from a damaged fuel pin; neutron monitors capable of measuring neutron flux over many decades of neutron flux even under extreme sub-criticality conditions; and sealed and structurally strong reactor vessel penetrations.

For the heat transport systems: Use of intermediate nonradioactive sodium heat transport system between the primary system and the sodium-air dump heat exchanger; low pressure system; elevated horizontal piping; natural circulation; pony motors to provide for continuation of sodium flow in the event of main motor loss; isolation valves in the primary and secondary sodium systems to isolate any loop which indicates possible leakages; design margins for loss of one loop, power transients and temperature transients; guard vessels to prevent loss of primary sodium in event of a system leak; sodium monitoring and purification instrumentation and equipment; control and safety systems (and instrumentation) equipped with interlocks, and with necessary redundancy of components and systems; separation of primary loop and reactor in steel-lined nitrogen-filled cells; sodium-air dump heat exchanger module separation; sealed and structurally strong penetrations for sodium components; and sodium-fire fighting equipment.

For radioactive gas waste systems: The radwaste system itself is a safety feature. Included in these systems are safety features such as filters to remove particulate matter; a 2 to 1 reduction in radioactivity in the compressor receiver; a cryogenic charcoal delay bed capable of decaying nearly all the radioactive xenon and other minor products; and a fractional distillation column which strips xenon and krypton from the flow stream after which it can be stored in a tank indefinitely or removed elsewhere for storage.

For tritium: The sodium system is capable of some tritium retention. Primary sodium cold trapping is very effective in keeping tritium concentrations at low levels.

A further safety feature is the separation of the nonradioactive sewerage (sanitary and process) systems from the radioactive liquid waste system.

An important set of safety features are those associated with the in-depth series of barriers which should assure the general public that the probability of radioactivity escaping to the atmosphere is indeed extremely low. This set of barriers includes:

The fuel which only slowly releases gaseous fission products and only above a certain burnup and temperature. Further, the (See Fig. II.B.2.7) fuel effectively contains the solid fission products.

- The fuel cladding, which even under large integrated neutron flux irradiation and high temperatures maintains its integrity. (Fig. II.B.2.7)

- A high integrity primary cooling system (Fig. II.B.2.2) made of welded stainless steel.

- A high integrity primary cooling system (Fig. II.B.2.2) made of welded stainless steel which is comprised of the reactor vessel, the reactor vessel, head plugs, (Fig. II.B.2.4) and the associated primary system piping, intermediate heat exchanger, pumps, and valves.

- The inerted equipment cells surrounding the primary system components which help isolate radioactive materials.

- The essentially gas-tight low leakage containment building which serves as the final barrier against release of radioactivity from the reactor to the environment. (Fig. II.B.2.2)

- The fuel subassembly cans (Fig. II.B.2.5) which surround bundles of fuel pins, and the guard vessels, though not leak-tight, provide a large measure of protection against communication of accidents to adjacent areas.

C. Anticipated Benefits

1. Technological and Economic Benefits

The prime mission of the FFTF is to test breeder fuels and materials so as to improve fuel and reactor component performance and to utilize more fully our fissionable resources. The present Light Water Reactors (LWR) are capable of utilizing only one to two percent of the uranium available. Breeder reactors can, on the other hand, utilize over 60% of the uranium mined, thereby conserving natural resources. Thus, the development of the breeder should enhance the utilization of man's resources in the long-term future. The thermal efficiency of current water reactor designs is approximately 33 percent. With breeders such as the LMFBR, the thermal efficiency increases to approximately 40 percent. Thus, the amount of waste heat generated by the breeder will be significantly less than that generated by the current LWR designs for producing a given amount of useful energy. These factors indicate that the timely introduction of the breeder should play a significant role in environmental protection and resource conservation.

The FFTF is a major element in the LMFBR research and development program. Without the FFTF, introduction of an economic LMFBR could be slowed substantially, resulting in reduced benefits. This is more fully discussed in Section IX. The design and development of the FFTF is advancing fast breeder component and system technology and developing the industrial capability required for demonstration and commercial breeder plants. These benefits result from the emphasis placed on the close relationship between the FFTF and other breeder program activities. The FFTF is providing a training ground for selected participants from industrial organizations and laboratories; it is currently the principal design activity for solving many of the LMFBR technology and engineering problems; and it continues to be the major vehicle for establishing program management capabilities and disciplined engineering methods, for developing and using LMFBR criteria, codes and standards, and for establishing a proof testing program.

As the principal operational test facility for the LMFBR program, technological, and in many respects, economic benefits will be derived from the FFTF. The FFTF will:

a. By providing a vehicle for verification of performance capabilities of LMFBR fuels and materials, reduce risks and costs which would otherwise be involved in attempting to test fuels and materials at limiting values in LMFBR demonstration and commercial plants.

b. Increase reactor fuel and plant operational limits, including:

   (1) Allowable fuel burnups and structural material neutron flux exposures

   (2) Fuel power ratings (i.e., kilowatts per foot of fuel pin)

   (3) Thermal plant efficiencies (by increasing allowable temperature limits)

   The increased limits will result in longer fuel life thereby reducing the number of refueling cycles and the attendant radioactive material losses as well as reducing fuel cycle costs.

c. Reduce LMFBR fuel fabricating and reprocessing costs by helping to establish:

(1) Improved quality assurance measures

(2) Improved fuel and subassembly designs

(3) Improved fuel fabrication procedures

(4) Improved fuel reprocessing procedures

(5) An industrial base with a substantial fuel throughput.

d. Facilitate the introduction of a safe, reliable and economic LMFBR and thereby realize the benefits which can be derived from breeder reactors.

The above reduced risks and costs and increases in operational limits will stem in major part from increased knowledge and understanding of behavior of LMFBR fuel, core neutronics, cladding, sodium coolant, components, instrumentation and control, systems and plants. The knowledge and understanding gained will be made use of by the FFTF and other LMFBR developmental organizations to determine LMFBR operational limits for:

a. Linear power of fuel pins

b. Temperature of fuel and clad

c. Fuel burnup

d. Structural material neutron exposure.

Also, the FFTF will provide information on the effects of clad swelling, zone enrichment, fuel shuffling and core restraint mechanisms on LMFBR design and performance.

Additionally, the FFTF will yield cumulative operational and maintenance experience of value to the LMFBR development program and will provide directly applicable training of personnel for LMFBR demonstration and commercial plant development, design, fabrication, erection, testing, operation and maintenance.

In addition to the technological-economic benefits from the FFTF experience, the FFTF program provides employment for about 2600 people of which about 1400 are located in the Tri-Cities. It is expected that FFTF-related employment (site, laboratories, other locations in U.S.) will remain at about 900 after plant construction is complete, with the majority of the employees located in the Tri-Cities area. Furthermore, the development, design, fabrication and construction of the FFTF will measurably contribute to employment in those other areas of the country where activities related to these operations will be performed.

2. Environmental, Political and Social Benefits

The operation of the FFTF should facilitate the introduction of safe, reliable and economic commercial LMFBRs. An advance in the date of introduction of LMFBRs would result in their substitution for fossil plants or LWRs and, consequently, in a reduction in the air pollution and/or thermal effects which would otherwise occur. Further, the FFTF will:

a. Aid in the development of equipment for LMFBR plant radioactive waste systems.

b. Demonstrate the capability to minimize radioactivity waste processing problems through experience in the operation and maintenance of such equipment.

c. Provide experience in the development, installation and operation of LMFBR plant radioactive monitoring equipment.

The United States is one of several countries today engaged in the development of breeder reactors. The success of the FFTF and its support in the development of a reliable and economic LMFBR will help maintain this country's world leadership in the production of safe, economical power production, thereby improving this country's international balance of payments with a world-wide competitive saleable product.

The FFTF program is planned to foster the greatest degree of participation by potential suppliers of LMFBR equipment. In addition, information developed from the program will be available throughout the industry for the advancement of breeder technology in this country. The FFTF, with its complex facilities, will become a center of education and training of a growing number of scientists, engineers and technicians needed to man the LMFBRs of the future. This broad participation, as well as the dissemination of essential data, will further the general technological capabilities of this country and improve the professional competence of the technical personnel associated with the project. Further, it is expected that the demonstration of this plant will enhance the public's confidence in the recognized attributes of clean, safe and economical nuclear power.

D. Characterization of the Existing Environment

1. Physical Features of the Region

a. Land

The FFTF is located in the south central part of the Hanford Reservation which is approximately in the center of the Pasco Basin. The plant site[36] is located on a wide bench of glaciofluvial materials at about elevation 550 and about 12 miles north, northwest of Richland, Washington as shown on Figure II.B.1.2. The Columbia River is about four miles to the east of the site and the Rattlesnake Hills are to the southwest about 8 to 10 miles away.

The region is underlain by three major geologic units:

a. The basaltic lavas of the Columbia River Basalt Group at the base with an upper surface at about elevation -50 at the site.
b. The sediments of the Ringold Formation with their upper surface about elevation 400 at the site.
c. The glaciofluvial sands and gravelly sands of late Pleistocene and early recent times. In the general vicinity of the site the surface of the glaciofluvial materials has been reworked by winds to form a shallow mantle of dune sands.

All structures are founded on and in the glaciofluvial deposits and the final design exploration involved determination of the engineering properties of this unit. The present ground water table is set at about elevation 387.

The Ringold Formation sediments beneath the site are compact, locally indurated silts, sands, gravels and local clays which are generally impure, poorly sorted and, consequently, of low permeability. They are Columbia River deposits laid down in Pliocene times as the result of continued downwarping of the Pasco Basin and the uplift of the enclosing anticlinal ridges, particularly the Horse Heaven Hills about 20 miles to the south.

The uplift of those ridges, beginning roughly ten million years ago, evidently has continued at a slow and probably nearly steady rate concomitant with comparable basining to the present day. The Ringold Formation silt-clay beds, as well as the sand and gravels, are completely contained beneath the Hanford Project area with no site toward which stress can be relieved or pore pressure rapidly reduced in a manner inducing liquifaction. The load to which the sediments have been subjected, both by stratigraphically higher beds prior to their erosion and the weight of the glacial Lake Missoula and related floods, evidently have helped compact them and minimize their permeability.

The site lies between the active earthquake zones of the Puget Sound Trough and the northern Rocky Mountains. It lies in Zone 2 of the Seismic Probability Map (1949) of the Uniform Building Code and the Seismic Risk Map of the ESSA Coast and Geodetic Survey (1969).

The maximum ground acceleration at the FFTF site caused by a historic earthquake was 0.03g.

Based upon conservative evaluations made by J. A. Blume and Associates,[37] using several different techniques, a design basis earthquake and associated ground acceleration at the site of 0.25g was chosen for the FFTF. This evaluation included a study of the earthquake history of the area, the results of geological surveys and comparison with other similar regions of the United States.

b. Water

Groundwater at the FFTF site occurs at about 387 feet above sea level or approximately 170 feet below grade. Movement of the groundwater is from west to east toward the Columbia River. Construction of the proposed Ben Franklin Dam is expected to provide a maximum pool level of 400 feet, thus raising the ground water level at the site to 405 feet or approximately 150 feet below ground surface. Figure II.D.1.1 is a groundwater contour map of the Hanford area derived from water levels in more than 1500 wells. Flow direction is down gradient, perpendicular to the contours.

Subgrade vaults associated with the design for FFTF will not penetrate to depths greater than approximately 80 feet below grade which would be approximately 90 feet above the current groundwater table.

Quality of the groundwater at the FFTF site (Well No. 1) on October 12, 1971 is shown on Table II.D.1.1. All procedures were performed in accordance with procedures outlined in Standard Methods of Test for Quality of Water to be Used in Concrete, ASSHO designation T26-51 and 13th Edition of the American Public Health Associations Standard Methods for the Examination of Water and Sewage.

Figures II.D.1.2, .3 and .4 are maps which show respectively the regional beta-emitting radioactive material, tritium and nitrate concentrations beneath the Hanford Project.[38]

During the past 21 years, the flow of the Columbia River varied from a minimum of 34,000 to a maximum of 659,000 cfs. Dam projects along the Columbia River (extending into Canada) will further minimize the occurrence and height of floods. By 1975 the 100-year maximum flood stage is estimated to be about

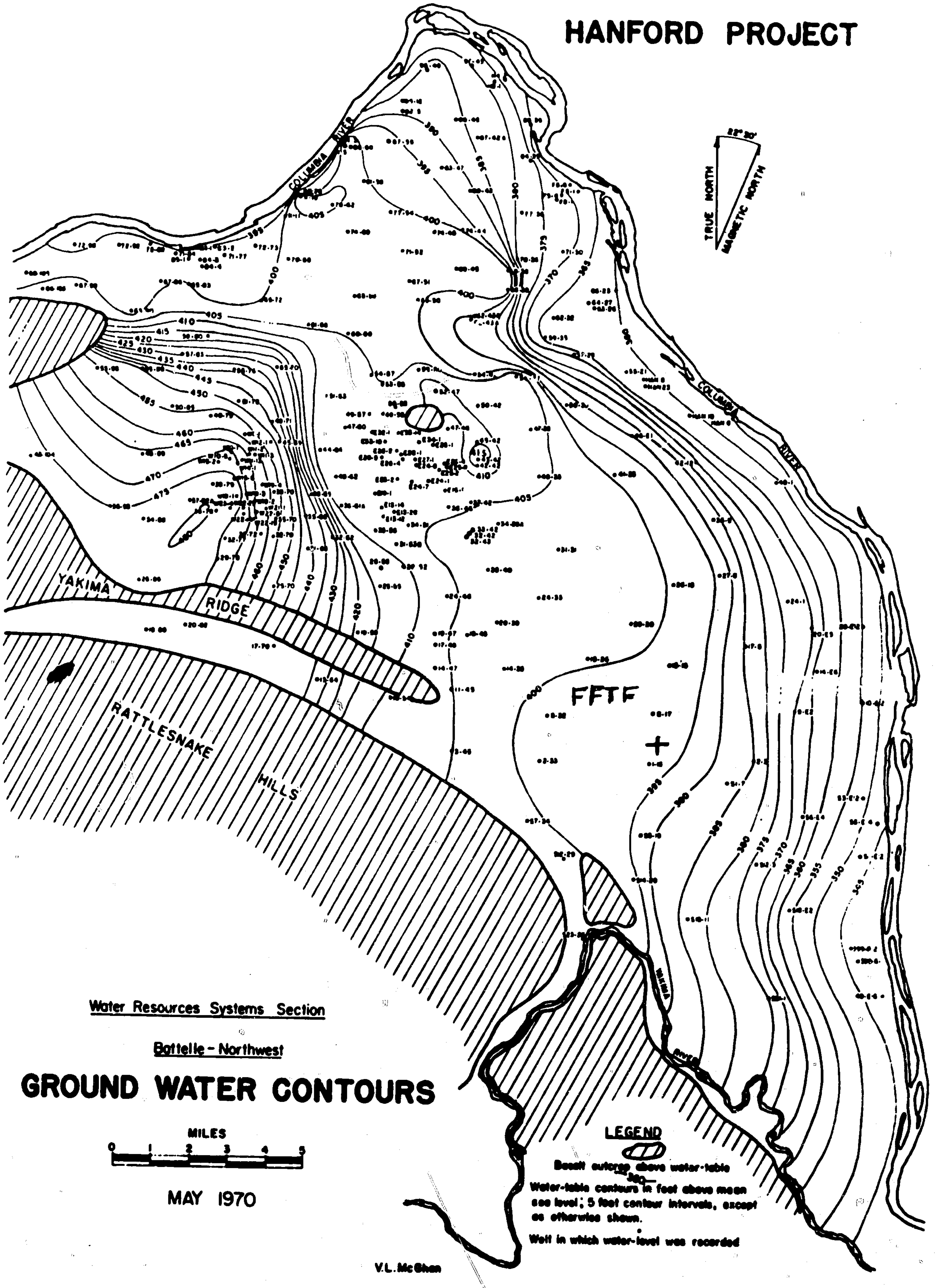


Figure II.D.1.1

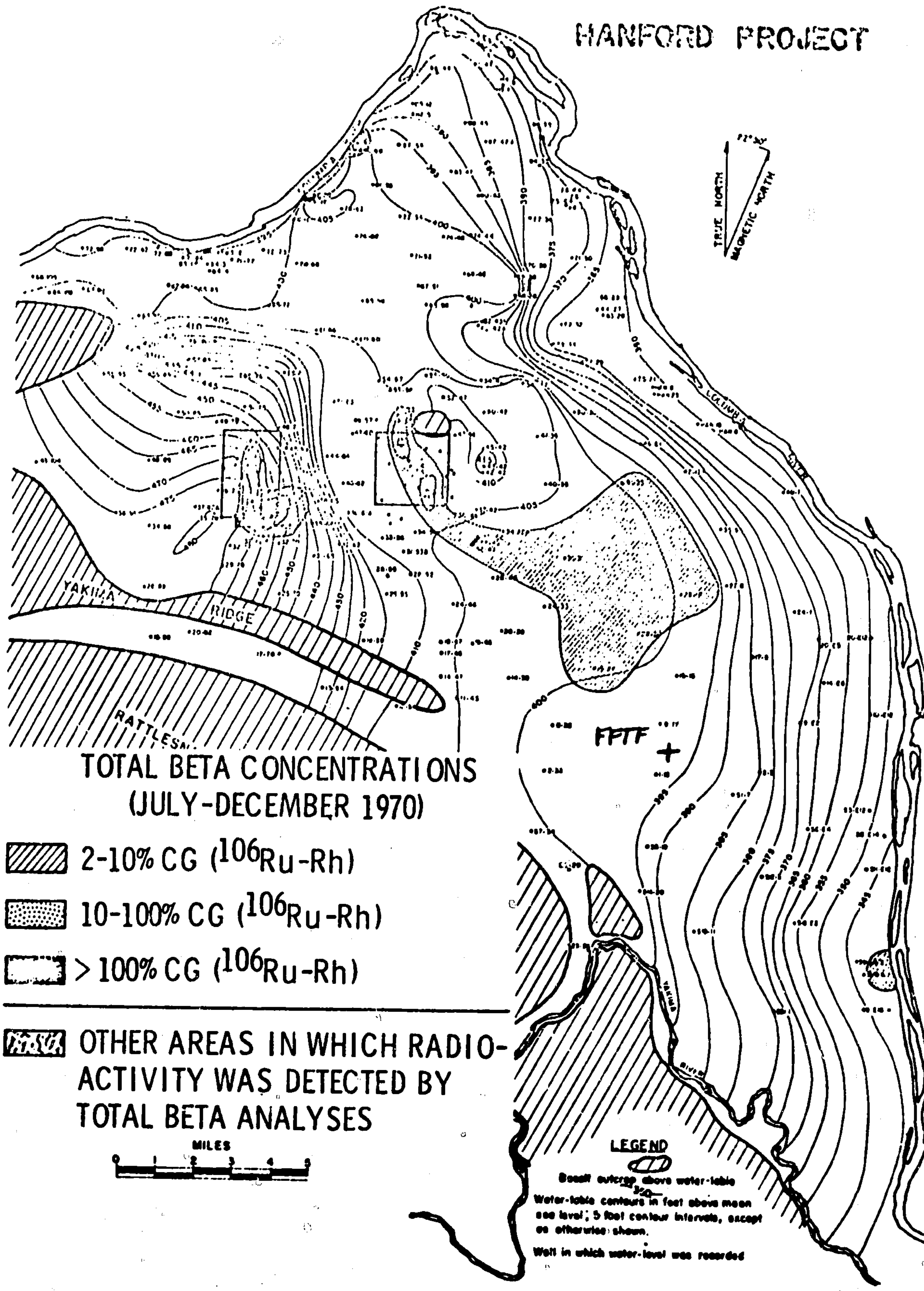


FIGURE II.D.1.2 Total Beta Concentrations Beneath the Hanford Project Expressed as Percent of ^{106}Ru Concentration Guide (10 pCi/ml per Table II of AECM-0524 Appendix 0524, Annex A)

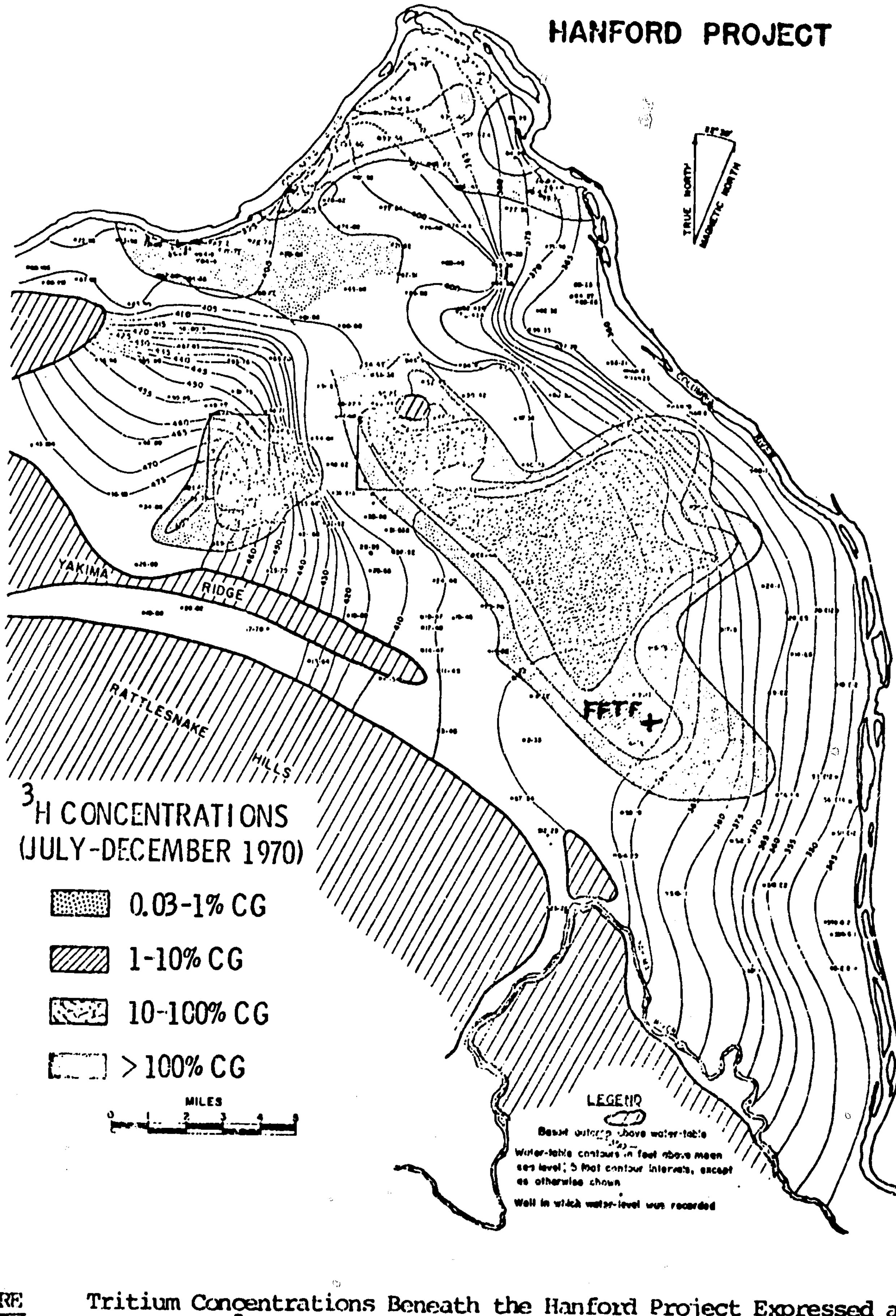


FIGURE II.D.1.3 Tritium Concentrations Beneath the Hanford Project Expressed as Percent of ^{3}H Concentration Guide (3000 pCi/ml per AECM-0524)

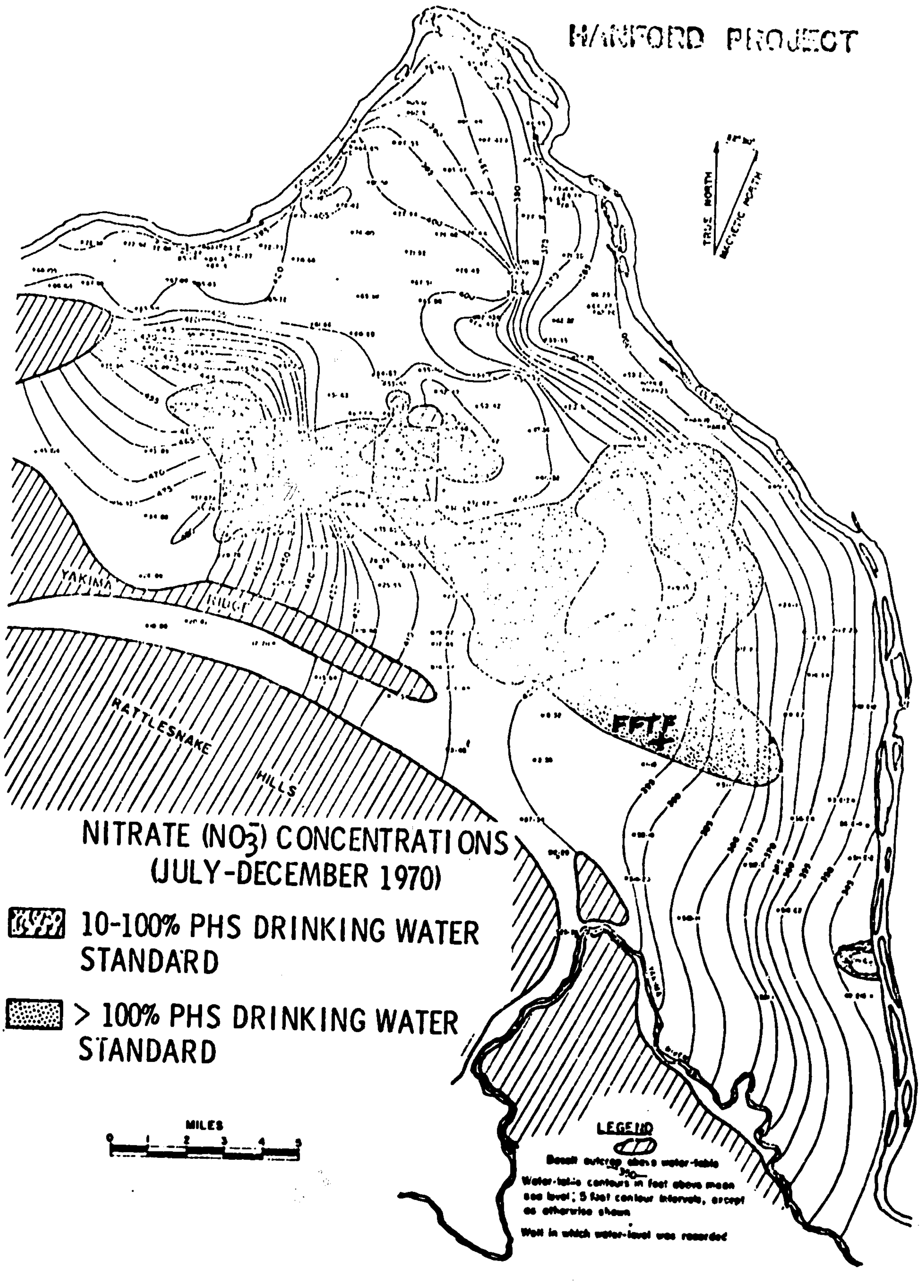


FIGURE II.D.1.4 Nitrate Ion Concentrations Beneath the Hanford Project Expressed as Percent of Public Health Service Drinking Water Standard (45 ppm)

440,000 cfs. The maximum probable flood[39] has been estimated by the Corps of Engineers to be 1,440,000 cfs which would result in a river level of approximately 390 feet.

The difference between the Corps of Engineers estimated maximum probable flood river level of 390 feet above sea level and the FFTF site 555 feet above sea level and located 4-1/2 miles from the river gives ample assurance that the river flooding is of no consequence to the FFTF.

Table II.D.1.1

WATER SAMPLE ANALYSIS, WELL NO. 1, FFTF SITE

October 12, 1971

Constituent	Concentration
Potassium	6.3 mg/liter
Sodium	25.2 " "
Magnesium	12.0 " "
Silica as SiO_2	34.5 " "
Fluoride	0.2 " "
Chloride	12.0 " "
Chlorine	<0.05 " "
Sulfate	36.2 " "
Nitrate	10.5 " "
Iron	0.1 " "
Chromium (Cr^{+6})	<0.001" "
Hardness as $CaCO_3$	151.0 " "
Calcium	25.7 " "
Turbidity	0.24 JTU
Acidity	12.0 mg/liter
pH	7.3
Total Residue	0.026 % by weight
Fixed Residue	0.020 % by weight
Bicarbonate Alkalinity as $CaCO_3$	160.5 mg/liter

2. Meteorology and Climatology

The climate of the FFTF site is a relatively mild continental steppe climate, subject to a rather wide seasonal range in temperature. The local climate is described by data from the U.S. Weather Bureau and by 27 years of meteorological data from a 408-foot-high meteorology tower 16 miles northwest of the FFTF site. The average summer temperature is 73.7°F, but temperatures greater than 100°F can be expected approximately 13 days per year. During the winter months, the mean daily temperature is 32.4°F. Temperatures below 0°F are expected approximately four days per year. The minimum and maximum recorded temperatures in the area were -27°F in December 1919 and 115°F in July 1939. The normal frost-free growing season is about 185 days, extending from mid-April to mid-October.

Precipitation averages 6.4 inches per year occurring mainly during the winter months. The heaviest rainfall of record occurred in October 1957 with 1.68 inches in six hours. The greatest snow depth of record is 12 inches which occurred in December 1964.

The principal source of meteorological data at Hanford is the 622R meteorology tower, also known as the Hanford Meteorology Station (HMS) Tower, a 408-foot tower in operation for 27 years to record temperature, humidity and wind velocities. The tower is located on a plateau near the center of the Hanford

Reservation adjacent to the 200 West Processing Plant area and 16 miles west northwest of the FFTF. Standard surface observations are also available from the Hanford Meteorological Station.

Since 1969 meteorological data have been obtained for the FFTF site. In addition, there is a 300-foot meteorology tower at the 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.

The FFTF Site is characterized by frequently light and variable winds, although windstorms are not uncommon. There are significant differences in wind patterns throughout the Hanford Reservation, as shown in Figure II.D.1.1, due largely to topographical features. Northwest winds predominate at the HMS Tower, but prevailing west winds have been observed at N reactor meteorological tower during the first two years of its operation. Gusts to 80 miles per hour (1-11-72) have been observed at the 50-foot level of the HMS tower.

Seasonal differences occur at the FFTF site and large differences frequently occur in the values of the meteorological data of the FFTF Site and the HMS Tower. Figure II.D.2.1 indicates that the most predominant winds at the FFTF Site in December are from the northwest, and in June the wind directions are much more evenly distributed (except for the virtual absence of winds from the northeast). Figure II.D.2.2 also indicates that northwest winds predominate at the HMS Tower during June just as they do during the rest of the year, and this predominance of northwest winds is not encountered at the FFTF site during the same month.

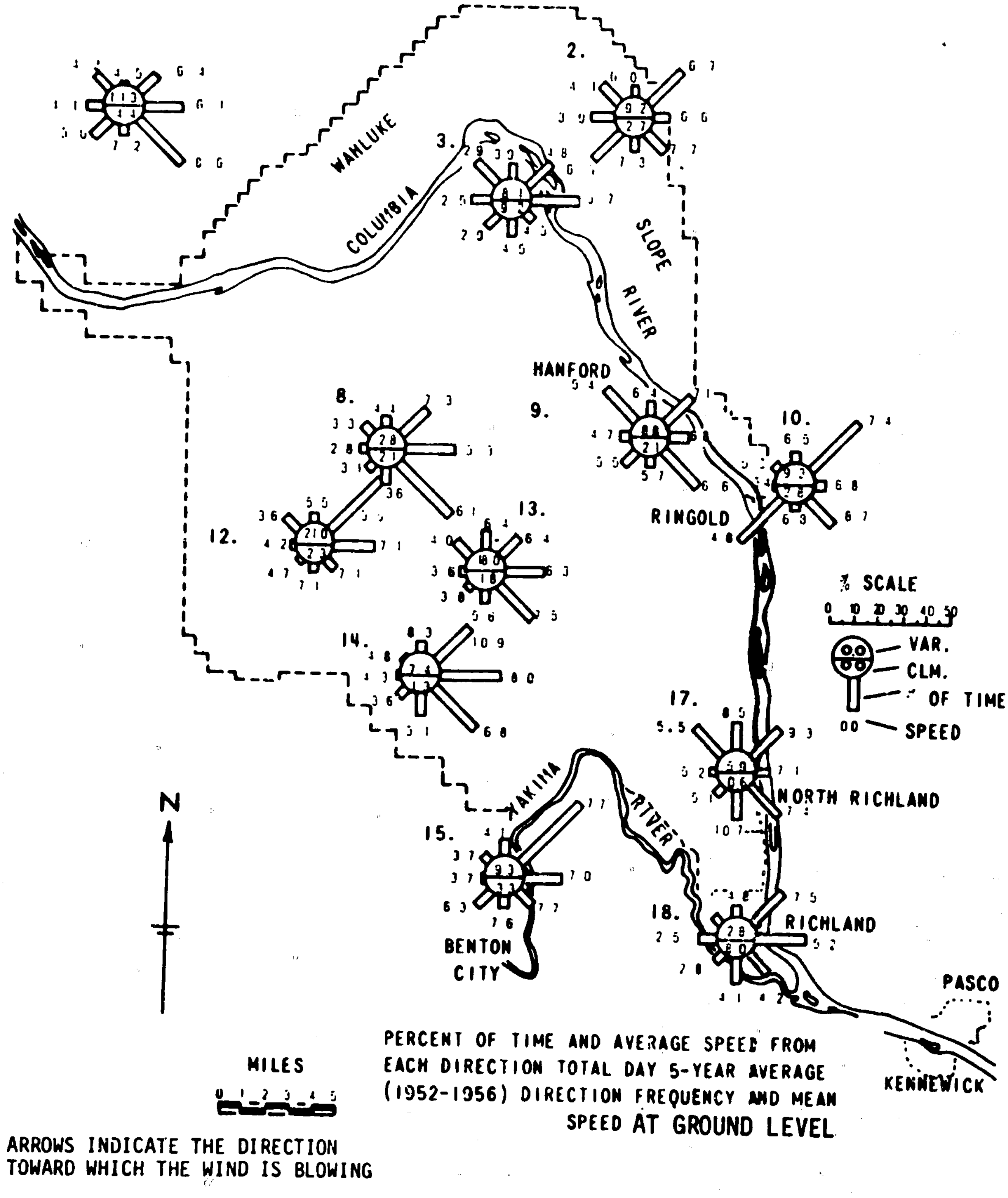


Figure II.D.2.1 Wind Roses for the Hanford Reservation

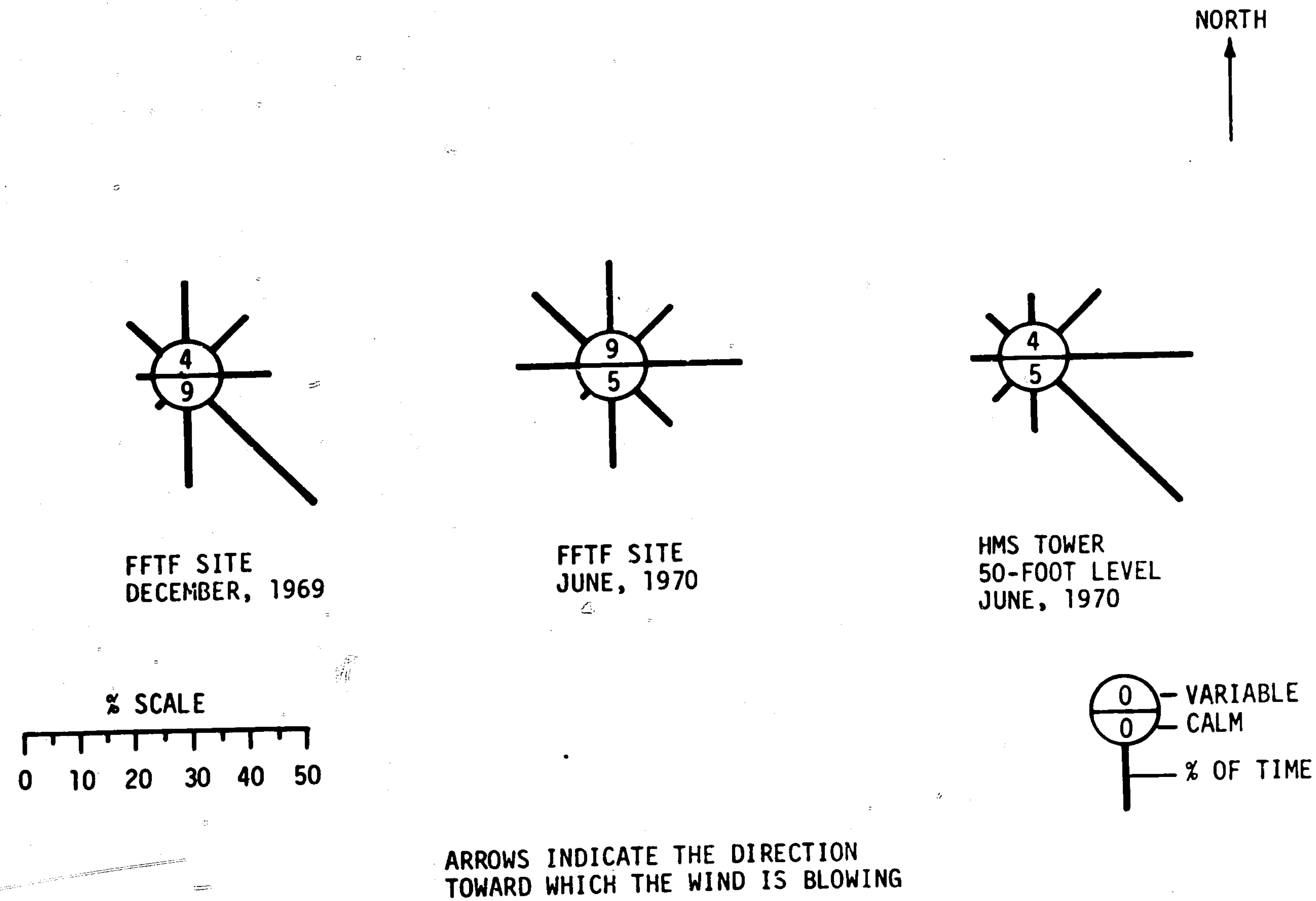


Figure II.D.2.2 FFTF and HMS Tower Wind Direction Data

Wind velocity data for the FFTF site[40] and for the HMS Tower are shown in Table II.D.2.1. The tabular data show that wind speeds at the FFTF site are much less than those recorded at the HMS Tower. At the FFTF site the higher frequency of winds with a velocity of 3 and 4 M/sec during June occurred during the afternoon hours, suggesting a diurnal effect of summer heating.

TABLE II.D.2.1

Percent Frequency of Wind Velocity

Wind Velocity		FFTF Site		HMS Tower (50 ft. Height)
Meters/sec.	Miles per hr.	Dec. 1969	June 1970	June 1970
Calm	Calm	10	6	5
1	2.2	46	48	10
2	4.5	34	28	15
3	6.7	8	13	13
4	9.0	2	5	17
5	11.2	-	-	7
6	13.4	-	-	10
7	15.7	-	-	7
8	17.9	-	-	6
9	20.2	-	-	4
10	22.4	-	-	2
11-12	24.6-26.8	-	-	3
		100	100	99

Table II.D.2.2 shows a classification of diffusion conditions that exist at the Hanford Reservation. These data show that diffusion in very stable conditions and with light wind speeds occurs only about 5% of the time.

TABLE II.D.2.2

DIFFUSION CONDITIONS

LARGE RATE CLASSIFICATION	FREQUENCY OF OCCURRENCE (%) WIND SPEEDS 3 MPH	ALL WIND SPEEDS
VERY STABLE	5.37	23.7
MODERATELY STABLE	5.17	33.7
NEUTRAL	5.47	14.0
UNSTABLE	5.38	28.6
TOTALS	21.4	100

The Pacific Northwest is one of the geographical areas of the country with the lowest frequency of tornadoes; none have been recorded on the Hanford Reservation, although a funnel was observed to touch the ground in June 1948. Nevertheless, plant design insures that safe shutdown of the reactor can be accomplished in the event of tornadic winds with rotational velocities of 150 mph (a reasonable upper limit for tornadoes in the area).

Limited data indicate that air at Hanford is very pure except for naturally occuring particulates. Continuous monitoring of SO_2 content of air on the bluff opposite 300 Area and near Ringold is performed for the AEC by Hanford Environmental Health Foundation. At all times for the past three years SO_2 concentrations have been less than 0.005 ppm. NO_2 concentrations in air during a quarter at the same sampling stations range from 0.002 to 0.010 ppm, with a maximum observed value of 0.029 ppm during one 15-month period. The observed values are less than the National ambient air quality standards established by the Environmental Protection Agency (EPA) and within the Washington State standards established by the Washington State Air Pollution Control Board.

Measurements of the particulate burden in air at a specific observation point in the 200 Area at Hanford showed values of around 100 mg/m^3 of air when the wind was less than 8 mph. The particulate content increased when higher winds were present, averaging 1,000 mg/m^3 with winds of 12 mph and 3,000 mg/m^3 with winds of 16 mph. These measured values are typical of desert areas.

3. Ecological Character of the Region

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 about five miles due east of the FFTF site.

a. Flora

The natural vegetation of the FFTF site and vicinity is dominated by desert shrubs. Especially abundant are big sagebrush and antelope bitterbrush. The understory subordinate to the shrubs consists mostly of grasses, especially Sandberg bluegrass and cheatgrass brome. These grasses are important for mule deer, but bitterbrush is the principal deer forage, especially in fall and winter.

A list of the principal terrestrial plant species on the Hanford Reservation is given in Table II.D.3.1.

The ecological characteristics of the Hanford environment have been continuously studied following the start of the operation of the plutonium production reactors and chemical separations facilities in 1944. This research was supported by the U. S. Atomic Energy Commission and had among its principal objectives the investigation of the effects of effluents from these facilities on the biota of the area.

There are several areas within the Hanford Reservation upon which the Atomic Energy Commission, through its contractor Battelle-Northwest, is conducting bioenvironmental research programs in terrestrial and aquatic ecology.[41] The abundance and distribution of wildlife, fish and other aquatic species have been documented over many years of Hanford operation. Figure II.D.3.1 shows the study areas which are located on the Hanford

TABLE II.D.3.1

Species List for the Hanford Environs

Terrestrial Plants and Animals

Plants	
Shrubs	
Big sagebrush	Artemesia tridentata
Bitterbrush	Purshia tridentata
Green rabbitbrush	Chrysothamnus viscidiflorus
Gray rabbitbrush	C. nauseosus
Spiny hopsage	Grayia spinosa
Snow Eriogonum	Eriogonum niveum
Forbs	
Longleaf phlox	Phlox longifolia
Balsamroot	Balsamorhiza careyana
Sand dock	Rumex venosus
Scurt pea	Psoralea lanceolata
Lupine	Lupinus laxiflorus
Pale evening primrose	Oenothera pullida
Desert mallow	Sphaeralcea munroana
Cluster lily	Brodiaea douglasii
Sego lily	Caluchortus macrocarpus
Tansy mustard	Descurainea pinnata
Tumble mustard	Sisymbrium altissimum
Cryptantha	Cryptantha circumscissa
Russian thistle	Salsola kali
Fleabane	Erigeron filifolius
Grasses	
Sandberg bluegrass	Poa sandbergii
Cheatgrass	Bromus tectorum
Indian ricegrass	Oryzopsis hymenoides
Squirrel tail	Sitanion hystrix
Six weeks fescue	Festuca octoflora
Thickspike wheatgrass	Agropyron dasystachum
Riparian Vegetation	
Willow	Salix exigua and others
Cottonwood	Populus trichocarpa
Sedges	Carex spp.
Rushes	Juncus sp.
Horsetail	Equisetum sp.
Cocklebur	Xanthium sp.
Wild onion	Allium sp.
Birds	
Mallard	Anas platyrhynchos
Green-winged teal	Nettion carolinense

Blue-winged teal	Querquedula discors
Cinnamon teal	Q. cyanoptera
Gadwall	Chaulelasmus streperus
Baldpate	Mareca americana
Pintail	Dafila acuta tzitzihoa
Shoveller	Spatula clypeata
Canvas-back	Nyroca valisineria
Scaup	N. affinis
American goldeneye	Glaucionetta clangula americana
Buffle-head	Charitonetta albeola
Ruddy duck	Erismatura jamaicensis rubida
American merganser	Mergus merganser americanus
Coot	Fulica americana
Horned grebe	Colymbus auritus
Western grebe	Aechmophorus occidentalis
Pied-billed grebe	Podilymbus podiceps
Canada goose	Branta canadensis
Snow goose	Chen hyperborea
White-fronted goose	Anser albifrons
Whistling swan	Cygnus columbianus
Great blue heron	Ardea herodius
White pelican	Pelicanus erythrorhynchos
Cormorant	Phalacrocorax auritus
California gull	Larus californicus
Ring-billed gull	L. delawarensis
Common tern	Sterna hirundo
Foster's tern	S. forsteri
Killdeer	Oxyechus vociferus
Long-billed curlew	Numenius americanus
Chukar partridge	Alectoris graeca
California quail	Lophortyx califorica
Ring-necked pheasant	Phasianus colchicus torquatus
Sage hen	Centrocercus urophasianus
Mourning dove	Zenzidura macroura
Red-tailed hawk	Buteo borealis
Swainson's hawk	B. swainsoni
Sparrow hawk	Falco sparverius
Golden eagle	Aquila chrysaetos canadensis
Bald eagle	Halioetus leucocephalus
Osprey	Pandion haliaetus carolinensis
Burrowing owl	Speotyto cunicularia
Horned owl	Bubo virginianus
Raven	Corvus corax
American magpie	Pica pica hudsonia
Red-shafted flicker	Colaptes cafer
Horned lark	Octocoris alpestris
Western meadowlark	Sturnella neglecta
Loggerhead shrike	Lanius ludovicianus
Western kingbird	Tyrannus verticalis
Eastern kingbird	Tyranus verticalis
White-crowned sparrow	Zonotrichia leucophrys
Sage sparrow	Melospiza melodia
Say's phoebe	Sayornis saya saya

Mammals	
Mule deer	Odocoileus hemionus
Coyote	Canis latrans
Bobcat	Lynx rufus
Badger	Taxidea taxus
Skunk	Mephitis mephitis
Weasel	Mustela frenata
Raccoon	Procyon lotor
Beaver	Castor canadensis
Muskrat	Ondatra zibethica
Porcupine	Erethizon dorsa
Blacktail jackrabbit	Lepus californicus
Cottontail rabbit	Sylvilagus floridanus
Ground squirrel	Citellus townsendi
Pocket mouse	Peromyscus parvus
Deer mouse	P. maniculatus
Harvest mouse	Reithrodontomys megalotis
Grasshopper mouse	Onchomys leucogaster
Pocket gopher	Thomomys sp.
Reptiles	
Northern Pacific rattlesnake	Crotalus viridus oreganus
Great Basin gopher snake (Bull snake)	Pituophis melanoleucus deserticola
Western yellow-bellied racer	Coluber constrictor mormon
Northern side-blotched lizard	Uta stansburiana stansburiana
Western fence lizard	Sceloperus occidentalis
Short-horned lizard	Phrynosoma douglassi
Great basin spadefoot toad	Scaphiopus intermontanus

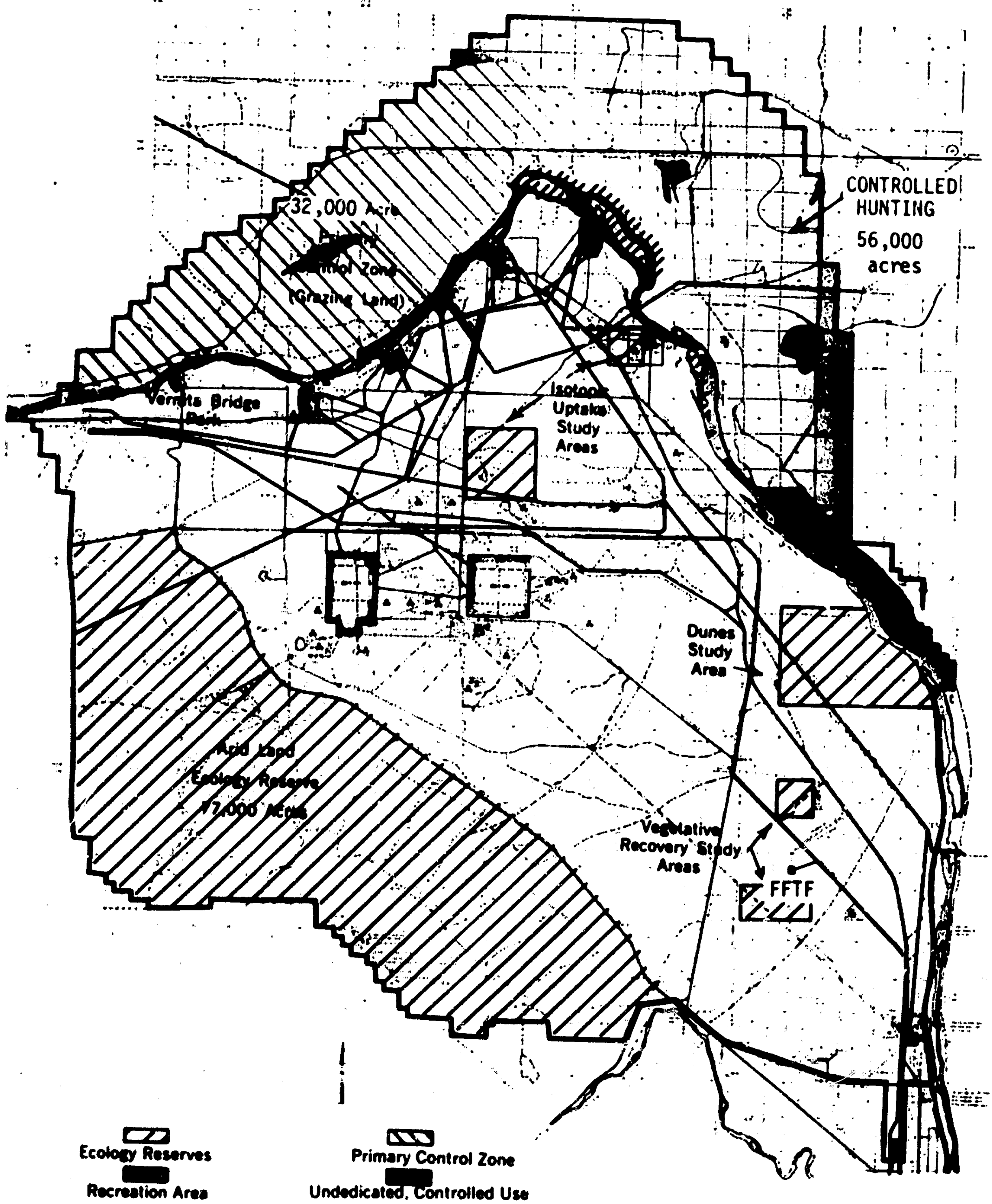


Figure II.D.3.1 Hanford Reservation Land Uses

Reservation. The vegetative recovery areas near the FFTF site are burned off areas from a range fire that occurred in 1970. Range fires pose the greatest threat to vegetation on the site.

b. Fauna

The only animal on the official endangered species list is the bald eagle, an occasional visitor to the Hanford Reservation. The eagle remains near the Columbia River during its winter visits because of the more abundant food supply. FFTF site activities, 4-1/2 miles from the river at its nearest point, cannot be expected to further endanger this species. Only the hardier, more adaptable, and therefore, more common, plant and animal species of this region are found at the FFTF site.

The mammals most commonly associated with the sagebrush-bitterbrush vegetation are pocket mice, deer mice, jackrabbits, coyotes and mule deer. By far the most abundant of these is the pocket mouse, which subsists largely on the seeds of grasses. Mule deer utilize this vegetation type mostly during fall and winter and forage upon the shoots of cheatgrass and the leaves and smaller twigs of bitterbrush.

A resident herd of 300 to 400 mule deer inhabit the reservation and this population provides some sport hunting when individual animals wander into areas accessible to the public. Approximately 100 coyotes also are resident in the Hanford reservation. Occasionally coyotes may prey on livestock and waterfowl in adjacent lands.

Birds are not abundant in the sagebrush-bitterbrush vegetation type. Meadowlarks and horned larks are the most abundant resident birds. The loggerhead shrike, although not an abundant bird, is a conspicuous member of the avifauna. The local vegetation type is seldom used by game birds such as the chukar partridge or the sage grouse. The vegetation type is used as a hunting area for birds of prey, especially the marsh hawk and golden eagle in winter and by the burrowing owl and Swainson's hawk in summer. Cheatgrass is foraged upon by migrating flocks of Canada geese during fall and winter.

Waterfowl are of major importance in the vicinity of the site. About 200 pairs of resident Canada geese nest on the river islands in the vicinity of Hanford. During the past eighteen years, this population has produced an average of 700 young annually. An estimated 100 pairs of ducks also nest within the area.

Two islands, one near Ringold (River Mile 354) and another near Coyote Rapids (River Mile 383) are used as rookeries by colonies of California and ring-bill gulls. Approximately 6,000 nesting pairs produce 10,000 to 20,000 young annually.

Resident populations of upland game birds, ring-necked pheasants and California quail live and breed along the river shoreline. There is considerable movement of these birds back and forth to areas on the opposite river shore that are open to public hunting.

Reptiles are not conspicuous animals in the sagebrush-bitterbrush vegetation type. Probably the most abundant reptile is the side-blotched lizard. Snakes, especially the gopher snake and the Pacific rattlesnake, are occasionally encountered.

Several important species of fish migrate through the Hanford reach of the Columbia on their way to and from spawning areas upstream. Salmon, steelhead trout and American shad are among the more important. Resident species such as bass, other spiney ray fish, catfish, whitefish, trout and sturgeon are locally important game fish.

4. Regional Land Use

a. Land Uses on the Reservation

The present use of Reservation lands[42] surrounding the site is indicated in Figure II.D.3.1. Many of the plutonium production areas, shown in the north part of the Reservation, have been deactivated by the AEC. Also shown is the proposed site[20] for the WPPSS Hanford No. 2 power plant which is located a little more than two miles northeast of the FFTF.

The cross-hatched 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 by Battelle-Northwest 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 Reserve (ALE) and the Columbia River Islands Reserve, other areas of ecological study shown on Figure II.D.3.1

are only temporarily restricted for studies such as the investigation of sagebrush and grass regrowth following a lightning-originated fire over approximately 19,000 acres which occurred in July 1970.

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

A 4,000-acre area presently used by the State of Washington Department of Game for controlled hunting is on the east side of the Columbia River opposite the original townsite of Hanford.

Approximately 52,000 acres north of the Controlled Hunting Area and east of the Primary Control Zone was recently opened for daylight hours hunting and is considered a potential grazing area.

The peak daytime working population on the Reservation in early June 1971 was 3,430 people. Of these, 460 employees were located in the production reactor zones (100 areas) adjacent to the Columbia River in the northern portion of the Reservation, 770 people were in the irradiated fuel processing zones (200 areas) in the central part of the Reservation, and 2,200 people were in the laboratory zones (300-3000 areas) in the southeast corner of the project.

b. Land Use Adjacent to the Reservation

Land use within a 30-mile radius of the site is illustrated by Figure II.D.4.1.

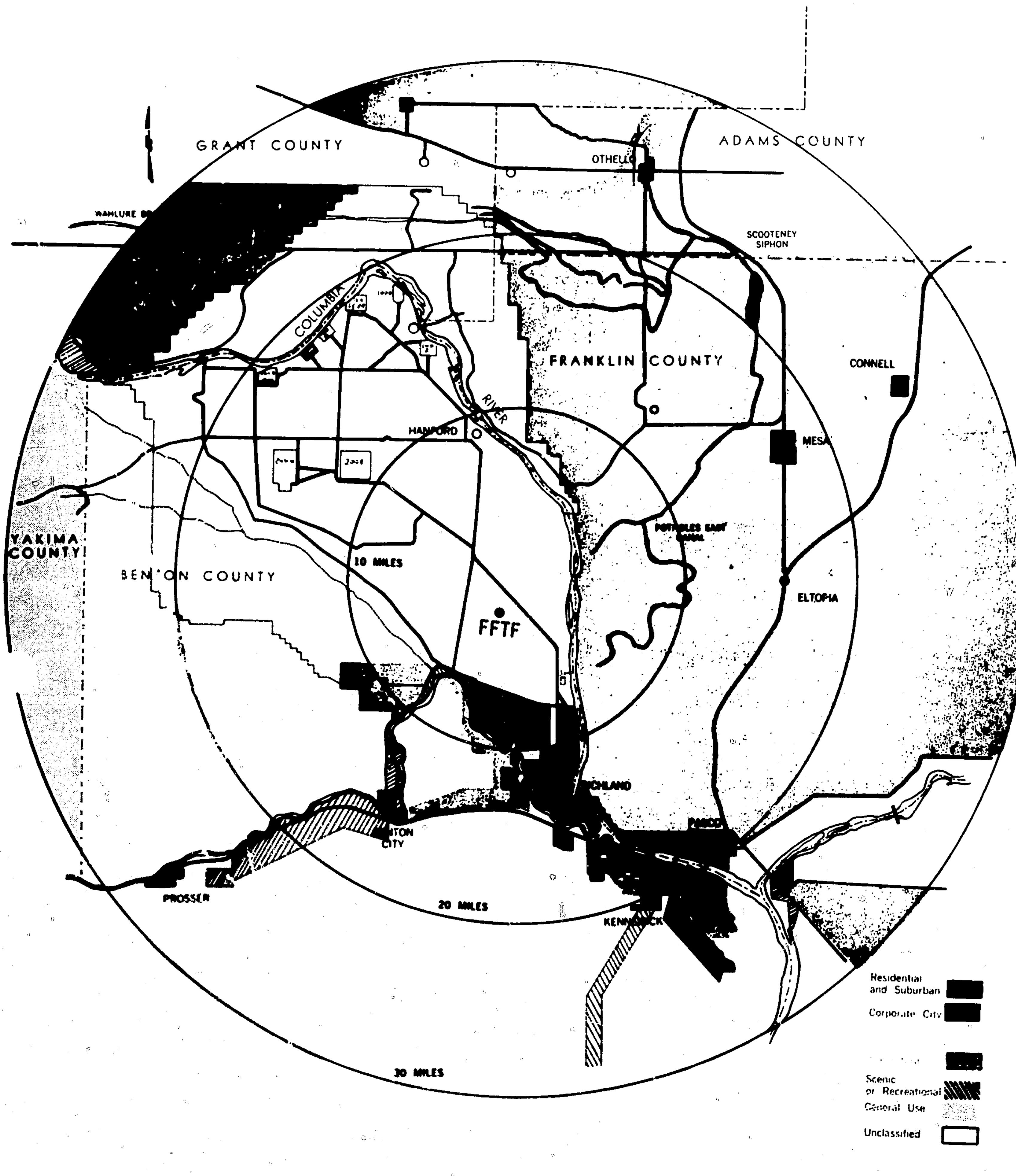


Figure II.D.4.1 Site Zoning Status

These uses include 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 FFTF site is agricultural with the nearest farms located along the east bank of the Columbia River in Franklin County, approximately 4-1/2 miles distant.

Industrial plants and laboratories located just south of the Hanford Reservation in North Richland include: Battelle-Northwest Laboratories, Jersey Nuclear, U. S. Testing Corporation Laboratories, Donald W. Douglas Laboratories, J. A. Jones shops and offices, Western Sintering Corporation Plant and NORTEC Plant. The combined peak working population of the offices and laboratories in this area is about 600.

5. Population

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 (Richland, 28,500; Kennewick, 16,500; and Pasco, 19,500) located to the south and southeast of the site represent the major population concentrations in the area. These communities consist principally of people highly skilled in all phases of engineering, construction and operation of a wide variety of nuclear facilities.
Table II.D.5.1 gives the resident population (based on 1970 census) as a

TABLE II.D.5.1 *Resident Population - 1970 Census*

Distance (miles)	Cumulative Population
1	0
2	0
3	0
4	0
5	25
6	150
7	830
8	1,510
9	5,895
10	13,830
20	56,690
30	83,710
40	120,607
50	160,725
60	274,505
70	371,947
80	394,177
90	478,602
100	517,624

function of radius from the site for distances up to 100 miles. Location of the FFTF on the Hanford Reservation results in a controlled area with a minimum radius of approximately five miles.

6. Future Development

The Tri-Cities area is in the central region of an expanding agricultural area which includes an agri-chemical complex in the Finley Industrial area southeast of Kennewick. The area near the proposed reactor site on the reservation may be made available to developers for nuclear or non-nuclear industrial purposes; however, no specific plans for development exist at this time except the Hanford No. 2 nuclear plant. Industrial expansion at the south end of the reservation between the 300 Area and Richland is likely to occur as this area has been zoned an industrial area, and a Port District has been formed to develop the area adjoining the river immediately north of Richland. Agricultural development to the east in the area adjoining the reservation is essentially complete since irrigation water has been available to these areas now for more than five years. Future development in this area is expected to be limited to the growth of specialized crops. Irrigation of lands in the Horse Heaven Hills south of the Tri-Cities is commencing.

Construction of the proposed Ben Franklin Dam on the Columbia River would give rise to a maximum daytime construction population of about 1000-2000 due east of the site.

There is no formal information on the number of personnel that would be associated with this project; however, based on building experience at other dam sites in the northwest, some 1700 people may be involved. The personnel would be primarily day shift, but it is estimated that some 300-400 of the estimated 1700 would be working shifts other than days.

7. Service Facilities

The FFTF site is located within one mile of a four-lane highway connecting to the public highway system at Richland, Washington. This four lane highway is part of approximately 270 miles of AEC-constructed two and four-lane primary roads, 175 miles of secondary gravel roads and 225 miles of gravel and unimproved roads. The layout of the Hanford road system is shown in Figure II.D.7.1.

The AEC-owned railroad system, illustrated in Figure II.D.7.2 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 up to 3,000 tons capacity can be accommodated along the Columbia River from the point adjacent to the Site to the point where it enters the Pacific Ocean.

8. Archaeological and Historical

Battelle-Northwest has identified the known archaeological sites in the Hanford Reservation area. A summary of the description, nature and recommendations for treatment of archaeological sites is given in Tables

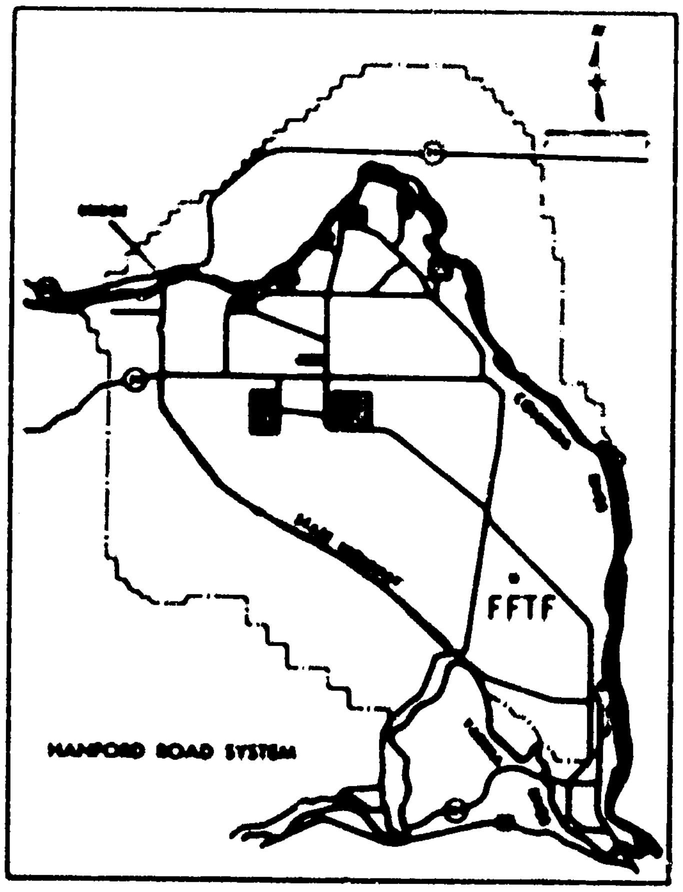


Figure II.D.7.1 Hanford Road System

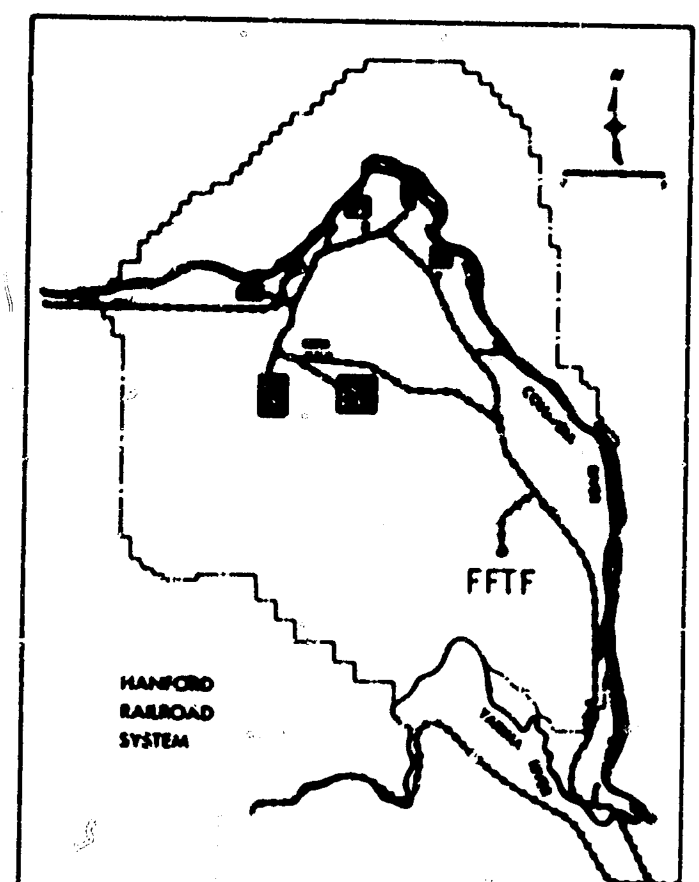


Figure II.D.7.2 Hanford Railroad System

II.D.8.1 and II.D.8.2. AEC procedures will assure protection of any antiquities or historic sites as required by the Antiquities Act of 1906 (16USC 431-433) and the Historic Sites, Buildings and Antiquities Act of 1935 (16USC 461-467).

A significant historical event relating to the site and the surrounding area was the establishment of the Hanford Engineering Works. Before 1943 the 559 square-mile area, later to become the Hanford Reservation, was a sparsely settled area of sand and sagebrush, broken only by small irrigated farms and orchards. At the Hanford townsite, for example, the original population of about 400 was swelled to over 50,000 people in a few months during World War II.

The area surrounding the FFTF site has served as a nuclear center since 1943, including the construction of nine plutonium production reactors and a number of test reactors, fuel processing plants, research laboratories and various support facilities. During this era, a substantial body of experience and data concerning environmental and ecological factors has been acquired that is directly relevant to the construction and operation of the FFTF.

TABLE II.D.8.1
SUMMARY OF SITE TYPES AND RECOMMENDATIONS

An "X" mark identifies the proper categories for each site. Total sample equals 26 sites.

SITE NUMBER	OPEN CAMP SITE	HOUSEPITS PRESENT	POSSIBLE HOUSEPITS	ETHNOGRAPHIC CAMP SITE	FISHING STATION	FLAKING FLOOR	HISTORIC SITE	TEST EXCAVATION	SURFACE COLLECTION	NO FURTHER WORK	TIME IN WEEKS REQUIRED FOR SALVAGE	ESTIMATED COST FOR SALVAGE IN 1968
	SITE TYPE							RECOMMENDATION				
45BN101	X	-	-	-	X	-	-	-	X	-	----	----
45BN102	X	-	-	-	X	-	-	X	-	-	0.50	$ 925
45BN103	X	-	-	-	X	-	-	-	X	-	----	----
45BN104	X	-	X	-	X	-	-	X	-	-	0,50	900
45BN105	X	-	X	-	X	-	-	X	-	-	1.00	1,535
45BN106	X	-	-	-	X	-	-	-	-	X	----	----
45BN145	X	X	-	X	X	X	-	-	X	-	----	----
45BN162	X	-	-	-	X	-	-	-	X	-	----	----
45BN163	X	-	X	-	X	-	-	X	-	-	1.00	1,535
45BN164	X	-	-	-	X	X	-	X	-	-	1.00	1,535
45BN165	-	-	-	-	X	-	-	-	-	X	----	----
45BN166	X	-	-	-	X	-	-	X	-	-	0.50	900
45BN167	X	-	X	-	X	X	-	X	-	-	1.00	1,570
45BN168	X	X	-	-	X	-	-	X	-	-	1.00	1,570
45BN169	X	X	-	-	X	-	-	X	-	-	1.00	1,570
45BN170	X	-	-	-	-	X	-	X	-	-	1.00	1,550
45BN171	X	-	-	-	-	-	-	X	-	-	0.50	915
45BN172	X	-	-	-	-	X	-	X	-	-	0.50	950
45BN173	X	-	-	-	-	-	-	X	-	-	1.00	1,600
45BN174	X	-	-	-	-	-	-	X	-	-	0.50	850
45BN175	X	-	-	-	-	X	-	-	-	X	----	----
45BN176	X	X	-	X	X	-	-	X	-	-	1.00	1,535
45BN177	X	-	X	-	X	-	-	X	-	-	0.50	900
45BN178	X	-	-	-	-	X	-	-	X	-	----	----
45FR266	X	-	-	-	X	X	X	X	-	-	1.00	1,535
45GR325	-	-	-	-	-	X	-	-	-	X	----	----
TOTALS	24	4	5	2	18	9	1	17	5	4	----	----

TABLE II.D.8.2

Archaeological Site and Description

Archaeological Sites

45BN101

This is an open camp site located on the southeastern end of the island opposite the old townsite of North Richland. (SE¼ of the NW¼ of Sec. 25, T.10N., R.28E., W.M.).

The site consists of concentrations of shell and camp rock. It is 100 feet long and about 50 feet wide.

Artifacts encountered include cobble tools.

Surface collection is recommended.

45BN102

This is an open camp site located on the east side of the island opposite the old townsite of North Richland. (SW¼ of the NW¼ of Sec. 24, T.10N., R.28E., W.M.).

The site consists of concentrations of shell and camp rock, and a hearth area exposed in the river bank. It is 300 feet long and 150 feet wide.

Artifacts include cobble hammerstones and a hopper mortar.

Test excavation is recommended.

45BN103

This is an open camp site located on the northeastern end of the island opposite the old townsite of North Richland. (NW¼ of the NW¼ of Sec. 24, T.10N., R.28E., W.M.).

The site consists of concentrations of camp rock. It is 150 feet long and about 75 feet wide.

Artifacts encountered include cobble tools and notched pebble sinkers.

Surface collection is recommended.

45BN104

This is an open camp site located on the west bank of the Columbia at the northeastern corner of the old townsite of North Richland. (Center of the NW¼ of Sec. 14, T.10N., R.28E., W.M.).

The site consists of scattered concentrations of camp rock along the river bank. There is also some possibility of housepits back from the bank, but this is inconclusive due to considerable disturbance from the old construction camp at North Richland. The site is 350 feet long and about 150 feet wide.

Artifacts encountered include corner-notched projectile points, scrapers, cobble hammerstones, cobble tools, and hopper mortars.

Test excavation is recommended.

45BN105

This is a possible housepit site located on a sheltered bench 1.0 miles north of the old North Richland townsite. (SW¼ of the SE¼ of Sec. 11, T.10N., R.28E., W.M.).

The site consists of scattered concentrations of camp rock along the river bank and may include as many as four or five housepits on the beach above the bank. The site is about 200 feet long and 150 feet wide.

Artifacts encountered include cobble tools and a hopper mortar.

Test excavation is recommended.

45BN106

This is an open camp site located immediately to the southeast of the 300 area along the river bank. The new biology building will be constructed on the bench above the bank. (Center of Sec. 11, T.10N., R.22E., W.M.).

The site consists of scattered concentrations of camp rock, flakes, and shell. It is about 400 feet long and 150 feet wide.

Artifacts encountered include stemmed projectile points, cobble tools, and hopper mortars.

No further work is recommended.

45BN145

This is an ethnographically reported camp site located on the south bank of the Columbia opposite a large island upstream from Locke Island. (NW¼ of Sec. 12, T.14N., R.26E., W.M.).

The site consists of three or four mat lodge depressions on a gravel bar close to water's edge. Much camp rock and many flakes are scattered around the encampment. The site was reportedly last occupied about 1915.

Artifacts encountered include cobble tools, hopper mortars, a chipped stone knife, corner-notched projectile points, and a grooved net weight.

Surface collection is recommended.

45BN162

This is an open camp site located along the river bank at the 300 area. (SE¼ of the SW¼ of Sec. 11, T.10N., R.28E., W.M.).

The site consists of scattered concentrations of camp rock, flakes, and shell. It is about 600 feet long and 150 feet wide.

Artifacts encountered include cobble tools, notched pebble sinkers, grooved net weights, hopper mortars, a glass trade bead, and a military button.

Surface collection is recommended.

45BN163

This is a possible housepit site located on the west bank of the Columbia just opposite the lower end of the island immediately upstream from the 300 area. (E½ of the NW¼ of Sec. 2, T.10N., R.28E., W.M.).

The site consists of scattered concentrations of camp rock, flakes, shell. Several hearth areas are exposed in the bank and there are five or six oval-shaped depressions strung in a line on the bench above the bank, suggesting housepits. The site is about 400 feet long and 100 feet wide.

Artifacts encountered include cobble tools, hopper mortars, and a facetted blue-glass trade bead.

Test excavation is recommended.

45BN164

This is an open camp site located on the southern end of the island just upstream from the 300 area. (Center of Sec. 2, T.10N., R.28E., W.M.).

The site consists of scattered concentrations of camp rock, flakes, and shell. It is about 250 feet long and 200 feet wide.

Artifacts encountered include cobble tools, notched pebble sinkers, and corner-notched projectile points.

Test excavation is recommended.

45BN165

This site is a fishing station located on the west bank of the Columbia about 1.0 miles north of the 300 area. (NE¼ of the SW¼ of Sec. 35, T.11N., R.28E., W.M.).

The site consists of concentrations of cobble tools and notched pebble sinkers. It is about 175 feet long and 30 feet wide.

No further work is recommended.

45BN166

This is an open camp site located on the west bank of the Columbia about 1.7 miles north of the 300 area. (SW¼ of the SE¼ of Sec. 26, and the W½ of the NE¼ of Sec. 35, T.11N., R.28E., W.M.).

The site consists of scattered concentrations of camp rock. Several hearth areas are eroding out of the bank. The site is about 300 feet long and 75 feet wide.

Artifacts encountered include cobble tools and a grooved net weight.

Test excavation is recommended.

45BN167

This is an open camp site located on the west bank of the Columbia about 2.1 miles north of the 300 area. (SW¼ of the NE¼ of Sec. 26, T.11N., R.28E., W.M.).

The site consists of concentrations of camp rock, flakes, and shell. Hearth areas are eroding out of the bank and it is possible that there are some filled-in housepits on the bench above the bank. The site is about 350 feet long and 100 feet wide.

Artifacts encountered include cobble tools, notched pebble sinkers, hopper mortars, a contracted-stemmed projectile point, and a blue-glass trade bead.

Test excavation is recommended.

45BN168

This is a housepit site located about 100 yards south of the lower end of Wooded Island on the west bank of the Columbia, or approximately 2.6 miles north of the 300 area. (NW¼ of the NE¼ of Sec. 26, T.11N., R.28E., W.M.).

The site consists of four or five housepit depressions on a bench overlooking the river. It is about 100 feet long and 50 feet wide.

No artifacts were encountered.

Test excavation is recommended.

45BN169

This is a housepit site located on a bench on the west bank of the Columbia about 0.3 miles northeast of the Benton Substation. (NW¼ of the NE¼ of Sec. 11, T.11N., R.28E., W.M.).

The site consists of eight to 10 housepits and shows scattered concentrations of camp rock, flakes, and shell at the base of the river bank. It is 200 feet long and 150 feet wide.

No artifacts were encountered.

Test excavation is recommended.

45BN170

This is an open camp site located at Rattlesnake Springs, which lies at the terminus of Yakima Ridge. (SE¼ of Sec. 20, T.12N., R.25E., W.M.).

The site consists of scattered concentrations of camp rock and flakes. It is severely eroded by wind deflation and is superimposed upon geological units which contain at least three volcanic ashes. It is about 600 feet long and 400 feet wide. Historically, this is the site of the Perkins Massacre which took place on or about July 10, 1878.

No artifacts were encountered.

Test excavation is recommended.

45BN171

This is an open camp site located about 0.2 miles east of Rattlesnake Springs on the north bank of Dry Creek. (Center of the SW¼ of Sec. 21, T.12N., R.25E., W.M.).

The site consists of small quantities of camp rock and scattered flakes. It has been severely eroded by wind deflation. The site is about 300 feet long and 150 feet wide.

Two leaf-shaped points were encountered.

Test Excavation is recommended.

45BN172

This is an open camp site located about 0.25 miles from the mouth of Snively Canyon on the east side of the road. (NW¼ of the SW¼ of Sec. 5, T.11N., R.25E., W.M.).

The site consists of scattered camp rock and flakes. It is about 150 feet long and equally wide.

Artifacts encountered include a corner-notched projectile point.

Test excavation is recommended.

45BN173

This is an open camp site located at the Snively Ranch. (NE¼ of the SW¼ of Sec. 8, T.11N., R.25E., W.M.).

The site consists of a few flakes, bone fragments, and some firecracked rock exposed in a bank to the southwest of the ranch house about 30 feet. It is about 50 feet long and 30 feet wide.

Artifacts encountered include a pestle and a piece of worked antler.

Test excavation is recommended.

45BN174

This is an open camp site located on the western side of Honey Lake, just south of the western terminus of Gable Mountain. (SW¼ of the NE¼ of Sec. 22, T.13N., R.26E., W.M.).

The site consists of a concentration of camp rock and flakes. It has been severely eroded by wind deflation. The site is about 75 feet long and 50 feet wide.

Artifacts encountered include corner-notched and contracted-stemmed points, and a bifacially flaked cobble tool.

Test excavation is recommended.

45BN175

This is an open camp site located at a spring close to the summit of Rattlesnake Mountain. (SE¼ of the SW¼ of Sec. 30, T.11N., R.26E., W.M.).

The site consists of scattered flakes on a rather rocky surface with a small amount of fill. The site has been largely destroyed by construction of a pumphouse and bulldozing for a road and transmission line. It is about 50 feet long and 30 feet wide.

Artifacts encountered include small stemmed and corner-notched projectile points.

No further work is recommended.

45BN176

This is an ethnographically reported camp site located about 0.2 miles east of 100-H area. (NW¼ of the SW¼ of Sec. 17, T.14N., R.27E., W.M.).

The site consists of three or four mat lodge depressions on a gravel bar, and a cache of belongings in an adjacent bank. Much camp rock and a few flakes are scattered around the encampment. The site was last occupied about 1942.

No Artifacts were encountered.

Test excavation of the cache is recommended.

45BN177

This is an open camp site located at the old site of Columbia Camp, just west of the Horn of the Yakima River. (SE¼ of Sec. 4, T.10N., R.27E., W.M.).

The site consists of scattered concentrations of camp rock, flakes, and shell. Along the western part of the site there is some possibility of housepits. The eastern end of the site has been destroyed, however, by bulldozing for a recreation area. It is about 800 feet long and 700 feet wide.

Artifacts encountered include cobble tools, corner-notched and small side-notched projectile points.

Test excavation at the west end of the site is recommended, otherwise no further work.

45BN178

This is an open camp site located on the west bank of the 100-F area slough in a sand dune. (NE¼ of the NE¼ of Sec. 4, T.13N., R.27E., W.M.).

The site consists of scattered concentrations of camp rock and flakes. It is about 400 feet long and 300 feet wide.

Artifacts encountered include a corner-notched projectile point.

Surface collection is recommended.

45FR266

This is a historic site located on the east bank of the Columbia opposite East White Bluffs townsite. (E½ of Sec. 29, T.14N., R.27E., W.M.).

The site consists of scattered concentrations of camp rock, flakes, and shell. In addition, the site is of historic interest because of a small log house which was reportedly built in the 1890's and used as a blacksmith shop. The site is about 2000 feet long and 500 feet wide.

Artifacts encountered include cobble tools, notched pebble sinkers, pestles, small corner-notched points, glass trade beads, and a clam shell disc bead.

Test excavation of the site and preservation of the log structure is recommended.

45GR175

This site is a flaking floor located on the Wahluke Slope above the White Bluffs and south of State Highway 11-A. (E½ of the SW¼ of Sec. 6, T.14N., R.26E., W.M.).

The site consists of scattered cores and chipping detritus. These have been exposed by wind deflation on the tops and sides of small knolls along Northern Pacific Railway right-of-way.

Artifacts encountered include cores and corner-notched projectile points.

No further work is recommended.

Archaeological Localities

Gable Butte Locality

The Gable Butte locality lies a short ways to the south of 100-D and 100-K areas. It includes area in Sections 13 and 14, T.13N., R.25E., and Sections 18, 19, and 20, T.13N., R.26E., W.M.

Several flakes and rock piles were found along the top of the ridge at the western end of the locality.

Corner-notched projectile points were encountered from this locality.

Further surface examination is recommended.

Gable Mountain Locality

The Gable Mountain Locality lies to the northeast of 200-E area. It includes area in Sections 13, 14, 15, 22, 23, 24, T.13N., R.26E., and Sections 18, 19, 20, and 21, T.13N., R.27E., W.M.

Relander (1956:306) reports that this locality was one of the principal places where Indian boys and girls were sent on their spirit quests.

A corner-notched projectile point was encountered.

Further surface examination is recommended.

The Shifting Dunes Locality

The Shifting Dunes locality lies along the west bank of the Columbia opposite Ringold Flat and the lower end of Savage Island. It includes area in Sections 8, 9, 15, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, and 28, T.12N., R.28E., W.M.

This locality evidently contains numerous small camp sites that have been deflated by wind erosion and then buried by the shifting sands.

Corner- and basal-notched projectile points were encountered.

Further surface examination is recommended.

E. Electric Power Supply and Demand

The FFTF will not supply electricity. It has no main generator for utilizing the power output of the reactor in supplying electric power. Rather, all of the heat output from the reactor is rejected directly to the atmosphere via sodium-air dump heat exchangers.

Two independent transmission lines[43] run into the FFTF site. The general location of these lines is shown on Figure II.E.1. One transmission line, rated at 115 kV and 120 MVA, provides normal service to the plant for all of the normal operating needs. This line extends as a tap from the main Bonneville Power Administration (BPA) line that runs from the Midway substation to the Benton substation and is approximately 6 miles in length. The other line, rated at 13.9 kV and 5 MVA, provides for continuity of service in the event power from the 115 kV line is accidently lost. This emergency service to the FFTF is provided from a station at the 300 Area. The 13.9 kV line is approximately six miles long. Both lines consist of single pole structures.

The final legs of the power transmission lines from both the main service and the emergency service are underground into the 13.8 kV switchgear that is located indoors. All of the electrical power distribution throughout the plant, including the lighting, is underground.

A substation shown in Figure II.B.2.1 is located on the western side of the site and reduces the 115 kV main power service to 13.8 kV. Included in the substation are a 50 MVA transformer, circuit switcher, lightening protective devices, buswork and a fence. It is estimated that the total plant electrical load will be about 40 MVA.

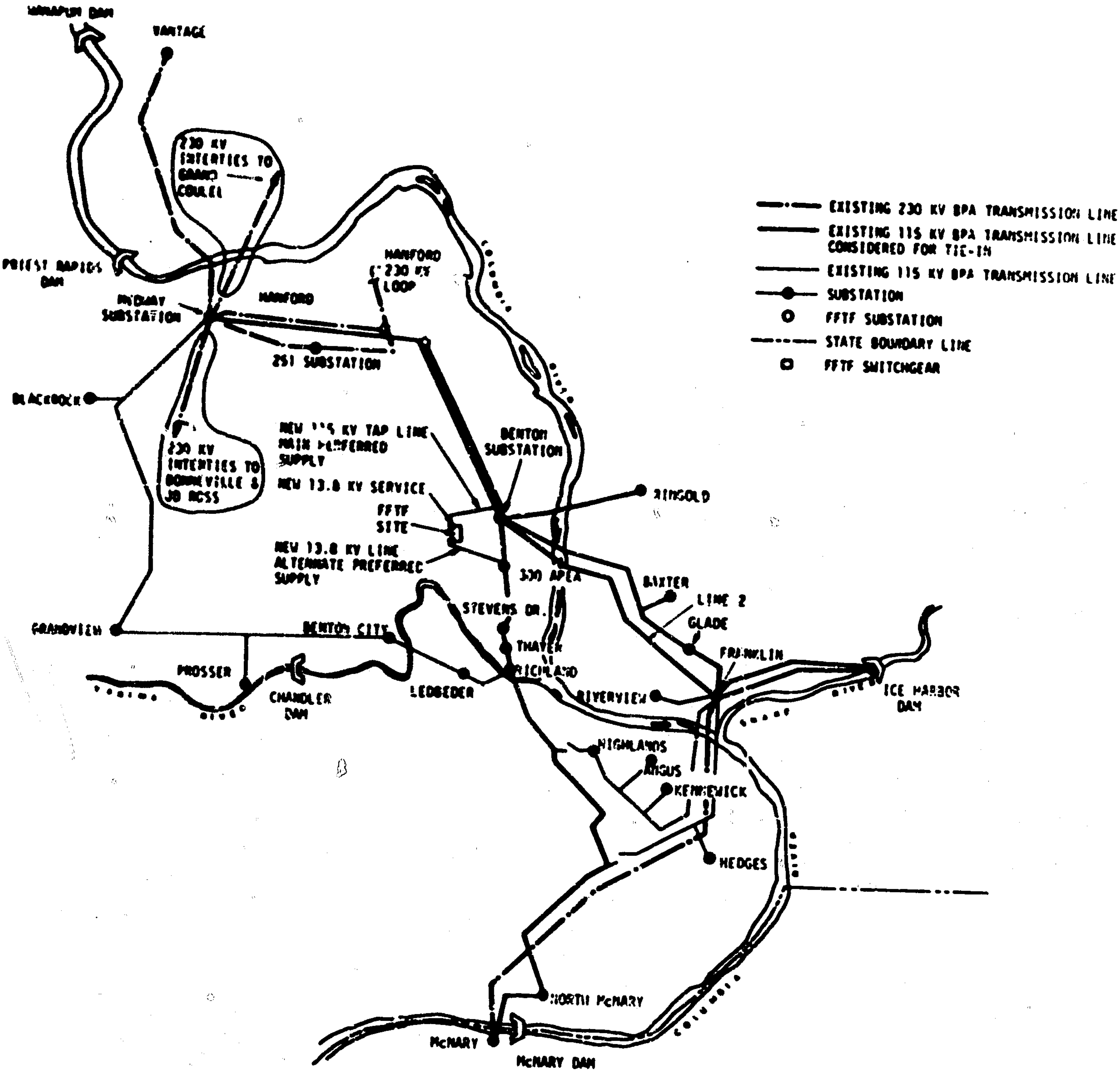


Figure II.E.1. Transmission Line Map-FFTF Interties

There will no no fossil fired units at the FFTF site. Heating and cooling needs will be supplied (other than by the reactor) by an external electrical supply.

III. ENVIRONMENTAL APPROVALS AND CONSULTATIONS

A discussion of relevant licenses, permits, and other approvals which will be required for FFTF and the status of efforts directed toward obtaining such approvals is presented in the following two subsections.

A. Environmental Approvals

State and local approvals are obtained whenever such approvals are applicable. Pursuant to the requirements of the National Environmental Policy Act, Public Law 91-190, and the applicable regulations of the U.S. Atomic Energy Commission, this environmental statement on the FFTF has been prepared.

While AEC-owned and operated facilities are exempt from the licensing or operating procedures established in Title 10 of the Code of Federal Regulations (10 CFR), FFTF operation must comply with the provisions of all AEC Manual Chapters including 0500, Health and Safety. These Manual Chapters provide requirements substantially the same as for licensed power reactor facilities including review by the AEC Regulatory staff and the Advisory Committee on Reactor Safeguards (ACRS). A Preliminary Safety Analysis Report (PSAR) was prepared and submitted for such review in September 1970.[44] The PSAR contains extensive information and data concerning the FFTF and its effect on the environment. The PSAR forms the basis for much of the work presented in this statement.

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A Final Safety Analysis Report (FSAR) containing final design and proposed operating information is in the process of being prepared and will be completed prior to operation of the facility

B. Consultations, Regional Economic Development and Zoning

1. Consultations

In planning for FFTF, the Bonneville Power Administration, U.S. Corps of Engineers, and U.S. Geodetic Survey have been consulted frequently regarding FFTF needs and impact on the region. The Washington State Department of Ecology has also been consulted with regard to waste disposal and other matters.

Consultation with Battelle-Northwest Laboratory in respect to meteorology, climatology, ecology and biology has aided in the planning and evaluation of potential environmental impact of construction and operation of the FFTF at Hanford.

2. Regional Economics and Zoning

Regional Economics and Zoning is covered in Sections II.C.1 and II.D.6.

IV. ENVIRONMENTAL IMPACT

A. Probable Environmental Effects

1. Land Use Compatibility

Siting of the FFTF on the 559-square-mile, federally-owned Hanford Reservation is compatible with AEC activities and existing zoning ordinances. The FFTF will have no significant adverse effect on present or contemplated future land use of the area. Supportive information is given below.

a. Impact on Land Uses

(1) On the Reservation

Detailed information on use of Reservation land is provided in Section II.D.4.a and shown in Figure II.D.3.1. It is considered that there will be no impact on other uses of Reservation lands due to normal operation of FFTF. During construction and occasionally after operation begins, large items of equipment and materials will be moved to the FFTF site. When this occurs, there may be some disruption of traffic, but any disruption will be of such short duration that the effect will be negligible. Construction of the FFTF denies the land occupied by the facilities to any other use. No other use for this land, however, was anticipated for the near future. In any case, land occupied by FFTF is less than one percent of Reservation lands.

(2) Adjacent to the Reservation

Detailed information on use of lands adjacent to the Hanford Reservation is provided in Sections II.D.4.b and II.D.6 and shown in Figure II.D.4.1. Because radioactive materials are not released to the environs during normal operations, no adverse impact is foreseen on those lands adjacent to the Reservation. Thus, there should be no radioactive fallout on forage or crop lands. Water used for irrigation and drinking should not contain radioactivity from the FFTF.

b. Preservation of the Environment

Construction activities at the FFTF site will be conducted in accordance with AECM-6301.[45] This specifies that provisions be made to minimize soil erosion and air and water pollution during and after construction. Construction activities are being conducted so as to disturb the natural environment to the minimum extent practicable. Following construction of FFTF, the site will be returned to as nearly a natural state as possible.

Road construction will conform to Washington State Highway Department standards. Surface changes resulting from road construction will be minimal since roads will generally follow natural contours, with cuts and embankments held to a minimum.

It is not planned to provide public recreation facilities at the FFTF site. Numerous recreational facilities exist around the Tri-Cities. Construction and operation of FFTF will not interfere with continued use of these facilities.

c. Historic Significance of the Site

The Hanford Reservation is of historical significance. It is the location of the first plutonium production reactors in the history of mankind, constructed during World War II. If some time in the future it is decided to make one of these original reactors (none of which are operating today) into a national monument, the presence of the FFTF will not deter such action.

A review of the 1971 Revision of the National Register of Historic Places (36 F.R. 3310 February 20, 1971) discloses no listed historical sites on the Hanford Reservation. There are no known archaeological sites in the area where major construction activities are to take place.

2. Water Use Compatibility

Since waste heat from the FFTF will be dissipated to the atmosphere by means of sodium-air dump heat exchangers, essentially a dry cooling tower system, there will be no demand for water to remove heat from the FFTF and the only water demand will be for fire protection, sanitary and process water.

A total groundwater pumping capacity of 450 gallons per minute (gpm) will be available for fire protection and other uses. The full capacity will be utilized only during reliability tests and emergencies. Approximately 110,000 gallons per day (gpd), an average of 76 gpm, will be used for sanitary and process water purposes. This water, less evaporative losses will be returned to the ground after treatment via two percolation ponds. The net effect on the regional water table is expected to be small beyond the confines of the FFTF.

Since the FFTF is a federal project, located on a Reservation of the AEC, a water use permit has not been requested.

a. Description of the Watershed

The FFTF site[36] lies in the south central part of the Hanford Reservation on a flat bench or terrace roughly 4-1/2 miles west and 200 feet above the Columbia River. The site area is blanketed by 5 to 15 feet of sand dunes which overlie glacio-fluviatile sands and gravels. Fine-grained, thinly-bedded locustrine deposits and gravelly sands of the Ringold formation (Section II-D) underlie the glacio-fluviatile sediments, extending from depths of approximately 150 feet to basalt bedrock. These sedimentary deposits form the principal aquifer matrix of the Hanford groundwater system. At the site groundwater movement is from west to east toward the Columbia River. Present groundwater levels are approximately 387 feet above sea level or 170 feet below land surface at the FFTF site. Construction of the proposed Ben Franklin Dam with a maximum pool elevation of 400 feet (mean sea level) would raise the groundwater table to 450 feet (approximately 100 feet below ground level at the site).

Subgrade vaults associated with the design for FFTF will not penetrate to depths greater than about 80 feet below land surface; 90 feet above the present groundwater table or 20 feet if the dam is constructed. Quality of the groundwater at the site is discussed in Section II.D.1.b.

In the FFTF reach of the Columbia River the average flow rate is 115,000 cfs. The main channel of the river is about 500 yards wide,and the river velocity in the main channel averages about 3 fps. The water is turbulent, with minor stratification.

More than half of the water flowing past the area originates in Canada. Major tributaries upstream from Hanford include the Wenatchee River (3000 cfs), Chelan River (2000 cfs), Okanogan River (3000 cfs), Spokane River (8000 cfs), Kettle River (3000 cfs), Pend Oreille River (26,000 cfs) and Kootenai River (28,000 cfs). The average flow of the Columbia River at the Canadian border is 95,000 cfs.

The river flow is higher in the spring of the year because of runoff caused by snowmelt. Reservoir projects are used to regulate the flow of the river. By 1973 there will be almost 35 million acre-feet of active storage; this is equivalent to a continuous flow of 115,000 cfs for 150 days. Because of regulation it is anticipated that the minimum and maximum monthly mean flow rates will be 60,000 and 260,000 cfs in the vicinity of the FFTF. Flows as low as 36,000 cfs (minimum licensed release for Priest Rapids Dam upstream of the FFTF) may be experienced for short periods of time (24-48 hours).

The quality of the Columbia River water at Hanford is excellent. The water is used for municipal drinking water by Richland and Pasco with minimal treatment. Coliform organisms range from zero to 430 per 100 ml, with a mean value of 131 per 100 ml; dissolved oxygen ranges from 9.5 to 14.0 mg/l, averaging 11.8 mg/l. For comparison, Class A fresh waters have been defined by the former Washington State Water Pollution Control Commission as having median values of total coliform organisms no greater than 240 and dissolved oxygen greater than 8.0 mg/l.

b. Impact on the Water Resource

Utility wastes consisting of non-radioactive liquid wastes from the facility are handled in either the sanitary sewer system or the process sewer system. The sanitary sewer system collects wastes from drinking fountains, showers and restroom floor drains and discharges them through the FFTF sewage treatment plant to two percolation ponds. The sewage treatment plant will be a package unit capable of treating 12,000 gallons per day of raw sanitary-type sewage or waste by the aerobic digestion process. The effluent produced from the sewage plant will meet the requirements of Executive Order 11507, "Prevention, Control and Abatement of Air and Water Pollution at Federal Facilities" and the Refuse Act of 1899. The process sewer system collects non-radioactive aqueous wastes generated in cooling non-radioactive equipment (e.g., air compressors) and discharges them to the percolation ponds. Each percolation pond has a capacity equal to the total maximum anticipated needs of both sewer systems.

Both the sanitary and process sewer systems are designed to prevent the introduction of radioactive material into the systems. All points of entry to these sewer systems are outside of radioactive material handling areas. Also, all areas where radioactive material may be handled or where small quantities of radioactive material might be found (e.g., the personnel decontamination sink) discharge only into the radioactive liquid waste system. Thus, introduction of radioactive wastes into either sewer system is unlikely.

The use of acids, bases and organic solvents, in quantity, is not anticipated for FFTF. Use of aqueous decontaminating agents is severely limited and stringently controlled. All wastes containing such materials will be collected using special handling and disposal practices.

Experience at the Hanford Reservation indicates that the sandy, clay-type soil will allow percolation of the treated sanitary and process water to the groundwater in the FFTF area without adversely affecting the purity of the groundwater. Except for the percolation ponds and some irrigation of shrubs and lawn, no other source of water discharge is planned, and the impact of water discharges to the environment is negligible.

c. Impact on Other Uses of the Water Resource

The influence of the cone of depression associated with pumping 110,000 gpd from the Ringold formation for utility and domestic uses at the FFTF is expected to be insignificant beyond a few hundred yards of the site. A test of Well No. 1 at the site resulted in a drawdown of 17 feet at a pumping rate of 200 gpm (288,000 gpd). Irregular transmissibility (transmissivity) values in the Ringold formation, which locally range from 100 ft^2/day to 10,000 ft^2/day, indicate that the cone may be asymmetric.

A maximum groundwater withdrawal rate of 110,000 gpd (<0.2 cfs) is very small in relation to low flows in the nearby Columbia River of 36,000 cfs. Consequently, the effect on the area's water resources is negligible. Consumptive losses under operating conditions will be approximately 80,000 gpd, with ∿30,000 gpd returned to ground after treatment through two seepage ponds.

Eventually, there will be some interaction between the water entering the soil as seepage and water table and the cone of depression of the pumping well or wells. This interaction is not expected to be regionally significant.

3. Heat Dissipation

The heat generated at the FFTF during all phases of reactor and closed loops operation will be rejected to the atmosphere via sodium-air dump heat exchangers. Heat generated by auxiliary and air conditioning processes will be rejected via forced-draft cooling towers.

The concept of dumping the FFTF-generated heat directly to river water was considered early in the conceptual phase of the project and was rejected. Following an evaluation[46] of sodium to steam/water and sodium to air heat rejection schemes, the latter was selected for FFTF. (See Section VI.C on alternate heat rejection methods).

a. Condenser Water Cooling System

As the main heat dumps for both the reactor and closed loop systems are sodium to air dump heat exchangers; there is no condenser water system. The auxiliary and air conditioning cooling towers constitute a closed system and no condenser water will be returned to any water source.

b. Heat Dissipation Equipment Description

The reactor cooling system is described in Section II.B.2.e. The final heat rejection to the atmosphere for both the main reactor and closed loop systems is via sodium to air dump heat exchangers.

The main reactor heat dumps consist of three separated groups each containing four closely spaced modules. A typical module is shown in Figure IV.A.3.1. (The closed loop modules are similar though reduced in size). The ambient air is drawn through inlet screens and inlet vane controls by a centrifugal fan which discharges the air through an isolation damper and across the heat exchange coil exchanger tubes (sodium on inside of tubes). The air leaves the coil traveling vertically through a stack containing another isolation damper. The stack assures sufficient natural draft air flow for decay heat removal. The isolation provisions are for control during shutdown and preheat operations. Each module is equipped with an oil-fired heating system.

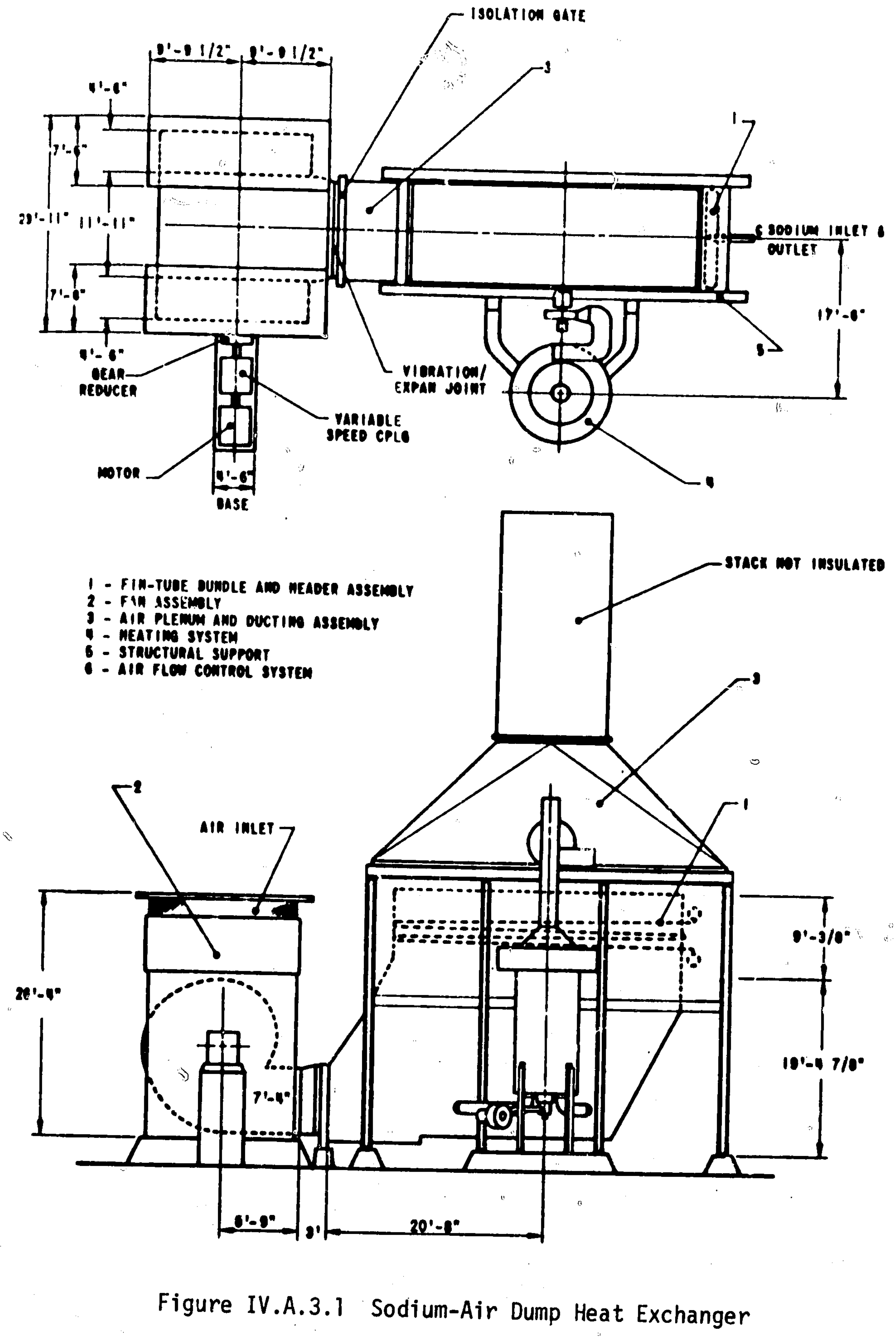


Figure IV.A.3.1 Sodium-Air Dump Heat Exchanger

The maximum air flow under any projected operation is ~500,000 SCFM ($2.3 \times 10^6\ lb_m/hr$) with an outlet temperature for initial operation of 294°F. (The corresponding sodium temperature at the reactor outlet is 858°F.) Improved and advanced operation require smaller air flow rates with correspondingly higher outlet temperatures. For example, the air flow rate will be $1.52 \times 10^6\ lb_m/hr$ and the outlet temperature 398°F for operation at a sodium (reactor outlet) temperature of 1100°F.

Since the closed loop sodium to air dump exchangers are an order of magnitude smaller than the main units, their environmental effect will be less. The main units will have no significant effect.

The auxiliary system and air conditioning heat dumps consist of two forced air cooling towers of two segments each. Each cooling tower has a heat dissipation rating of 1.9×10^7 BTU/hr. A maximum of three segments will be in use at any given time. This corresponds to a heat input to the atmosphere of ~8.4 MWt, compared to 400 MWt by the main heat dumps. The heat input of these towers will have a minor effect on the environment. Likewise, the moisture addition of this size of cooling tower will have a negligible environmental effect outside the immediate vicinity of the towers.

c. Expected Environmental Impact

(1) Plume Effects

The main heat dumps will create a plume of heated air. The three groups of four modules are assumed to be sufficiently separated that they can be considered as independent heat sources to the ambient environment. The four modules are assumed to interact so as to constitute a single source.

The plume rise has been estimated for various atmospheric conditions using the method of Briggs.[47]

For a stable atmosphere and light wind (0.85°K/100 m) the hot plume from the dump heat exchanger would reach an elevation of ~104 m (380 ft) above the top of the stack. For the near neutral case 0.01°K/100 m, the calculated plume rise is 458 m (~1500 ft). If the atmosphere were unstable, and local transient thermal activity were to pass over the heat dump, the hot discharge could reach higher elevations.

For the case of a stable but windy atmosphere, the plume rise would be as indicated in Table IV.A.3.1. The altitudes are given in meters for various wind velocities and stabilities. These tabulated values are in agreement with values reported by Briggs.

TABLE IV.A.3.1
PLUME RISE FOR STABLE WINDY ATMOSPHERE

Stability °K/100 m	Wind Speed, m/sec 1	2	3	4	5	6	7	8	9	10
0.85	104	83	72	66	61	57	53	47	41	37
0.50	124	99	86	78	73	68	65	62	60	58
0.25	156	124	108	99	92	86	82	78	75	73
0.20	169	134	117	106	99	93	88	84	81	78
0.15	186	147	129	117	108	102	97	93	89	86
0.10	212	169	147	134	124	117	111	106	102	99
0.05	268	212	186	169	156	147	140	134	129	124
0.01	458	363	317	288	268	252	239	229	220	212

Plume Rise, m

(2) Meteorological Effects

The calculated plume rise for a light wind, near neutral atmosphere indicate that the heated discharge from the dump heat exchangers could reach a height of about 600 m (2000 ft). This rise will cause some minor modification of the local wind field. This will be augmented by the ingress of ambient air into the heat exchangers. This effect will be localized and will not be of significance outside the immediate FFTF area. For instance, no effect is expected for the cooling system for WPPSS Hanford No. 2.

(3) Fogging

The occurrence of vapor condensation into fog is determined by reference to Figure IV.A.3.2, which is a plot of specific humidity versus temperature. Areas below and to the right of the saturation curve represent unsaturated air; areas above the curve represent air which is supersaturated so that fogging can occur. In this figure point A represents ambient air conditions. Since no moisture is added, heating in the heat exchanger progresses along a line of constant specific humidity until discharged at condition B. If we assume that the discharged air mixes with ambient air of the same condition as that which enters the heat exchanger, mixing of the effluent would also take place along the line AB. Since this line nowhere crosses the saturation curve, there will be no condensation and no visible fog. Assuming in the extreme that the plume rises into saturated air before appreciable mixing occurs, the mixing might take place along a line like BC, however, the same conclusion applies and no visible fog could result.

(4) Formation of Clouds

Since the FFTF dump heat exchangers add no moisture to the effluent air, the formation of clouds will be rare, but not unknown. The heat dump effluent will entrain ambient air and carry it higher in the atmosphere. This will, on occasion, be sufficient to create a cloud after the plume penetrates the condensation level in the atmosphere. These clouds will have virtually no local effects.

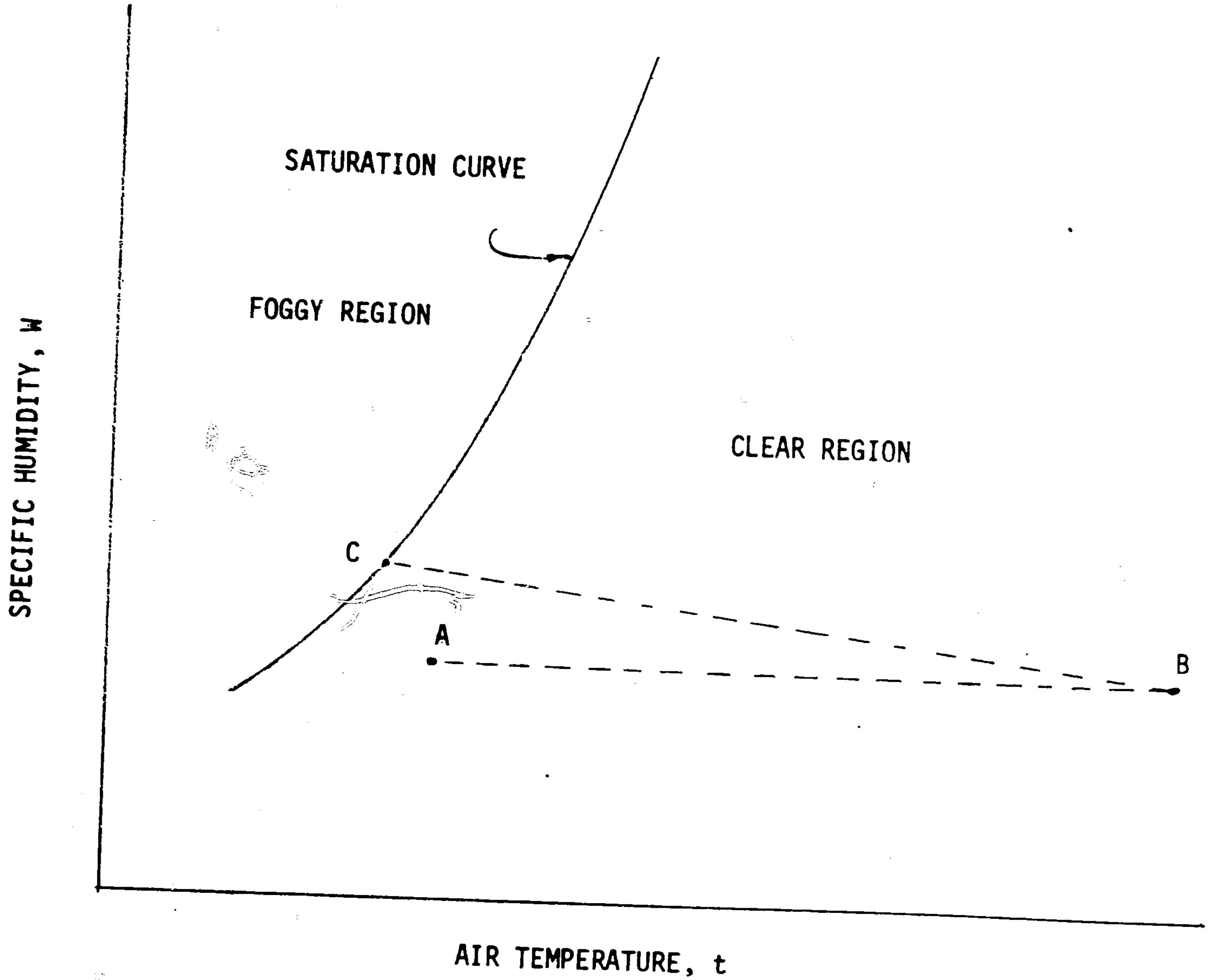


Figure IV.A.3.2 Specific Humidity vs. Temperature

The most frequent effect of the FFTF heat exhaust system will be to reduce natural local cloudiness because of the dry nature of its operation. Stratiform cloud decks would be locally warmed and, thus, reduce the relative moisture content. Cumulus clouds, with their associated updraft and downdraft systems, could either be enhanced or suppressed dependent upon the particular life cycle of the cloud that occurs in the immediate FFTF environs. If the cloud is already precipitating and has an existing downdraft, the most likely result would be a slight decrease in precipitation in the immediate vicinity of FFTF. The other instance, where the cloud has an already existing updraft, the effect of the FFTF dump heat exchangers would add to the updraft and cause some additional growth. Each of these effects is expected to be transitory since the cloud systems that could be influenced are moving phenomena and would be under the FFTF dump heat exchangers influence for only a short time.

d. Applicable Thermal Standards

No discharges of water to streams or lakes are planned. Heat discharged from the plant will be to the atmosphere, and there are no standards which apply to thermal discharges to air.

e. Water Quality Certification

Section 21 (b) of the Water Quality Improvement Act of 1970 requires certification of any discharge into the navigable waters of the United States. No discharges are planned to any navigable waters.

f. Effects on Water Quality of Other States

No water effluents are being discharged to streams or lakes, and, therefore, the quality of the waters of other states will not be affected.

4. Chemical Discharges (Nonradioactive)

Bulk materials such as Mobiltherm used as a coolant fluid within containment, ethylene glycol solutions used in the chiller units, NaK used as a coolant for the interim decay storage and cold traps and non-radioactive sodium may require replacement. Disposal will be in conformance with AEC Manual AECM 0510, 40 CFR, and State of Washington Plans for Water Qualification Regulations.

Gaseous effluents include water vapor from auxiliary cooling towers, products of combustion from the oil-fired heaters in the dump heat exchangers, exhausts from the diesel-powered emergency generators and fire pump and nitrogen gas from cell purging operations. The water vapor (approximately 54 gpm) is essentially pure, and the contribution to the normally arid atmosphere should be noticeable. The oil-fired heaters are used only during reactor shutdown to prevent sodium freezing in the dump heat exchangers. These heaters are of the stationary type which provide nearly complete combustion. The diesels are operated only during loss of off-site power and for periodic readiness checks. The nitrogen gas is essentially pure and is exhausted from central filtered exhaust already mixed with quantities of air so that nitrogen enrichment of the air is unnoticable.

Minor amounts of chemicals from water treatment will be discharged through the process sewer. These discharges have a negligible effect upon the environment but are described in more detail on the following pages.[48]

a. Additives

Water treatment chemicals are discharged in the aqueous effluent to the percolation pond. These chemicals may come from three sources: chlorination of sanitary water and sewage, treatment of the small 8.4 MWt auxiliary cooling tower water or regeneration of the demineralizer. All represent negligible sources of chemical additions.

Chlorination of sanitary waste results in free chlorine in the percolation pond. Most of this chlorine evaporates and does not affect the soil.

The water in the cooling tower system is treated with sodium hypochlorite once daily to control algae and slime. Most of the chlorine evaporates either from the cooling tower or from the pond if discharged in the blowdown. In operation at maximum conditions, 67.5 gpm of makeup water is supplied to compensate for 54 gpm lost to evaporation and 13.5 gpm lost to blowdown and windage. This results in a concentration of the natural salts by a factor of 5 resulting in a concentration of about 1300 ppm. To maintain the pH of the water between 7 and 7.5, sulfuric acid is added as necessary (3500 lb/per month max). The net effect is equivalent to reducing the bicarbonate alkalinity from 160 to 8 mg/l and increasing the sulfate from 35 to 182 mg/l prior to concentration. The resulting effluent would be too saline for palatability but would be suitable for irrigation. A small (5 gpm) demineralizer is used to treat the water used for sodium cleaning. Although that water is discharged to radioactive waste, regeneration of the demineralizer may result at most in the addition of several pounds of sodium sulphate (maximum) per month to the soil.

b. **Discharges**

Aqueous discharges are in the form of clear and odorless liquid effluents from the process and sanitary sewer systems. Each of these systems drain separately into a percolation pond having an area of 1150 square feet. The total discharge of 30,000 gallons daily includes the process sewer effluent of about 20,000 gallons per day. Total discharge will be to one of the two percolation ponds during normal operation. Alternate use of the two ponds will be made. Effluent in the process sewer system is from the cooling tower and via floor drains in areas where no chemicals or radioactive materials are handled. The salts which become concentrated in the cooling tower should have a negligible effect upon the soil and probably none upon the groundwater. The percolation pond is located 170 feet above the water table and 1700 feet from the sanitary water wells.

5. <u>Sanitary Wastes</u>

The sanitary sewer system collects wastes from toilets, drinking fountains, showers, and restroom floor drains, and discharges them through the FFTF sewage treatment plant to a percolation pond. (This is the same pond to which the process sewer system is discharged.) The sewage treatment plant includes a package unit capable of treating 12,000 gallons per day of raw sanitary-type sewage or waste by the aerobic digestion process. This capacity is sufficient for the maximum 1,000 persons during the construction period and the projected population of 330 persons during normal operations. One percolation pond only will be provided during the construction period. The other pond will be added prior to assumption of normal operations. The effluent will be a clear, odorless liquid treated by a metering-pump-type hypo-chlorinator with 12% hypochlorite solution prior to discharge into the percolation pond. A sludge removal service is provided at Hanford by Atlantic Richfield Hanford Co. The sludge is pumped from the sludge holding tank into tanker trucks which discharge it into abandoned gravel pits on the Hanford Reservation. The sludge, although clean and odorless, is normally covered with earth.

6. Biological Impact

a. Ecological Studies

Since the mid-forties when operations began at the Hanford Reservation, a variety of studies have been performed that were aimed at identifying ecological characteristics of the region and the impact of these operations on regional biota and the environment.[49,50] To date these studies have not demonstrated any apparent detrimental effects.

(1) Important Species

The biota which may be found in the Hanford Reservation region of Washington are listed in Table II.D.3.1 and discussed in Section II.D.3. On the basis of importance to sport or commercial use or because of uniqueness, only the mule deer is found in and around the FFTF site.

(2) Importance of the Locale

The Hanford reach of the Columbia River is important to the existence of a broad variety of fauna. The FFTF, however, will have no impact on the Columbia River or its fauna because of the distance between the FFTF site and the river and because the FFTF neither withdraws water from nor returns water to the river. None of the biota found at the FFTF site are unique to that site or dependent for continued existence on the site. No special ecological significance can, therefore, be attached to the site selected for construction of the FFTF.

(3) Thermal Discharge Effects

The thermal plume created by dissipation of FFTF heat output to the atmosphere is expected to have a minimal effect on plant and animal life in the vicinity of the site.[31] The primary effect may be on birds. Important migratory game birds (ducks and geese) fly at such altitudes at the FFTF site that the effect of the plume will not be noticeable.

(4) Effect on Planktonic Forms and Fish Larvae

The FFTF will not use Columbia River water for cooling. Water for drinking, sanitary systems and process systems will be supplied from wells located at the site.[34] Possible effect of passage through the condenser on planktonic forms and fish larvae does not apply to FFTF.

(5) Effects of Withdrawal and Return of Cooling Water

The FFTF will not use water for cooling. Thus, water will be neither withdrawn from nor returned to the Columbia River. Possible environmental effects of withdrawal and return of cooling water do not apply to FFTF.

(6) Adequacy of Ecological Studies

There are several areas within the Hanford Reservation upon which the Atomic Energy Commission, through its contractor, Battelle-Northwest, is conducting bioenvironmental research programs in terrestrial and aquatic ecology. The abundance and distribution of wildlife, fish and other aquatic species have been documented over many years of Hanford operation. Study areas under the "Arid Lands Ecology" program will remain uninfluenced by the operation of the FFTF.

Ecological studies on the Hanford Reservation have been in progress for the past 27 years because of the plutonium production and radioactive waste processing activities on the Reservation. The environmental monitoring program described in Section IV.6.c will identify any contribution by FFTF to ecological changes observed on the Hanford Reservation.

b. Ecological Studies, Plant Design, and Plant Operation

(1) Ecological Studies

No ecological studies have been performed or are planned specifically in support of the FFTF. As previously noted, the AEC continues to support such studies which have provided the necessary data to characterize the full impact of Commission activities in this area.

(2) Plant Design and Operation

Plant designs and operating procedures which will minimize or eliminate impact of FFTF on the environment are under study. Liquid waste handling is described in Sections IV.A.2, 4, 5, and 7. In addition to these systems, the reactor and primary heat transfer systems are located within a containment building which assures that leakage of no more than one percent per day will occur.[51] The systems and procedures described in other sections will assure that routine operation of FFTF poses no threat to the environment. The containment building, in conjunction with these systems and procedures, assures that there will be a minimum threat to the environment, even in the unlikely event that an accident should occur at the FFTF.

c. Environmental Monitoring Programs

(1) General

At present, an extensive environmental monitoring program already exists under Atomic Energy Commission auspices. The program described herein will be conducted routinely as part of this AEC program. This program will be subject to future modification to place greater emphasis on potential problem areas and decreased emphasis on areas of lesser concern as warranted by the data obtained from the program.

(2) Radiologicrl Environmental Monitoring Program

The AEC maintains a comprehensive, radiological environmental surveillance program for the entire Hanford Reservation, including both on-site and off-site monitoring. In addition to water and air samples, selected samples of wildlife and foodstuffs are collected and analyzed (Table IV.A.6.1.).

The primary intent of the surveillance program is to provide assurance that radiation exposure received by the surrounding population from Hanford Plant activities remains a small fraction of the radiation dose limits specified in AEC Manual Chapter 0524. The data are also of use for evaluating trends in environmental radionuclide levels and for evaluating the impact of releases of radioactivity from the site.

Environmental sampling locations are shown in Figure IV.A.6.1, and typical measurements taken are given in Table IV.A.6.1.[50]

(3) Non-radiological Environmental Monitoring Program

The AEC maintains a comprehensive, nonradiological environmental surveillance program for the entire Hanford Reservation, including both on-site and off-site monitoring.[52] The program includes air and water samples.

The primary intent of the program is to assure that effluent concentrations are less than limits specified by the State of Washington and the Environmental Protection Agency. The data are also used to evaluate trends in environmental levels and for evaluating off-normal releases of materials from the site.

TABLE IV.A.6.1. Hanford Surveillance Program Sampling Information

Type of Sample	Type of Analysis	Number of Periodic Samples D	W	SM	M	SQ	Q	SA	A	Annual Total
WATER										
Columbia River Water	Radioactivity	1			2					284
	Dose Rate				6					72
Sanitary Water	Radioactivity		6		3					348
Waste Water	Radioactivity		1		8					148
Ground Water Wells	Radioactivity				2	16	62	31		462
AIR										
Filters	Radioactivity		17	24						1460
Scrubbers	Radioactivity		3							156
Charcoal Cartridges	Radioactivity		5	15						620
OTHER										
Radiation Level	Dose Rate			19	59					1164
Ground Control Plots	Radioactivity	4	6	16	21	16	6			2140
Road Survey	Radioactivity				10		3			132
Aerial Survey	Radioactivity							5		10
Milk	Radioactivity		1	5	1					184
Fish Columbia River	Radioactivity				18					216
Wild Fowl	Radioactivity						6		140	164
Foodstuffs:	Radioactivity									
Meat	Radioactivity				2		6		6	54
Eggs	Radioactivity				2		1			28
Produce	Radioactivity				2				48	72
Oysters	Radioactivity				1					12
TOTAL										7726

D - Daily
W - Weekly
SM - Semi- monthly
M - Monthly
SQ - Semi-Quarterly
Q - Quarterly
SA - Semi-annually
A - Annually

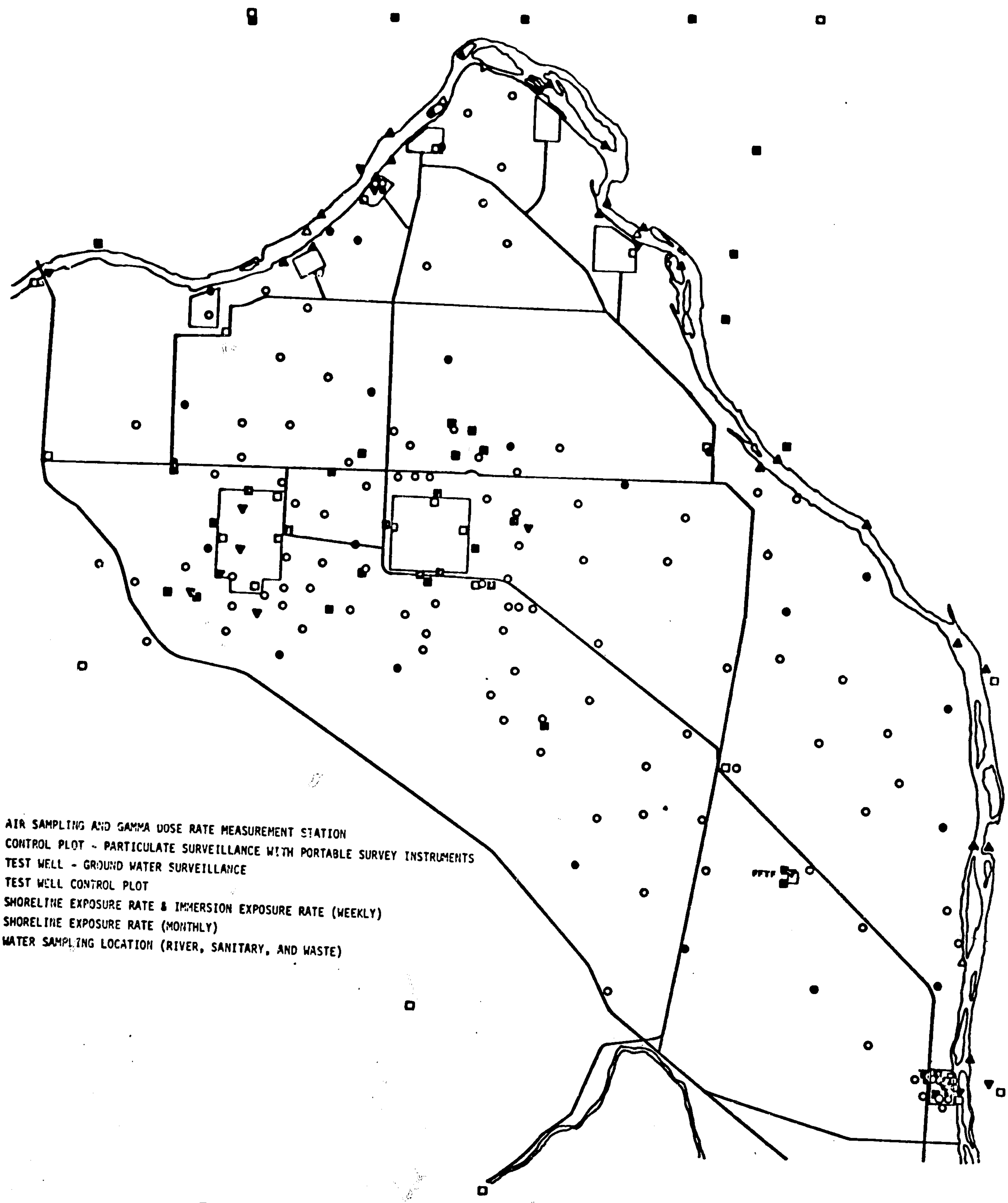


Figure IV.A.6.1 Environmental Sampling Locations

Chemical effects will be monitored by analyzing all ground water samples for pH, dissolved solids and free chlorine.

The hydrological monitoring program will be limited to measuring the water tables whenever ground water samples are collected.

The AEC is conducting a meteorological program at the FFTF site. The wind velocity, direction and temperature are measured.[53] Similar data are collected at the AEC Hanford Meteorology tower, approximately 15 miles northwest of FFTF.[54-61] This information will be used to provide assessments of the transport of any gaseous effluent.

Operation of the dump heat exchangers should increase the noise level in the vicinity to only a small degree. Noise levels will be measured periodically on and around the FFTF site to assure levels are within safe limits for operating personnel.

d. Potential Hazards of Cooling Water Intake and Discharge

The FFTF is a sodium-cooled system which does not produce electricity and will not require water for heat removal. The only cooling water on site will be that withdrawn from wells to be used for fire and other process water needs.

7. Radioactive Discharges

Introduction

This section of the report provides a description of the FFTF waste processing system, the expected discharge of radioactive material during normal operation, and an estimate of the resultant exposure to man and species populations. The FFTF is being designed to prevent any release of radioactive effluents to the surroundings during operation. The only identifiable release involves a minute quantity of tritium and noble gas fission products which may leak out of various systems even though an extraordinary effort is being made to assure that all components are as leaktight as possible. All radioactive liquid and solid waste will be collected and shipped to a remote processing and storage site within the Hanford Complex or to another AEC approved location.

a. Waste Processing System Descriptions

Introduction

The FFTF provides waste processing systems to minimize the release of radionuclides to the environment during normal operation. The four waste systems are described below and consist of the following:

- Gaseous Waste System
- Liquid Waste System
- Solid Waste System
- Sodium Waste System

The gaseous waste system processes all radioactive gases that may be generated in the primary systems during reactor operation. The system is being conservatively designed to process the gas release from 1% failed fuel in the reactor core (160 failed pins) and failure of all fuel pins in the closed loop systems. The expected failures in the reactor and closed loop systems should be far below these design values and the actual number of failures at any point in reactor operation will depend on the previous reactor experience. The present reference fuel failure rate is described in Section IV.A.7.b.2.

The liquid waste system provides for collection and temporary storage of liquid waste generated throughout the facility. The main source of waste results from the steam-argon cleaning of residual sodium from core components. The liquid waste system is conservatively designed to handle up to 47,500 gallons of waste per year even though the expected volume will be much less depending to a large extent on reactor operating history.

The solid waste system provides for the collection and temporary storage of filters, activated core components, cold traps (if and when these are removed), and miscellaneous contaminated small equipment and parts. These wastes are packaged and shipped to the Hanford disposal site.

The system for the disposal or storage of bulk metallic sodium wastes is currently under development. The system is scheduled to be available for service prior to operation of the FFTF.

The paragraphs that follow provide a more detailed description of these four waste systems.

(1) Gaseous Waste System[62]

Two separate systems are utilized in FFTF to control radioactive noble gases. These two systems are entitled: (1) the Radioactive Argon Processing System, and (2) the Radioactive Cell Atmosphere Processing System.

Radioactive Argon Processing System

Radioactive effluent from all cover gas systems is passed to the Radioactive Argon Processing System (RAPS). The RAPS is divided into two main sections; the collection/storage section, and the cryogenic processing section. The effluent from all potentially contaminated cover gas systems is drawn into the suction tank of the collection/storage section (refer to Figure IV.A.7.1) by the compressors. The gases are then drawn through filters to remove particulate material and are passed to a compressor receiver where they are delayed prior to injection into the processing section. Under normal conditions, the gas flow rate through this section will be approximately 4 scfm and provides an effective delay time of 0.28 days. The out flow of radioactivity from the receiver is approximately one-half of the input rate. The difference between the inflow and outflow is due to radioactive decay of short-lived noble gas isotopes in the receiver. The cryogenic processing section includes heat exchangers which utilize liquid nitrogen to cool the process stream to low temperatures. The cold process stream is passed sequentially through four vessels filled with granular charcoal. The xenon and krypton are absorbed more strongly by the charcoal than is the argon carrier gas. This phenomenon delays the passage of the xenon and krypton through the charcoal-filled vessels (delay beds). The four delay beds provide an effective delay of 2.8 days for krypton gases and 140 days for xenon gases. Thus, the radioactivity flowing from the last of the four charcoal-filled vessels is almost entirely krypton.

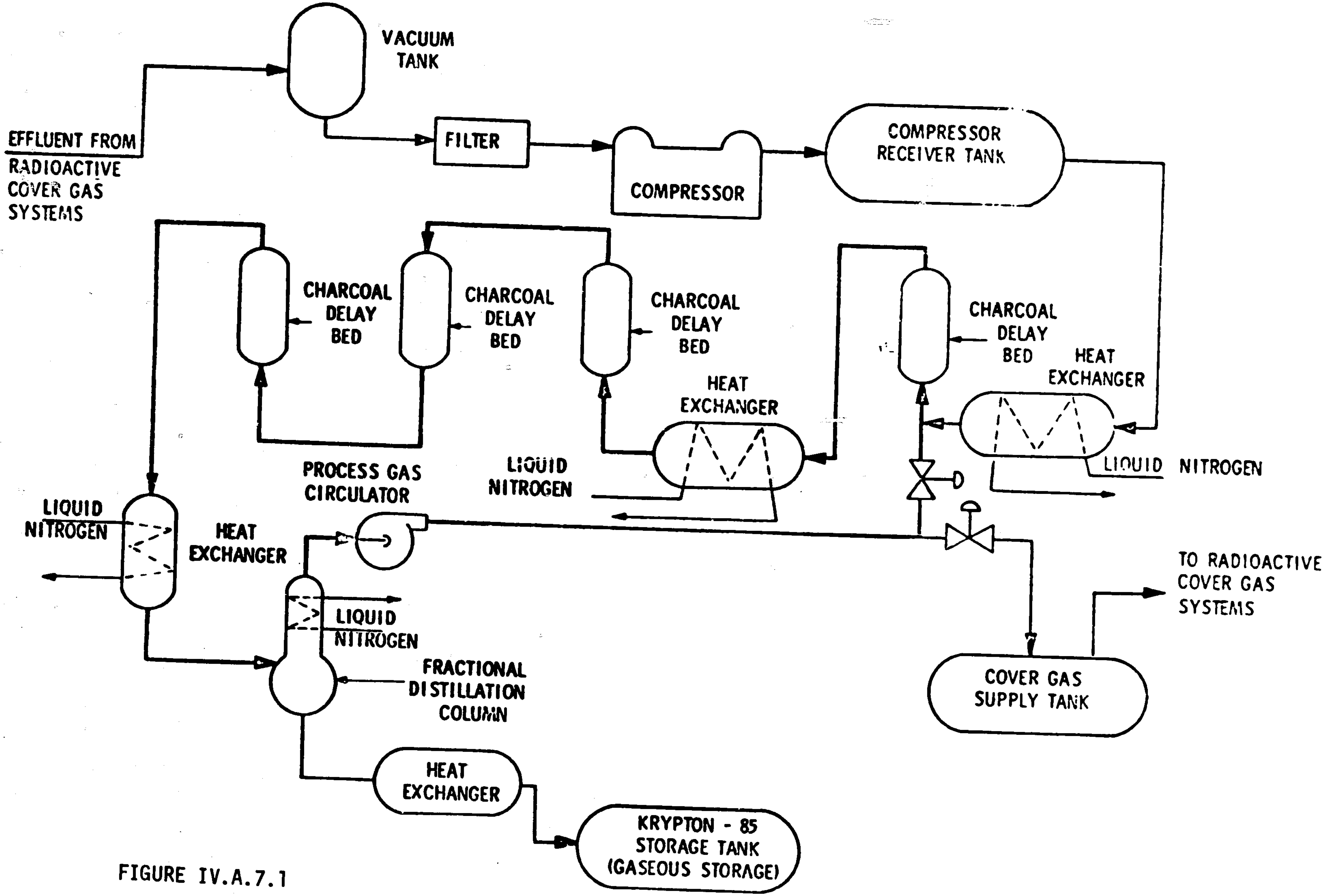


FIGURE IV.A.7.1

RADIOACTIVE ARGON PROCESSING SYSTEM

The final element of the cryogenic processing section is a fractional distillation column. Xenon and krypton are stripped out of the process stream in this unit, and are collected in a pool of liquid argon in the bottom of the column. Liquid nitrogen is used to provide the necessary heat removal. The gas stream leaving the top of the distillation column passes to a storage tank which supplies cover gas for the reactor system. The gas entering that storage tank has a concentration of radioactive noble gases that is less than the Maximum Permissible Concentration (MPC) level for ^{85}Kr of 1×10^{-5} μCi/cc.

Thermal control of the cryogenic processing section is maintained by recirculating argon around the processing loop to transfer the heat liberated in the delay beds by radioactive decay processes from the delay beds to the liquid nitrogen in the process heat exchangers.

Periodically, the xenon/krypton concentrate in the bottom of the distillation column is drained to a heat exchanger in which the cryogenic liquid is vaporized. The ultimate disposition of the xenon/krypton concentrate from the Argon Processing System has not yet been determined. The system is being designed to allow retention of the concentrate and for transfer from the FFTF plant to a suitable storage location.

Radioactive Cell Atmosphere Processing System

The effluent from all cells and spaces subject to potential contamination by radioactive gases is passed to the Radioactive Cell Atmosphere Processing System (CAPS). The CAPS is designed to process the effluents to minimize the releases of radioactive noble gases and other contaminants. The processed effluent leaving the CAPS is released to the central exhaust facility of the Heating and Ventilating System.

The CAPS is divided into two sections: the collection/storage section, and the processing section as shown on Figure IV.A.7.2. The effluent from all potentially contaminated cells is drawn into the vacuum tank of the collection/storage section by the compressors. The gases are then drawn through filters to remove particulate material and are passed to a compressor receiver where they are delayed prior to injection into the processing section. The gas flow into the receiver varies between zero and 50 scfm depending on demand.

The processing section consists of water removal units, liquid nitrogen cooled heat exchangers, two charcoal-filled vessels (delay beds) and circulation blowers. The gas leaving the surge/delay tank passes through desiccant units which dry the gas to a dew point of -90°F or less; these units essentially eliminate any tritiated water vapor from the flowing gas. The dry gas leaving is cooled to low temperature. The cold process stream then passes sequentially through two delay beds filled with granular charcoal. Xenon and krypton are absorbed more strongly by the charcoal than is the nitrogen/air carrier gas. This delays the passage of xenon and krypton through the beds; the delay provides sufficient time for the radioactive xenon and krypton to decay. The delay time is a function of carrier gas flow rate and operating temperature. The CAPS is designed to provide a decay time of 53 days for xenon and 2 days for krypton at a flow rate of 25 scfm and a temperature of -100°F. The effluent from the CAPS is released to the central exhaust facility. It should be emphasized that the CAPS could release radioactive gases only as a result of an accident such as a leak or spill. The normal release from CAPS is essentially zero.

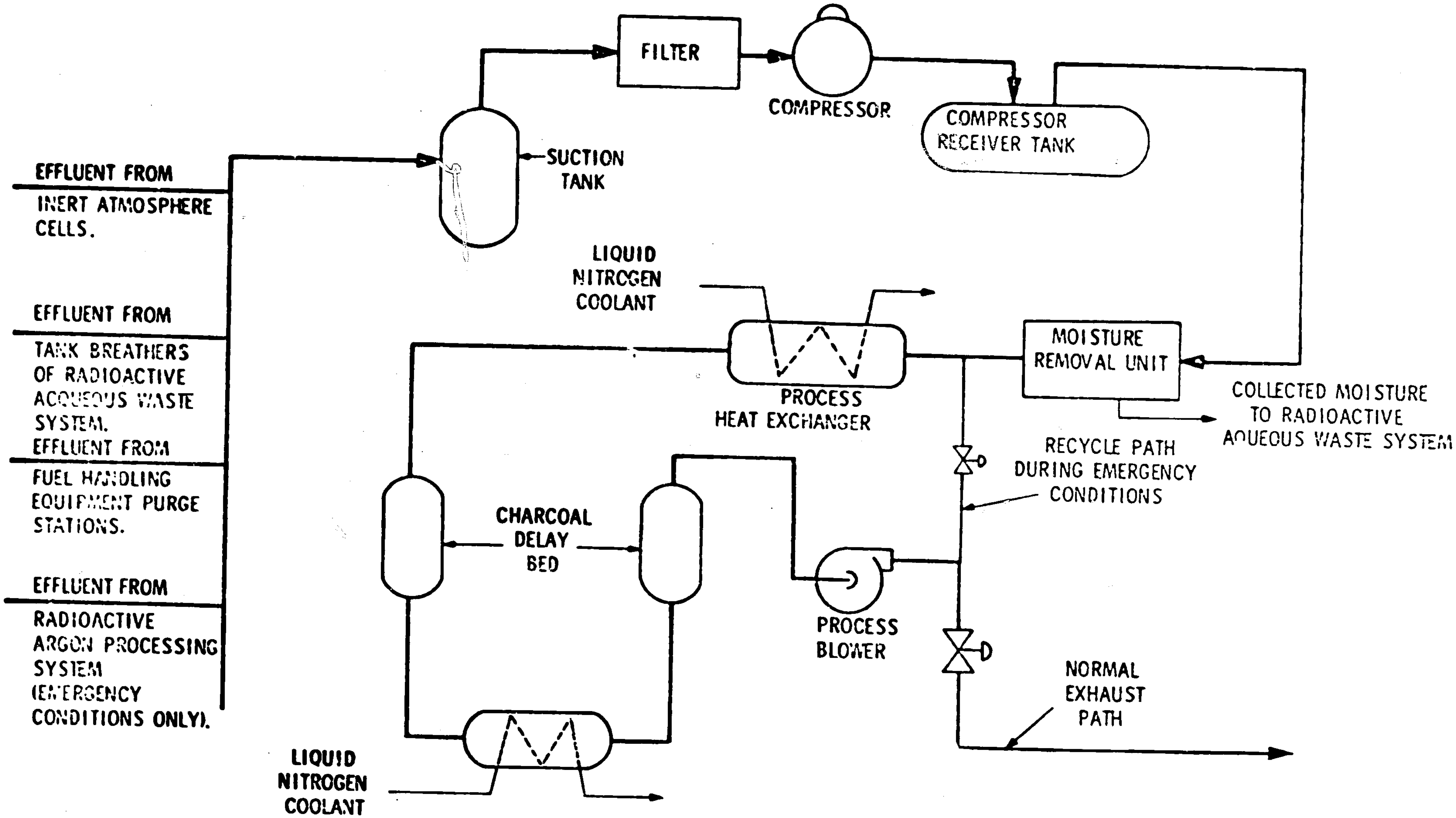


FIGURE IV.A.7.2

RADIOACTIVE CELL ATMOSPHERE PROCESSING SYSTEM

(2) Liquid Waste System[63]

The FFTF provides the equipment and facilities for collection and transfer of radioactive liquid waste resulting from operations and maintenance of the FFTF.

The radioactive liquid waste collection and removal process is illustrated in Figure IV.A.7.3. All areas where potential liquid waste could be generated are provided with liquid waste drains. This includes all areas where radioactive material is handled. A brief description of the collection process is as follows:

Liquid waste generated is either gravity drained or pumped from the waste drainage tanks through check valves and the liquid waste piping gas seal traps. This prevents gas and liquid backflow to the operating areas. The waste drainage tanks are not shown in Figure IV.A.7.3. They collect waste from the analytical laboratory and the radioactive gas decay Cell Atmosphere Processing System. Tanks and pumps are provided since the waste cannot be drained by gravity into the main storage tanks.

From the seal trap the liquid waste passes thorugh a radiation monitor which automatically actuates valves to divert waste to the ≤ 1 μCi/cc temporary storage tanks or the ≥ 1 μCi/cc temporary storage tank.

During the temporary storage period, the liquid waste undergoes agitation to prevent sedimentation, circulation through radiation monitors, sampling by removal of small volumes of waste to determine radionuclide composition, and pH neutralization.

The tanks are vented to the radioactive gas decay processing system to prevent release of any radioactive gas to the environment.

Piping, valves and loadout station are provided in the Reactor Service Building for transferring the waste into the 20,000 gallon railroad tank car or the 500 gallon shielded transfer cask. The tank car and cask are vented

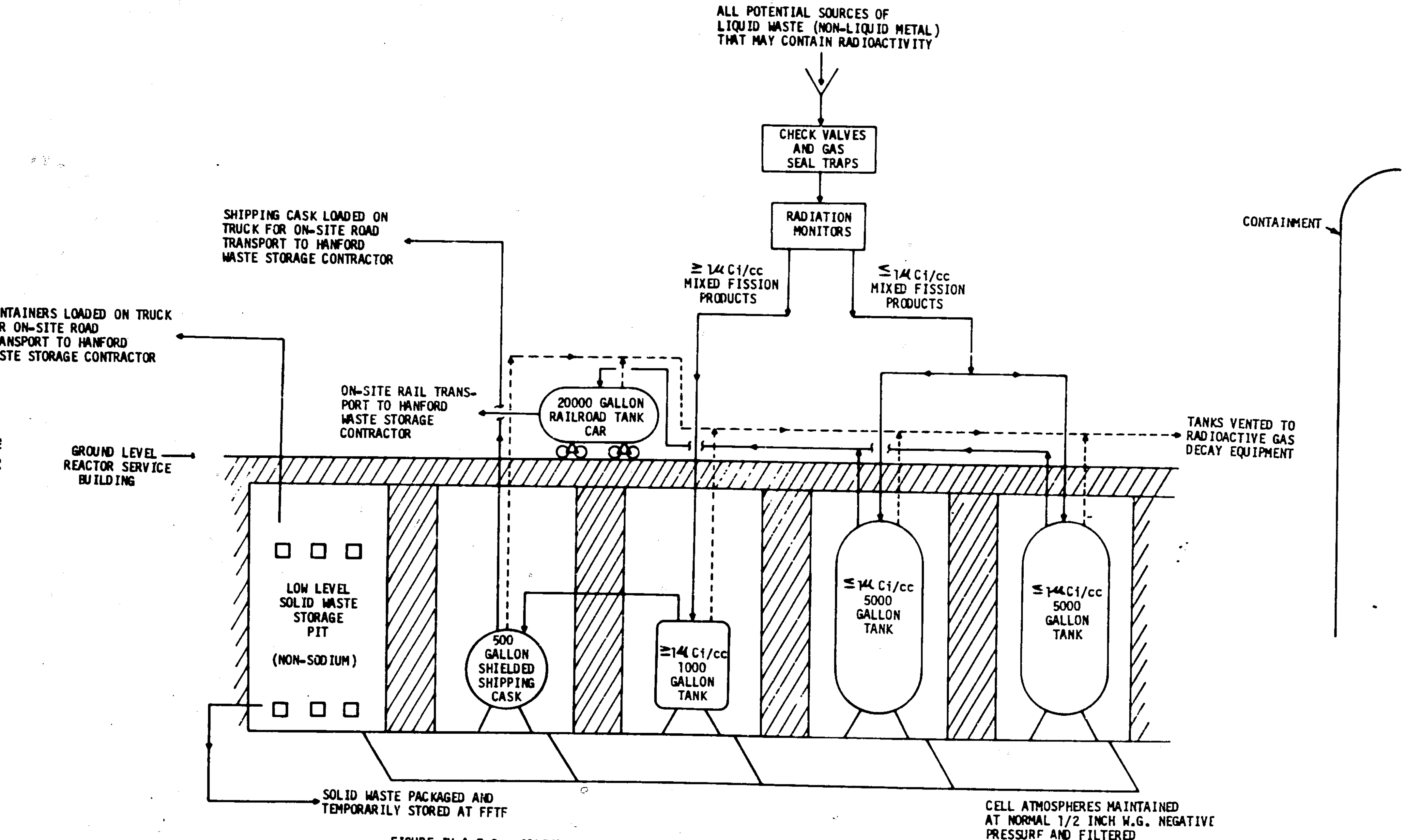


FIGURE IV.A.7.3. SCHEMATIC OF LIQUID AND SOLID WASTE COLLECTION, TEMPORARY STORAGE AND TRANSFER TO THE HANFORD WASTE STORAGE AREA to the radioactive gas decay equipment during the transfer process in order to prevent release of radioactive gas. The liquid waste quantity discharged from the temporary storage tanks to the transport container is measured by flowmeters in the discharge line. The total quantity of radionuclides removed from FFTF is obtained from the measured flow and the liquid sampling to determine the radionuclide concentration prior to discharge from the temporary storage tanks.

The liquid waste in the tank car is transported by rail to the Hanford site waste storage area and that in the shielded cask is transported to the storage area by truck on the Hanford site road system. The use of the railroad tank cars and shielded cask is standard Hanford practice for transport of liquid waste to the waste storage area. (See Section IV.A.8)

The total quantity of liquid waste with an activity of ≤ 1 μCi/cc is projected to be approximately 36,000 gallons per year. The waste will be transported to the 200 Area of the Hanford site approximately five (5) times a year. Although the design provides for the collection, temporary storage, sampling

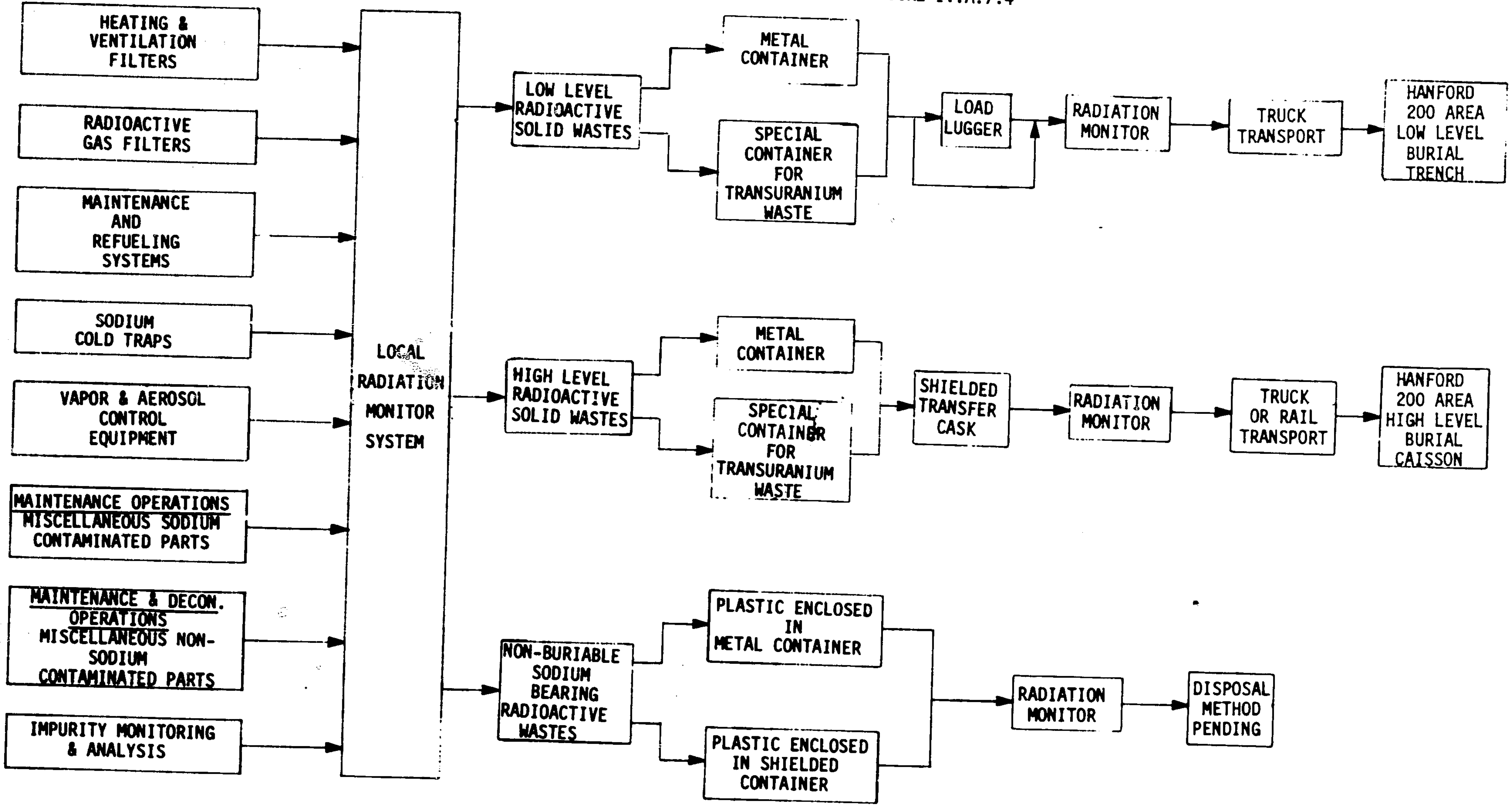
The design provides for the collection, temporary storage, sampling and transfer of waste with an activity of ≥ 1 μCi/cc. The source of this waste has not been identified.

(3) Solid Waste System[63]

The solid waste collection and transfer is schematically shown on Figure IV.A.7.4 Routinely generated solid wastes are packaged and then transferred to the solid waste storage pit located in the Reactor Service Building.[64] The waste accumulates until a sufficient quantity of waste is generated to provide economical transport for burial. The solid waste storage pit has approximately 280 square feet of floor storage. Access is provided through the floor hatch in the Reactor Service Building. The solid waste is truck or rail transported to the Hanford 200 Area site for burial. The packaging and waste segregation

RADIOACTIVE SOLID WASTE FLOW DIAGRAM

FIGURE IV.A.7.4



conforms to the standards specified for Hanford.[65] Conformance with these requirements and data on radioactivity present in the packages are sent with the shipment records. It is anticipated that cardboard cartons and polyethylene bags will be used for packaging low-level wastes. These will then be placed into metal containers for transfer to burial.

Shielded casks are used for packaging and transport of high level wastes. These will not be temporarily stored at FFTF but will be shipped for burial in caissons at the 200 Area.

(4) Sodium Waste System[63]

A system for the disposal or storage of bulk metallic sodium wastes from FFTF is currently under study. The purpose of this program is to develop equipment capable of processing small quantities of radioactive or nonradioactive sodium. The timing of the program is such that the waste sodium treatment equipment should be tested and available for service prior to operation of the FFTF. Nonroutine sodium wastes generated prior to the availability of the new facility will be contained in an inert atmosphere and stored on site.

b. Principal Radionuclides Discharged

This section provides a description of the sources, pathways, and possible routes by which radionuclides can be discharged from the facility. The first section discusses the production migration and possible release of tritium during FFTF operation. Tritium is expected to be present in both the gaseous and liquid waste streams. The second section describes the sources, inventory, and possible leakage paths for gaseous radionuclides including tritium and noble gases. FFTF is being designed to prevent any planned release of these gaseous materials during normal operation.[62] The only release will be a very small amount of gaseous material which might be expected to leak through the various system components and piping as described below.

The third section describes the sources of liquid waste expected from the facility. Most of this waste results from steam cleaning of sodium bearing core components. The liquid waste is not discharged to the environment but is collected/shipped to the Hanford Waste Disposal Facilities for processing.

The fourth section describes the sources of solid waste that are expected from FFTF. Most of this material will be in the form of activated stainless steel or inconel components. Finally, small amounts of contaminated sodium may require disposal during the lifetime of the facility. Improved procedures for accomplishing this disposal are under development.

(1) Tritium

With most of the tritium generated by the FFTF tied up chemically by the sodium or in the cold traps, and with no water cooling, the main source of tritium will be that which escapes through barriers. Only inhalation exposures are considered in this report since the other sources are negligible or non-existent, and all liquid wastes are stored. The beta particle given off is of low energy and low penetrating power. It is not a significant hazard. Nevertheless, the capability of tritium to diffuse through metals such as stainless steel, requires that knowledge and understanding be obtained of the sources of tritium production, its migration and means of controlling it.

The important sources of tritium production in the FFTF as for other fast reactors are fuel ternary fissions, boron (n,t) reactions, and neutron reactions with lithium. Boron carbide is being used as a control material in the FFTF.

boron-11 and lithium-7 reactions have threshold energies of about 9.6 MeV and 2.8 MeV, respectively, and the average cross sections for the boron-10 and lithium-7 reactions are small in fast reactor spectra. The boron-10 (n,t) 2 alpha reaction will be the main producer of tritium activity from boron in fast reactors. It is estimated that about 40 curies of tritium are produced per FFTF full power day for all reactions.

The total tritium activity produced in large fast power reactors may be greater than that produced in large light-water power reactors because of (a) the higher yield of tritium in plutonium-239 fission compared to that in uranium-235 fission, (b) the greater activity produced from boron-10, and (c) the possibly higher yields from fission with high-energy neutrons compared to those with thermal neutrons.

Though the knowledge of tritium migration in an LMFBR is incomplete at the present time, an increasing understanding of the complex processes involved is being obtained from the operation of EBR-II. Tritium is tied up to a large degree in the sodium as sodium titride. Cold trapping of sodium titride in EBR-II appears to be effective. Further work to determine this behavior is underway. Further understanding and knowledge of the behavior of tritium and means for its control will be obtained in the operation of the Fast Flux Test Facility and the LMFBR Demonstration Plants.

A model, based on Figure IV.A.7.5, was developed to describe the transport of tritium through the FFTF system.[66]

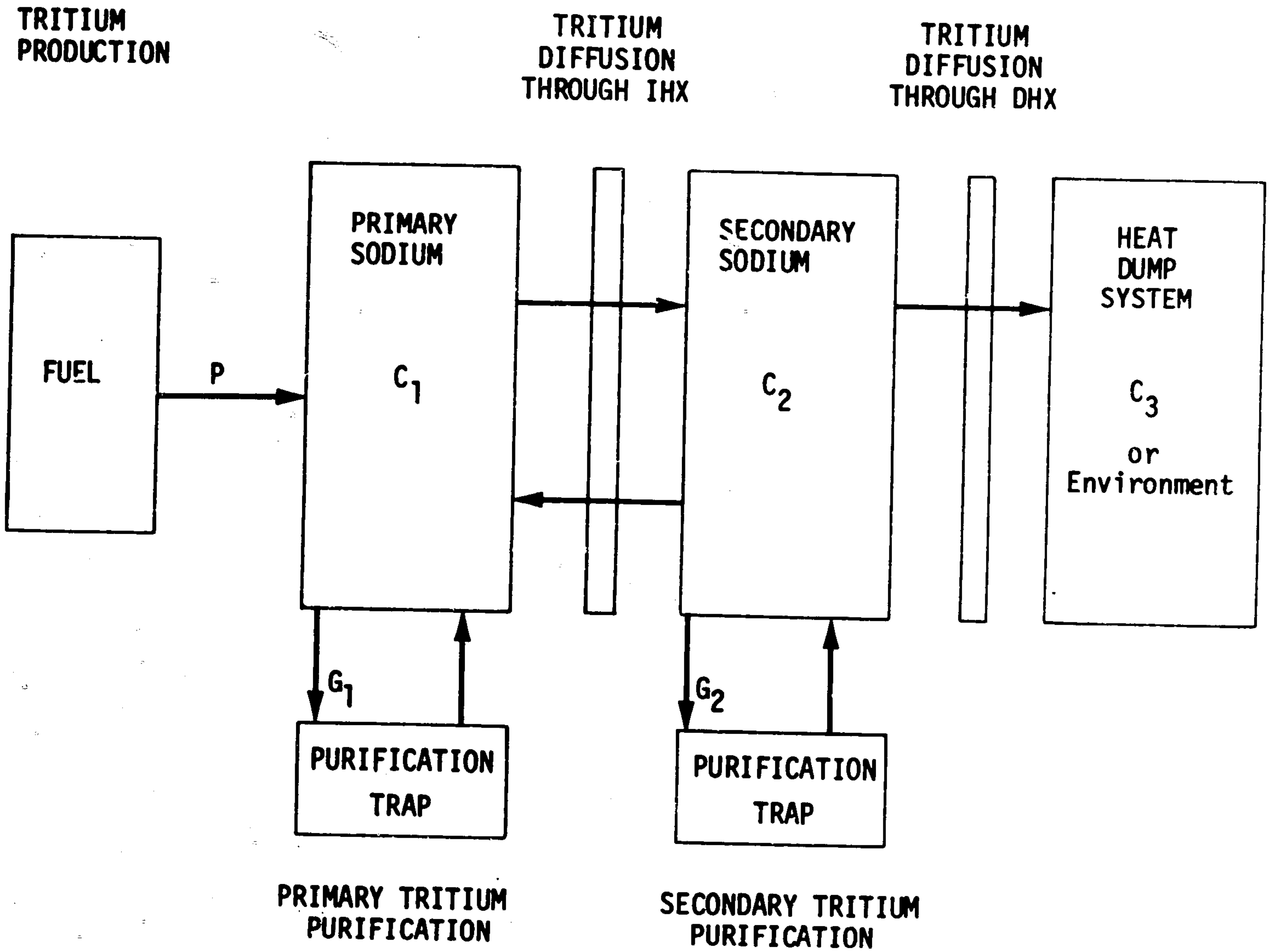


FIGURE IV.A.7.5 TRITIUM TRANSPORT PATH IN FFTF

Releases to primary and secondary heat transport system cells were estimated by calculating a diffusion coefficient for heat transport system piping exclusive of heat exchangers and using that coefficient and the sodium side tritium concentration to calculate an average daily release rate.

(a) <u>Purification Coefficients</u>

A range of purification coefficients (which defines the efficiency of tritium removal by cold trapping) was studied to determine the effect of cold trap operation on tritium transport. These ranges are given below.

(1) Primary System - Two cold traps with a capacity of 60 gpm each are available for primary sodium purification. Therefore, calculations were made for cold trapping flow rates of 120, 60 and zero gallons per minute.

(2) Secondary System - each heat transport loop on the secondary has a cold trap with a capacity of 15 gpm. Cold trapping rates for the secondary system of 45 gpm and zero were investigated.

(3) Cold Trap Efficiency - Cold traps were assumed to reduce gross hydrogen concentrations in sodium from 0.5 ppm to 0.135 ppm, which corresponds to a hydrogen removal efficiency of 73%. An efficiency of 25% was also investigated.

Using the above model, calculations were made for the FFTF for a range of primary and secondary system purification rates. The results are shown on Table IV.A.7.1.

It should be noted from Table IV.A.7.1 that the estimated tritium releases to the environment from the FFTF will be low with adequate cold trapping in

TABLE IV.A.7.1

ESTIMATED TRITIUM RELEASE*

Case	Cold Trapping Rate (GPM)		Tritium Concentration (Curies/cc)		Tritium Release Rate from DHX ** (Curies/Day)	Tritium Release Rate *** to Inerted Cells (Ci/Day)	
	Primary	Secondary	Primary	Secondary		Primary	Secondary
1	120	45	8.2×10^{-8}	5.3×10^{-9}	0.044	0.054	0.003
2	60	45	1.5×10^{-7}	1.0×10^{-8}	0.088	0.105	0.005
3	0.0	45	3.3×10^{-6}	2.1×10^{-7}	1.61	2.16	0.107
4	120	0.0	8.3×10^{-8}	5.0×10^{-8}	0.416	0.055	0.025
5	60	0.0	1.6×10^{-7}	9.8×10^{-8}	0.82	0.108	0.049
6	0.0	0.0	Release rate increases until 100% release occurs				
7	120.0	30.0	2.3×10^{-7}	4.8×10^{-8}	.404	0.15	0.023

* Cases 1-6 - Hydrogen removal efficiency = 73%
Case 7 - Hydrogen removal efficiency = 25%

** A release rate exceeding 1300 Ci/day is necessary to produce MPC for controlled areas at the DHX exit point. To produce MPC for uncontrolled areas requires a release rate greater than 50 Ci/day.

*** Tritium released to inerted cells will be oxidized and collected in the CAPS, removing it as a source of environmental contamination.

Reference: - Kabele, T.J., Estimates of the Tritium Distribution in the FFTF, HEDL-TME 72-19, 1972.

the primary sodium system. Failure of all secondary cold traps (Case 4) or of all secondary and one primary cold traps (Case 5) results in significantly lower tritium releases than the failure of both primary cold traps (Case 3). Operation with no cold traps (Case 6) for more than ten hours results in a release rate of greater than one curie per day which further increases with time to 40 curies per day.

It should also be noted from Table IV.A.7.1 that the estimated tritium release to the primary heat transport system cells is of the same order of magnitude as the tritium release through the dump heat exchangers. This is due to a combination of a higher concentration driving force in the primary system and the removal of tritium by purification of the secondary sodium.

(2) Gaseous Waste

The FFTF radioactive gas waste systems will contain argon-41 from activation of the primary system cover gas; tritium which has diffused through the stainless steel clad and has not been trapped by the sodium; sodium-22 and sodium-24 in the form of vapor; neon-23 produced by the n,p reaction with sodium-23; and gaseous fission products escaping from failed fuel pins. The quantities of these products will depend on the operating characteristics of the reactor or the closed loops, the time involved, and the number of failed fuel elements. As noted in Section IV.A.7.a. previosuly, a gas radwaste system is provided to remove these contaminants which are not in solution in the sodium, plated out on components, or cold trapped. In the process, an inventory is built up in the reactor primary system or primary of the closed loops and in the Radioactive Argon Processing System (RAPS).

The argon-41 and tritium inventory in the gas system is expected to be low compared to the noble gas inventory. Neon is expected in the cover gas but the inventory decays rapidly in the downstream sections of the gas processing system because of its short 38 second half-life. Any sodium-22 and 24 that is contained in the gas stream will be removed by the filters contained in the RAPS system.

The expected inventory of noble gases in various portions of the gaseous waste system is shown on Table IV.A.7.2. These values are presented for operating conditions where 0.1% of the fuel in the FFTF core is defective and 35% of the gases from this fuel escapes. A similar inventory is presented for a typical closed loop with 0.2% of the fuel defective and a 35% release. It should be noted that FFTF is being designed conservatively to operate with 1% failed fuel in the reactor core and complete gaseous release from all closed loops. During initial operation no failed fuel is expected in the reactor core.

Release of Gaseous Radionuclides from FFTF

FFTF will be designed and constructed such that there will be no planned releases of radioactive gases to the environment. The effluent from main and closed loop primary cover gas systems will be recirculated after being cleaned. The effluent from inert atmosphere cells, and other areas subject to contamination by radioactive gases, will be cleaned up before discharge. However, some leakage from systems contaminated by radioactive gases will inevitably occur through welds, connections and valves in various systems which contain radioactive gases (Table IV.A.7.3).

TABLE IV.A.7.2

EXPECTED INVENTORIES (Ci) OF NOBLE GAS RADIONUCLIDES IN FFTF GASEOUS WASTE SYSTEMS

Isotope	Closed Loop Typical (1)	Reactor System (2) Reactor Vessel	Reactor System (2) Reactor Overflow Tank	Radioactive Argon Processing System (2) Compressor Receiver	Radioactive Argon Processing System (2) Cryogenic Processing Section
Xe - 131m	4.2×10^{-2}	6.3×10^{-2}	2.7×10^{-1}	2.2×10^{0}	1.4×10^{2}
Xe - 133m	1.1×10^{0}	1.6×10^{0}	6.0×10^{0}	4.9×10^{1}	5.6×10^{2}
Xe - 133	2.1×10^{1}	3.2×10^{1}	1.3×10^{2}	1.1×10^{3}	2.9×10^{4}
Xe - 135	9.1×10^{1}	1.5×10^{2}	4.6×10^{2}	2.7×10^{3}	4.9×10^{3}
Kr - 83m	3.4×10^{0}	8.0×10^{0}	1.1×10^{1}	3.8×10^{1}	4.6×10^{0}
Kr - 85m	8.4×10^{0}	1.6×10^{1}	3.5×10^{1}	1.8×10^{2}	1.0×10^{2}
Kr - 85	8.4×10^{-4}	1.1×10^{1}	4.9×10^{-3}	4.2×10^{-2}	4.9×10^{2}
Kr - 87	1.3×10^{1}	2.1×10^{1}	2.4×10^{1}	7.0×10^{1}	3.1×10^{0}
Kr - 88	1.4×10^{1}	3.1×10^{1}	5.6×10^{1}	2.3×10^{2}	1.0×10^{2}
Totals	1.5×10^{2}	2.7×10^{2}	7.2×10^{2}	4.4×10^{3}	3.5×10^{4}

(1) Assumes 0.2% failures in loop with 35% release (typical of 4 closed loops).

(2) Assumes 0.1% failure in reactor core with 35% release.

High integrity seals will be used in FFTF wherever welded joints or seal welds cannot be used. Extensive leak checking by mass spectrometers or instruments of equivalent sensitivity will be performed to assure that the as-built plant conforms to design criteria in this respect.

An estimate of the leakage from various systems components containing radioactive noble gases is presented in Table IV.A.7.3. This estimate considers only leakage into air atmosphere areas, since radionuclides released by leakage into inert atmospheres will be essentially eliminated by radioactive decay during the time they reside in the inert atmospheres in the cells or during the time they take to pass through the CAPS system that processes the effluent from the inert atmosphere cells.

An estimate of the amount of gaseous leakage from FFTF has been made by combining the data on inventories (Table IV.A.7.2) and the data on leakage (Table IV.A.7.3). If the reactor is operated with 0.1% of the fuel pins defective and 35% of the gas is actually released from the defected pins, the leakage is approximately 0.003 Ci/day. If the two closed loops are operated with 0.2% defective pins and 35% of this gas is released, an additional leakage of approximately 2×10^{-4} Ci/day would be expected. This would be a typical expected operating condition. The radioactive gas waste system is designed to accommodate 1% fuel failure in the reactor core and complete failure in all closed loops - a large margin above expected operating conditions.

TABLE IV.A.7.3

LEAKAGE ESTIMATE FROM GAS COMPONENTS AND SYSTEMS IN AIR ATMOSPHERE SPACES

Location	Contributor	Estimated Leak Rate (atm - cc/sec)
Containment work area (including head cavity)	Reactor Head	10^{-4}
	Primary HTS Pumps	3×10^{-7}
	Exposed Gas Piping	6×10^{-7}
	IDS Tank (radioactive gas not normally present)	0.5
Containment Level Below 500' Elevation	Gas Piping	2×10^{-5}
	Valves (102)	10^{-5}
	Reactor Sampling Compressor	1.2×10^{-4}
Radioactive Gas Equipment Cell (Ex-Containment)	Piping	2×10^{-5}
	Compressors	4×10^{-4}
	Valves	2×10^{-6}
	Tanks and Miscellaneous	10^{-6}
Gas Sampling Area (Ex-Containment)	Piping (all other components in isolation cells)	10^{-5}

NOTE: This estimate was based on the following criteria:

1. Piping - 10^{-7} atm cc/sec per weld
2. Valve (bonnet) - 10^{-7} atm cc/sec
3. Compressors - 10^{-6} atm cc/sec per centimeter of seal length (Manufacturer's data)

(3) Liquid Waste[63]

An estimate of the quantities of liquid waste generated during FFTF operation is shown on Table IV.A.7.4. The cleaning of residual sodium from spent core and system components with a steam-argon process is expected to generate the major portion of the total annual volume of liquid waste. This waste will contain small quantities of activation and fission products, depending on the amount of failed fuel present during previous operating cycles. The remaining waste is generated by various operations that are related to decontamination.

Tritium activity will be present in the coolant as explained previously. The amount of tritium in the liquid waste system will depend on the extent of the cleaning operations and the operating efficiency of the cold traps. This will be investigated during FFTF operation.

Manganese, cobalt, tantalum, iron and chromium activities appear in the coolant as a result of activation and corrosion processes. The major source of such corrosion activity is the fuel elements; the Inconel 600 reflectors contribute a small portion of the total activity in the coolant. Equilibrium corrosion correlations applied to both 316 stainless steel and Inconel 600 can predict corrosion as a function of flow rate, oxygen concentration and metal temperature.

(4) Solid Waste

A list of radioactive solid waste is shown in Table IV.A.7.5, including that generated at other locations associated with FFTF operation. Filters in the heating and ventilation and the gas systems might be expected to have some low amounts of contamination if any spills, leaks or other incidents occur during operation of the facility. The reflectors located on the periphery of the active core region may build up an inventory of activation products

TABLE IV.A.7.4

FFTF RADIOACTIVE LIQUID WASTE QUANTITIES

	WASTE VOLUME			
	GAL/MONTH	AVERAGE GAL/YR	MAX (DESIGN) GAL/MONTH	MAX (DESIGN) GAL/YR
Cleaning Fuel Subassemblies				22,500
Decontamination				
1. LMFBR Casks, 3-4 Casks/Yr	0	0	10	30
2. Solid Waste Casks 1 Cask/Week	5	50	20	250
3. Special Casks, 1 Cask/Week	5	50	10	120
Tank Car Decontamination (4 to 6/yr)	100	500	100	1,000
Maintenance Cask Decontamination	5	20	25	100
LMFBR Cask Loading Pit	50	50	100	100
Low Level Solid Waste Storage	100	200	100	200
Personnel Safety Shower	0	0	200	1,000
Personnel Decontamination Area	900	2,700	1,600	5,200
HTS Service Bldg 60	100	1,000	250	1,500
Condensate From Gas Processing	115	125	240	1,250
IEM Cell Decontamination	0	0	100	100
Central Exhaust Filter Area Drain	0	0	100	100
Spent Core Components Sodium Removal Pit	50	50	100	100
Radioactive Waste Pipeway Drain	0	0	100	100
Sodium Removal Equipment Area	0	0	100	100
Future Aqueous Waste Sources	50	500	500	1,500
Decontamination of Low/Inter Level and High Level Storage Tank Cells	0	0	200	200

TABLE IV.A.7.5

QUANTITIES OF SOLID WASTES CONTAINING FISSION PRODUCTS
ANNUAL RATE

Produced at Reactor Site		
High Level Solid	ft^3/yr	4,500
	Kilograms/yr	9,000
	Number of 55 gal. drums/yr	630
	Repository space required, ft^2/yr	4,000
Low Level Solid	ft^3/yr	750
	Kilograms/yr	1,300
	Number of 55 gal. drums/yr	105
	Burial ground area, ft^2/yr	680
Produced at Reprocessing Plant Site		
High Level Solid	ft^3/yr	30
	Kilograms/yr	1,800
	Number of 6" x 10' containers/yr	15
	Repository space required, ft^2/yr	3,000
Cladding Hulls	ft^3/yr	100
	Kilograms/yr	10,000
	Number of 30 gal. drums/yr	25
	Storage area required, ft^2/yr	200-700*
Other Solids	ft^3/yr	4,000
	Kilograms/yr	75,000
	Number of 55 gal. drums/yr	560
	Burial ground ft^2/yr	3,600
Produced at Fabrication Plant Site		
Pu Contaminated Wastes	ft^3/yr	1,500
	Number of 55 gal. drums/yr	210
	Repository volume ft^3/yr	2,800

*Depends on disposal site

during reactor operation. Induced activation in the radial reflectors will result from the following reactions:

$^{181}Ta(n, \gamma)^{182}Ta$

$^{58}Ni(n, P)^{58}Co$;

$^{59}Co(n, \gamma)^{60}Co$;

$^{54}Fe(n, P)^{54}Mn$;

$^{50}Cr(n, \gamma)^{51}Cr$

$^{58}Fe(n, \gamma)^{59}Fe$.

The remaining items shown on Figure IV.A.7.4 involve items used in maintenance and decontamination operations. The makeup of the radioactive materials discharged due to these operations will be determined mainly by the requirements of maintenance during operation.

(5) Sodium Waste

Some sodium waste will be produced during FFTF operations. The sources of this sodium waste are mainly from cleaning components and from cold traps if and when these are removed.

During reactor operation with no failed fuel the activity collected in the cold traps would be composed of activation products and tritium. During operation with quantities of failed fuel the volatile and solid fission products released would also be expected to plate out in the cold traps. Sodium cold traps would be disposed of as shown in Figure IV.A.7.4 in the Hanford 200 Area High Level Burial Caisson.

c. Exposure to Man

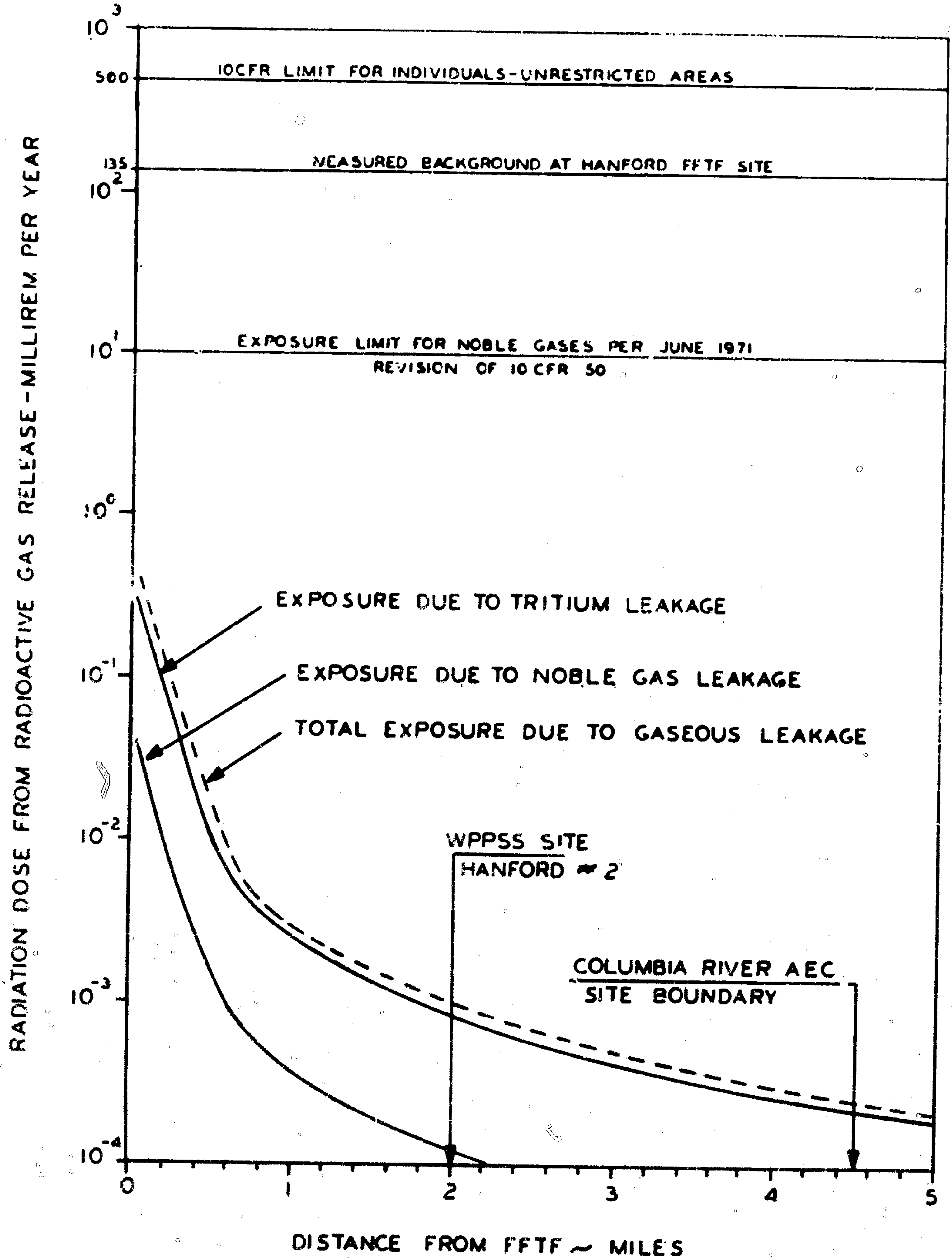
(1) Gaseous Waste

The exposure to man resulting from leakage of gases from various FFTF systems has been estimated based on the description in Section IV.A.7.b above. The expected exposure due to tritium is based on Case 1 of Table IV.A.7.1 where the tritium release from the DHX is calculated as 0.044 ci/day. In the event of operation with 0.1% failed fuel in the reactor core and 0.2% fuel in two closed loops, noble gas leakage from various reactor system will result in an additional leakage of approximately 0.0032 Ci/day of noble gases. Diffusion of these gaseous materials was estimated using the procedures outlined in Reference 67. The dilution factor [X/Q (sec/m^3)] for an extended release is used to estimate the decrease in gaseous activity concentration as a function of distance from the facility. Ground level release is assumed. For the tritium release the internal whole body exposure is calculated based on a breathing rate 2 x 10^7cm^3 per day and a dose conversion factor of 126 millirems per microcurie of tritium inhaled. The exposure due to noble gas leakage is based on the semi-infinite cloud approximation with the average gamma energy of the noble gas mixture taken as 0.25 MeV per disintegration.

The results of these calculations for distances within the confines of the AEC Hanford Reservation boundary are shown on Figure IV.A.7.6. Also shown for comparison purposes are the various 10 CFR exposure guidelines and the measured background at the Hanford site.[68] The exposure falls well below background for all leakage conditions. At the closest occupied area, the Washington Public Power Supply System (WPPSS) Hanford #2 site, the dose rate is approximately 10^{-3} mrem per year.

FIGURE IV.A.7.6

EXPOSURE WITHIN THE HANFORD RESERVATION DUE TO RADIOACTIVE GAS RELEASE BASED ON TABLE IV.A.7.3



The average exposure to the general public within a 100-mile radius of the FFTF site has also been evaluated. The exposure rates shown in Figure IV.A.7.6 were extended out to 100 miles. These exposure rates at various distances were then combined with the resident population distribution within a 100-mile radius as shown on Table II.D.5.1.. The exposure to the general population is 0.006 man-rem per year when reactor is operated with 0.1 percent failed fuel in the reactor core plus 0.2% failed fuel in two closed loops. In contrast, the exposure to this same population due to background radiation is 70,000 man-rem per year.

(2) Liquid Waste

The exposure to man resulting from the liquid waste generated during FFTF operation is expected to be insignificant. As mentioned in the system description, all liquid wastes are collected and transported to the Hanford Waste Disposal Facilities.

(3) Solid Waste

The solid wastes generated by FFTF operation, as mentioned previously, are mainly in the form of activation products in the various stainless steel and inconel core components. These components will remain within the confines of the Hanford Reservation.

(4) Sodium Waste

Disposal of solid sodium waste, as mentioned in a previous section of this report, is currently under study. Exposure to man outside the Hanford Reservation boundary will be prevented by careful design and monitoring of the processes involved in disposal.

d. Effects on Species Populations

There should be no radiological effects on important populations due to radionuclide discharge from FFTF during normal operation. The radioactive gas leakage activity is well below the normal background levels of radioactivity at Hanford. Since FFTF does not discharge any liquid waste radionuclides into the surrounding water sources no indirect contamination of species can occur due to water intake.

e. Plutonium Toxicity Considerations

The toxicity and other potentially hazardous properties of plutonium have been recognized from the time the element was discovered. Research on the biological factors involved in the control of plutonium hazards has been conducted for 25 years and is continuing. The excellent record in controlling plutonium hazards in the nuclear power industry has resulted largely from the increase in knowledge of its physiological and toxicological behavior that has kept pace with its greater availability. Research and development on the properties of plutonium relating to the safety and other aspects of its use as a nuclear fuel has been continually underway in the U.S. and other countries for 20 years.[69] For example, a complete reactor loading of fuel elements containing plutonium was used to fuel the Materials Testing Reactor (MTR) in Arco, Idaho, as early as 1958. Mixed oxides of plutonium and uranium (PuO_2- UO_2) prepared from plutonium recycled from LWRs is currently being tested in a number of commercial LWRs.

The fuel for the FFTF will be mixed oxides of plutonium and uranium (PuO_2- UO_2). This mixed oxide is a noncombustible, dense and refractory material that is most difficult to reduce to particles of respirable size even under postulated reactor accident conditions. Some of the uranium in the fuel will be converted to plutonium during the course of reactor operation. At equilibrium conditions, the total quantity of plutonium in FFTF will be in the order of 600 kg. However, this plutonium would consititute a hazard only if there were some way in which it could escape from the separate protective barriers of fuel cladding, primary coolant system, primary systems compartments and containment with which it is surrounded and somehow enter the environment. (Section II.B.2) Providing assurance that radioactive material will not escape has been one of the important objectives of the AEC's program in the development of water cooled reactors, and has received primary emphasis in the development, design and construction of the FFTF. The necessity for safe operation of the FFTF has been considered in great detail and has been extensively evaluated during the FFTF safety reviews. Similarly, the containment of plutonium during normal operating and accident conditions has received careful attention and was extensively evaluated during these reviews. Adequate precautions have been developed to assure the safe handling of plutonium and to avoid its release to the environment. These precautions are applied to all phases of fuel fabrication, handling, storage, transportation and reprocessing.

The specific safety design features of the FFTF have been described in the PSAR.[44] As noted above, these intensive reviews and precautions were taken and are continuing because of the recognized potential toxicity of plutonium, primarily through inhalation. This is reflected in the recommendations of the various radiation standard-setting bodies.

It should be pointed out that occupational limits are based on a constant rate of exposure. However, in an accident situation, the plutonium would presumably be deposited in a single exposure. Thus, the radiation dose delivery to the lung would decrease as a function of time after exposure.

At the present time, no biological effects have been attributed to plutonium exposure in a group of 25 human subjects who accidentally inhaled plutonium particles, some of them more than 24 years ago.[70] In the case of 10 of these 25 individuals, it has been calculated, based on the knowledge of their burdens, that the average deposition of plutonium in the lungs was roughly equivalent to 6 times the maximum value permitted for occupational exposure.

Over the past 20 years, long term studies of plutonium toxicity have been conducted by the AEC in several animal species employing various routes of administration. In particular, inhalation studies in Beagle dogs have been in progress since the late 1950's. These animals demonstrate that inhaled plutonium can lead to lung neoplasia and that the time of onset is inversely related to dose. However, extrapolation of the results of these studies from dogs to man supports the adequacy of the present occupational exposure limits. These and additional experiments are continuing.

It is recognized that the ingestion of plutonium might also be a problem.[71-78] Because of this, numerous experimental studies with animals have been conducted and are continuing on this route of exposure. These studies have shown that the absorption of ingested plutonium can occur to only a very small degree. The absorption is low due to the very effective barrier presented to plutonium absorption by the intestinal mucosa.

8. Transportation - Shipment of Radioactive Materials

Shipments of radioactive materials will be made in casks designed and fabricated to conform to the Hazardous Materials Regulations of the U.S. Department of Tran portation. Those regulations are published in Title 49 of the Code of Federal Regulations (49 CFR 170-189). Additional packaging standards are imposed by the AEC in its regulations on packaging of radioactive material for transport (10 CFR 71 and AECM 0529). All shipments of radioactive materials to and from the FFTF will be made in accordance with those regulations. They specify performance requirements for the shipping containers under both normal and accident conditions, for the shipper in preparing his packages for shipment, and for carriers in providing safe separation of these shipments from passengers, transportation workers, and other freight (particu-larly other hazardous cargo).

The shipments which contain substantial amounts of radioactivity must be in containers designed to withstand the impact from truck or rail accidents and fires that may result from such accidents. To ensure that they have this capability, several accident damage test conditions are specified in the regulations. A few representative tests which are specified in Appendix B of 10 CFR 71 and in AECM 0529 include:

Free Drop

A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.

Puncture

A free drop through a distance of 40 inches striking, in a position for which maximum damage is expected, the top end of a vertical 6 inch diameter cylindrical mild steel bar mounted on an essentially unyielding, horizontal surface.

Thermal

Exposure to a thermal test, or an actual fire, in which the heat input to the package is not less than that which would result from exposure of the whole package to a thermal radiation environment of 1475°F for 30 minutes.

Water Immersion (Fissile Material Containers Only)

Immersion in water to the extent that all portions of the package to be tested are under at least 3 feet of water for a period of not less than 8 hours.

Each container must be so d[illegible]d and constructed that, when tested under these conditions, the [illegible]ainer will retain its shielding and integrity such that the radiation level outside of the container will remain within acceptable levels and any loss of contents of the container will be limited to contaminated coolant or inert gases not exceeding certain specified levels. It is to be noted that although 6 of about 1000 containers of reactor fuel and waste that have been shipped in the past 20 years have been involved in serious transportation accidents, none has ever been breached.

Spent nuclear reactor fuel and radioactive waste shipments have been made for many years. Shipping containers for these materials are proven standard items. The equipment and procedures that have been developed and the experience that has been acquired with LWRs in shipping new fuel, spent fuel, and radioactive wastes meet the FFTF fuel cycle requirements except for spent fuel from the core region of the FFTF. These latter spent fuel materials will require additional protection during transportation due to the increased amount of radioactive decay heat which mainly arises from the higher specific power at which the FFTF fuel operates. Several different methods, approved by both the AEC and the DOT, will be available to handle the problem of heat removal. Although the particular method to be used has not been selected, it will involve a heat transfer medium in the fuel cavity of the cask, with an appropriate cooling system to maintain fuel temperatures at a level which will maintain the integrity of the fuel cladding and will also control external surface temperatures of the cask to remain within the DOT regulatory limits. Volume-expansion chambers will also be provided to accept the coolant's increased volume under emergency high temperature conditions.

In order to ensure that the radioactive material containers do, in fact, meet the approved design requirements, formal quality assurance programs will be established for the manufacturing process. Welds will be non-destructively tested for integrity, lead shielding will be checked for possible voids by gamma radiography, and visual inspections will be made throughout the fabrication process. Finished containers will be leak tested. For reusable containers and spent fuel casks, detailed inspections will be made before and after each use of the containers to assure that they continue to meet the approved design requirements.

The capability of a container to withstand accident conditions and proof tests is analyzed in detail, and a safety analysis report (SAR) is prepared for the container. The SAR is reviewed by the AEC. When the AEC staff concurs with the adequacy of the design and the accuracy of the report, a specific certification or license amendment is issued for the container. Under the present regulations, the safety analysis report along with the AEC certification is sent to the Office of Hazardous Materials, Department of Transportation, for further review and approval.

The probabilities and consequences of transportation accidents have been analyzed for a number of general cases and will be reported in the AEC's statement on the environmental considerations relating to the transportation of radioactive materials to and from nuclear power plants.

Maximum radiation levels at selected distances from the casks under both normal and accident conditions are prescribed in the regulations. The philosophy of recognizing potential hazards and developing practical engineering solutions is a fundamental element of the operating approach to transportation problems.

In summary, casks are available or under development which will assure that spent fuel from FFTF operations will be shipped in full compliance with all AEC and Department of Transportation regulations.

The experience in designing shipping casks and safely shipping large quantities of solid fission products lends assurance that adequate design features and procedures can be established for the shipment of gaseous radioactive materials. The same standards, tests and other requirements imposed on the shipping containers for solid radioactive materials will be applied as necessary to the containers used for gaseous fission products.

a. <u>Non-Irradiated Fuel Transport</u>

FFTF fuel pins and fuel subassemblies are fabricated at subcontractor plants and at comparable facilities located at 300 Area, Hanford, Richland, Washington.

It is now planned that fuel pins in groups or complete fuel subassemblies will be shipped to the FFTF 308 building in a T-144 shipping container. This container will be designed to protect the public against normal and accident conditions which might occur during the transport of unirradiated fissile material over public surface transportation routes. The shipping container will be certified to meet all AEC regulations and U. S. Department of Transportation Regulations. Quality assurance standards for the FFTF (RDT F-2-2, "Quality Assurance Program Requirements," and RDT F-4-2, "Quality Verification Requirements,") are the standards which will be used to assure that the container will meet applicable codes and standards for public safety.

The design features of the shipping container include:

(1) Prevention of contamination release, including Pu, by a sealed structural alloy container capable of receiving a group of individual fuel pins or a complete fuel subassembly.

(2) A fixed mechanical structure relative to location of the alloy container, assuring a conservatively safe critical spacing of adjacent fuel.

(3) Compliant suspension of the alloy container within the "bird cage" structure to absorb impact forces, protecting container and contents.

The container will meet tests such as those described in the introduction to Section IV.A.8.

The fresh fuel shipping containers are normally transported by truck. However, rail and air shipments are not precluded.

b. Irradiated Fuel Transport

It is now estimated that 25 fuel assemblies will be exchanged in the reactor per operating cycle of about 102 days; or approximately 2.8 cycles per year. The irradiated fuel subassemblies are stored in FFTF Decay Storage facilites for an average of 200 days to permit the heat to decay to approximately 1.5 kW. After the prescribed decay cycle at FFTF, the irradiated fuel subassemblies will be transferred to a shipping cask load-out facility at the FFTF site. RDT F-2-2, "Quality Assurance Program Requirements", and RDT F-4-2, "Quality Verification Requirements", have been applied to the design and fabrication of the cask[79] as further assurance that the cask meets applicable codes and standards for irradiated fuel transport.

To assure adequate safety, the design features of the shipping cask will include:

(1) Preclusion of criticality by fixed geometry of the fuel canister within the cask body, including positive loading of each fuel element within its canister.

(2) A cask body structure which includes neutron and gamma radiation attenuation and structural integrity sufficient to withstand normal and hypothetical accident conditions during shipment.

(3) Natural convection coolant circulation within the cask, assisting in the rejection of fuel decay heat to the cask body, which includes external cooling fins for passive rejection of the decay heat to ambient atmosphere.

(4) Prevention of contamination (including Pu) escape from the cask interior by primary and secondary cask closures, each containing double seals.

(5) The cask, including all support equipment and radiation, temperature, and pressure monitoring instrumentation, will be transportable on a standard railroad car.

(6) The cask closure interface design will be compatible with FFTF fuel transfer components and fuel reprocessing facility equipment for transfer of irradiated fuel without exceeding established design and operational safety limits.

The container will meet tests such as described in the introduction to Section IV.A.8.

Present planning contemplates shipment by rail of irradiated subassemblies to the AEC Savannah River Processing Plant in Aiken, South Carolina. This does not preclude shipment to other locations. No difficulty is anticipated in completing shipments to other locations serviced by rail.

c. Irradiated Non-Fueled Core Components

Reflector and control rod assemblies will be removed from the reactor and transferred to FFTF decay storage facilities, and subsequently to sodium removal facilities at FFTF.

Fueled test assemblies will be removed from the reactor and transferred to FFTF decay storage facilities. Subsequently, they are transferred to the Interim Examination facility for sodium removal and disassembly down to individual pins. Irradiated fuel assembly metal waste is generated during these operations.

Activated reflectors, control rod assemblies and fuel assembly metal scrap will be packaged in sealed containers prior to transport to storage facilities.

A high level radioactive material waste shipping cask[80] will be provided as part of the FFTF radioactive material handling system. The waste shipping cask will interface with the FFTF cask loading station or Interim Examination cell for loadout of waste drums. The design features of the waste shipping cask include:

(1) Closure valve and seals to isolate potential airborne contamination and attenuate radiation during and after waste container transfer.

(2) Grapple and hoist mechanisms for transfer of waste container into and out of cask interior.

(3) Cask body structure which includes gamma radiation attenuation and structural integrity sufficient to withstand normal operation and hypothetical accident conditions without rupture of cask.

(4) Transportable by rail or truck between the FFTF and waste storage sites in the 200 Area.

Waste containers will be stored in permanent shielded storage facilities by the Hanford Waste Contractor. A permanent map of storage sites with serialized waste container identification will be maintained to permit retrieval of a specific radioactive waste inventory.

The estimated annual shipping requirements for FFTF fuel and wastes are shown on Table IV.A.8.1

TABLE IV.A.8.1

ESTIMATED ANNUAL SHIPPING REQUIREMENTS FOR FFTF FUEL AND WASTES

1. Feed Preparation	
MTU	1.6
No. of Trucks	0.06
2. Fabrication - Fresh Fuel	
MTU or MT (U+ Pu)	2.2
No. of Trucks	3
3. Fabrication - Low Level Waste	
Cubic Feet	--
No. of Trucks	--
4. Fabrication - Pu Bearing Waste	
Cubic Feet	1,500
No. of Rail Cars	6
5. Reactor - Spent Fuel	
Mt (U+ Pu)	2.2
No. of Rail Cars	5
Megacuries/shipment (90 days)	16
Megacuries/shipment (150 days)	12
Watts/shipment (90 days)	34,000
Watts/shipment (150 days)	24,000
6. Reactor - Low Level Waste	
Cubic Feet	750
No. of Trucks	1.6
7. Reprocessing Wastes	
a. High Level	
Cubic Feet	30.0
No. of Rail Cars	0.4
b. Cladding	
Cubic Feet	100
No. of Rail Cars	1.6
c. Noble Gas	
Megacuries	0.025
No. of Trucks	0.1
d. Low Level	
Cubic Feet	4,000
No. of Trucks	8.4
8. Reprocessing - UO_2	
MTU	1.6
No. of Trucks	1.7
9. Reprocessing - Recycle PuO_2	
MTPu	0.5
No. of Trucks	0.4
Megacuries/shipment (10 years)	1.2
Watts/shipment (10 years)	3,300

MTU - Metric Tons Uranium
MTPu - Metric Tons Plutonium

9. Transmission Lines

The FFTF is a test facility which does not generate electricity. The only transmission lines required are to provide power for the facility. Normal power will be provided via a new 115 kV line about six miles long connecting to the tieline between Benton Switching Station and Midway Substation.

In the event of accidental loss of normal service, continuity of electric service to the FFTF will be maintained by a 13.8 kV transmission line about six miles long extending from the 300 Area to the new substation at the FFTF site.

Both lines will be of single pole structure. Design and construction of the new lines and the FFTF primary substation are in accordance with Bonneville Power Administration Standards and practices for commercial power supplies.

Both the 115 kV and 13.8 kV transmission lines are constructed across a desert area that has not been previously inhabited. These transmission lines are comparatively short (about six miles) and are located entirely on the Hanford Reservation.

No significant adverse environmental effect either on or off the Hanford Reservation is anticipated in connection with the routing of these transmission lines.

10. Construction Effects

a. Plans and Schedules

The general FFTF construction schedule and current status is summarized as follows: Construction is scheduled to be complete for critical tests of the reactor in mid-1974.

Construction Completed in 1970

Site explorations

Site preparation

Construction Completed in 1971

Railroad

Access Road

13.8 kV transmission line

Water wells

Construction facilities including warehouse

Reactor containment excavation

Electrical substations

Construction Completed to May 1972

Fire Alarm Loop

Water Tanks

Underground air and water piping

Concrete batch plant

Construction in Progress, May 1972

Containment vessel (bottom head and 10th ring complete - total = 60%)

Sanitary sewers

Pump house

b. Impact of Construction Activities

Construction activities not localized in the plant area will be limited to power transmission line installation and road building with the major construction activity restricted to the immediate site area. With the exception of the normal dust and traffic problems associated with any large construction activity, the ecology of the area except in the immediate vicinity of the site will not be changed by construction. Such activity at the site will have little or no impact on the resident population miles away. Upon completion of the work, a landscaping program will be implemented for the purpose of improving the aesthetics and preventing erosion.

In all cases of planning for borrow pits and spoil areas, procedures will be initiated to limit the amount of raw soil erosion, protect the exposed faces from erosion by wind and water, and encourage the restoration of vegetation by natural methods or reseeding in areas where special treatment is appropriate. Accumulation of any precipitation within the excavation will be directed to a sump and allowed to infiltrate into the permeable soils, thereby preventing interference with operations in the borrow pit.

Plans for deposition of excess (spoil) material will include grading to reasonably conform to existing topography as well as shaping to control surface water runoff. This will include such practices as sloping at less than natural angle of repose and shaping the top of the spoil area to retain moisture and encourage revegetation.

Water for use during construction and operation will be taken from wells drilled into the existing groundwater table. The amount of water (110,000 g/day maximum) to be used will not significantly affect the groundwater profile or availability of groundwater for use by others.

c. Work in Adjacent Waters

A barge slip may be dredged on the shoreline of the Columbia River to receive heavy equipment items. AEC will comply, and will require all construction contractors to comply, with all federal, state and local codes and regulations applicable to the construction of a barge slip. To assure minimal environmental impact due to use of a barge slip, plans will be developed jointly with federal, state and local agencies (e.g., the Corps of Engineers, Washington State Department of Ecology) having departmental interest or regulatory authority over plans, designs and schedules of the barge slip facilities. AEC will comply, and will require its contractors to comply, with all conditions and limitations imposed by permits and approvals required for barge access to the unloading point near the project site. Other than the possible dredging of a barge slip, there is no construction work planned in or near adjacent waters.

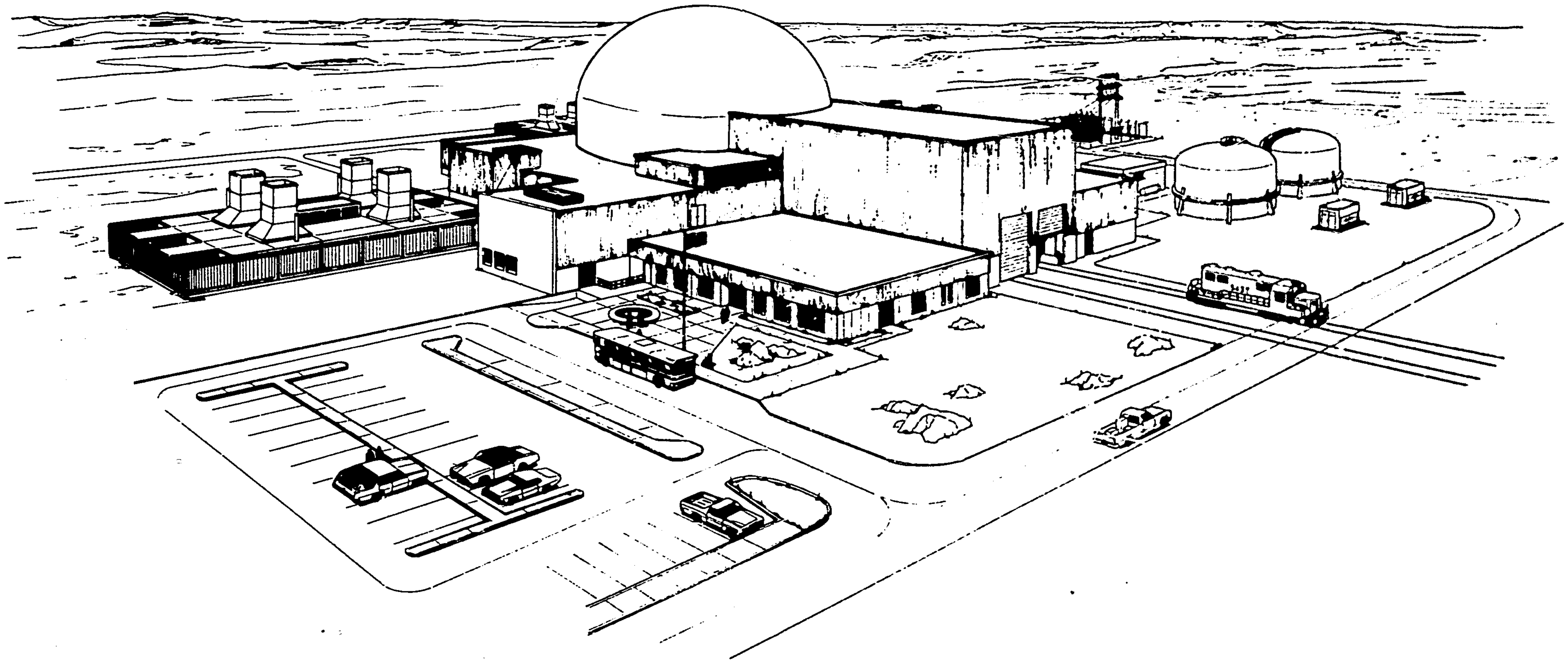
11. Aesthetics

The design of the FFTF provides a facility that complies with the policy and program objectives of the AEC Manual Chapter 6301, General Design Criteria. Aesthetic appearance of the completed facilities is given appropriate consideration commensurate with programmatic requirements and optimum economy in operation, maintenance, sound building practices and the 20-year design life of the facilities.

The landscape architecture provided for the facility is compatible with the desert terrain of the AEC Hanford Reservation and minimizes the use of irrigation to maintain the landscape vegetation consisting of a relatively small plot of grass and low shrubbery near the main personnel entrance to the Control Building.

Vegetation in the immediate vicinity of the site disturbed or destroyed as a result of construction will be replaced with indigenous species so as to return the ground cover to its natural state. Native rock will be used to stabilize the fine sand materials. This will provide a measure of fire control.

Figure IV. A.11.1 provides a sketch of the preliminary design illustrating the principal FFTF structures. The largest structure is the Reactor Containment Vessel, 135 ft. in diameter and extending about 108 ft. above the ground level. The Reactor Support Buildings provide a continuous structure around the containment vessel whose heights and geometric configurations are directly the result of space requirements imposed by the systems and functional areas within. Precast concrete panels are blended with poured-in-place concrete, sheet metal siding and horizontal builtup roofs over structural steel framing. The low



AEC-RL Richland, Wash.

Figure IV.A.11.1

FAST FLUX TEST FACILITY STRUCTURES

building in the foreground is the Control Building, a single story structure above grade. Behind the Control Building is the Reactor Service Building which provides the only equipment access to the containment building. All fuels, tests, operating materials and equipment and all radioactive wastes of the FFTF are handled through this building. Redundant auxiliary equipment and emergency power supplies are housed in the two auxiliary equipment buildings, one behind the Reactor Service Building and one left of the Control Building. The secondary coolant equipment and monitoring and analysis laboratory are housed in the HTS Service Buildings East, West and South, which extend for approximately 270 degrees around the back side of the containment vessel. The main dump heat exchangers are geographically separated in the background beyond the building structure.

An overall color scheme is currently being developed by the Architect-Engineer which will be consistent with the new sodium facilities within the Hanford Engineering Development Laboratories in the 300 Area of the AEC Hanford Reservation.

B. Extraordinary Adverse Environmental Effects

1. FFTF Safety Considerations

a. Safety Approach

Protection against potential accidents of all types has always received and continues to receive priority attention in the design, construction and operation of all nuclear reactors so that they will be safe and reliable. The FFTF is being built and tested in accordance with this approach as described in this statement and in detailed design documentation, such as the SDD, the PSAR and the FSAR, so that any environmental impact from normal and abnormal operation and from potential accidents and malfunctions will be identified and minimized. To accomplish this, the reactor plant is being built in accordance with the "defense-in-depth" concept which has evolved in the U.S. nuclear power program.[12,81,82,83] This concept is expressed in terms of three levels of safety as follows.

The first level concerns the intrinsic features of the design of the nuclear plant and the quality, redundancy, testability, inspectability, and fail safe features of the components of the reactor and plant. The design must be such that the plant is unquestionably safe in normal operation and has a maximum tolerance for errors, abnormal operation and component malfunction. Analyses have been made and test programs conducted to find those types of malfunctions or faults that could affect safety so that they can be guarded against by design, quality assurance, or fail-safe features as appropriate. A reactor plant built in this way and routinely tested and monitored provides a maximum of protection for the operating staff and the public.

The second level concerns such incidents as partial loss of flow, reactivity insertions, failure of parts of the safety system, or fuel handling errors, which are assumed to occur in spite of the care taken in design, construction, and operation. This second level provides fault de. ction equipment and design features which enable such occurrences to be arrested or accommodated safely. Conservative design practices, adequate safety margins, and parallel, independent, redundant arrangements of detecting and actuating equipment (so that if one fails, others will be available to provide protective action) have been used in the design and operation of the FFTF reactor protection systems. In addition, these systems have been designed to be readily inspected and tested so that there is a high degree of assurance that they will operate reliably in the infrequent event they are required.

The third level concerns the postulated failure of protective safety systems simultaneously with the accident they are intended to control. The consequences of such hypothetical accidents have been evaluated and understood. Furthermore, practical design means have been found to provide additional measures of safety to mitigate the accident or accommodate the consequences. These include design items such as adequate reactor head and reactor plug hold-downs.

b. Safety Research and Development Program

To help achieve and substantiate the safety and other environment-related requirements, the designers, operators, regulatory groups and other groups concerned with the success of the FFTF have relied for guidance upon many sectors of the nuclear industry.[12,19,22,37-41,45,47,49,50,52-61,66-79,81,82] This guidance has helped provide realism and confidence in the understanding and analysis of accident situations; develop and evaluate safety systems for the prevention of accidents and mitigation of their consequences; provide information on which quantitative evaluations of safety margins can be based; and develop standards and codes for the safe design, siting, construction, and operation of the plant. The LMFBR safety research and development (R&D) program has been used directly to resolve technical uncertainties, and provide realistic, technologically-sound frames of reference within which judgments can be made.

Many of the inherent characteristics of the LMFBR and other more specific features of LMFBR design and operation that bear upon safety of the demonstration plant have been under investigation in the LMFBR safety R&D program for over 20 years. The efforts under this program have been increased significantly as part of the recent emphasis on designing the FFTF and developing the demonstration plant program. Thus, priorities for conducting this R&D are continuing to be developed as the designs of these plants move ahead. The scope of the LMFBR development programs related to safety includes the phenomena associated with errors and emergency abnormal operation, identification of potential accident mechanisms, and the development of quality assurance procedures and safety systems designed to prevent accidents and to limit their consequences, should they occur.[84] These considerations are discussed in depth in this statement and in the FFTF Preliminary Safety Analysis Report (PSAR),[44] which has been submitted to the AEC Regulatory bodies and to the ACRS, and reviewed in accordance with established procedures. A Final Safety Analysis Report (FSAR) is being prepared.

In response to the needs of the FFTF program, the LMFBR safety program had addressed the occurrence of postulated accidents and the potential effects of events that could be assumed to follow, such as destructive energy releases, sodium fires, fission-product and plutonium releases and core meltdown. While recognizing that the design of the FFTF emphasizes accident prevention and early detection and control of potential errors and defects that can be postulated to lead to accidents, the safety R&D program for the FFTF also has included studies of consequence-limiting safety systems designed to ameliorate the effects of such accidents in the plant.

Detailed design work on the FFTF has taken advantage of progress in the demonstration plant program and other ongoing LMFBR development programs. The design effort has concentrated on reactor plant reliability and integrity through a systematic engineering approach embodying the development and application of improved engineering standards, codes and criteria and strengthened quality assurance practices. These engineering approaches were delineated in guidelines which governed the reactor design and which have been and are being implemented in detail in the System Design Descriptions (SDDs) prepared for this plant. The evaluation of these design efforts has been presented in the PSAR.[44] They include:

(1) The identification of abnormal operations, component malfunctions, and system faults that have potential safety implications.

(2) The characterization of conditions that could lead to damage of the reactor or plant.

(3) The development of accident analysis and safety evaluation methods.

(4) The demonstration of the adequacy of protection systems and devices.

(5) The identification of the information on which adequate designs of containment buildings and consequence-limiting safety systems can be based, including sources of potential releases of energy and radioactivity.

As the FFTF design and development programs have proceeded, these considerations were subject to continuing review by the designer and by review or regulatory groups. Where problems arose, the plant designer had options which he exercised and continues to exercise to provide the required protection for plant operators and the public.

c. FFTF Safety Characteristics

Certain basic plant design features are extremely important in the assessment of the various aspects of the FFTF related to safety. The first of these features is that a number of barriers must be breached before the radioactive materials in the fuel could be released to the environment. The first barrier is the fuel material and its metal cladding, which are designed to provide a high degree of retention for these radioactive materials. The fuel rods and the sodium coolant are contained in a high integrity steel primary system which comprises the second independent barrier to the escape of radioactive materials. The third barrier serves to prevent the dispersal of any radioactive materials that might be released beyond the confines of the fuel cladding and the primary system.

This barrier includes the inerted equipment cells surrounding the primary system components which would help isolate radioactive materials, and the low leakage containment building which serves as the final barrier to their release to the environment. These barriers were described in Section II.B.2.h.

In addition to the presence of multiple barriers, a second notable characteristic of the nuclear power program, applicable to the FFTF, is the degree of conservatism and the extent of the safety margins provided in nuclear power plant design and operation. The FFTF has been designed with large margins or "safety factors" between normal operating conditions and those conditions which could begin to raise safety concerns. These margins take the form of the number of errors and failures which must occur and remain uncorrected, the number of protective devices to control progression from normal to abnormal conditions, and the amount by which specific conditions would have to change, before safety limits would be approached. These margins are identified in the detailed FFTF plant system design descriptions and in the FFTF safety analysis reports.

Certain inherent characteristics of the FFTF which provide a third feature bearing upon its safety have been optimized through design efforts.[85,86,87] One of these inherent characteristics is the excellent heat transfer properties of the sodium coolant. The high thermal conductivity of sodium along with its thermal capacity permits arrangement of the cooling system so that little, if any, forced circulation of the sodium is necessary to remove after-heat from the reactor core without fuel cladding failure in the event that all normal pumping capacity for the coolant is inadvertently lost, or if a major leak occurs anywhere in the main coolant system.

In addition, the boiling point of sodium is much higher than the normal operating temperature of the FFTF, allowing the plant to be operated at near-atmospheric pressures. This low pressure operation improves the potential for maintaining system integrity and reduces the possible propagation of small leaks, should they occur, into larger ones. Also, this permits the use of a low pressure containment building with its attendant simpler design and fabrication requirements. These characteristics of sodium permit design configurations to be employed which give a high degree of assurance that the reactor core will remain covered and the fuel cladding protected even under extremely pessimistic accident assumptions. They will permit after-heat to be removed from the core despite severe system disruptions.

Yet another intrinsic feature of LMFBRs such as the FFTF, is the Doppler coefficient, a characteristic of the neutronic properties of U-238. The Doppler effect acts to reduce the power level of the reactor whenever the fuel temperature increases. In a postulated off-normal operating situation, such as a rapid unanticipated rise in power level at a rate beyond the capability of the control system to regulate, the fuel temperature would rise with the power level. As the fuel temperature rises, the increasing Doppler effect would act in a way to limit the rise in power.

While these and other favorable intrinsic features are taken advantage of and optimized in the design, the reactor designer has taken into appropriate account other inherent features which could prove unfavorable from the standpoint of safety.[44] These, of course, are among the key concerns which have been investigated in the research, development and design programs for the FFTF. One of these is the positive feedback effect of sodium void coefficient on power level. Sodium voids which could be postulated to occur in the core (for example, as a result of a major overpower transient or reduced sodium coolant flow due to fuel element flow blockage) could cause an undesired increase in power level and possibly some fuel damage. In recognition of this possibility, methods have been developed[44] to reduce the possibility of voids occurring in the reactor core and to mitigate and accommodate safely any unfavorable voiding effect, should it occur. Blockage by voiding is prevented by multiple flow passages in the fuel subassembly inlet. Loss of coolant is further prevented by guard vessels and pipes around the reactor and piping. Research and development programs are continuing to improve further the understanding of sodium void effects, confirm safety margins and provide necessary information to permit improved design approaches for future FFTF cores.

Another important intrinsic characteristic of the FFTF which has influenced its design is the chemical reactivity of sodium with air. Sufficient experience with sodium reactor systems has been obtained to assure that this matter is amenable to straight-forward design treatment. For example, as noted in Section II.B.2.f, the primary coolant system will be contained in inert cells to minimize the adverse effects of leaks, should they occur. Other, more difficult problems associated with the use of sodium coolant relate to normal operating conditions, particularly maintenance, due to sodium's high activation under irradiation and its high melting point.

d. Technical and Administrative Reviews

Reinforcing the use of sound design, engineering standards, engineered safety features and supporting R&D as means of preventing and limiting accidents are the requirements and procedures for comprehensive technical and administrative reviews of all factors affecting plant design and safety. These reviews are conducted by the AEC, by the AEC's Regulatory staff and by independent review bodies. Finally, regular inspections of nuclear power plants during construction and operation by the staff are employed to afford continuing assurance of safety.

e. Postulated Accidents

Despite the care taken to assure the safety of nuclear power plants, the possibility of errors, malfunctions and accidents of varying degrees of severity cannot be ruled out completely. Therefore, these possibilities and their potential consequences have been analyzed for the FFTF. This has been accomplished as an integral part of the design process and summarized in the S[illegible]Ds and the PSAR, and a final analysis will be presented in the FSAR. The accidents evaluated in the course of the safety review process include a highly conservative series of assumptions, taking into account the likelihood of occurrence, the nature of potential initiating mechanisms, and the course and consequences of resulting events. The purpose of this conservative approach was to establish limits on the potential consequences for the types of events studied, to determine the plant's potential responses to such events and to assure that public health and safety is adequately protected.

The information and studies conducted on fast reactor accidents show that three general classes of accidents may be defined for the FFTF in terms of the estimated likelihood of their occurrence and the corresponding level of consequences that may result. Plant protection analyses were conducted to examine how the design of the plant will accommodate these accident classes. The first class consists of those accidents or abnormalities which can reasonably be expected to occur during the lifetime of the FFTF. Such events must, of course, be accommodated with little or no damage or interruption of the power-producing capability of the plant and with little repair costs. Examples of this type of event are loss of off-site electrical power, loss of flow from a primary cooling pump, and malfunction of the automatic control systems.

A plant protection analysis has also been carried out for the second class of accidents, i.e., those more unlikely events not expected to occur but which cannot be ruled out. For such accidents a greater degree of damage or interruption can be accepted, but not to such a degree that plant operation cannot eventually be resumed. The type of accidents considered include local fuel failures, fuel subassembly or sub-channel flow blockage, single subassembly meltdown, reactor core misloading, and sodium spills and fires.

Clearly defined safety or damage criteria have been established against which to assess the effects of each type of accident discussed above. A common manner of expressing such criteria is in terms of fuel clad temperature or percentage of fuel clad failure. Thus, in this category of accidents, an important safety consideration is the amount of plutonium and fission products released from the damaged fuel into the primary coolant system. Adequate precautions have been developed to avoid the release of these materials to the environment in such instances.

The third class of accidents is comprised of the more severe hypothetical accidents which are not expected to occur. This class of accidents has been analyzed to assure that sufficient safety margin and capabilities of the containment and the reactor systems exist for the safety of the public. Among the accidents in this category are postulated transients caused by very large reactivity insertions. Included in this category are primary pump failures or large primary pipe failures with simultaneous failure of the reactor shutdown system. Depending on the plant design characteristics and analytical assumptions, such accidents may lead to various degrees of core melting and disruption, and corresponding releases of fission products and plutonium from the fuel. The capability of post-accident heat removal systems to operate as required, and of the reactor containment building to maintain its integrity following such hypothetical events, have been analyzed in conjunction with the anticipated small leak rate of the containment building to determine the radiological consequences of these postulated accidents. These analyses have treated each of the important radioisotopes to determine potential effects on the health and safety of the public.

Among the more severe hypothetical accidents are reactivity insertions sufficient to cause the power level to rise rapidly beyond that for which the reactor was designed, leading to events which could damage the core before the previously described inherent shutdown phenomena or normal control actions take effect.[88] The potential consequences of the most severe accidents of this type that one can conceive within applicable physical laws is a compaction of the fuel into a more reactive configuration resulting in a disruptive energy release. In spite of the extreme conservatism used in core disruptive accident analysis and the remote possibility of such an event occurring, its potential occurrence has been considered in the FFTF design. The PSAR for the FFTF covers the design of the reactor structure and containment and show that there is no credible rearrangement of the FFTF core which could lead to the release of explosive energy with a force sufficient to breach the containment. With the containment intact and little driving force available, there would be little release of noble gases and little, if any, release of other fission products or plutonium to the environment. These conclusions for the FFTF are reinforced by analyses and tests that have been conducted of the behavior of reactors with similar features and structures.[89,90]

While it is impossible to postulate with precision the detailed course of accidents, including their likelihood and possible environmental consequences, it is possible to place bounds on such accidents. The design criteria, guidelines and philosophy that have been developed to assure the safety of previous liquid metal-cooled plants have required that features be built into the FFTF which are consistent with such bounds. Hypothetical accidents have been analyzed for the FFTF, which along with existing information about accidents of these types, make the AEC confident that the design criteria that potential radioactive releases must be safely contained within the plant will be met. There is an extensively body of literature on the safety of LMFBRs from which to draw such conclusions.[91] Major manufacturers have been working for several years on designs for both the FFTF demonstration plants and the commercial LMFBRs with particular attention to analysis of potential safety problems. The PSAR for the FFTF[44] summarizes the latest information from the ongoing R&D programs, as well as on the safety on LMFBRs. Critical experiments with FFTF cores have contributed experimental verification of many of the analytical codes and models essential for the design of the FFTF. Analytical and operating experience has also been obtained from fast reactors such as EBR-II, Fermi, and SEFOR from which important information has been drawn for the FFTF.

2. FFTF Safety Analysis

In spite of the care taken in design, construction and operation, accidents cannot be statistically ruled out. Described below are various classes of such accidents considered in the design of the FFTF.

a. Sodium Leaks or Spills

(1) Radioactive Sodium

During operation of the reactor neutron irradiation of the sodium-23 reactor coolant produces the radionuclides sodium-22 and sodium-24. The total activity of sodium activation products will be about 1.2×10^7 Ci of sodium-24 and 100 Ci of sodium-22 at 7×10^{15} n/cm^2/sec.[36] The activated sodium is contained within the reactor vessel,[24] the main heat transport system[31] and the closed loops,[25] with the exception of sodium sampling lines which carry small quantities of activated sodium to the impurity monitoring and analysis system.[92] The stainless steel barrier prevents release of the radioactive sodium. Any sodium leak developing in the radioactive system would be to the inert nitrogen atmosphere contained in the primary cells and the servicing system cells. The reactor would be shut down, if necessary, to determine the source of the leak, and for necessary repairs if any were needed. The inert atmosphere prevents the occurrence of a sodium fire. The inerted cells are steel-lined and, in the event of a sodium leak from the primary systems or service systems, prevent further leakage of sodium to the surroundings. FFTF sodium coolant systems will employ the highest standards of state-of-the-art construction and quality control for circulating sodium in welded stainless steel piping and vessels. This, together with the low sodium pressures employed, assures that leaks are very unlikely. The structural integrity and the low sodium pressure also assure that in the event of leaks they will be small. Postulated pipe breaks should be regarded as hypothetical. Nonetheless, FFTF design assures that even a hypothetical pipe break can be contained successfully without impairing the outer containment vessel capability to limit leakage of airborne materials.[93] A sodium leak detection system monitors the primary system boundary to detect small leaks.[94]

If small quantities of the sodium do leak out of the inert cells into the containment building, monitoring equipment is available. In the event that sodium activity is detected in the containment building ventilation system, the containment building ventilation valves are shut off to isolate the containment building. Any leakage through the ventilation system is drawn through a high-efficiency filter system to remove any remaining particulate matter before release to the outside environment. Further, nitrogen can be bled from the cells and monitored to detect abnormally high activity. If radioactivity is detected, the nitrogen is processed through the CAPS prior to release.

Small quantities of sodium that are removed for sampling (about 35 grams per month for each of 12 samples/mo) are run to inerted cells where sampling operations are performed. Leakage from these operations goes first to the cell, and any amount leaking from the cell is drawn through the filter system outside the building before being released to the outside atmosphere. In summary, sodium leaks from the reactor primary system or servicing system cells must go through multiple monitoring points and barriers before any release occurs to the outside atmosphere, making such release highly improbable.

(2) Nonradioactive Sodium

The interface between the primary and secondary sodium which is used to cool the reactor occurs at the intermediate heat exchanger (IHX), both in the main systems and on the closed loops. Normally, the secondary sodium should not be radioactive, but there is expected to be some contamination by tritium diffusion from the primary to the secondary system. Tritium contamination levels will be extremely low in the secondary system. (See Section IV.A.7.b) Radioactive contamination of secondary sodium with other radionuclides contained in the primary sodium system can occur in the event of a leak in the IHX barrier. The activity level in the secondary sodium side of the IHX is monitored by instrumentation to detect such contamination. Leaks of secondary sodium in the vicinity of the secondary sodium piping, the dump heat exchangers or sodium storage facilities for new sodium could react with air producing sodium oxide which could create a hazard in the immediate vicinity of the FFTF site. Procedures are being developed to cope with this hazard.

(3) Detection and Control[34]

Sodium leaks are normally indicated directly by leak detection devices installed on piping and components, atmospheric space sensors within the cells to detect sodium vapor, storage vessel level changes, or by reduction in cooling/flow capability. Devices installed on piping and components are electrode-type leak detectors. Space sensors are smoke detectors. Leaks may also be detected by a drop in sodium level as indicated by level detectors. Changes in flowmeter and EM pump performance and abnormal heat exchanger temp temperature distribution could also give an indication of a sodium leak.

Upon detection, the affected portion(s) of the system can be shut down, depressurized and drained before large quantities of sodium can escape. Drip pans located beneath equipment and vertical runs of pipe serve to collect leakage and reduce the fire hazard by minimizing the escaped sodium surface area. Oxidation within inerted cells will be slow and minimal. When leaks occur into air atmospheres, rapid oxidation becomes more probable, and steps must be taken to bring the situation under control.

At the DHX the leaking lines can be isolated. If a fire has started, the involved DHX can be shut down, isolated and filled with nitrogen. Catch pans in the DHX housings are of a design that minimizes burning surface area.

Fire fighting will consist of taking those steps necessary and using the materials appropriate to bringing the situation at hand under control. Fire fighting methods and materials are still undergoing considerable development. Once the fire has been brought under control, no further action will be taken until the sodium has cooled and solidified.

(4) Sodium Leaks during Maintenance

Sodium leaks or spills could occur within the containment building during maintenance operations on primary components including closed loops located within the heat transport cells. During maintenance these cells contain an air atmosphere. Prior to maintenance, the activity of sodium-24 would decrease to insignificant levels by radioactive decay to allow access, but small quantities of corrosion and fission products and sodium-22 may be present in the primary coolant due to operation with failed or vented fuel prior to shutdown. If a leak or spill occurs under this situation, the release would be to the air atmosphere in the cell which is open to the containment building. During these operations, the air exit from containment as noted before, is monitored by instrumentation to isolate the containment building upon detection of an abnormal amount of activity. This system is backed up by a filtration system which limits release to the environment to insignificant levels.

b. Sodium Contamination following Fuel Clad Failures

Tritium activity is produced by neutron capture in B_4C control rods, tenary fission and neutron capture in lithium impurities in the fuel. Tritium generated at FFTF will be found throughout the sodium and radioactive gas handling systems. Based upon information gained from operation of other fast reactors, it is expected that the majority of tritium diffusing from fuel pins and control rod mechanisms will be retained in the cold traps, but some tritium will be found in the inerted cells and primary and secondary sodium. The small quantities of tritium in the inerted cells will be oxidized and removed as tritiated vapor whenever the CAPS is operated. Details regarding tritium production and movement through the FFTF are given in IV.A.7. Based on that analysis, a concentration of 10^{-7} Ci/cc of tritium in the coolant may be typical, assuming cold trapping in sodium (Table IV.A.7.1). A concentration of about 10^{-10} Ci/cc in the cover gas may be typical.

Entrainment of noble gas fission product activity in the coolant is expected to be negligible. This activity is expected to be found only in the cover gas. The FFTF radwaste system is designed to accommodate failure of one percent of the fuel with a release of gaseous fission product activity into the cover gas of about 10^4 Ci. Expected inventories are more than an order of magnitude smaller.

Potential nongaseous fission product activities in the coolant include only nuclides that have boiling points in the elemental or oxide forms that are >1300°F. Further, if the half-life of the nuclide is shorter than 0.1 day, migration time in the fuel will be sufficient to preclude release of the nuclide or its daughter activity into the coolant. As noted in Section IV.A.7, FFTF is designed to permit continued operation with as much as one percent of the driver fuel failed with complete release of volatiles. Design margins are an order of magnitude higher than expected failures and allow for abnormal accidental releases.

c. Radioactive Waste System Leaks or Spills

The FFTF radioactive waste systems are described in Section IV.A.7 of this report. The waste equipment is located in cells below ground in the reactor service building near containment.[80] The gas system is designed to accommodate the gaseous fission products generated due to operation with one percent fuel failures in the core and defected fuel failures of all fuel pins in four of the closed loops. The maximum design inventory of noble gases in the gas system is estimated at 10^5 Ci. The liquid waste system is designed to collect various categories of waste, including low/intermediate level, high level and transuranium contaminated waste. The liquid waste system is designed to handle 47,500 gallons of waste per year.

In actual operation the number of fuel pin failures, and consequently the actual curie inventory, and the liquid waste throughput are expected to be one to several orders of magnitude less than design values.

The inventory of noble gases leaked from the fuel is expected to remain within the confines of the RAPS during normal operation of the facility. In the event that some abnormal leak develops within this system, this leakage will go to the surrounding cells. The atmosphere in these surrounding cells is monitored and, in the event of an abnormally high activity level, the atmosphere is routed to the CAPS. CAPS is designed to process gas from the inerted and air cell atmospheres which have the potential of containing radioactive gas. As described in Section IV.A.7, the CAPS will reduce the noble gas radioactivity in the process gas so that the AECM 0524 restricted area concentration limits are not exceeded at the heating and ventilating exhaust exit. Any particulate matter is removed by the filter system in the exhaust which exits to the environment.

Leaks in lines carrying cover gas that occur in the head cavity region result in leakage of radioactive gases into the containment building. When the activity is above a pre-set level (to be determined), the containment building ventilation valves close and escape of the contaminated atmosphere to the environs is determined by the leak rate of the containment building and decay rate from the radionuclides. Should leaks develop in lines carrying cover gas while inside an inerted cell, the contaminated cell atmosphere is diverted through the CAPS for decontamination before release to the environs. Material that leaks from the RAPS because of a line rupture or other failure is diverted through the CAPS for decontamination before release to the environs. The CAPS is basically an accident system, operating only when activity levels in monitored effluents are above pre-determined levels (to be determined). Accidental leaks from the CAPS require occurrence of an accident to that system simultaneous with the accident leading to activation of the CAPS; such an occurrence is considered highly unlikely. In all cases of such leakage, steps would be taken to end the leakage, effect repairs and return to normal operation as quickly as possible.

Should cooling to charcoal delay beds be interrupted, the affected bed(s) will heat at a rate of approximately 10°F/hr. Temperatures of 1000 to 1700°F would be reached in seven to ten days, depending upon the particular bed(s) which lost cooling. If only one bed is affected, that bed can be bypassed and the effect on the system will be rather small. If cooling was lost for an entire system, delay and distillation of krypton and xenon nuclides would no longer be possible. In the case of the RAPS this would mean that cover gas activity would increase until repairs could be made, but there would not be significant radioactivity releases to the environment. For the CAPS such an event is considered incredible since simultaneous failure of two independent systems is required.

The liquid waste system is designed to minimize the potential release to the environment in the event of leakage from the system. Liquid waste cells are equipped with sumps to collect any liquid which should leak or spill in the area. Any spillage is thus routed to a tank or component which is in working condition. In the event of leakage during sampling operations, the spillage will be contained within glove boxes. Redundant valves are provided in the sample lines in order to prevent uncontrolled leaks. Fires in liquid waste areas are unlikely since no combustible material is used in the liquid waste storage process. The atmosphere in the liquid waste cell area is routed through the H&V filter system prior to release to the atmosphere. Thus, no adverse environmental effects are expected due to spills or leaks in the liquid waste handling area.

In the solid waste storage vault, the only identifiable method of releasing radioactive material is the remote possibility of a fire. Packaging procedures require that flammable materials are separately packaged to minimize the possibility of fire. If a fire should occur, it will be localized within the cell. The heating and ventilation system filters prevent radioactive particles from being released to the atmosphere. Standard fire fighting techniques will be used to extinguish the fire and to minimize damage.

d. Fuel Meltdown

Fuel meltdown has occurred in sodium-cooled reactors due to either a reactivity disturbance as in EBR-I or coolant blockage as in SRE and Fermi.[81] FFTF design has incorporated a number of features which preclude such meltdowns. Movement of core components has been made impossible by the use of core restraints. Voiding within any significant fraction of a subassembly has also been made impossible in all but very hypothetical situations by a design which assures that there shall always be flow paths around any potential flow blocker. Guard pipes have been included around piping to assure that leaks in primary piping cannot result in loss of cooling to the reactor.

If a meltdown were to occur, the noble gases released would be expected to migrate through the sodium to the cover gas space. The cover gas is processed by the Radioactive Argon Processing System (RAPS) during normal operation, Section IV.A.7.a.1. In the event of an abnormally high activity in the cover gas line leading from containment to the RAPS, present plans call for the cover gas to be isolated automatically. This is under review. At a later time the noble gas inventory could be bled to the RAPS for processing in a controlled manner.

The remaining fission products and fuel released from the cladding as a result of the meltdown would remain with the primary sodium. Radioactive decay during recovery operations would decrease the amount of activity present. If a single subassembly were to melt resulting in the release of one hundred per cent of the halogen and volatile fission products and one per cent of the solid fission products and fuel, the following activities would be present in the sodium after 100 days of decay: 20 Ci of halogens, 9000 Ci of fission products, and 10,000 Ci of plutonium. These fission products and fuel would be cleaned from the sodium by continued cold trapping of the primary sodium.

e. Fuel Handling Incidents

Numerous fuel handling operations are performed in FFTF involving movement of new fuel into the reactor and removal of spent fuel and test fuel after irradiation.[30] The driver fuel elements are expected to remain within the reactor vessel in a storage position for one operating cycle (about 100 days) to allow decay prior to removal.

The fuel handling equipment is designed with multiple cooling systems and multiple barriers to prevent the release of radioactivity outside the machine. In the unlikely event of loss of both of these redundant cooling mechanisms, or the even more unlikely possibility of mechanical damage, causing damage to the cladding or partial meltdown, partial release of the gaseous inventory might be expected. With the fuel handling machine located inside the containment building, the release occurs to the containment building atmosphere. Monitors on the containment building exhaust detect the abnormal rise in activity level and isolate the containment building. Any leakage that occurs prior to actuation of containment or due to leakage through penetrations after isolation is routed through the containment building ventilation filter system for removal of particulate matter. If a fuel handling incident occurs outside of containment in the reactor service building, release would occur to the reactor service building atmosphere. This atmosphere is also routed through the filter system to remove particulate matter. Thus, release to the environment due to fuel handling incidents is minimized, first, by multiple means of cooling the fuel element during transfer, second, by multiple barriers surrounding the fuel element within the fuel handling equipment design, third, by the containment isolation system if the accident occurs inside containment, and fourth, by the filtration system located outside containment.

The irradiated fuel that is removed from the in-vessel storage positions is normally placed in the interim decay storage vessel (IDS). This vessel is located in an inerted vault below the operating floor of the containment building. The IDS is equipped with redundant cooling systems to prevent any overheating in the event of a single failure. **Based on 112 fuel subassemblies (not expected in practice), and decay heat of 240 KWt and assuming loss of both cooling systems, it takes two days to reach sodium boiling. Fuel melting would not occur until all sodium boiled away. Corrective action can be taken before this happens. A** battery operated cooling system could be connected to prevent clad failure. Even if all three cooling systems fail, no adverse environmental effect is expected since the fission products released would be processed by the CAPS. In addition, the gaseous fission product activity present in the IDS fuel has decayed to very low levels during the 100 days of in-vessel storage.

Irradiated fuel may be routed to the Interim Examination and Maintenance (IEM) Cell for inspection and/or disassembly of the fuel assembly. The IEM Cell is located below the operating floor in the containment building in a shielded inerted valut. Two recirculating redundant cooling systems are provided for cooling of the argon atmosphere in the cell. In addition, two recirculating redundant cooling systems are provided to cool test assemblies located within the cell. Each of these systems is provided with pre-filters and HEPA filters to prevent the release of any particulate matter which may be generated in the cell. Any gas released due to overpressure is routed to the CAPS system for processing.

A sodium removal system is also provided to remove residual sodium from spent core components and irradiated fuel. This operation may be done within the IEM cell or within the core component cleaning cell located in the reactor service building. The cleaning operation is performed by placing the fuel element in a sodium removal chamber and passing moist argon over the assembly to react the residual sodium. This is followed by a water rinse to remove the reaction products. The argon cooling system is provided with redundant blowers to assure adequate cooling at all times. In the event of complete failure of the gas cooling system during cleaning, the decay heat can be removed by circulating the cleaning water. Failure of both these systems could result in partial melting of a fuel subassembly in the IEM cell. In the core component cleaning cell the fuel will have been decayed for 200 days eliminating nearly all gaseous fission product activity except krypton-85. Meltdown cannot occur in this area. Any release from a fuel element will be confined to the sodium removal system. Thus, no adverse environmental effect is expected from these operations.

f. Hypothetical Accidents[44]

In addition to the above incidents, FFTF has been analyzed to determine its capability to contain a hypothetical core disruptive accident (HCDA) with a minimum environmental effect. A massive increase in reactivity or a severe loss of cooling capability is postulated to occur in the reactor unabated. This event is hypothesized even though extensive instrumentation and shutdown systems are provided for the express purpose of preventing the HCDA (Section II.B.2.c). The HCDA is calculated to result in disassembly of the reactor core with only a modest work energy release. This is substantially below the design capability of 150 MW-sec provided by the containment systems, including the reactor vessel and the heat transport systems.

Following such a postulated event, some radioactivity may be released to the inerted spaces surrounding the primary system. Aerosol fallout in this region reduces the amount of material that leaks to the containment building atmosphere. The fraction of material that leaks to containment is reduced further by fallout in this volume combined with the very low leakage rate from the containment building to the surrounding reactor support buildings.

To further increase the knowledge and understanding of the behavior of the FFTF fuel, the reactor and the coolant, the LMFBR R&D program incorporates studies to characterize these. Coolant studies include investigations into coolant behavior under a variety of high heat conditions, sodium fires and coolant/cladding reactions. Reactor studies are underway to investigate transients from loss-of-flow and overpower conditions and response of containment to severe pressure and blast loadings following large energy inputs. Fuel studies include the investigation of failure mechanisms and dynamic plastic deformation of subassemblies. Computer codes are being developed to permit more rapid, accurate modeling of reactor, coolant and fuel behavior under hypothetical accident conditions. Further details have been discussed in Section IV.B.1.b.

3. Criticality Considerations

One of the potential problems in working with fissionable materials that is applicable to all stages in the fuel cycle is the possibility of accidently achieving a critical mass. This problem is well understood, and many years have been spent in developing and refining procedures, controls and protective devices to preclude the possibility of a criticality accident. The several criticality accidents that have occurred over the more than 25 year history of the nuclear age have resulted in only local effects, limited to those workers in the immediate vicinity of the vessel, tank, or other container in which the accident occurred.

The basic control factors for nuclear criticality safety in the handling, storing and processing of fissionable materials are geometry controls, mass controls, density controls and spacing controls. Geometry control is defined as the limitation on dimensions for containers and equipment in which fissionable material is placed to that dimension in which a critical condition cannot be attained. Similarly, mass control is applied so that the allowable mass of fissionable material in one batch or location is subcritical for all credible conditions to which it could be exposed during processing, handling, etc. The control factors may be applied in as many combinations as required for any particular circumstances in the handling of fissionable material. In general, sufficient factors are applied so that at least two unlikely, independent and concurrent changes in process conditions would be necessary before a nuclear incident could occur.[95-98]

In addition to the physical parameters used to preclude accidental criticality, various administrative procedures are employed as required in specific cases. They may include, but are not limited to, written plans and procedures for receiving, inspecting, storing and handling fissionable material, pre-operational process analyses to determine critical masses or densities, identification of required control factors, and other procedures. The necessary administrative procedures are identified and analyzed in the safety analysis reports that must be prepared covering each step in the handling of fissionable material.

In summary, the problem of criticality control for fissionable material to be fabricated, shipped, stored, processed, etc., for the FFTF is no different from that for other nuclear facilities. Proper precautions are being established for each step in the FFTF fuel cycle, and will be documented in the separate safety analysis reports prepared covering each facility at which nuclear fuel is handled. Based on these detailed analyses and their reviews by the AEC, and on the procedures and safety measures that have been developed and proven effective in preventing criticality, it is felt that inadvertent criticality can be avoided in handling nuclear materials from the FFTF and will present no new or significant environmental problems.

V. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

The construction and operation of the FFTF will have both short-range and long-range effects on terrestrial and biological ecosystems. The disturbances which bring about an alteration to the environment include general noise, increased traffic, road construction, operation of power and sanitary facilities, development of areas for materials and temporary storage, erection of permanent buildings and considerable earthmoving. Alterations to the local environment due to plant construction, including the effect on local wildlife, should be comparable to that of other large construction projects undertaken with comparable work forces (about 800-1000 men). The specific effects on the wildlife indigenous to the selected site are addressed in this environmental statement. It is anticipated that after construction is completed, and the plant site is cleaned of debris and construction equipment and has been landscaped, the surrounding site area beyond the immediate several acres occupied by the FFTF will be restored to conditions comparable to those which existed originally. The physical plant will cause a visible change to the landscape, but through architectural design the FFTF should blend aesthetically with the natural environment.

There should be no pollution of water resources due to operation of the FFTF. The sewage system is of a design which should have no unavoidable adverse environmental effects. FFTF is located approximately 4-1/2 miles from the Columbia River and groundwater which moves toward the river is some 170 feet below the FFTF site. Contamination of the groundwater or the river by waste water generated at FFTF is not foreseeable.

A small amount of unavoidable radioactive gas will be released to the atmosphere via seal leakage, etc., as described in Section IV.A.7. Diesel exhaust from periodic testing and operation of the diesel generators and dump heat exchanger preheat system will result in combustion products released to the atmosphere.

The only unavoidable adverse thermal effect of the dump heat exchanger system may be the effects on birds entering the heated plume near the heat exchanger air outlet. The heat will be dry and plume rise is well below minimum ceilings for aircraft above the Hanford Reservation so that no other adverse effects are anticipated. Occasional low-level altitude flights are authorized by the AEC; however, the path of these flights can be controlled and it is not likely that any severe effects would be realized unless aircraft were to fly at very low levels. The heat discharged to the atmosphere is not expected to have local effect on weather conditions or ecological systems.

The number of persons employed at the FFTF site will vary from as many as 1000 during construction to 250-275 during operation. This number of persons is small compared with the total employment and employment changes in the area.

Parking at and roads to the FFTF site will be adequate. The facility will neither create nor aggravate traffic or other congestion.

The noise level in the area of the FFTF during construction will be typical of that for any heavy construction operation and is not expected to particularly affect local fauna. Following construction, the chief noise source at the site will be the operating dump heat exchangers. This noise should be less than 90 db at the heat exchanger buildings and is not expected to significantly affect local fauna. Because of the distance to other facilities and residence populations, no nuisance effects should be noticed.

VI. ALTERNATIVES

A. Alternative Neutron Flux Sources

Thermal flux test facilities

Fast breeder reactor fuels and materials require a test environment of high temperature flowing sodium, a fast neutron flux environment, and high sodium temperature differentials necessary to adequately duplicate the behavior of LMFBR fuels and materials. Such an environment has been shown to be significantly different from a thermal flux reactor environment. For example, fuel and structural materials in future fast breeder reactor cores may be exposed to sodium temperatures of 1,300°F to 1,400°F (associated with sodium bulk outlet temperatures of up to 1,200°F), fast neutron fluxes of up to 10^{16} n/cm^2-sec, fast neutron fluences of up to 10^{24} n/cm^2 and sodium temperature differentials up to 400°F.

None of the existing thermal flux reactors could in any way be altered to provide a large enough fast flux and a proper environment for use in the LMFBR fuels and materials test program.

Fast flux test facilities

Since 1960 many studies[99-109] have been conducted to determine alternative ways of providing adequate fast flux irradiation test facilities. It was determined that existing fast flux reactors, EBR-II and Fermi, not designed originally as fuels and materials test facilities, could provide an interim measure of fast flux tests, but were inadequate to accomplish the in-depth testing needed for demonstration LMFBR plants and commercial LMFBR plants.

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Both EBR-II and Fermi have limitations as to neutron flux spectrum, sodium coolant conditions prototypic of the future LMFBRs, testing capability required for highly instrumented and controlled fast flux environment tests, and adequate test space which can be provided for only in closed and open loops and the driven fuel section of the FFTF reactor core.

The U.S. has been fortunate to have EBR-II which is the only currently available U.S. facility performing fast neutron flux irradiation of LMFBR fuels and materials. This facility has been modified and upgraded sufficiently to provide for the development of the first cores of the FFTF and the LMFBR demonstration plants. Though the test specimens cannot be instrumented (except for one instrumented in-core test subassembly) and precisely controlled (i.e., items such as sodium chemistry, sodium temperatures, and sodium flows in a given test position), valuable and meaningful data is being obtained from this facility. The use of EBR-II has been given top priority and all reasonable means taken to increase its plant availability factor and testing capability.

Fermi, a sodium-cooled fast breeder located in Michigan, could be used to supplement EBR-II irradiations depending on its availability. High availability of Fermi at high temperatures and high flux conditions would give this country another source of fast neutrons.

As the result of the series of both thermal neutron flux and fast neutron flux test facility studies, a decision was reached in 1965 by the AEC that construction of a Fast Flux Test Facility (FFTF) must be undertaken if the national objectives of the LMFBR research and development program were to be achieved. The FFTF was initiated by the AEC in 1966.

B. Alternative Sites

1. Off the Hanford Reservation

The principal locations considered for the FFTF were the National Reactor Testing Station (NRTS) in Idaho and the Hanford Reservation. Both of these are isolated, sparsely settled controlled access sites essentially deserts. Location of the FFTF at either site would result in similar environmental effects. Because of their characteristics they have been used for decades for reactor experiments and test operations.

The Hanford Reservation site was selected over other sites for several reasons including: (1) availability of qualified management and technical personnel, (2) availability of project and design resources, (3) availability of improved communication and travel facilities, (4) considerable experience in the development of plutonium fuels, and (5) experience in the design and construction of large scale reactors such as the "N" reactor.

2. On the Hanford Reservation

There are many satisfactory sites for nuclear plants at Hanford. Figure VI.B.2.1 shows the location of several sites which were considered. The four sites selected for detailed evaluation[110] are shown with distance radii encircling the sites. The site selected for the FFTF is labeled "recommended site" except this site was later moved 2 miles northwest to a higher evaluation to minimize any conceivable groundwater problems that might occur as a result of the proposed Ben Franklin Dam (shown on figure) or construction of nearby cooling ponds for potential nuclear power plants.

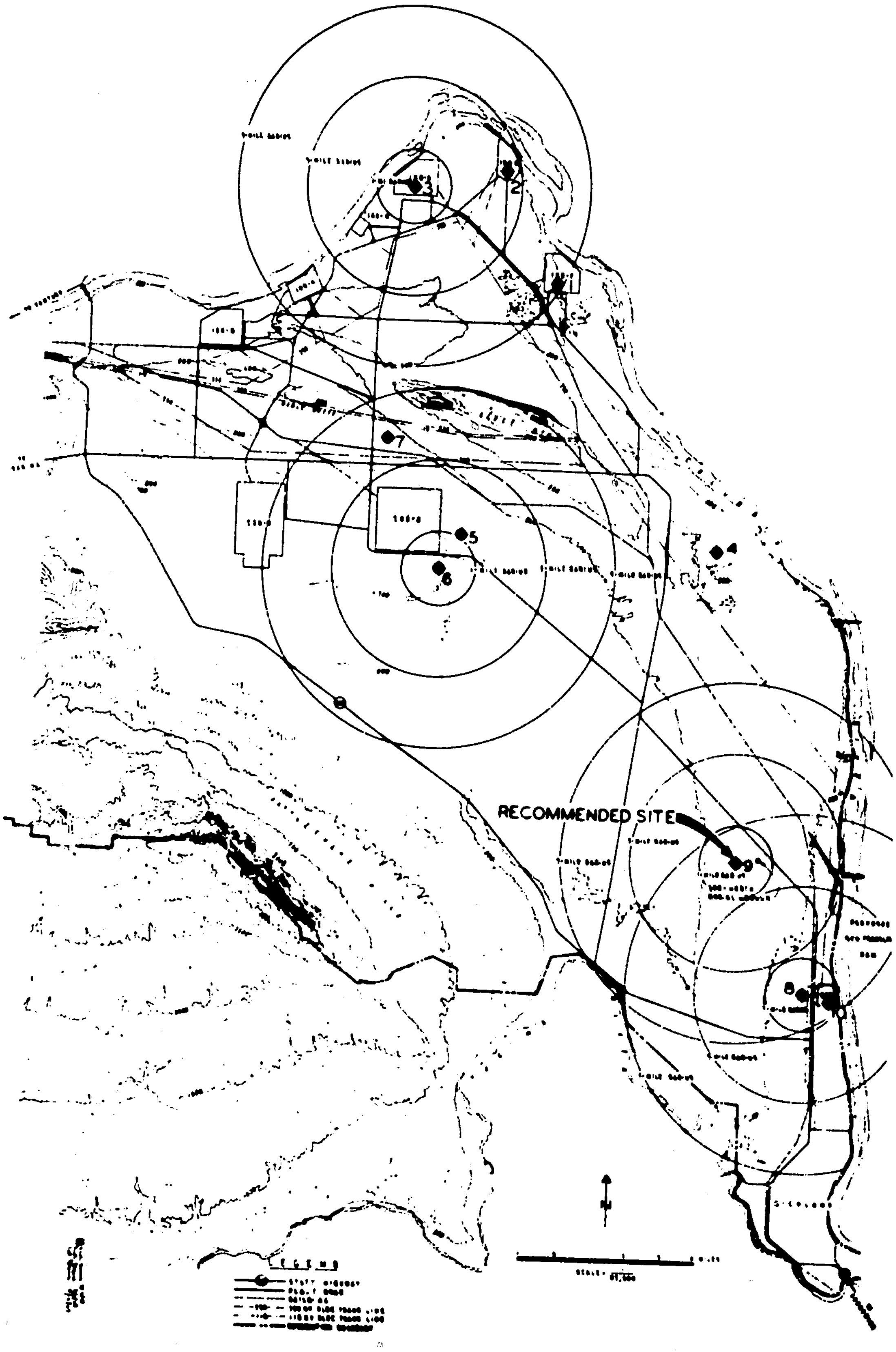


Figure VI.B.2.1 Site Study Map

Figure VI.B.2.2 shows the site in relation to other Hanford Reservation land uses. The vegetative recovery study areas shown near the site will not be affected by the FFTF. These are burned areas which were damaged in a brush fire in 1970.

The principal advantages in selecting the present site were:

1) Convenient access to the extensive laboratory and test facilities in the 300 Area.

2) Substantial isolation from other facilities on the reservation and from populated areas.

3) Lower construction and operating costs compared to sites further north on the reservation.

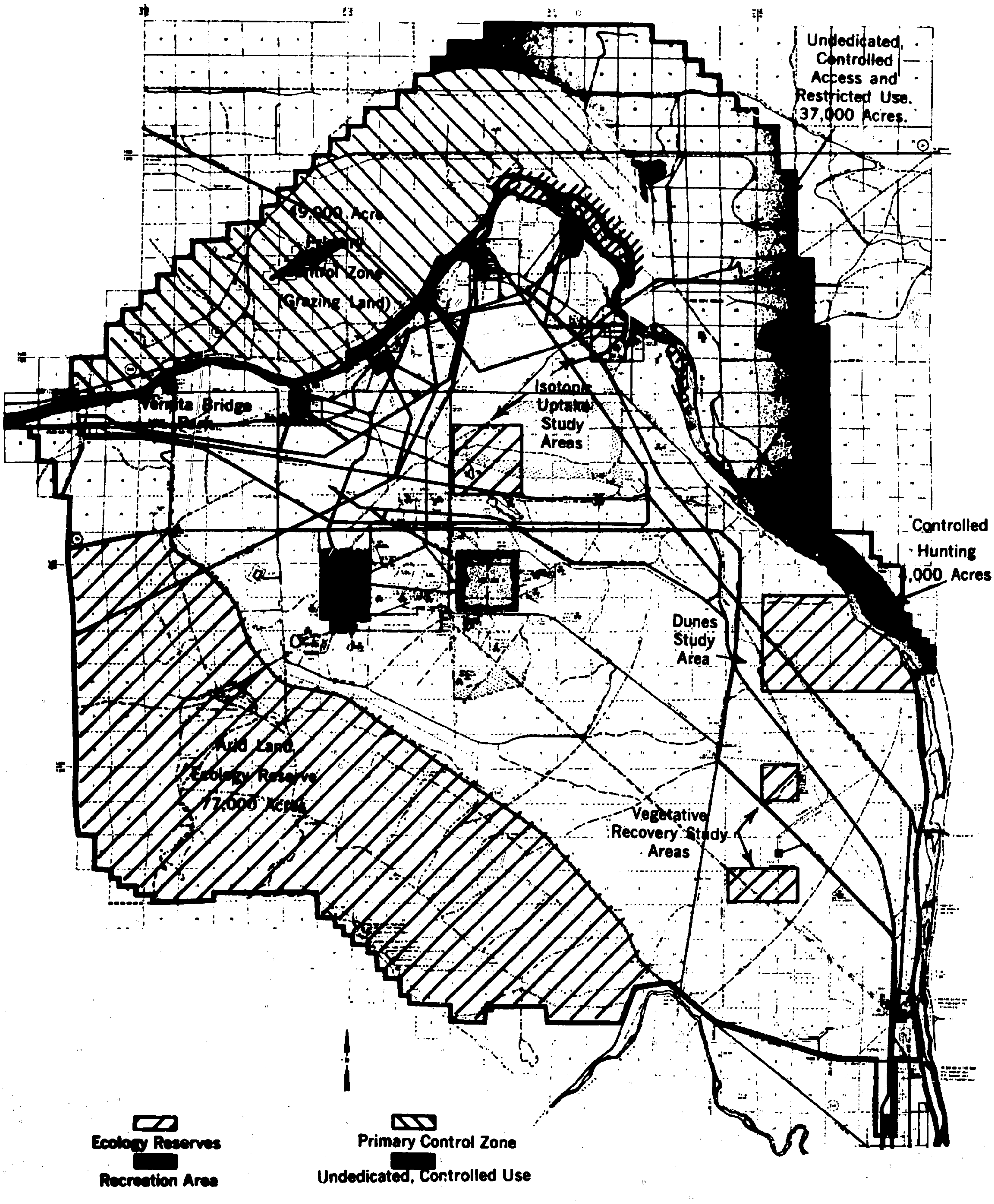
C. Alternative Heat Handling Methods

Alternatives to the air heat dump method, which is the selected heat handling concept for the FFTF are:

1) Rejection of heat from the secondary coolant by steam generation in a tertiary water loop.

2) Direct rejection of heat from the secondary coolant to cooling water in a surface cooler.

3) Electrical power generation with heat rejection from the turbine's waste heat.



HANFORD RESERVATION LAND USES

Figure VI.B.2.2

Methods which are commonly used for the disposal of the waste heat and which are applicable to the above alternatives are:

1) Once through cooling using river water or a cooling lake.

2) Continuous recirculation water cycles using spray ponds, wet cooling towers, or dry cooling towers. The cooling towers may be mechanical draft or natural draft types, and the mechanical draft towers may be further identified as having forced draft or induced draft.

These alternatives were carefully considered before the air heat dump concept was selected.[111]

1. Air Heat Dump

The selected air heat dump method causes no significant environmental problems; Possible side effects due to the large volumes of air passing through the FFTF's dump heat exchangers and the high air discharge temperatures have been considered, and no problems are anticipated. Direct heating at the ground by the hot air is negligible, primarily because of the rapid buoyant rising and mixing of the hot exhaust air with the cooler ambient air. Good mixing occurs because of the large density differences between the hot air and ambient air. Increased cloudiness should not occur because no water is added to the incoming air within the heat dumps. Induced air circulation because of the increased surface velocities near the fan inlets, and ground level eddies, which may be created due to high turbulence above the heat dumps, are expected to be insignificant. Finally, the elevations of the heated plumes resulting from the FFTF operation are well below the 10,000 foot minimum flying height for aircraft flying within the Airspace Restricted Area over the Hanford Reservation.

2. Electric Power Generation

There is no incentive to generate electrical power because the primary mission of the plant is to test fuel and fuel element design. The objective is maximum availability of the plant for neutron irradiation tests. Qualitative comparisons of the availability of an FFTF plant with the realtively simple air heat dump equipment versus a plant with the added complexities of electric power generation equipment clearly showed a preference for the air heat dump method.

3. Water Heat Dump

Preliminary studies were conducted on the direct rejection of heat from the secondary coolant via water cooled surface coolers. Studies and analyses indicated that the sodium-air dump heat exchanger was less complex, less costly and would provide greater plant availability.

4. Steam Heat Dump

A steam heat dump was studied in considerable detail and was carefully compared to the air heat dump.[111] Although the steam heat dump appeared to be feasible, studies and analyses indicated that the sodium-air heat exchanger was less costly, less complex and would provide for greater plant availability.

5. Environmental Impact of Alternate Heat Rejection Methods

If the plant were to be used to generate electricity, it would still be necessary to reject on the order of 70% of the energy developed. This heat could either be rejected to the Columbia River using a conventional once-through cooling system or rejected into the atmosphere through the use of a wet cooling tower. The environmental impact of the once-through system involves the possibility of undesirable ecological impact of waste heat on aquatic species in the river. The wet tower system involves the release of chemicals used to prevent fouling and corrosion and minerals concentrated during the evaporative process to surface streams. The use of a direct water heat dump not associated with the production of electricity would also involve the possibility of adverse thermal effects on the receiving water body. The steam heat dump would be similar to that of the once-through cooling system or water heat dump methods except that a smaller quantity of cooling water would be released at a higher temperature.

VII. RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The construction and operation of the FFTF is not expected to have any adverse effects on the short- and long-term productive use of the site and its environs.

The FFTF will be designed for a twenty-year operating life. This time span would place the decommissioning of the FFTF about the year 1995. At that time, measures must be taken to put the plant into a permanent radiologically safe condition. This act of decommissioning may involve removal of spent fuel, decontamination of accessible areas, removal of radioactive equipment, components, and sodium and sealing the plant against any radioactive leakage that could be harmful to the health and safety of the public. By the time it becomes necessary to utilize these procedures, a wealth of additional experience will have been gained from the decommissioning of nuclear power plants where similar decommissioning considerations are involved.

Sufficient experience is available from the AEC's civilian power program to indicate that decommissioning of a reactor does not introduce any significant new or unknown technical problems of a safety nature which differ significantly from those that may occur during refueling and maintenance of the reactor. Under AEC regulations, procedures for dismantling of the plant will be subject to specific AEC approval and will be required to meet the standards for protection of the workers and the general public. Actually, after removal of the fuel from the reactor early in the decommissioning process, the precautions required for safety are far less than those required for an operating reactor.

A number of alternatives are available for decommissioning the FFTF. These alternatives vary from complete removal of the reactor plant from the site to the other extreme of leaving the plant substantially intact and providing adequate public safety protection in accordance with AEC regulations. Subject to prescribed safety and environmental requirements, it is to be expected that the alternative selected will be that offering the least economic penalty and the greatest assurance of environmental protection, considering such factors as the cost of dismantling all or part of the plant; the extent to which it is profitable to remove individual items of equipment in order to use them elsewhere or recover their salvage value; and the advantage to be gained from reusing the structures at the exact location of the plant. Regardless of the mode of decommissioning selected, the cost will not be substantial in relation to the resources provided for the construction and operation of the plant. In any case, adequate procedures for protection of the public must be established.

On the basis of experience with decommissioning a number of small nuclear power plants, the AEC is confident that the decommissioning of the FFTF can be accomplished with complete safety.

A. Decommissioning Procedures

Considerable experience has been gained in the process of decommissioning of U.S. reactors (e.g. Hallam,[112] CVTR, BONUS, EBWR, PIQUA, SRE, Pathfinder and Elk River). This experience has indicated that reactors can be decommissioned in a safe, predictable and economic manner. The objective of decommissioning the FFTF would be to effectively deactivate and dismantle the plant in such a manner as to protect the health and safety of the public.

The following criteria would be used to judge if the safe decommissioning objective is met:

1. The reactor plant must be made completely inoperable.
2. The fuel must be removed and reprocessed or stored in accordance with standards, regulations and guides.
3. The coolant must be removed and disposed of in accordance with standards, regulations and guides.
4. The radioactive systems must be decontaminated to the predetermined safe level.
5. The plant must be dismantled consistent with Federal, State, and local laws and regulations, and AEC directives.
6. The dismantled units must be removed or stored on site.
7. The final site must be isolated in accordance with codes, standards, regulations, and directives.
8. There must be effective long-term control of the site.

Several options can be exercised as to the means of decommissioning:

(1) Isolation on site of reactor building (Piqua).

(2) Isolation on site of reactor cavity (Hallam).

(3) Complete removal of plant (Elk River).

The following requirements for meeting the criteria delineated are only very preliminary ideas on FFTF decommissioning and in no way can be construed as final. Other ideas include leaving the facility essentially intact after removing fuel, control rods, sodium, and radioactive wastes, decontaminating, and then sealing and isolating the below-floor equipment.

(1) Remove fuel from the FFTF site.

(2) Remove control rods from the FFTF site.

(3) Remove reflector rods from the FFTF site.

(4) Remove in-reactor closed loops from the FFTF site.

(5) Remove reactor vessel internals (in-reactor fuel handling machines, instrument trees and other items) from the FFTF site.

(6) Remove all sodium; remove from site for disposal.

(7) Decontaminate sodium system to maximum extent possible.

(8) Remove control rod drives, rotating plug drives, instrument tree drives, in-reactor fuel handling machine drives, and other equipment above the reactor, decontaminate if necessary, and put into inventory or scrap.

(9) Dismantle non-contaminated parts of ex-vessel fuel handling equipment and put into inventory or scrap.

(10) Decontaminate contaminated parts of ex-vessel fuel handling equipment and put into inventory or scrap.

(11) Decontaminate any other equipment above the floor and put into inventory or scrap.

(12) Permanently seal all operating floor penetrations.

(13) Isolate the reactor by capping and sealing all pipes and pipeways thereto.

(14) Provide a permanent barrier against access to the reactor, the Interim Decay Storage Cell, the Interim Examination Cell, the primary and closed loop cells.

(15) Dismantle and remove gaseous radwaste system and remove 85 Kr storage tank offsite for disposal off the FFTF site.

(16) Remove radioactive waste from storage tanks and remove from site. Decontaminate radwaste system to predetermined levels.

(17) Isolate, seal, and provide a permanent barrier against access to the liquid radwaste system including storage tanks.

(18) The secondary system of both main heat removal and closed loops (piping to the IHX's, secondary pumps, valves, and sodium-air heat exchangers) could be removed, cleaned of sodium and put into inventory. The piping leading to the IHX would be stubbed and capped.

Equipment would be cleaned of sodium and/or decontaminated to the extent deemed necessary. Sodium to be removed from the FFTF site would be shipped after necessary radioactive decay.

A determination would have to be made if items such as (3), (4), (5), (8), (10), and (11) which are listed for removal from the FFTF site could be left in the reactor or left in place above the reactor as the case may be.

Essentially all that need remain of the FFTF would be the below floor reactor vessel and primary piping system including the IHX's up to the secondary piping stubs and caps, the Interim Examination Cell and the Interim Decay Storage Cell.

Considerable experience has been gained in the U.S. and other countries in the removal of sodium utilizing a mixture of nitrogen and steam. This procedure was used successfully for removing radioactive sodium residue in decommissioning the Hallam Nuclear Power Facility. Steaming is continued until several hours after the hydrogen (from reaction) is undetectable. The steaming is followed by a dry nitrogen purge. Non-condensable gases are vented to the radwaste gas system which could be maintained in operation for such cleaning and dismantled afterwards. The systems could be dried by circulating hot dry nitrogen.

The FFTF isolation structure would consist of concrete cells, the concrete and steel biological shield at the floor level, and the steel reactor vessel head, with all accesses and penetrations sealed, and exposed surfaces weatherproofed if necessary. This isolation structure constitutes a permanent barrier against access. All penetrations would be sealed using welded steel closures or equivalent. Stairways could be sealed with concrete. Leak tests would be made to assure tightness of closure.

The containment building, a gas-tight structure, could remain in place with all penetrations sealed, or could be dismantled. All penetrations would be welded, except for a bolted, sealed access door needed for isolation, structure surveillance and inspection.

Inventory Disposal

An inventory of all usable equipment including sodium would be made and circulated to determine if such usable items could be reused or would require storage or scrapping. It is expected that adequate means of disposing of sodium will have been developed before any off-site sodium disposal is required.

Buildings

Buildings other than the containment and reactor service building would be either reused onsite or dismantled and demolished.

Potential Hazards

The main items of concern are:

(1) Loss of isolation integrity

(2) Hazards resulting from loss of integrity

Loss of integrity could stem from:

(1) External corrosion from surface water or ground water

(2) Tornadoes

(3) Seismic disturbances

(4) Sabotage

Item 1. The ground water is far below the containment building. Quality assured weatherproofing and its inspection should insure against surface water penetration. In the unlikely event of surface water leakage into the containment building, the second barrier (assuming the containment building remains), the isolation structure itself would further prevent leakage. Postulating a small degree of water penetration into the reactor, one can assume the water will become contaminated. Its leakage outward would be again barred by two barriers. A worst case corrosion model could be used to determine, in the more unlikely event of outward leakage of contaminated water, as to what radioactive concentrations could result. The radioactive contamination would mainly consist of the activated products Fe-55, Co-60 and Ni-63. Seepage of such contamination could not spread more than a short distance away from the building before detection by surveillance. Experimentally derived factors indicate that in a short distance decontamination (through reaction with soil) by several orders of magnitude occurs.

In connection with contamination release after decommissioning is the fact that with the removal of the fuel and control rods, the sodium, and the sodium reaction products after steam cleaning, there is little radioactivity left with essentially no fission products, essentially no Na-22 and only those long-lived activated corrosion products which have bonded to the structural parts.

<u>Item 2 and 3</u>. Since the isolation structure has already been designed for tornadoes and seismic disturbances, there should be no loss of integrity due to these two conditions.

<u>Item 4</u>. The problem of sabotage is one which is not likely to occur on a restricted site such as FFTF. Further, the act of sabotage would require

complex heavy equipment for removal of welded closures. Third, surveillance of the site would be in force. Fourth, even forcible entry or demolition could release but a small amount of contamination to the surrounding area.

Surveillance and Inspection

It will be necessary to institute a periodic surveillance and inspection of the containment building (if remaining) and the isolation structure to assure that structural integrity is being maintained.

VIII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The operation of the FFTF will involve a small irretrievable commitment of plutonium and natural uranium resources. In comparison with projected LWR, HTGR, and LMFBR operations over the life of the FFTF, the commitment can be considered trivial.

Construction and operation of the FFTF will not effect the development of any mineral resources that may be discovered at the site.

Small amounts of reactor materials used for instrument sensors, control mechanisms, etc. which become irradiated will ultimately have to be committed to long term radioactive waste storage. Also included in this waste would be the fuel cladding and some core structure materials such as the inconel reflector. The reflector and other core materials are not considered scarce material,and the loss of the material to future use should not be critical. Some core material such as the boron-10 in the control rods may be recovered for future use.

IX. COST-BENEFIT ANALYSIS

A. Analysis of Benefits

The primary mission of the FFTF is to test breeder fuels and materials in a controlled prototypic environment and in a manner which will result in increased and improved fuel and reactor plant component performance, as well as improved utilization of our fissionable resources. A secondary objective is to use the FFTF as a centralized facility which can provide experience in the design, fabrication, testing, and operation of sodium components and systems and fuel handling. The FFTF is a key to the orderly and timely introduction of the LMFBR into the nation's electric utility generation industry. This section develops cost-benefit information in the following sequence:

- Development of improved performance LMFBR fuel
- Reduction in LMFBR risks.
- Components and Systems Experience.
- Training.
- Other Environmental Benefits
- LMFBR Cost/Benefit Analysis

1. Development of Improved Performance LMFBR Fuel

The development of a long-lasting, high power density fuel element is essential to the success of the breeder program. This development will require extensive irradiation testing of potential fuel element configurations and their component parts. Resulting information will help determine

LMFBR operational limits on linear power of fuel pins, fuel and cladding temperatures, fuel burnup, and neutron exposure-related structural material parameters. This will result from the irradiation tests and will increase knowledge and understanding of behavior of fuel and fuel materials, cladding, sodium, and so forth.

Increases in fuel performance are related to the following items:

(a) Increased burnup

(b) Increased fuel rating in terms of kilowatts per foot

(c) Increased clad operating temperature related to increased reactor sodium outlet temperature and thereby an increase in plant efficiency.

Some measure of benefits to be derived are as follows:

(a) Each increase of 10,000 megawatt-days per ton of fuel means the equivalent of 24 x 10^7 kilowatt-hours per ton, and assuming 3 tons of fuel per reactor, this adds up to about 72 x 10^7 kilowatt-hours of heat production or about 28 x 10^7 kW-hrs electrical. Assuming fuel cycle costs of 0.75 mills per kW-hr electrical, this is equivalent to a savings of about $200,000. Considering that in a lifetime of a 1000 MWe LMFBR a total of 10 cores may be processed, the savings per reactor of about $2 million is substantial.

(b) The importance of increased kilowatt per foot rating is measured by the decrease in the total number of fuel pins (one million) to be fabricated over the lifetime; subassemblies to be built; and other hardware. An increase from 8 to 12 kW thermal (average per foot) would result in a saving of one-third in the total number of pins for the same height core. This could average out to several hundred thousand pins in a lifetime, a very substantial amount.

(c) Each percent improvement in thermal efficiency gained by increasing the temperature rating improves the impact on the environment by reduction in thermal effects. It also results in a direct decrease in kilowatt-hours thermal output of the reactor which in turn has an impact in the total fuel requirement and other component requirements. This is somewhat offset by increase in component costs due to higher temperature operation. The net is a benefit.

2. Reduction in LMFBR Risks

The FFTF will reduce the risks and costs involved in attempting to test fuels and materials at their limits in demonstration or commercial plants. The enormous investment in these types of plants, and the need to utilize them for their intended purposes, virtually precludes their use for fuel testing. This is not to say that the FFTF is not obtained at a cost. But this cost is more than offset by the potential benefits. The ability to test at or near present limits will permit the eventual establishment of limits on the basis of actual experience rather than prediction. The growth of technology in the light-water reactor field provides ample evidence that such testing and advancement will produce economic benefits due to increased burnup, increased linear power ratings and increased thermal efficiency through increased allowable temperatures. Similarly, fuel fabrication costs will be reduced by determining or establishing optimal quality assurance measures, optimal fuel and subassembly designs, and the industrial base with fuel throughput for later expansion as needed.

The investment in the first cores of a 1000 MWe LMFBR may run as high as $10 million. An investment of this magnitude cannot be jeopardized by high risk experiments. Further, each day of downtime in a plant costing about $300 million involves carrying charges alone amounting to about $200,000 not including the additional costs of buying firm power to replace the lost kilowatt-hours.

3. Components and Systems Experience

In addition to fuels and materials testing, much knowledge will be gained from the FFTF as a direct result of reactor operation. For example, understanding of core neutronics, behavior of sodium system components, instrumentation and control systems, and interplay between various systems and the plant will all be greatly enhanced simply through operation of the reactor. At the same time, the FFTF will determine the effects of core restraint mechanisms. Fuel-related areas of interest, such as effects of fuel shuffling, zone enrichment and cladding swelling, will also benefit from reactor operation as well as from specific irradiation tests.

4. Training

In a similar manner, the FFTF will be a training ground for the LMFBR program. Personnel trained as a result of the FFTF will be needed in demonstration and commercial plant development, design, fabrication, erection, testing, operation, and maintenance. In the latter areas of operation and maintenance, the FFTF will provide not only a cadre of trained personnel, but also a wealth of expertise and applicable experience which will be necessary to the success of the LMFBR development program.

5. Other Environmental Benefits

The LMFBR is, from an environmental point of view, an attractive heat source for electrical energy production. Unlike fossil fuel plants, it does not emit SO_2 or NO_x or noxious fumes and particulate matter. Further, its plant thermal efficiency approaches that of fossil plants. The FFTF, by facilitating the introduction of a commercial LMFBR, would, by such advancement contribute toward reduction of the air pollution which would otherwise have been caused. Equipment applicable to LMFBR radioactive waste removal and disposal will be developed through the FFTF. Experience in the operation and maintenance of such equipment will naturally accumulate. Experience gained from development, installation, and operation of radioactive monitoring equipment, both onsite and off-site, will have direct application to the LMFBR program. The choice of air-cooled exchangers precludes any direct degradation of the quality of the Columbia River and thereby avoids environmental costs to the river, since no direct withdrawals from the river are needed. The groundwater will experience only a very minor perturbation from the facility both in terms of flow and quality. The problem of rejecting heat directly to hot water has been traded for a problem of rejecting heat directly to the atmosphere. This is considered to be a very localized problem. The problem of sodium-water reactions is replaced by that of sodium-air reactions. The overall benefits of using air as a final cooling medium outweigh the disadvantages of this particular application.

The FFTF will provide an arena for the professional advancement of personnel in their respective fields, technical and managerial. And the presence of a staff as large as that supported by the FFTF produces spin-off in the educational field as well, through activities in PTA, on school boards, or within the educational system itself. This additional population will require additional school facilities, municipal facilities, commercial units, housing, and roads with their attendant environmental impact.

6. Cost-Benefit Analysis of U.S. Civilian Nuclear Power

An overall review of the U.S. Civilian Nuclear Program was initiated in 1965 by the Atomic Energy Commission (AEC) with broad participation by National Laboratories and industrial firms.[113-126] In the review, designs for 1000 MWe reactors typical of types under consideration in the U.S. were developed, and their performance characteristics evaluated. A mathematical model of the U.S. electrical energy economy was also developed and costs obtained for a number of possible growth patterns. These analysis tools and data were then used in a cost-benefit analysis of the power program.[2,127]

Three reactor types were selected for consideration in this analysis: a Light Water Reactor (LWR) representative of both boiling and pressurized types, the Liquid Metal Fast Breeder Reactor (LMFBR), and the High Temperature Gas Reactor (HTGR). The LWR was selected by virtue of its acceptance by the electric utility industry, and the LMFBR was selected because of its position as the highest priority U.S. civilian reactor development effort. The HTGR was selected on the basis of its potential.

Parameters used in the study were electrical energy demand, uranium cost, fossil fuel costs, projected power plant capital costs, and the introduction date of the breeder. Sensitivity studies were performed on the key parameters.

No constraints were placed on the total fossil or LWR power plant capacity and economics alone control the number of these plants introduced. Introduction of the HTGR and LMFBR were governed by reasonable projections of vendor capability. Plant capital costs reflected allowances for environmental factors including use of alternate cooling techniques but not including SO_2 or NO_x removal facilities for fossil fuel plants. Other assumptions critical to the validity of the results are reported in Reference 129. Quoting from Reference 128:

"The numerical results of the analysis for the case with the breeder introduced in 1986 show the undiscounted gross benefits of the breeder to be $358 billion and the 7% discounted gross benefits $21.5 billion. The 7% discounted cost of the research and development program is $2.4 billion, and the net benefit of introducing the breeder in 1968 is $19.1 billion and the benefit/cost ratio is 9. Interpreted in plainer language, these results say that, in terms of 1970 dollars and with money discounted at 7% per year, the U.S. electric power consuming public will save $21.5 billion between now and the beginning of 2020 in the cost of electricity. Since the projected governmental expenditures to develop the LMFBR are approximately $2.4 billion, the net savings to the U.S. public will be $19.1 billion with a 9 to 1 payoff on the dollars spent for the U.S. Government's research and development program.

"The results also indicate that with existing uranium reserves, introduction of the breeder by 1986 will decrease U_3O_8 requirements by 2,360,000 tons, over 50% of the U_3O_8 requirements if the breeder were not developed. Stated in terms of the price of the resource, without the breeder the Nation will be using $50 per pound U_3O_8 by the year 2020 while with the breeder, the price of U_3O_8 will not exceed $27.50 per pound. Furthermore, only a minor amount of uranium will be required to sustain the Nation's power economy for many decades beyond 2020.

"Regarding separative work, the study indicates that without the breeder the separative work capacity required to sustain the U.S. power economy constantly increases reaching 270,000 metric tons per year by 2020. With the breeder, the capacity increases to 81,000 metric tons per year in 1992 and no additional capacity is required beyond 1992."

The major conclusions drawn by the authors are:

(a) Introduction of the breeder into the U.S. electric economy will provide substantial financial benefits while reducing long-range uranium and separative work requirements.

(b) The benefit/cost ratio is significantly greater than one for most of the cases examined, demonstrating the strong incentives for an aggressive research and development program to support the LMFBR.

(c) Deferring introduction of the LMFBR reduces the discounted benefits by about $2 billion per year. Thus, there is a strong incentive to pursue a program which will result in introduction of the LMFBR at the earliest possible date.

(d) Increases in fossil fuel prices adversely affect the competitive position of fossil fuel plants. Correspondingly, allowance for air pollution control (removal of SO_2, NO_x) provides in the results a comfortable margin for unanticipated cost penalties to the LMFBR.

There are other benefits. Again, quoting from Reference 128:

". . . there are many other benefits not as readily susceptible to quantitative analysis but of substantial consequence, which would accrue from early introduction of the breeder. A number of these relate to the significant economic, technological and industrial coupling between the light water reactor and the fast breeder reactor. These benefits include:

(a) Access to a virtually limitless supply of low-cost electricity and the potential use of this low-cost electricity in energy intensive applications.

(b) An ample supply of low-cost electricity to areas which have been denied low-cost energy.

(c) The virtual elimination of air pollution from electric power plants.

(d) Assurance that low-cost uranium ore reserves will be most efficiently used.

(e) A premium market for plutonium produced by light water reactors.

(f) The most beneficial utilization of the stockpile of depleted uranium from the diffusion plants.

"(g) The efficient use of the manpower and facility resources committed to the breeder program by the AEC National Laboratories, by U.S. industry and U.S. utilities.

(h) Stimulation of improved efficiency and economy in other energy producing industries, including those associated with the production, transportation and utilization of fossil fuels."

A major conclusion from the Civilian Nuclear Power Cost-Benefit Analysis is that deferring introduction of the LMFBR reduces the discounted benefits by about $2 billion for each year of deferral. The extent to which the operation of the FFTF advances the introduction of the LMFBR on a large scale determines the benefits to be derived from its operation as it concerns timing.

B. Analysis of Costs

1. Costs associated with the design, fabrication, construction and operation of the FFTF fall into the following categories:

   a. Impact on the environment from the production, transportation and final disposal of materials required for the FFTF, other than fuel.

   b. Direct money costs.

   c. Environmental costs associated with the construction, operation, maintenance and decommissioning of the FFTF for the local area.

   d. Environmental costs associated with reprocessing of the FFTF fuel.

e. Environmental costs associated with the disposal of radioactive and other wastes generated by the operation and maintenance of the FFTF.

As this environmental statement indicates, the environmental costs are minimized by a well proven design, a disciplined engineering approach, the application of strong quality assurance practices, and the establishment and good use of above average operation and maintenance procedures. The economic benefits to be derived should far outweigh any direct money costs.

2. There also are environmental costs associated with not operating the FFTF. These are described in Section IX.A. in terms of benefits to be derived by operating FFTF. For clarification and better understanding these environmental costs are listed below:

   a. Heat rejection at LMFBR plants would be at higher levels than would be obtained with application of knowledge gained by operating FFTF.

   b. More uranium for LMFBRs would be mined than would be necessary with application of knowledge gained by FFTF operation which would result in higher fuel ratings, i.e., less fuel needed per core.

c. More uranium for light water reactors or other thermal converters would be mined as the result of delays in introducing a safe, reliable, and economical commercial LMFBR which probability is increased if FFTF were not operating.

The AEC concludes that the environmental costs associated by not operating the FFTF far exceed the environmental costs associated with operating the FFTF.

C. Conclusions

The FFTF is a key element in the orderly and timely introduction of the commercial LMFBR as a safe, reliable and efficient producer of economic power. The environmental impact of the FFTF is minimal. Direct costs, including environmental costs, are outweighed by the potential benefits to be derived.

The construction of this facility should continue, and its operation initiated at the earliest date with the project's program.

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ANNEX

COMMENTS RECEIVED ON DRAFT ENVIRONMENTAL STATEMENT AND AEC RESPONSES

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

SEP 8 1971

Mr. John A. Erlewine
Assistant General Manager for Operations
Atomic Energy Commission
Washington, D. C. 20545

Subject: Draft Environmental Statement -- Fast Flux Test Facility

Dear Mr. Erlewine:

As requested by your letter of July 12, 1971, the following comments are offered, in accordance with the National Environmental Policy Act of 1969 and the role of expertise assigned to the Federal Power Commission by the Council on Environmental Quality's Guidelines dated April 23, 1971. As such, the comments concern the electric power supply and fuel resource aspects of the proposed project. The comments also relate to the Commission's responsibilities for the adequacy and reliability of electric power and its concern for achieving a realistic balance between energy supply and preservation of the environment.

The Federal Power Commission has stated that it considers the fast breeder reactor program to be uniquely important, based on its view of the present and prospective demand for electric power and the fuel resources to provide this energy. We refer to the attached copy of our letter to you concerning the Draft Environmental Statement for the Liquid Metal Fast Breeder Reactor (LMFBR) for fuller coverage of our views on the overall importance of the breeder program. As an essential element in the technological development of the LMFBR, construction of the Fast Flux Test Facility (FFTF) is endorsed as a contribution to the assurance of an adequate and economic electric power supply.

In view of the importance and magnitude of the FFTF project, it is suggested that the environmental statement provide an expanded discussion of the relationship of the facility's test results to the LMFBR program, showing more specifically how FFTF data will be used in demonstration plant design, operation, and modification, and in commercial plant design and improvement. A schedule diagram would be helpful, showing phases of FFTF construction and operation in relation to the development, construction, and operation of the demonstration and commercial plants, and indicating the timing and character of FFTF inputs to the demonstration and commercial plants.

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Mr. John A. Erlewine

We appreciate the opportunity to offer these comments.

Sincerely,

John N. Nassikas
Chairman

Attachment

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Mr. John N. Nassikas
Chairman
Federal Power Commission
Washington, D.C. 20426

Dear Mr. Nassikas:

Thank you for your letter of September 8, 1971, commenting on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering your comments, comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

In answer to your comments, the final statement provides for an expanded discussion of the relationships of the facility's test results to the LMFBR program, showing more specifically how FFTF data will be used in LMFBR plant design, operation, modification and improvement. This discussion is in Sections II.A.4, II.A.5, II.C. and X.

The FFTF schedule is covered in Sections II.A.7. and IV.A.10.a.

Your comments on the Draft Environmental Statement and your support of the Liquid Metal Fast Breeder Reactor Program are greatly appreciated.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

SEP 17 1971

Dear Mr. Erlewine:

In response to your July 12 request, this Department has reviewed the draft environmental statement for the proposed Fast Flux Test Facility (FFTF), Hanford Reservation, Washington. The following comments are herewith submitted for your consideration.

We found the draft statement to be a generally satisfactory and well-written discussion of the possible environmental effects that might arise from the construction and operation of the proposed facility. In President Nixon's recent message on Clean Energy, the importance of developing the breeder reactor was stressed. To further breeder reactor development will require facilities such as the FFTF. Furthermore, the proposed location is an established and isolated test area that has been used by the AEC for more than 20 years. A few comments follow on specific sections of the statement which we believe will strengthen the document.

On page 3, it is stated, "Since our supplies of economically recoverable fossil fuels are dwindling fairly rapidly---." This may be true in the case of fluid fuels but our country is endowed with an abundance of coal reserves.

To alleviate some of the adverse effect (page 28) the discharge of high temperature air will have on ground level atmospheric conditions, consideration should be given to discharging the heated air at a higher elevation, thereby dissipating the heat over a greater area.

Beginning on page 43, the need for breeder reactors is discussed and it is suggested that the LMFBR will ease the problem of thermal pollution. The LMFBR will ease the problem of thermal pollution only insofar as the LWR is concerned. The 40 percent efficiency of the LMFBR is the same as that of a modern fossil fuel plant. Although the primary function of the FFTF is to test and evaluate fuels and materials, serious consideration should also be given to the utilization of the enormous amount of waste heat that will be produced.

On page 46, some discussion should be included describing how the large quantities of liquid sodium will be decontaminated.

Adherence to the plant design and operating characteristics described in the statement should produce little or no adverse effects on adjacent fish and wildlife. We are concerned, however, about the storage of radioactive materials on the Reservation. In light of existing information related to past storage of materials in this area and the seismic nature of the area, we suggest that alternatives to radioactive material storage on the Hanford Reservation be analyzed. Such an analysis would complement the geological work currently being conducted by the Geological Survey at the request of the AEC.

With the exception of Figure 7, "Hanford Reservation Land Use Map," on page 59, recreation is neither mentioned nor described in the draft environmental statement. In our view, the environmental statement should identify or otherwise describe land use, including recreation, of the Hanford Reservation and the surrounding area. We recognize that Hanford is a controlled access site and assume that public use is precluded or extremely limited. The AEC should include this information in the final environmental statement and briefly describe the limited access or control "policy" for the Hanford Reservation. This should be done whether or not operation of the FFTF will adversely affect outdoor recreation resources. This approach greatly assists reviewers and decisionmakers in more fully understanding available and/or utilized resources in the project area. Recreation plans, if any, associated with the proposed Ben Franklin Dam should also be mentioned in the environmental statement.

We appreciate the opportunity of commenting upon this statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Mr. John A. Erlewine
Assistant General Manager
for Operations
U.S. Atomic Energy Commission
Washington, D. C. 20545

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Mr. John W. Larson
Assistant Secretary - Program
Policy
Department of the Interior
Room 4160
Washington, D.C. 20240

Dear Mr. Larson:

Thank you for the letter of September 17, 1971 providing the Department of Interior comments on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering your comments, comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statament. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

In answer to your comments, the wording on page 3 of the July 1971 statement has been revised to indicate that economically recoverable liquid and gaseous fossil fuels are dwindling rapidly.

The analysis indicated in Section IV.A.3.c. shows a substantial plume rise from the sodium-air heat exchangers of about 1500 feet for the near neutral case and 380 feet above the stack for stable atmosphere and light wind and would rise to 2000 feet for light wind near neutral atmosphere. No adverse effects are expected.

Page 43 of the July 1971 statement referred to the use of the LMFBR to ease the problem of thermal pollution. Section IX.A.5. states that the LMFBR plant thermal efficiency approaches that of fossil plants.

Section VI.E. of the final statement discusses alternative heat handling methods and reaffirms previous conclusions that the utilization of sodium-air heat exchangers is the best solution to the disposal of the FFTF heat.

Disposal of sodium waste is currently under study.

Spent fuel will be disposed of from reprocessing plants which will probably be off-site. As stated, sodium waste disposal is still under study.

The ultimate disposition of the Xenon-krypton concentrate has not yet been determined. Land use is described in Sections II.B.1, II.D.4-5-6-7, and III.B.2.

Alternatives to storage of other radioactive wastes on the Hanford Reservation have been studied and conclusions are that such disposal is the best solution.

Your comments on the Draft Environmental Statement of the Fast Flux Test Facility are greatly appreciated.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

August 13, 1971

Mr. Christopher L. Henderson
Assistant Director for Regulation
Atomic Energy Commission
Wa. hington, D. C. 20330

Dear Mr. Henderson:

Please refer to Mr. Erlewine's letter of July 12 which forwarded copies of the draft environmental impact statement entitled "Fast Flux Test Facility" for Department of Commerce review.

Enclosed are the comments offered by the Air Resources Environmental Laboratory, National Oceanic and Atmospheric Administration. Please note that the same set of comments applies also to the draft statement for the "Liquid Metal Fast Breeder Reactor Demonstration Plant" forwarded by Mr. Erlewine on the same date.

I hope that the enclosure may prove of some assistance to you in strengthening the final version of both environmental impact statements.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosure

Comments on

U.S. Atomic Energy Commission Environmental Statement

for

(1) Fast Flux Test Facility
and
(2) Liquid Metal Fast Breeder

dated July 1971

Prepared by

Air Resources Environmental Laboratory
National Oceanic and Atmospheric Administration

August 6, 1971

The lack of supporting meteorological data in both Environmental Statements makes it difficult to evaluate the effect of atmospheric transport and diffusion on downwind radiological doses. In the case of the Liquid Metal Fast Breeder, not even a specific site is discussed. In both cases, it is categorically stated that no routine releases of radioactive effluents to the environment will occur during normal plant operation with the exception of small leaks through the seals. No consideration and analysis is given to an inadvertent or accidental release of radioactivity to the atmosphere. In our opinion, such a discussion is warranted for a complete evaluation of the environmental impact of the plant.

In short, both statements appear rather inadequate and insufficiently detailed to permit meaningful comments.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Mr. Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs
Office of the Assistant Secretary
of Commerce
Washington, D.C. 20230

Dear Mr. Galler:

Thank you for your letter of August 13, 1971, commenting on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering your comments, comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

In answer to your comments, the final statement incorporates supporting meteorological data necessary to evaluate the effect of atmospheric transport and diffusion on downwind radiological doses in Sections II.D.2 and IV.A.3.c.

The release of radioactive gaseous waste and its exposure to man is discussed in Section IV.A.7.c. Accidents analyzed in Section IV.B. indicate no adverse external environmental effects and that containment even under hypothetical accident conditions is adequate to confine any releases.

Thank you for your comments which have been most helpful to us in revising the Draft Environmental Statement.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

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

Mr. John A. Erlewine
Assistant General Manager
for Operations
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Erlewine:

The Draft Environmental Statement - Fast Flux Test Facility - sent with your letter of July 12, 1971, has been reviewed within this Department.

The Draft does not contain quantitative information such as estimated production of radioactivity within the system, possible maximum discharges of activity to the environment through leaks or due to other factors, or quantities and character of wastes to be channeled to existing Hanford facilities. Neither does the report describe or discuss the adequacy of existing waste disposal facilities to be utilized and their actual or potential effect on the environment.

The Draft contains no information on monitoring systems to be used to detect releases of radioactivity or possible increases in environmental radioactivity in the environment. If existing systems are to be used, a description should be provided. No description is offered of facilities or systems to be used in the event of an incident, fire or otherwise.

The Draft Report is judged not to be adequate as a basis for evaluating the proposed facility from the standpoint of health and safety, and effect on the environment.

Sincerely yours,

Merlin K. DuVal, M.D.

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Dr. Merlin K. DuVal
Assistant Secretary for
Health and Scientific Affairs
Department of Health, Education,
and Welfare
Washington, D.C. 20201

Dear Dr. DuVal:

Thank you for your letter of September 2, 1971, commenting on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering your comments, comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

In answer to your comments, Section IV.A.7. of the final statement incorporates inventories and releases of FFTF radioactivity including quantities and character of wastes to be channeled to existing Hanford waste disposal sites or other facilities.

With reference to your question concerning waste disposal facilities, you can be assured that accepted standards for any waste disposal will be met.

Monitoring systems for detecting releases of radioactivity or possible increases in environmental radioactivity are discussed in Section IV.A.6.c. Existing monitoring systems will be used as described in this section. Sampling information is listed in Table IV.A.6.1 and sampling locations in Figure IV.A.6.1.

Facilities or systems to be used in the event of an incident, fire or otherwise are described in Sections IV.A.3.b., II.B.2.b-c-e-g and h., IV.A.3.b., IV.A.6.c., IV.A.7.a. and IV.B.

Your participation in the review of the Draft Environmental Statement for the Fast Flux Test Facility is appreciated.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

September 14, 1971

Mr. John A. Erlewine
Assistant General Manager
for Operations
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Erlewine:

We have had the draft environmental statement for the Fast Flux Test Facility reviewed in the relevant agencies of the Department of Agriculture. Other than to suggest that as in the case of the Liquid Metal Fast Breeder Reactor we think it important that this project move ahead rapidly, we have no comments to make.

Four copies of the statement are returned herewith.

T. C. Byerly

T. C. BYERLY
Assistant Director
Science and Education

Enclosures

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Dr. T. C. Byerly
Assistant Director
Science and Education
Department of Agriculture
Washington, D.C. 20250

Dear Dr. Byerly:

Thank you for your letter of September 14, 1971, commenting on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

Your participation in this review activity and your support of the Liquid Metal Fast Breeder Reactor Program are appreciated.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD(WS)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: 202 426-2262

25 August 1971

Mr. John A. Erlewine
Assistant General Manager
for Operations
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Erlewine:

This is in response to your letter of 12 July 1971 addressed to Mr. Herbert F. De Simone, Assistant Secretary for Environment and Urban Systems, concerning the draft environmental impact statement for the Fast Flux Test Facility to be located at Hanford Reservation, Benton County, Washington.

The concerned operating administrations and staff of the Department of Transportation have reviewed the draft statement for this project. In view that adequate provisions have been made for off-site shipments of radioactive material from the plant, which will be in compliance with this Department's regulations, no comment is made concerning the draft statement. The impact resulting from the construction of this project upon transportation appears to be minimal at present. The long range impact, should the project prove feasible, will be greater when viewed from the point that less cooling water than required for conventional nuclear plants will be used and less lead and radioactive contaminants will be discharged into the water. With the ever greater demands being placed upon water resources and the dwindling supply of these resources available, the liquid metal fast breeder reactor is a most important step in the direction of conservation, not only of water resources, but of the nation's uranium reserves. The Department concurs with the project and recommends early implementation.

The opportunity for this Department to review and comment on the draft environmental statement for the Fast Flux Test Facility is appreciated.

Sincerely,

W. M. Benkert

W. M. BENKERT
Captain, U. S. Coast Guard
Acting Chief, Office of Marine
Environment and Systems

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Rear Admiral W. M. Benkert
United States Coast Guard
Chief, Office of Marine
Environment and Systems
400 Seventh Street, S.W.
Washington, D.C. 20590

Dear Admiral Benkert:

Thank you for your letter of August 25, 1971, commenting on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

Your participation in this review activity and your support of the Liquid Metal Fast Breeder Reactor Program are appreciated.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF THE ADMINISTRATOR

DEC 15 1971

Mr. John A. Erlewine
Acting Assistant General Manager
for Operations
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Erlewine:

This is in response to your letter of July 12, 1971, which requested comments on the Fast Flux Test Facility (FFTF) draft environmental impact statement. We have studied the draft statement, and our detailed comments are enclosed. We apologize for the delay, but internal reorganizations and recent office moves have slowed the review process.

In general, the draft environmental impact statement does not contain sufficient information for a comprehensive evaluation of the impact of the project. It is our recommendation that the final statement be expanded to include additional discussion of the environmental effects due to routine operation of the facility and consider the consequences of various potential accidents. Our review was somewhat impaired by the lack of a Preliminary Safety Analysis Report which is routinely utilized by the Office of Radiation Programs in reviewing licensed facilities. It is requested that updated radioactive waste system information and a copy of the Final Safety Analysis Report be furnished to that Office when available.

We recognize the importance of the FFTF project to the fast breeder reactor program, and if we can be of further assistance to you on this or any related environmental matter, please contact Mr. George Marienthal of our Office of Federal Activities.

Sincerely,

Robert W. Fri
Deputy Administrator

Enclosure

Introduction and Conclusions.

This report summarizes an evaluation by the Environmental Protection Agency of the potential environmental effects of the design and construction of the Fast Flux Test Facility (FFTF) to be located at the AEC's Hanford Reservation in Benton County, Washington. The main element of the complex is a 400 MWt nuclear reactor fueled with PuO_2 - UO_2 which will provide a fast neutron irradiation environment for testing fuel and material specimens.

Our evaluation is based on the information presented in the draft environmental statement submitted by the Atomic Energy Commission and concludes that the draft statement is not adequate for a comprehensive technical analysis of the environmental impact of the FFTF. Our specific comments are as follows:

1. Although an assessment of the yearly dose rate at the nearest Hanford Reservation boundary is stated (0.01 mrem/yr), the assumptions regarding source terms (degree of seal leakage), containment holdup or delay times, and applicable meteorological diffusion parameters are not presented. Since the functional requirements of seals would appear to receive their severest test during fuel handling operations, particular emphasis should be given to the radiological calculations pertinent to such operations.

2. Since the FFTF is an experimental facility, equipment and procedures have undoubtedly been developed for proper control of abnormal situations which might arise during both closed loop and open loop experiments. The draft statement does not include

a description of the equipment and procedures to be employed in such situations. For example, a general discussion of the maintenance and recovery procedures applicable in the event of a planned or unplanned fuel failure within the driver fuel or test loop experiments should be presented. Of particular interest is the handling and disposal of the defective component(s) and any contaminated sodium which would result from the component failure.

3. The draft statement does not include a discussion of, or reference to, completed or in-progress developmental efforts in programs concerning: (1) maintenance actions to be used to handle radioactively contaminated equipment or materials, (2) equipment designs which could have an effect on the performance of radioactive waste handling systems.

4. Facility emergency planning and surveillance procedures employing the applicable design features of the plant, including the responsibilities and authorities for protecting health and safety of offsite personnel under emergency conditions.

5. The relationship between the FFTF and other existing sources of radiation exposure at the Hanford Reservation is not discussed in the statement.

6. There is no mention of the methods for control of fugitive dust and disposal of combustible waste caused by construction activities.

7. A statement describing the monitoring (for contamination) and disposal of the non-radioactive solid wastes is not presented in the statement.

The remainder of this review is directed toward a more detailed discussion of the above comments. The information presented is discussed in terms of normal and abnormal (emergency) operations.

Normal Operation Review

The normal operation of the FFTF will lead to the production of gaseous, liquid, and solid radioactive waste. The environmental statement specified that the recycled argon primary cover gas system will include charcoal delay beds, and a "krypton removal process;" and therefore, no gaseous release from the cover gas system to the environment is expected other than through seal leakage. The details of the facility design and operating procedures which support the above conclusion require further elaboration. For example:

1. The absorption efficiency of the charcoal beds with an argon cover gas should be discussed in support of any statement regarding noble gas holdup times.

2. The procedures utilized to concentrate and remove krypton from the cover gas should be detailed.

3. The frequencies of cover gas purification system maintenance actions and any associated radiological consequences should be stated for both the reactor and the closed loop systems.

4. A discussion of the design and operation of vapor traps, especially with regard to any potential effect on the cover gas purification system, is warranted.

5. The handling of the gas in the cells containing the closed test loops and in the primary sodium containing equipment should be more adequately described and defined.

In responding to the above comments, consideration should be given to the expected activities required for both scheduled maintenance actions and those postulated in the event of equipment failures. Regarding the liquid coolant, the cleanup or disposal of potentially contaminated sodium is of particular interest. Any developmental programs used to determine cleanup system designs or maintenance activities, should be referenced. Furthermore, the evaluation predicting the extent of seal leakage and the data required to calculate the dose at the Hanford Reservation boundary should be presented.

The myriad of operations involving the handling of both driver and experimental fuels, require further explanation. Since the fuel experiments, in particular, could result in a loss of structural integrity of system assemblies, all operations covering fuel removal from the reactor to receipt at the ultimate disposal area are of interest. Analyses of the consequences of fuel handling incidents during this out-of-reactor operational phase are considered a necessary part of a comprehensive environmental statement on this type of facility.

A description of the offsite surveillance program should be included in the statement with a discussion of the administrative and operating procedures proposed to insure that the general public is not being unduly exposed to radiation originating at the site.

Abnormal Operation Review

Besides the radioactivity released to the cover gas during "normal operations", the possibility also exists that additional radioactivity could be released from driver or experimental fuels as a result of planned or unplanned failures. Information should be presented on the potential quantities of those isotopes which could reach the cover gas and the degree to which they are removed by the gas purification system. A discussion of both the design basis and lesser magnitude accidents and their potential radiological consequences is also warranted. The draft statement should specify the radiation level required to isolate the containment ventilation system and should describe the reliability of the system under various operational conditions. Also, an estimate of the quantity and composition of liquid wastes following accidents and the related capacity of the receiving tanks should be presented.

Finally, detailed information should be presented on the administrative and operational controls which will be exercised to minimize population exposure as well as the contamination of foodstuffs and livestock in the event of an accident or other emergency.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Mr. Robert W. Fri
Deputy Administrator
Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Fri:

Thank you for your letter of December 15, 1971, commenting on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering your comments, comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

In answer to your comments:

1. The FFTF radioactivity source terms, hold-up and delay times, are described in Section IV.A.7. Meteorological diffusion procedures are referenced, and the dilution factor is indicated. Leakages are indicated in Table IV.A.7.3.

2. Fuel handling incidents are covered in Section IV.B.1.e. Detailed procedures for maintenance and recovery from fuel handling incidents will be available prior to FFTF operation. Disposal of waste sodium is under study. You can be assured that such disposal will be in accordance with accepted standards.

3. FFTF developmental efforts are now concentrated on designing components for greatest reliability to minimize maintenance. Work has started on development of maintenance casks, tools, and procedures. Again, these will be covered in procedures to be issued prior to FFTF operation. Design which would have an effect on the performance of the radwaste systems is described in Section IV.A.7.a.

4. Detailed FFTF facility emergency planning and surveillance procedures will be issued prior to FFTF operation.

5. Radiation from FFTF as contrasted to background is described in Section IV.A.7.c. Also, see Figure IV.A.7.6. The final statement indicates even lower radiation from the FFTF than indicated in the July 1971 draft.

6. Impact and control of on-site construction is treated in Section IV.A.10.

7. The nonradiological environmental monitoring program is covered in Section IV.A.6.d.

8. The Radioactive Argon Processing System with its filters, charcoal delay beds and fractional distillation column for concentrating and removing Xenon-krypton is described in Section IV.A.7.a. More detailed description is referenced - System Design Descriptions No. 24 and 82.

9. Radiological consequences of radioactive waste system leaks or spills are discussed in Section IV.B.1.c.

10. Design and operation of vapor traps is reviewed in the referenced System Design Descriptions No. 24 and 82.

11. Handling of gas in the cells contained in the closed test loops and of the cover gas in the primary system are covered in Section IV.A.7.a.(1).

12. Consideration will be given to expected activities required for both scheduled maintenance actions and those postulated in the event of equipment failures during preparation of maintenance procedures.

13. Sodium cleanup systems designs will be made available when prepared. Such systems are now in the process of development. You can be assured that they will be designed and operated in accordance with accepted standards.

14. Operations covering fuel handling are discussed in Sections II.B.2. and fuel handling incidents in IV.B.1.e. Transportation of fuel is discussed in Section IV.A.8.

15. The off-site environmental surveillance program is covered in Section IV.A.6.c. This program covers the entire Hanford Reservation including the FFTF.

16. The release of radioactivity from fuel is considered a nonnormal activity but is included in design considerations. Release due to loss of coolant following fuel melting, during fuel handling incidents and during hypothetical accidents, is covered in Section IV.B.

17. Design of containment to accommodate large arbitrary energy releases is discussed in Section IV.B.1.f.

18. The radiation level required to isolate the containment ventilation system will be specified in the FFTF technical specifications.

19. It is not expected that liquid wastes following accidents will exceed the capacity indicated in Section IV.A.7.a.(2).

20. Controls to minimize population exposure are reviewed in Section II.B.2.h.

Thank you for your comments which have been most helpful to us in revising the Environmental Statement.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR
OFFICE OF PROGRAM PLANNING AND FISCAL MANAGEMENT
INSURANCE BUILDING
OLYMPIA, WASHINGTON 98501

DANIEL J. EVANS
GOVERNOR

WALTER C. HOWE, JR.
DIRECTOR

September 16, 1971

Mr. John A. Erlewine
Assistant General Manager for Operations
Atomic Energy Commission
Washington, D.C. 20545

Fast Flux Test Facility
DRAFT ENVIRONMENTAL STATEMENT

Dear Mr. Erlewine:

In accordance with your request and the provisions of the National Environmental Policy Act, the State of Washington has completed its review of the draft environmental statement for the Atomic Energy Commission's Fast Flux Test Facility. This proposed facility is to be located on the AEC Hanford Reservation in Benton County, Washington.

The state's overall reaction to the draft statement is highly favorable. In fact this particular draft statement is one of the best we have received, containing an excellent discussion of the proposed project and its expected environmental impact. With regard to the draft statement, the state has only minor comments which include the following:

1) Assurance should be given that the operation of the FFTF with respect to the substantial number of BTU's to be wasted to the atmosphere would not impair or complicate the evaporative capability or operation of the cooling towers slated for installation at the WPPSS Hanford Number 2 plant. Assurance should also be given that obscuration of the Pasco airport will not occur as a result of the placement and use of the heat liberation complex.

2) It would be extremely helpful to the State Department of Ecology and other interested state agencies if results could be provided of any air and water quality monitoring projects at the facility site.

We have attached to the state's letter full text of copies of all agency review responses for your information and utilization.

It is extremely encouraging to the state to see development occur that promises to reduce demand on non-renewable fosil fuel resources through substitution of fuels from seemingly unlimited nuclear energy sources. With its potential for providing an ultimate source of power generation that would create a minimum of environmental disruption and would be accomplished with lower development costs and the use of more renewable rather than non-renewable resources, the Fast Flux Test Facility proposal is highly supported by the State of Washington.

Yours very truly,

STATE PLANNING DIVISION

Paul T. Benson, Jr.
Assistant Director

PTB:ms

Attachments

cc: Timothy Atkeson
Council on Environmental Quality

James M. Dolliver
Office of the Governor

John W. McCurry, Deputy Director
Office of Program Planning & Fiscal Management

STATE PLANNING

Director / Carl N. Crouse

Assistant Directors / Ralph W. Larson
Ronald N. Andrews

Game Commission

Arthur S. Coffin, Yakima, Chairman
Harold A. Pebbles, Olympia
Elmer G. Gerken, Quincy
James R. Agen, LaConner
Glenn Galbraith, Wellpinit
Claude Bekins, Seattle

DEPARTMENT OF GAME

600 North Capitol Way / Olympia, Washington 98501

August 20, 1971

Paul T. Benson, Jr.
Assistant Director
Office of Program Planning and Fiscal Management
Insurance Building
Olympia, Washington 98501

Dear Mr. Benson:

We reviewed your request for comments from the Department of Game on the draft environmental statement for Fast Flux Test Facility prepared by the United States Atomic Energy Commission.

The statement was very informative and comprehensive, and adequately covered aspects of the project related to this department's responsibilities.

We recommend an addition to a portion of the statement (page 3, end second paragraph), which refers to the contribution of the facility to reducing "...the environmental impact associated with present day steam-electric power generation." Adverse impact of hydro-electric power generation facilities were not mentioned and should be included to fully recognize the alternatives.

With this minor addition, we concur with the environmental statement and appreciate the opportunity to review and comment on it.

Sincerely,

THE DEPARTMENT OF GAME

E. S. Dziedzic

Eugene S. Dziedzic, Asst. Chief
Environmental Management Division

ESD:jb

THERMAL POWER PLANT SITE EVALUATION CO[UNCIL]
820 EAST FIFTH AVENUE, OLYMPIA, WASHINGTON 98501 PHONE: 753-7384

GOVERNOR DANIEL J. EVANS
Chairman: Oswald Greager

September 2, 1971

Mr. Paul T. Benson, Jr., Assistant Director
Program Planning and Fiscal Management
Insurance Building
Olympia, Washington 98504

Re: Fast Flux Test Facility
Environmental Statement

Dear Mr. Benson:

By letter of August 12, 1971, you requested our review and comment regarding the referenced draft environmental statement. From the point of view of this office, the most significant statement in that report is contained in the first paragraph of the section titled "Environmental Impact" on page 28. The indication that this facility is not intended to generate electricity removes it from this Council's direct concern as set forth by our enabling legislation, RCW 80.50 (see 80.50.010 and 80.50.020(9)).

Recognizing that the facility described in the subject report is to be located within a very few miles of the proposed Washington Public Power Supply System Hanford No. 2 nuclear power plant whose certification application is presently before this Council, we did compare that portion of subject report titled "Site Characteristics and Environmental Setting" (pages 21-27) with the Environmental Report recently submitted by the Supply System to the Atomic Energy Commission. This comparison indicated a general agreement between elements of this section of subject report and the information supplied by the Washington Public Power Supply System in their Hanford No. 2 Environmental Report. The individual items set forth in the above-mentioned section are also each extensively addressed in the "Application for Washington State Site Certification" submitted to this Council by the Supply System on January 28, 1971. The information contained in the application again appears to correlate well with that contained in the Hanford No. 2 Environmental Report and the above-mentioned section of subject report. To date the members of the Council have not taken significant exception to the information presented in the application regarding these items. Although the certification process is still underway, it seems unlikely that any Council member will express significant concerns regarding this information at this late date.

Regarding other sections of the subject report, we do not feel this office possesses sufficient expertise in this area to offer a meaningful critique. I would suggest that if you have not already done so you contact Mr. James A. Lastrapes, Staff Assistant for Nuclear Energy in the Office of Nuclear Energy Development of the Department of Commerce and Economic Development. Mr. Lastrapes should be able to offer meaningful commentary on those other areas of the subject report.

If you desire more extensive discussion of any item contained in that section of the subject report entitled "Site Characteristics and Environmental Setting" or additional information regarding the status of the Council evaluation of the Hanford No. 2 application, we will be happy to attempt to supply such information.

Very truly yours,

Joseph F. Lightfoot
Executive Secretary

JFL:els

cc: James A. Lastrapes

STATE PLANNING

WASHINGTON
DEVELOPING THE ECONOMY THRU • TOURISM • INDUSTRY • RESEARCH • FOREIGN TRADE • NUCLEAR PROJECTS
DEPARTMENT OF COMMERCE AND ECONOMIC DEVELOPMENT
GENERAL ADMINISTRATION BLDG.
OLYMPIA, WASHINGTON 98501
Daniel B. Ward DIRECTOR
Daniel J. Evans GOVERNOR

September 13, 1971

TO: Paul T. Benson, Jr., Assistant Director
Office of Program Planning & Fiscal Management

FROM: Daniel B. Ward *Dan*
Director

SUBJECT: <u>Environmental Statement -- FFTF</u>

As has previously been mentioned on the phone to you, the comment from this Department is in the form of seeking assurance that;

1. The operation of the FFTF with respect to the substantial number of BTUs to be wasted to the atmosphere would not impair or complicate the evaporative capability or operation of the cooling towers slated for installation at the WPPSS Hanford #2 plant, and

2. An evaluation of the temporary humidity increase on the across-river farming area has shown that 24-hour harvesting capability will not be affected as a result of,

   a. placement and use of the heat liberation complex, and

   b. obscuration of the Pasco airport as a result of placement and use of heat liberation complex.

DBW:LBB:ts

cc L. B. Bradley

SEATTLE OFFICE:
312 FIRST AVE. NO. (98109)

SPOKANE OFFICE:
ROOM 307, GREAT WESTERN BLDG. (99201)

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

DANIEL J EVANS
GOVERNOR

JOHN A. BIGGS
DIRECTOR

9/16

September 15, 1971

Mr. Paul T. Benson, Jr.
Assistant Director
Office of Program Planning
and Fiscal Management
Olympia, Washington 98504

Dear Paul:

This letter will provide you with our comments and Department assessment of the environmental aspects of the Atomic Energy Commission proposal for the Fast Flux Test Facility at Hanford as described in the draft Environmental Statement of July, 1971.

The review within the Department of Ecology has been coordinated by Dennis Lundblad of this office, and has concluded with a favorable determination regarding the facility proposal. The AEC project incorporates several features that not only make substantial progress towards minimizing environmental effects, but further, has the long range effect of reducing the demands upon our non-renewable fossil fuel reserves. It is extremely encouraging to see developments occur that promise to reduce this demand through substitution of fuel from seemingly unlimited nuclear energy sources. The FFTF leading to the eventual development and demonstrations of the Liquid Metal Fast Breeder Reactor (LMFBR) program holds this promise.

Under the overall favorable attitude of this Department on the proposal, several specific points were determined that deal with considerations during and after construction and the subsequent gathering of data.

Added information would be helpful to all concerned with respect to any potential for release and extent of scattering of Alpha particles as a part of project operation. It would be helpful for the Department of Ecology to receive copies of radionuclide monitoring results at the project.

In connection with the contiguous ground water resources, there may be a question regarding the ground water conditions that would prevail if the Ben Franklin Dam were ever to be constructed. The influence to ground water, even under full Ben Franklin Reservoir conditions, would seemingly be well above the expected ground water level. However, a thorough determination should be made as to the possibilities of saturation of the silts, sands, and clays within the Ringold Formation underlying the project. If saturation were to occur it could possibly materially change the engineering properties of the soil in the area. This condition does not appear likely but is cited as a checkpoint during project planning and construction.

In further connection with the ground waters of the area, it would be helpful for the Department of Ecology to be apprised of any AEC ground water quality monitoring program results.

With the potentials for providing a source of power generation that would create a minimum of environmental disruption, would be accompanied by lower development costs and the use of more renewable, rather than non-renewable resources, the FFTF proposal should receive broad support from State interests through joint participation in planning and follow-on project operation. The proposal stands as an outstanding example of applied research, coupled with resource conservation.

Very truly yours,

for Robert L. Stockman
Executive Assistant Director

RLS:mch
64/1

cc: Fred Hahn
George Hansen
Dennis Lundblad
ER & E Project File

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

The Honorable Daniel J. Evans
The Governor of Washington
Olympia, Washington 98501

Dear Governor Evans:

Thank you for the letter of September 16, 1971 from Mr. Paul Benson enclosing comments on the July 1971 Draft Environmental Statement for the Fast Flux Test Facility, Richland, Washington.

The final statement has been extensively revised in considering your comments, comments from other Federal agencies and reviewing organizations, and AEC guidelines issued since July 1971. Enclosed for your information is a copy of the Final FFTF Environmental Statement. We believe this Statement conforms to both the letter and the spirit of the National Environmental Policy Act of 1969.

In answer to your comments, the operation of the FFTF will in no way impair or complicate WPPSS Hanford #2 Nuclear Power Plant operation.

Sections IV.A.3.c.(3) and (4) of the final statement covering fogging and cloud formation indicate no condensation, no visible and no fog. There would be rare formation of clouds with virtually no local effects. Obscuration of Pasco airport should not occur. Also, there should be no effect on agricultural uses.

Air and water quality monitoring projects are covered in Section IV.A.6.c. of the final Statement.

Section II.B.2.h. describes controls taken to assure no release of alpha particles during operation.

As discussed in Section IV.A.2, percolation of treated sanitary and process water will not adversely affect the purity of the groundwater. The impact of this discharge on the environment is considered negligible. Interaction between water entering the soil as seepage and the water table is not expected to be regionally significant. The influence of the core of depression is small beyond a few hundred yards from the site.

The thoughtful comments of your office and the several State of Washington agencies on the Draft Environmental Statement for the Fast Flux Test Facility are greatly appreciated.

Sincerely,

Julius H. Rubin
Assistant General Manager
for Environment and Safety

Enclosure:
Environmental Statement -
Fast Flux Test Facility