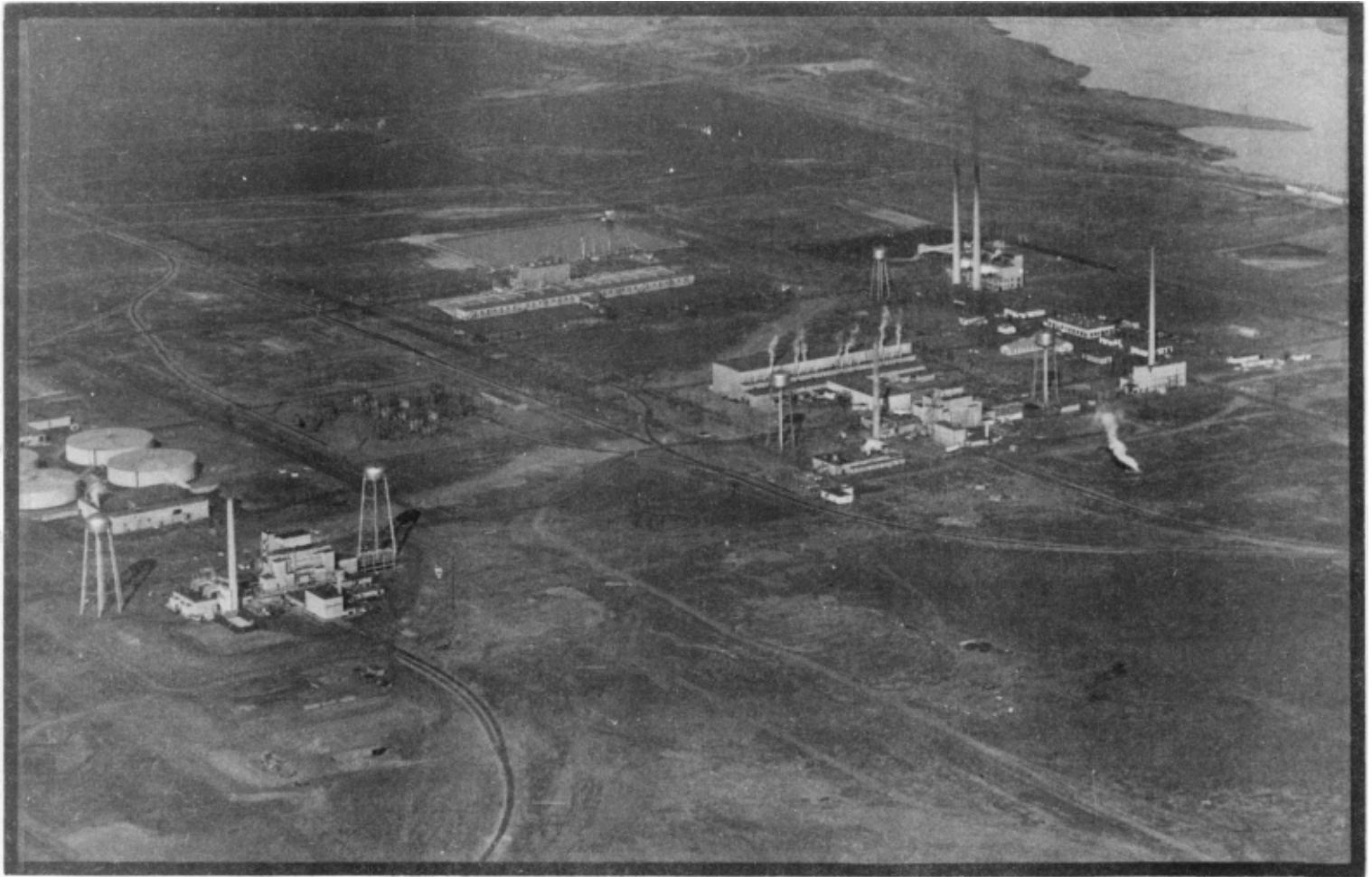


**National Historic  
Mechanical Engineering  
Landmark**

**HANFORD B-REACTOR**



History and Heritage Committee  
The American Society of Mechanical Engineers

Columbia Basin Section  
Richland, Washington



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## INTRODUCTION

The Hanford B-Reactor was the first plutonium production reactor to be placed in operation. It proved that all of the physics calculations and engineering decisions required for construction of the graphite pile and cooling system were correct and within proper limits to sustain a controllable chain reaction.

Loading of the B-Reactor was started on the afternoon of Wednesday, September 13, 1944 and was completed on September 27 with Enrico Fermi in personal charge of the loading. The first irradiated slugs were discharged from the reactor on Christmas day, 1944.

The successful operation of the Hanford B-Reactor was a major milestone for the Hanford Project and made possible the subsequent development of atomic energy. The research work, engineering and planning required to make the reactor operate should be included in history as one of man's most brilliant scientific and advanced engineering achievements.

Although many different types of scientists and engineers contributed to the ultimate success, much of the reactor core, cooling system, shielding and auxiliary support systems were designed by mechanical engineers. For this reason, the Hanford B-Reactor has been declared a National Historic Mechanical Engineering Landmark.

## HANFORD B NUCLEAR REACTOR

### PRIOR EVENTS

The Project objective was the building of a plant for the production of plutonium in the shortest possible time and in a sufficient amount to provide for military requirements. The project required the construction of a manufacturing plant including fuel fabrication, the reactors or piles, remotely operated chemical separations facilities, a large construction camp, a village for operations personnel and all of the attendant supporting services. Special consideration was given to the unprecedented problems created by the magnitude of the Project, the long distances between plant units, isolation of the site, the short time available, the high quality of construction and the need for military secrecy and security.

Management was assigned to the Corps of Engineers and the Manhattan District was organized for the procurement and engineering phases of the work. By the summer of 1942, the program was known as the "Manhattan Project," and General Leslie R. Groves was placed in charge of the Army activities. He took an active part in the selection of the Hanford area where the Bonneville and Coulee dams were a reliable source of electrical power, and the Columbia River water provided abundant quantities of cold cooling water having very little dissolved or suspended materials. The area selected is shown as the "Hanford Reservation" in the Washington area map, Figure 1. Key features of the Hanford Reservation area are shown in Figure 2.

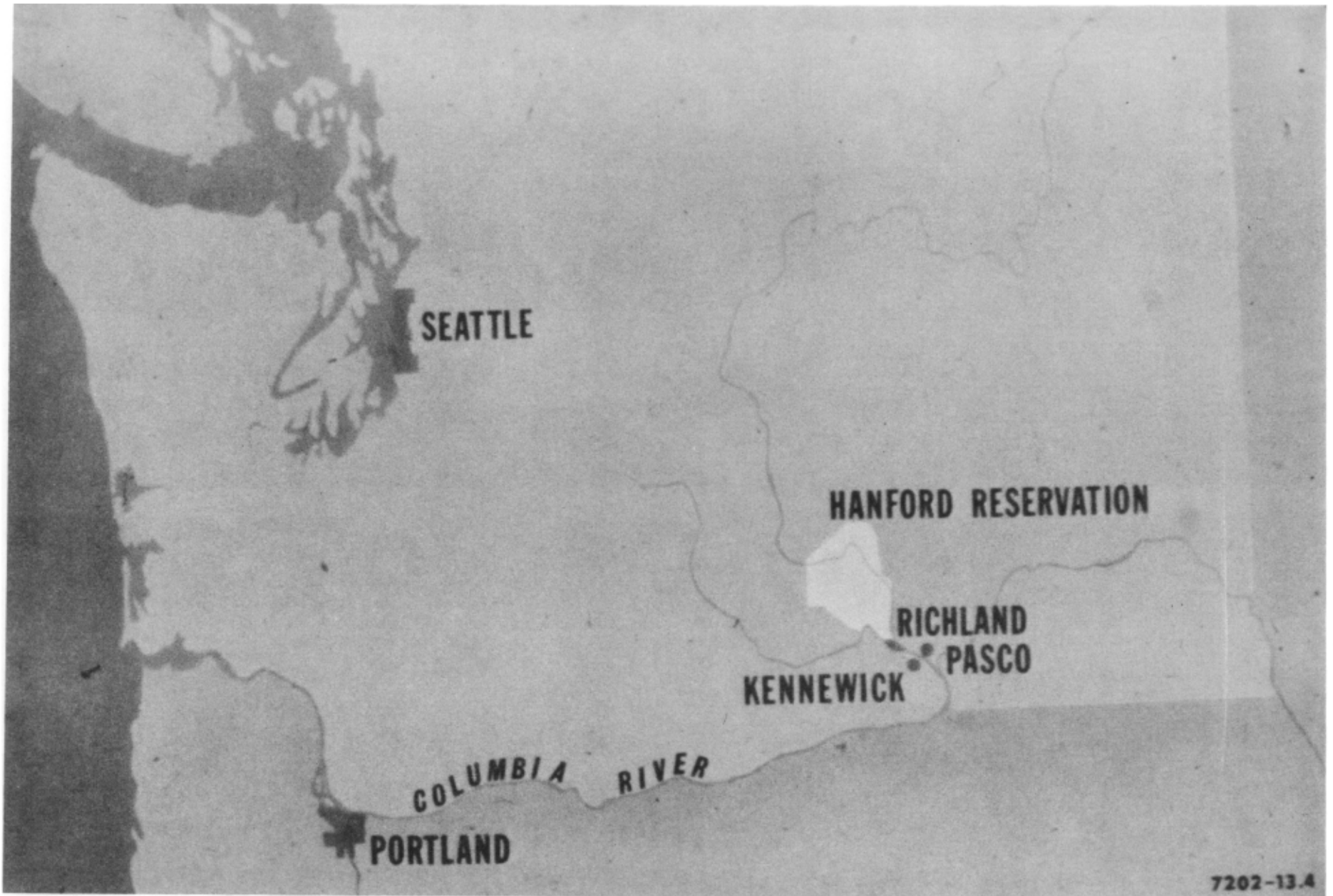


Figure 1 Area Map Showing Location of Hanford Reservation  
in Southeast Washington State.

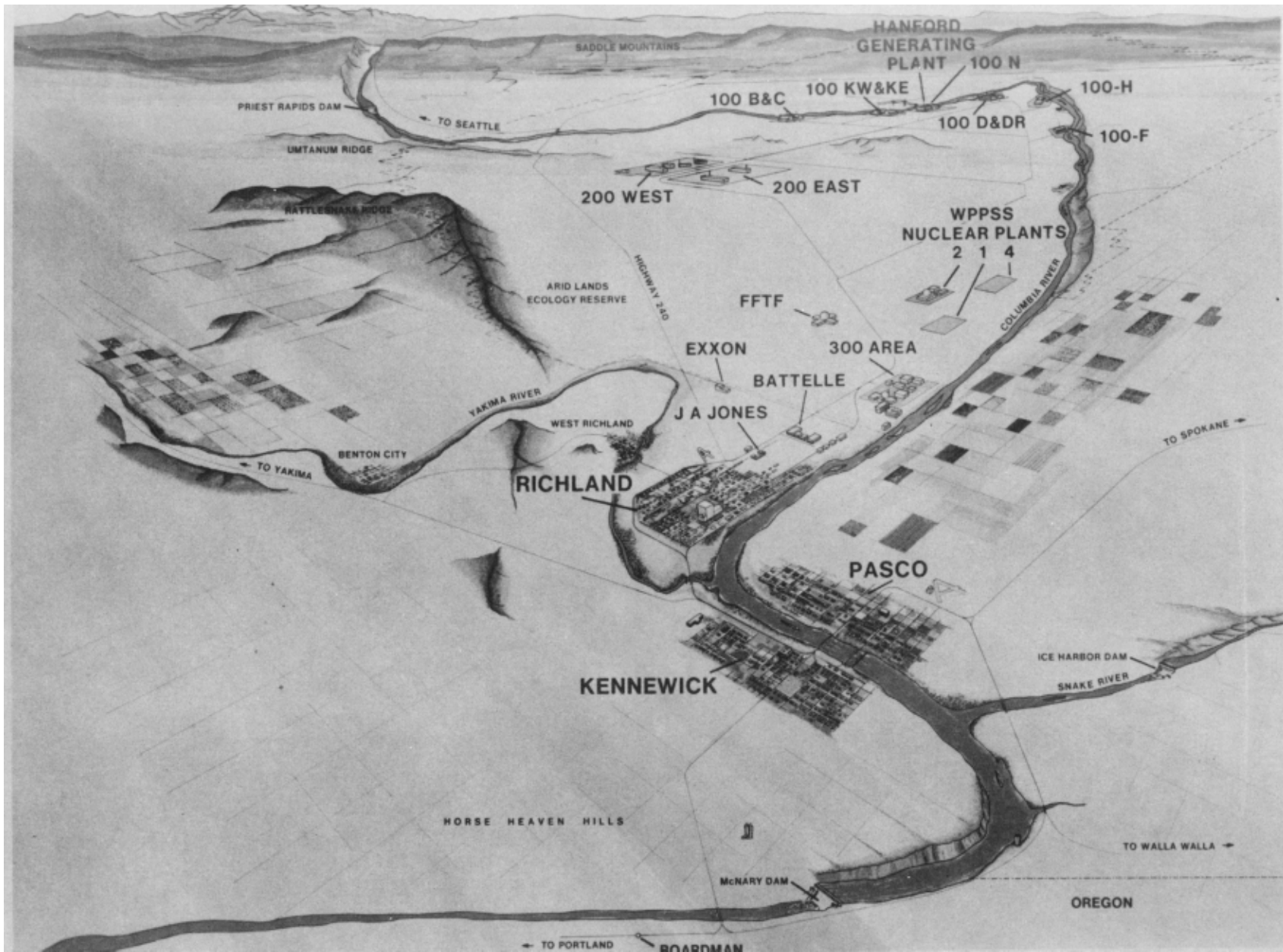


Figure 2 - Key Features of the Hanford Reservation

Geologic studies of the area proved that the soil and substrata were capable of supporting massive structures. Concrete was the most extensively needed material for the plants and plenty of aggregates were readily available. The selected site occupies about 670 square miles.

E.I. du Pont de Nemours and Company was selected as the prime contractor, and ground was broken for Camp Hanford on April 6, 1943. Ultimately Camp Hanford, pictured in Figure 3, was to house some 54,000 workers. The project was named the "Hanford Engineer Works" to preserve secrecy as to the nature of the final product.

#### THE REACTOR

Construction of the B-Reactor started June 7, 1943, and Figure 4 is a photograph of the partially completed complex. The reactor went critical in September 1944. The completed facility is shown in Figure 5. Key features of the reactor known as the "Pile," shown in Figure 6, are described as follows:

The pile required 2,000 tons of machined graphite blocks bored to permit installation of 2,004 aluminum tubes having two channel flow ribs for allowing water circulation around the canned uranium slugs. The graphite bars formed a 36 x 36 x 28-foot block with 10" of cast iron and 4' of masonite, steel and concrete surrounding it for shielding. Elevators spanning the front and rear face of the reactor were provided for access to the nozzles. The front face elevator supported a machine for charging fuel slugs into the tubes. The rear face elevator had a shielded cab for mechanically moving from behind a barrier to the face of the reactor and performing simple emergency operations. About 30,000 gallons per minute of cooling water was forced through the .086 inch wide



Figure 3 Camp Hanford - Construction Camp for Hanford Nuclear Facilities.



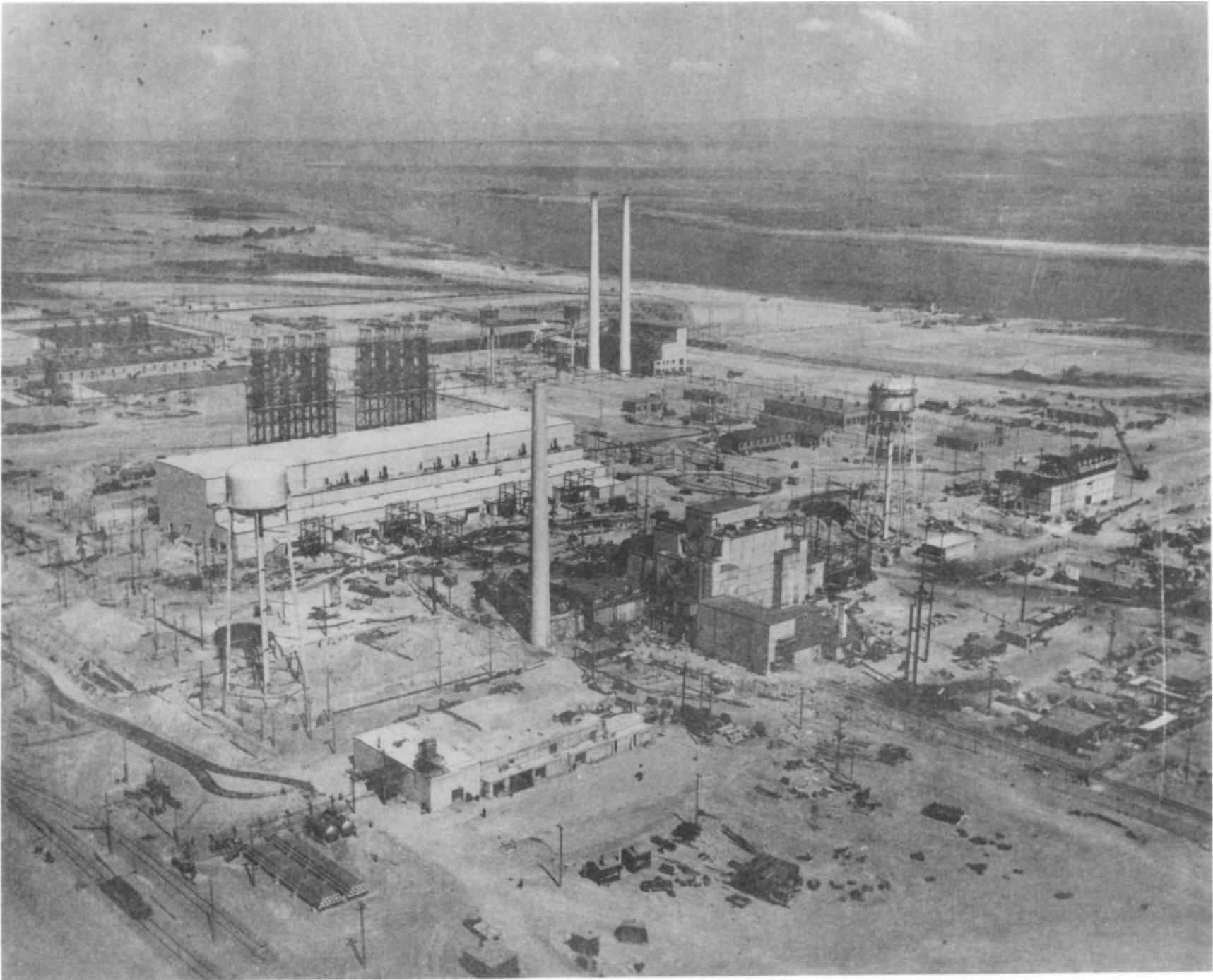


Figure 4 Photo of Hanford B Reactor During Construction



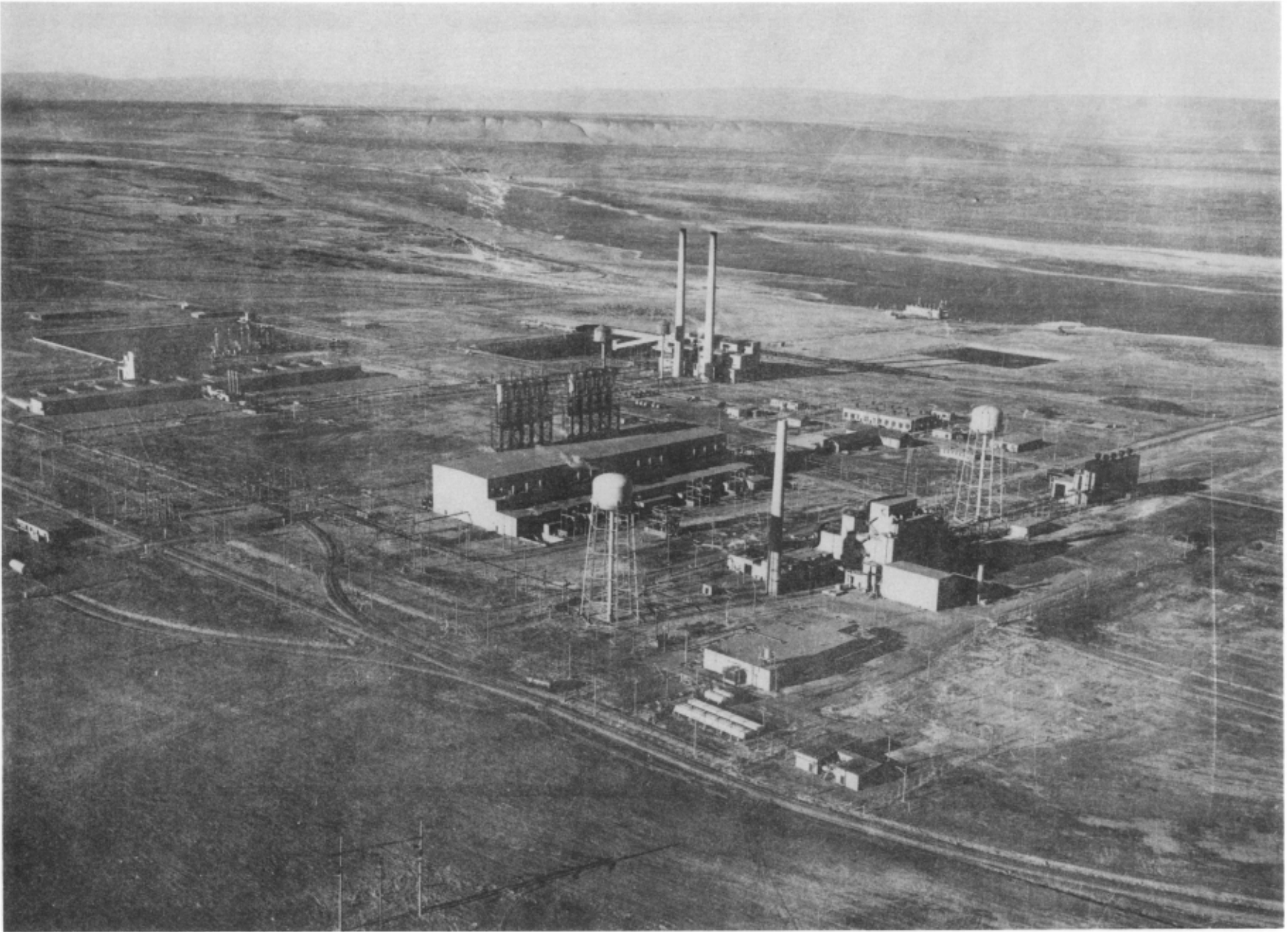


Figure 5 Photo of Hanford B Reactor after Completion of Construction

# CUTAWAY OF TYPICAL REACTOR BUILDING

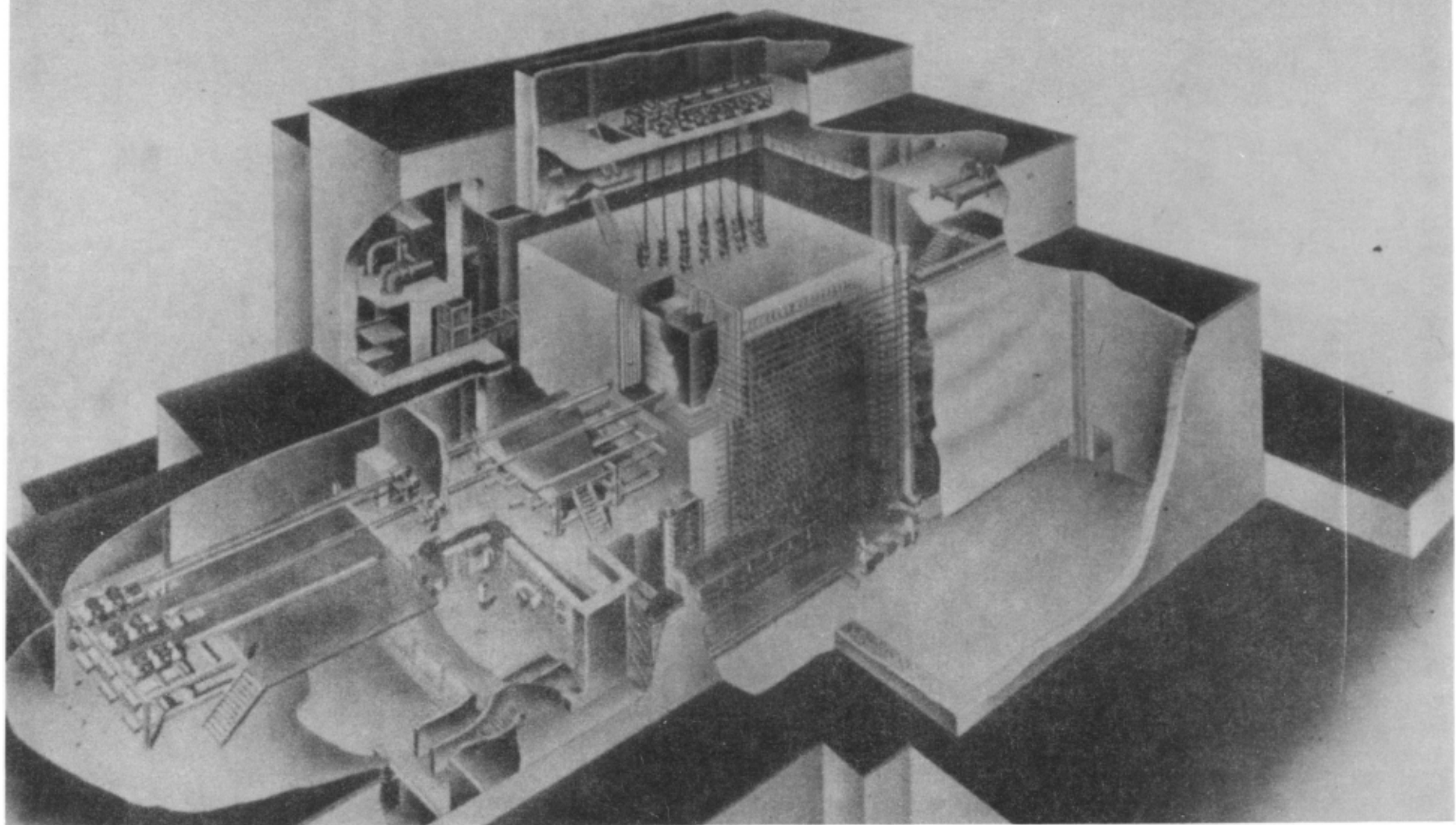


Figure 6 Cutaway of Typical Graphite Pile Reactor

annulus formed between the uranium slugs and the tubes at a velocity of about 19.5 feet per second. To minimize corrosion of the aluminum tubes and uranium sheathing, it was considered necessary to provide elaborate purification and deaeration of the water. The need for this precaution was quite evident when the failure of as few as ten tubes could cause failure of the pile. The reactor capability for producing plutonium was limited by the rate at which heat could be removed. Based on this fact, refrigerating equipment having a capacity of 10,000 tons of ice per day was considered for increasing capacity by precooling water during the summer months. A later decision was made not to install the refrigerated system at the B-reactor because it was not necessary for safe operation.

To insure continuity of water, completely independent pumping and water lines were installed. The pumps were capable of being driven by both steam and electric motors. In order to continue a nominal water flow for the first few seconds of a power failure, heavy flywheels were mounted on the electric motor drives. As a secondary water supply for emergencies, two 30,000-gallon water tanks were connected directly to pile-cooling water headers. The piping was arranged and instrumented so that the reserve would cut in automatically in case of a system pressure drop.

The original plan called for a helium-cooled reactor, but the difficulty of getting large blowers quickly, the hazard of high-pressure gas leaking into the atmosphere and the uranium fuel element loading difficulties led to the water-cooled concept. Although the helium cooling was abandoned, a low pressure of helium gas was maintained inside the pile structure and was purified by equipment installed for that purpose. The gas displaced air, removed moisture and other impurities, and

provided a medium for more efficient heat transfer from the graphite to the cooling tubes. The completed assembly consisted of 100,000 graphite bars, the inner thermal shield composed of a 10-inch-thick envelope of cast iron blocks of special shapes and bored for the tubes and control rods, and the 4-foot-thick biological shield of masonite and steel which produced a mass of nearly 10,000 tons. Supplementing the extensive pile shielding, the room walls were constructed of solid concrete 3 to 5 feet thick having labyrinth entrances for secondary protection of personnel and the delicate instruments in the control room. The control room was 45 feet square and had lead shielding for additional operator protection.

The control mechanism for regulating the pile activity consisted of nine mechanically operated control rods designed to be moved either automatically or manually at variable speeds into the side of the pile. In addition, 29 safety rods were suspended above the pile for instantaneous drop into thimbles in case of an emergency. All of these rods required special materials work for the addition of boron and mechanical testing of the operating mechanisms to insure fail-proof operation. A third safety device, designed to stop the pile reaction by filling the safety rod thimbles with boron solution, was provided as a final protective measure. This system was designed for remote operation from the control room.

Water was pumped from the river pump house to a 25 million-gallon reservoir designed so that 15 million gallons were held in reserve for emergencies. Most of the raw water was then pumped to the filter plant with a capacity of 38,000 gpm and then to the ten deaerators of 3,000 gpm each, thence to the pump house for delivery to the crossheaders

feeding the pile tubes. The effluent cooling water piping in the building was shielded with concrete and run outside underground to a 12 million-gallon retention basin equipped with specially designed instruments for monitoring the water prior to its release back to the river. Ventilation was supplied from a dual installation of electric and steam turbine-driven fans at a rate of 100,000 cubic feet per minute, first to the occupied areas, then to a reactor room and finally to a 200-foot stack.

Discharge of the slugs from the tube ends required a means to direct them into a discharge basin without injury or rupture. Many schemes were tried and considerable development work was performed before the problem was solved. Subsequently, the system adopted used a free fall of the slugs onto a sloping neoprene mattress.

#### SUPPORT FACILITIES

The support facilities can be identified by referring to Figure 5 and tracing the flow of water from the river pump house and water treatment buildings to the reactor.

The river pump house in the north part of the area had two pump wells. The first section contained a 40,000 gpm electric and a 7,500 gpm steam turbine-driven pump. The second section had a 30,000 gpm electric and a 15,000 steam-driven unit. The installed pumping capacity provided 92,500 gpm. Provision was made in the building to install additional capacity should this become necessary. The intake channels were 10 feet deep and extended to the main river channel. Traveling fish screens were installed in the pump intake structures.

The water supply reservoir on the west side of the area has two sections, one of 15 million gallons known as the reserve and the other,

called a working section, held 10 million gallons. The pump house, located on the east side of the reservoir, contained 19 pumps ranging from 1,000 to 6,000 gpm and from 200 to 1,000 horsepower. These units were arranged to pump from individual suction wells to allow for isolation and drainage during maintenance operations. The systems were interconnected and valved to allow for back-up pumping in case of a power failure. A water filter building located adjacent to the reservoir pump house consisted of four structures: the chemical storage and mixing, flocculation and subsistence basins, the filter building and a clear water reservoir and pump room. The clear well had two 5 million-gallon reservoirs with a pump room in between. Fourteen pumps were installed ranging in size from 300 gpm and 20 hp for sanitary service up to 11,000 gpm and 700 hp for the filtered process water.

The deaeration plant can be identified by the 10 high towers west of the reactor. These units are four-stage rubber-lined tanks supported on 100-foot-high steel structures. The tanks then rise to a height of 174 feet above the building floor. Acid feed systems were connected to the water inlet and outlets of each deaerator.

Water flows by gravity from the deaerators to four tanks in the main pump house. These tanks had a steel pontoon floating roof which was sealed against air infiltration by a continuous neoprene-impregnated curtain having one side attached to the tank and the other to the pontoon. A water inlet control valve operated by an automatic mechanism held the level of the pontoon within small limits. Support legs were installed in the tank to support the pontoon when the tank was drained for repairs. These tanks were equipped with a 12 inch rubber lined valve for batch dumping if the water failed to meet specifications.



Twelve electrically-driven 800 hp, 3,000 gpm pumps were in series with 12 steam turbine-driven pumps for delivery of process water. In case of power failure, the previously mentioned flywheels on the electrically-driven pumps maintained water pressure until the turbine pumps could come up to speed to provide an additional measure of safety.

A reuse water reservoir was installed in the southwest corner of the building about 12 feet below ground level. Waste water from the steam jet condensers was collected in this reservoir and pumped back to the main supply reservoir during the winter months to keep the process water slightly above 35° F.

Helium gas was supplied from 33 high-pressure tanks each having a capacity of 250 cubic feet and filled to a pressure of 700 psi. Two low-pressure tanks each of 1,000 cubic feet operated at 50 psi for delivery to the pipe system.

The steam power plant contained four boilers rated at 100,000 pounds per hour each, generated steam at 225 psi and with about 50 degrees of superheat. Coal was fired in a thin bed on grates which were dumped by manually control led power.

The chemical pump house was three stories high and located east of the reactor building. The chemicals were stored on the third floor, mixing and pumping on the second, and the ground floor had an 18,000 cfm fan to provide heated air for the entire building. The railroad siding was covered and equipped with bulk dumping and conveying equipment. Lime, sodium silicate, oxalic acid, sodium dichromate and sulfuric acid were the principle chemicals used for water treatment.

#### MISCELLANEOUS ITEMS

1. Xenon gas poisoning of the transmutation process was discovered during the first few hours of operation. This occurred because Iodine-135 is rapidly formed during the fission process, and although it is not a strong neutron absorber, it quickly decays and forms Xenon-135, which does have an exceptionally large absorption cross section for thermal neutrons. When the B-Reactor was started with a 1500-tube cylindrical geometry, the effect of xenon poisoning caused the reactor to shut down. The correction was made by adding more nuclear fuel in the 500 peripheral tubes. The added neutron source overcame the xenon poisoning.
2. 40,000 carloads of material were shipped to the project in a period of 22 months.
3. The B area batch plant produced 102,304 cubic yards concrete between October 11, 1943 and April 11, 1944.
4. 30% of the concrete was pumped directly into the forms with Rex Pumpcrete machines having a capacity of 50 yards per hour.
5. 45,000 employees were working during the peak of construction in 1944.
6. The graphite blocks were laid to a tolerance of plus or minus .005".
7. The aluminum tubes were hydrostatically tested to 350 psi.