



Hanford Site

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The **Hanford Site** is a mostly decommissioned nuclear production complex operated by the United States federal government on the Columbia River in the U.S. state of Washington. The site has been known by many names, including: **Hanford Project**, **Hanford Works**, **Hanford Engineer Works** and **Hanford Nuclear Reservation**. Established in 1943 as part of the Manhattan Project in Hanford, south-central Washington, the site was home to the B Reactor, the first full-scale plutonium production reactor in the world.^[1] Plutonium manufactured at the site was used in the first nuclear bomb, tested at the Trinity site, and in Fat Man, the bomb detonated over Nagasaki, Japan.

During the Cold War, the project expanded to include nine nuclear reactors and five large plutonium processing complexes, which produced plutonium for most of the more than 60,000 weapons in the U.S. nuclear arsenal.^{[2][3]} Nuclear technology developed rapidly during this period, and Hanford scientists produced major technological achievements. Many early safety procedures and waste disposal practices were inadequate, and government documents have confirmed that Hanford's operations released significant amounts of radioactive materials into the air and the Columbia River.

The weapons production reactors were decommissioned at the end of the Cold War, and decades of manufacturing left behind 53 million US gallons (200,000 m³) of high-level radioactive waste^[4] stored within 177 storage tanks, an additional 25 million cubic feet (710,000 m³) of solid radioactive waste, and 200 square miles (520 km²) of contaminated groundwater beneath the site.^[5] In 2011, DOE emptied 149 single-shell tanks by pumping nearly all of the liquid waste out into 28 newer double-shell tanks. DOE later found water intruding into at least 14 single-shell tanks and that one of them had been leaking about 640 US gallons (2,400 l; 530 imp gal) per year into the ground since about 2010. In 2012, DOE discovered a leak also from a double-shell tank caused by construction flaws and corrosion in the bottom, and that 12 double-shell tanks have similar construction flaws. Since then, DOE changed to monitoring single-shell tanks monthly and double-shell tanks every 3 years, and also changed monitoring methods. In March 2014, DOE announced further delays in the construction of the Waste Treatment Plant, which will affect the schedule for removing waste from the tanks.^[6] Intermittent discoveries of undocumented contamination have slowed the pace and raised the cost of cleanup.^[7]

In 2007, the Hanford site represented two-thirds of the nation's high-level radioactive waste by volume.^[8] Hanford is currently the most contaminated nuclear site in the United States^{[9][10]} and is the focus of the nation's largest environmental cleanup.^[2] Besides the cleanup project, Hanford also hosts a commercial nuclear power plant, the Columbia Generating Station, and various centers for scientific research and development, such as the Pacific Northwest National Laboratory and the LIGO Hanford Observatory.

On November 10, 2015, it was designated as part of the Manhattan Project National Historical Park alongside other sites in Oak Ridge and Los Alamos.^[11]



Nuclear reactors line the riverbank at the Hanford Site along the Columbia River in January 1960. The N Reactor is in the foreground, with the twin KE and KW Reactors in the immediate background. The historic B Reactor, the world's first plutonium production reactor, is visible in the distance.

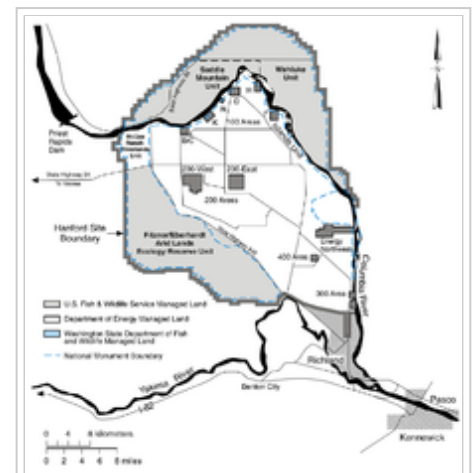
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Geography

The Hanford Site occupies 586 square miles (1,518 km²)—roughly equivalent to half of the total area of Rhode Island—within Benton County, Washington.^[2] This land is closed to the general public. It is a desert environment receiving under 10 inches of annual precipitation, covered mostly by shrub-steppe vegetation. The Columbia River flows along the site for approximately 50 miles (80 km), forming its northern and eastern boundary.^[12] The original site was 670 square miles (1,740 km²) and included buffer areas across the river in Grant and Franklin counties.^[13] Some of this land has been returned to private use and is now covered with orchards and irrigated fields. In 2000, large portions of the site were turned over to the Hanford Reach National Monument.^[14] The site is divided by function into three main areas. The nuclear reactors were located along the river in an area designated as the 100 Area; the chemical separations complexes were located inland in the Central Plateau, designated as the 200 Area; and various support facilities were located in the southeast corner of the site, designated as the 300 Area.^[15]

The site is bordered on the southeast by the Tri-Cities, a metropolitan area composed of Richland, Kennewick, Pasco, and smaller communities, and home to over 230,000 residents. Hanford is a primary economic base for these cities.^[16]



A map shows the main areas of the Hanford Site, as well as the buffer zone that was turned over to the Hanford Reach National Monument in 2000

Climate

Climate data for Hanford Site, Washington													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °F (°C)	65 (18)	71 (22)	87 (31)	95 (35)	103 (39)	110 (43)	115 (46)	110 (43)	101 (38)	89 (32)	73 (23)	68 (20)	115 (46)
Mean maximum °F (°C)	56.74 (13.74)	60.20 (15.67)	73.13 (22.85)	84.80 (29.33)	93.40 (34.11)	102.21 (39.01)	107.59 (41.99)	102.93 (39.41)	94.03 (34.46)	80.86 (27.14)	64.43 (18.02)	58.70 (14.83)	107.88 (42.16)
Average high °F (°C)	38.28 (3.49)	45.77 (7.65)	59.43 (15.24)	68.69 (20.38)	77.61 (25.34)	85.60 (29.78)	93.98 (34.43)	91.12 (32.84)	79.99 (26.66)	66.68 (19.27)	49.68 (9.82)	39.82 (4.34)	66.39 (19.11)
Average low °F (°C)	22.10 (−5.5)	25.98 (−3.34)	32.43 (0.24)	39.00 (3.89)	46.19 (7.88)	53.77 (12.09)	59.01 (15.01)	56.71 (13.73)	48.49 (9.16)	39.14 (3.97)	29.58 (−1.34)	24.25 (−4.31)	39.72 (4.29)
Mean minimum °F (°C)	5.13 (−14.93)	11.24 (−11.53)	20.53 (−6.37)	26.19 (−3.23)	33.50 (0.83)	43.00 (6.11)	48.32 (9.07)	45.47 (7.48)	36.50 (2.5)	26.25 (−3.19)	16.07 (−8.85)	7.26 (−13.74)	−2.88 (−19.38)
Record low °F (°C)	−22 (−30)	−19 (−28)	12 (−11)	12 (−11)	28 (−2)	33 (1)	41 (5)	40 (4)	25 (−4)	17 (−8)	0 (−18)	−27 (−33)	−27 (−33)
Average precipitation inches (mm)	0.84 (21.3)	0.57 (14.5)	0.28 (7.1)	0.42 (10.7)	0.52 (13.2)	0.58 (14.7)	0.10 (2.5)	0.19 (4.8)	0.34 (8.6)	0.56 (14.2)	1.05 (26.7)	0.91 (23.1)	6.14 (156)
Average snowfall inches (cm)	5.84 (14.83)	3.74 (9.5)	0.12 (0.3)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	1.94 (4.93)	4.44 (11.28)	16.08 (40.84)
Source: ^[17]													

Early history

The confluence of the Yakima, Snake, and Columbia rivers has been a meeting place for native peoples for centuries. The archaeological record of Native American habitation of this area stretches back over ten thousand years. Tribes and nations including the Yakama, Nez Perce, and Umatilla used the area for hunting, fishing, and gathering plant foods.^[18] Hanford archaeologists have identified numerous Native American sites, including "pit house villages, open campsites, fishing sites, hunting/kill sites, game drive complexes, quarries, and spirit quest sites",^[13] and two archaeological sites were listed on the National Register of Historic Places in 1976.^[19] Native American use of the area continued into the 20th century, even as the tribes were relocated to reservations. The Wanapum people were never forced onto a reservation, and they lived along the Columbia River in the Priest Rapids Valley until 1943.^[13] Euro-Americans began to settle the region in the 1860s, initially along the Columbia River south of Priest Rapids. They established farms and orchards supported by small-scale irrigation projects and railroad transportation, with small town centers at Hanford, White Bluffs, and Richland.^[20]

Manhattan Project

During World War II, the S-1 Section of the federal Office of Scientific Research and Development (OSRD) sponsored an intensive research project on plutonium. The research contract was awarded to scientists at the University of Chicago Metallurgical Laboratory (Met Lab). At the time, plutonium was a rare element that had only recently been isolated in a University of California laboratory. The Met Lab researchers worked on producing chain-

reacting "piles" of uranium to convert it to plutonium and finding ways to separate plutonium from uranium. The program was accelerated in 1942, as the United States government became concerned that scientists in Nazi Germany were developing a nuclear weapons program.^[21]

Site selection

In September 1942, the Army Corps of Engineers placed the newly formed Manhattan Project under the command of General Leslie R. Groves, charging him with the construction of industrial-size plants for manufacturing plutonium and uranium.^[13] Groves recruited the DuPont Company to be the prime contractor for the construction of the plutonium production complex. DuPont recommended that it be located far away from the existing uranium production facility at Oak Ridge, Tennessee. The ideal site was described by these criteria:^[22]

- A large and remote tract of land
- A "hazardous manufacturing area" of at least 12 by 16 miles (19 by 26 km)
- Space for laboratory facilities at least 8 miles (13 km) from the nearest reactor or separations plant
- No towns of more than 1,000 people closer than 20 miles (32 km) from the hazardous rectangle
- No main highway, railway, or employee village closer than 10 miles (16 km) from the hazardous rectangle
- A clean and abundant water supply
- A large electric power supply
- Ground that could bear heavy loads.

In December 1942, Groves dispatched his assistant Colonel Franklin T. Matthias and DuPont engineers to scout potential sites. Matthias reported that Hanford was "ideal in virtually all respects," except for the farming towns of White Bluffs and Hanford.^[23] General Groves visited the site in January and established the Hanford Engineer Works, codenamed "Site W". The federal government quickly acquired the land under its war powers authority^[24] and relocated some 1,500 residents of Hanford, White Bluffs, and nearby settlements, as well as the Wanapum people, Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe.^{[25][26]}

Construction begins

The Hanford Engineer Works (HEW) broke ground in March 1943 and immediately launched a massive and technically challenging construction project.^[27] DuPont advertised for workers in newspapers for an unspecified "war construction project" in southeastern Washington, offering "attractive scale of wages" and living facilities.^[28]

The construction workers (who reached a peak of 44,900 in June 1944) lived in a construction camp near the old Hanford townsite. The administrators and engineers lived in the government town established at Richland Village, which eventually had accommodation in 4,300 family units and 25 dormitories.^{[29] [30]}



Hanford High School, shown before residents were displaced by the creation of the Hanford Site



Hanford High after abandonment



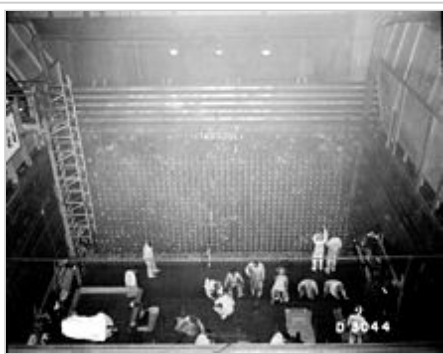
B Reactor construction (1944)

Construction of the nuclear facilities proceeded rapidly. Before the end of the war in August 1945, the HEW built 554 buildings at Hanford, including three nuclear reactors (105-B, 105-D, and 105-F) and three plutonium processing canyons (221-T, 221-B, and 221-U), each 250 meters (820 ft) long.

To receive the radioactive wastes from the chemical separations process, the HEW built "tank farms" consisting of 64 single-shell underground waste tanks (241-B, 241-C, 241-T, and 241-U).^[31] The project required 386 miles (621 km) of roads, 158 miles (254 km) of railway, and four electrical substations. The HEW used 780,000 cubic yards (600,000 m³) of concrete and 40,000 short tons (36,000 t) of structural steel and consumed \$230 million between 1943 and 1946.^[32]

Plutonium production

The B Reactor (105-B) at Hanford was the first large-scale plutonium production reactor in the world. It was designed and built by DuPont based on an experimental design by Enrico Fermi, and originally operated at 250 megawatts (thermal). The reactor was graphite moderated and water cooled. It consisted of a 28-by-36-foot (8.5 by 11.0 m), 1,200-short-ton (1,100 t) graphite cylinder lying on its side, penetrated through its entire length horizontally by 2,004 aluminium tubes.^[33] Two hundred short tons (180 t) of uranium slugs, 1.625 inches (4.13 cm) diameter by 8 inches (20 cm) long, sealed in aluminium cans went into the tubes.^[34] Cooling water was pumped through the aluminium tubes around the uranium slugs at the rate of 30,000 US gallons (110,000 L) per minute.^[33]



The B Reactor during construction

Construction on B Reactor began in August 1943 and was completed on September 13, 1944. The reactor went critical in late September and, after overcoming nuclear poisoning, produced its first plutonium on November 6, 1944.^[35] Plutonium was produced in the Hanford reactors when a uranium-238 atom in a fuel slug absorbed a neutron to form uranium-239. U-239 rapidly undergoes beta decay to form neptunium-239, which rapidly undergoes a second beta decay to form plutonium-239. The irradiated fuel slugs were transported by rail to three huge remotely operated chemical separation plants called "canyons" that were about 10 miles (16 km) away. A series of chemical processing steps separated the small amount of plutonium that was produced from the remaining uranium and the fission waste products. This first batch of plutonium was refined in the 221-T plant from

December 26, 1944, to February 2, 1945, and delivered to the Los Alamos laboratory in New Mexico on February 5, 1945.^[36]

Two identical reactors, D Reactor and F reactor, came online in December 1944 and February 1945, respectively. By April 1945, shipments of plutonium were headed to Los Alamos every five days, and Hanford soon provided enough material for the bombs tested at Trinity and dropped over Nagasaki.^[37] Throughout this period, the Manhattan Project maintained a top secret classification. Until news arrived of the bomb dropped on Hiroshima, fewer than one percent of Hanford's workers knew they were working on a nuclear weapons project.^[38] General Groves noted in his memoirs that "We made certain that each member of the project thoroughly understood his part in the total effort; that, and nothing more."^[39]

Initially six reactors or "piles" were proposed, when the plutonium was to be used in the gun-type Thin Man bomb. In mid-1944 a simple gun-type bomb was found to be impractical for plutonium, and the more advanced Fat Man bomb required less plutonium. The number of piles was reduced to four and then three; and the number of chemical separation plants from four to three.^[40]

Technological innovations

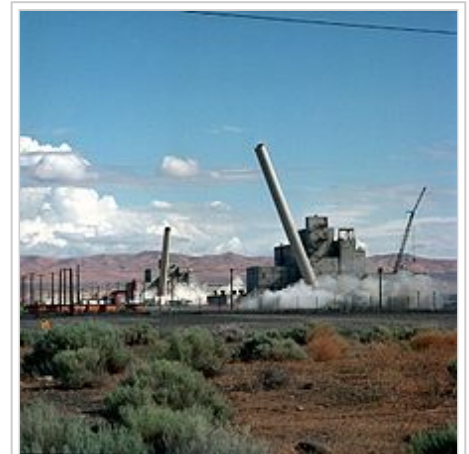
In the short time frame of the Manhattan Project, Hanford engineers produced many significant technological advances. As no one had ever built an industrial-scale nuclear reactor before, scientists were unsure how much heat would be generated by fission during normal operations. Seeking the greatest possible production while maintaining an adequate safety margin, DuPont engineers installed ammonia-based refrigeration systems with the D and F reactors to further chill the river water before its use as reactor coolant.^[41]

Another difficulty the engineers struggled with was how to deal with radioactive contamination. Once the canyons began processing irradiated slugs, the machinery would become so radioactive that it would be unsafe for humans ever to come in contact with it. The engineers therefore had to devise methods to allow for the replacement of any component via remote control. They came up with a modular cell concept, which allowed major components to be removed and replaced by an operator sitting in a heavily shielded overhead crane. This method required early practical application of two technologies that later gained widespread use: Teflon, used as a gasket material, and closed-circuit television, used to give the crane operator a better view of the process.^[42]

Cold War expansion

In September 1946, the General Electric Company assumed management of the Hanford Works under the supervision of the newly created Atomic Energy Commission. As the Cold War began, the United States faced a new strategic threat in the rise of the Soviet nuclear weapons program. In August 1947, the Hanford Works announced funding for the construction of two new weapons reactors and research leading to the development of a new chemical separations process. With this announcement, Hanford entered a new phase of expansion.^[43]

By 1963, the Hanford Site was home to nine nuclear reactors along the Columbia River, five reprocessing plants on the central plateau, and more than 900 support buildings and radiological laboratories around the site.^[2] Extensive modifications and upgrades were made to the original three World War II reactors, and a total of 177 underground waste tanks were built.^[2] Hanford was at its peak production from 1956 to 1965. Over the entire 40 years of operations, the site produced about 63 short tons (57 t) of plutonium, supplying the majority of the 60,000 weapons in the U.S. arsenal.^{[2][3]} Uranium-233 was also produced.^{[44][45][46][47]}



Decommissioning D Reactor

Decommissioning

Most of the reactors were shut down between 1964 and 1971, with an average individual life span of 22 years. The last reactor, N Reactor, continued to operate as a dual-purpose reactor, being both a power reactor used to feed the civilian electrical grid via the Washington Public Power Supply System (WPPSS) and a plutonium production reactor for nuclear weapons. N Reactor operated until 1987. Since then, most of the Hanford reactors have been entombed ("cocooned") to allow the radioactive materials to decay, and the surrounding structures have been removed and buried.^[48] The B-Reactor has not been cocooned and is accessible to the public on occasional guided tours. It was listed on the National Register of Historic Places in 1992,^[49] and some historians advocate converting it into a museum.^{[50][51]} B reactor was designated a National Historic Landmark by the National Park Service on August 19, 2008.^{[52][53]}

Weapons Production Reactors^[54]

Reactor name	Start-up date	Shutdown date	Initial power (MWt)	Final power (MWt)
B Reactor	Sep 1944	Feb 1968	250	2210
D Reactor	Dec 1944	Jun 1967	250	2165
F Reactor	Feb 1945	Jun 1965	250	2040
H Reactor	Oct 1949	Apr 1965	400	2140
DR ("D Replacement") Reactor	Oct 1950	Dec 1964	250	2015
C Reactor	Nov 1952	Apr 1969	650	2500
KW ("K West") Reactor	Jan 1955	Feb 1970	1800	4400
KE ("K East") Reactor	Apr 1955	Jan 1971	1800	4400
N Reactor	Dec 1963	Jan 1987	4000	4000

Later operations

The United States Department of Energy assumed control of the Hanford Site in 1977. Although uranium enrichment and plutonium breeding were slowly phased out, the nuclear legacy left an indelible mark on the Tri-Cities. Since World War II, the area had developed from a small farming community to a booming "Atomic Frontier" to a powerhouse of the nuclear-industrial complex.^[55] Decades of federal investment created a community of highly skilled scientists and engineers. As a result of this concentration of specialized skills, the Hanford Site was able to diversify its operations to include scientific research, test facilities, and commercial nuclear power production.



Highway sign on a road entering the Hanford Site

As of 2013, operational facilities located at the Hanford Site include:

- The Pacific Northwest National Laboratory, owned by the Department of Energy and operated by Battelle Memorial Institute
- The Fast Flux Test Facility (FFTF), a national research facility in operation from 1980 to 1992 (its last fuel was removed in 2008^[56])
- LIGO's Hanford Observatory, an interferometer searching for gravitational waves^{[57][58][59][60]}
- Columbia Generating Station, a commercial nuclear power plant operated by Energy Northwest.
- A US Navy nuclear submarine reactor dry storage site contains sealed reactor sections of 114 US Navy submarines (as of 2008).^[61]

The Department of Energy and its contractors offer tours of the site. Sixty public tours, each five hours long, were planned for 2009. The tours are free, require advance reservation via the department's web site, and are limited to U.S. citizens at least 18 years of age.^[62]

Environmental concerns

A huge volume of water from the Columbia River was required to dissipate the heat produced by Hanford's nuclear reactors. From 1944 to 1971, pump systems drew cooling water from the river and, after treating this water for use by the reactors, returned it to the river. Before its release into the river, the used water was held in large tanks known as retention basins for up to six hours. Longer-lived isotopes were not affected by this retention, and several

terabecquerels entered the river every day. The federal government kept knowledge about these radioactive releases secret.^[63] Radiation was later measured 200 miles downstream as far west as the Washington and Oregon coasts.^[64]

The plutonium separation process resulted in the release of radioactive isotopes into the air, which were carried by the wind throughout southeastern Washington and into parts of Idaho, Montana, Oregon, and British Columbia.^[63] Downwinders were exposed to radionuclides, particularly iodine-131, with the heaviest releases during the period from 1945 to 1951. These radionuclides entered the food chain via dairy cows grazing on contaminated fields; hazardous fallout was ingested by communities who consumed radioactive food and milk. Most of these airborne releases were a part of Hanford's routine operations, while a few of the larger releases occurred in isolated incidents. In 1949, an intentional release known as the "Green Run" released 8,000 curies of iodine-131 over two days.^[65] Another source of contaminated food came from Columbia River fish, an impact felt disproportionately by Native American communities who depended on the river for their customary diets.^[63] A U.S. government report released in 1992 estimated that 685,000 curies of radioactive iodine-131 had been released into the river and air from the Hanford site between 1944 and 1947.^[66]



The Hanford Reach of the Columbia River, where radioactivity was released from 1944 to 1971



Salmon spawning in the Hanford Reach near the H-Reactor

Beginning in the 1960s, scientists with the U.S. Public Health Service published reports about radioactivity released from Hanford, and there were protests from the health departments of Oregon and Washington. In response to an article in the *Spokane Spokesman Review* in September 1985, the Department of Energy announced to declassify environmental records and, in February 1986, released 19,000 pages of previously unavailable historical documents about Hanford's operations.^[63] The Washington State Department of Health collaborated with the citizen-led Hanford Health Information Network (HHIN) to publicize data about the health effects of Hanford's operations. HHIN reports concluded that residents who lived downwind from Hanford or who used the Columbia River downstream were exposed to elevated doses of radiation that placed them at increased risk for various

cancers and other diseases.^[63] A mass tort lawsuit brought by two thousand Hanford downwinders against the federal government has been in the court system for many years.^[67] Two of six plaintiffs who went to trial in 2005 were awarded \$500,000 in damages.^[68]

On February 15, 2013, Governor Jay Inslee announced that a tank storing radioactive waste at the site had been leaking liquids on average of 150 to 300 gallons per year. He said that the leak posed no immediate health risk to the public, but said that should not be an excuse for not doing anything.^[69] On February 22, 2013, the Governor stated that "6 more tanks at Hanford site" were "leaking radioactive waste"^[70] As of 2013, there are 177 tanks at Hanford, 149 of which have a single shell. Historically single shell tanks were used for storing radioactive liquid waste and designed to last 20 years. By 2005, some liquid waste was transferred from single shell tanks to (safer) double shell tanks. A substantial amount of residue remains in the older single shell tanks with one containing an estimated 447,000 gallons of radioactive sludge, for example. It is believed that up to six of these "empty" tanks are leaking. Two tanks are reportedly leaking at a rate of 300 gallons (1,136 liters) per year each, while the remaining four tanks are leaking at a rate of 15 gallons (57 liters) per year each.^{[71][72]}

Since 2003, radioactive materials are known to be leaking from Hanford into the environment. "The highest tritium concentration detected in riverbank springs during 2002 was 58,000 pCi/L (2,100 Bq/L) at the Hanford Townsite. The highest iodine-129 concentration of 0.19 pCi/L (0.007 Bq/L) was also found in a Hanford Townsite spring. The WHO guidelines for radionuclides in drinking-water limits levels of iodine-129 at 1 Bq/L, and tritium at 10,000 Bq/L.^[73] Concentrations of radionuclides including tritium, technetium-99, and iodine-129 in riverbank springs near the Hanford Townsite have generally been increasing since 1994. This is an area where a major groundwater plume from the 200 East Area intercepts the river ... Detected radionuclides include strontium-90, technetium-99, iodine-129, uranium-234, -235, and -238, and tritium. Other detected contaminants include arsenic, chromium, chloride, fluoride, nitrate, and sulfate."^[74]

Occupational health concerns

Since 1987, workers have reported exposure to harmful vapors after working around underground nuclear storage tanks, with no solution found. More than 40 workers in 2014 alone reported smelling vapors and became ill with "nosebleeds, headaches, watery eyes, burning skin, contact dermatitis, increased heart rate, difficulty breathing, coughing, sore throats, expectorating, dizziness and nausea, ... Several of these workers have long-term disabilities." Doctors checked workers and cleared them to return to work. Monitors worn by tank workers have found no samples with chemicals close to the federal limit for occupational exposure.^[75]

In August 2014, OSHA ordered the facility to rehire a contractor and pay \$220,000 in back wages for firing them for whistleblowing on safety concerns at the site.^[76]

On November 19, 2014, Washington Attorney General Bob Ferguson said the state planned to sue the DOE and its contractor to protect workers from hazardous vapors at Hanford. A 2014 report by the DOE Savannah River National Laboratory initiated by 'Washington River Protection Solutions' found that DOE's methods to study vapor releases were inadequate, particularly, that they did not account for short but intense vapor releases. They recommended "proactively sampling the air inside tanks to determine its chemical makeup; accelerating new practices to prevent worker exposures; and modifying medical evaluations to reflect how workers are exposed to vapors".^[75]

Cleanup era

On June 25, 1988, the Hanford site was divided into four areas and proposed for inclusion on the National Priorities List.^[77] On May 15, 1989, the Washington Department of Ecology, the United States Environmental Protection Agency, and the Department of Energy entered into the Tri-Party Agreement, which provides a legal framework for environmental remediation at Hanford.^[10] As of 2014 the agencies are engaged in the world's largest environmental cleanup, with many challenges to be resolved in the face of overlapping technical, political, regulatory, and cultural interests. The cleanup effort is focused on three outcomes: restoring the Columbia River corridor for other uses, converting the central plateau to long-term waste treatment and storage, and preparing for the future.^[78] The cleanup effort is managed by the Department of Energy under the oversight of the two regulatory agencies. A citizen-led Hanford Advisory Board provides recommendations from community stakeholders, including local and state governments, regional environmental organizations, business interests, and Native American tribes.^[79] Citing the 2014 Hanford Lifecycle Scope Schedule and Cost report, the 2014 estimated cost of the remaining Hanford clean up is \$113.6 billion – more than \$3 billion per year for the next six years, with a lower cost projection of approximately \$2 billion per year until



Image of the surface of waste found inside double-shell tank 101-SY at the Hanford Site, April 1989

2046.^{[80][81][82]} About 11,000 workers are on site to consolidate, clean up, and mitigate waste, contaminated buildings, and contaminated soil.^[4] Originally scheduled to be complete within thirty years, the cleanup was less than half finished by 2008.^[82] Of the four areas that were formally listed as Superfund sites on October 4, 1989, only one has been removed from the list following cleanup.^[83]



Spent nuclear fuel stored underwater and uncapped in Hanford's K-East Basin

While major releases of radioactive material ended with the reactor shutdown in the 1970s and many of the most dangerous wastes are contained, there are continued concerns about contaminated groundwater headed toward the Columbia River and about workers' health and safety.^[82]

The most significant challenge at Hanford is stabilizing the 53,000,000 US gallons (200,000,000 l; 44,000,000 imp gal) of high-level radioactive waste stored in 177 underground tanks. By 1998, about a third of these tanks had leaked waste into the soil and groundwater.^[84] As of 2008, most of the liquid waste has been transferred to more secure double-shelled tanks; however, 2,800,000 US gallons (11,000,000 l; 2,300,000 imp gal) of liquid waste, together with 27,000,000 US gallons (100,000,000 l; 22,000,000 imp gal) of salt cake and sludge, remains in the single-shelled tanks.^[4] DOE lacks

information about the extent to which the 27 double-shell tanks may be susceptible to corrosion. Without determining the extent to which the factors that contributed to the leak in AY-102 were similar to the other 27 double-shell tanks, DOE cannot be sure how long its double-shell tanks can safely store waste.^[6] That waste was originally scheduled to be removed by 2018. As of 2008, the revised deadline was 2040.^[82] Nearby aquifers contain an estimated 270,000,000,000 US gallons (1.0×10^{12} l; 2.2×10^{11} imp gal) of contaminated groundwater as a result of the leaks.^[85] As of 2008, 1,000,000 US gallons (3,800,000 l; 830,000 imp gal) of radioactive waste is traveling through the groundwater toward the Columbia River. This waste is expected to reach the river in 12 to 50 years if cleanup does not proceed on schedule.^[4] The site includes 25 million cubic feet (710,000 m³) of solid radioactive waste.^[85]

Under the Tri-Party Agreement, lower-level hazardous wastes are buried in huge lined pits that will be sealed and monitored with sophisticated instruments for many years. Disposal of plutonium and other high-level wastes is a more difficult problem that continues to be a subject of intense debate. As an example, plutonium-239 has a half-life of 24,100 years, and a decay of ten half-lives is required before a sample is considered to cease its radioactivity.^{[86][87]} In 2000, the Department of Energy awarded a \$4.3 billion contract to Bechtel, a San Francisco-based construction and engineering firm, to build a vitrification plant to combine the dangerous wastes with glass to render them stable. Construction began in 2002. The plant was originally scheduled to be operational by 2011, with vitrification completed by 2028.^{[82][88][89]} As of 2012, according to a study by the General Accounting Office, there were a number of serious unresolved technical and managerial problems.^[90] As of 2013 estimated costs were \$13.4 billion with commencement of operations estimated to be in 2022 and about 3 decades of operation.^[91]



Grand opening of the Environmental Restoration Disposal Facility (ERDF)

In May 2007, state and federal officials began closed-door negotiations about the possibility of extending legal cleanup deadlines for waste vitrification in exchange for shifting the focus of the cleanup to urgent priorities, such as groundwater remediation. Those talks stalled in October 2007. In early 2008, a \$600 million cut to the Hanford cleanup budget was proposed. Washington state officials expressed concern about the budget cuts, as well as missed

deadlines and recent safety lapses at the site, and threatened to file a lawsuit alleging that the Department of Energy is in violation of environmental laws.^[82] They appeared to step back from that threat in April 2008 after another meeting of federal and state officials resulted in progress toward a tentative agreement.^[92]

During excavations from 2004 to 2007 a sample of purified plutonium was uncovered inside a safe in a waste trench, and has been dated to about the 1940s, making it the second-oldest sample of purified plutonium known to exist. Analyses published in 2009 concluded that the sample originated at Oak Ridge, and was one of several sent to Hanford for optimization tests of the T-Plant until Hanford could produce its own plutonium. Documents refer to such a sample, belonging to "Watt's group", which was disposed of in its safe when a radiation leak was suspected.^{[93][94]}



Wikinews has related news: ***Milestone at world's largest cleanup site: Hanford nuclear basin removed***

Some of the radioactive waste at Hanford was supposed to be stored in the planned Yucca Mountain nuclear waste repository, but after that project was cancelled due to the opposition of citizens of Nevada, Washington State sued. They were joined by South Carolina. Their first suit was dismissed, and second suits have been filed.

A potential radioactive leak was reported in 2013; the clean up was estimated to have cost \$40 billion with \$115 billion more required.^[95]

Hanford organizations

The Hanford site operations were initially directed by Colonel Franklin Matthias of the U.S. Army Corps of Engineers. Postwar the Atomic Energy Commission took over, and then the Energy Research and Development Administration. Hanford operations are currently directed by the U.S. Department of Energy. It has been operated under government contract by various private companies over the years – the table which follows summarizes the operating contractors through 2000.^[96]

Year begun	Month	Organization	Responsibility	Remarks
1942	December 12	U.S. Army Corps of Engineers	Lead U.S. Government entity	Held role until January 1, 1947
1942	December 12	E.I. DuPont de Nemours & Company (DuPont)	All site activities	Initial Hanford site contractor
1946	September 1	General Electric Company (GE)	All site activities	Replaced DuPont
1947	January 1	Atomic Energy Commission	Lead U.S. Government entity	Replaced U.S. Army Corps of Engineers
1953	May 15	Vitro Engineers	Hanford Engineering Services	Assumed GE's new facility design role
1953	June 1	J.A. Jones Construction	Hanford Construction Services	Assumed GE's construction role
1965	January 1	U.S. Testing	Environmental & bioassay testing	Assumed GE's environmental and bioassay testing role
1965	January 4	Battelle Memorial Institute	Pacific Northwest Laboratory (PNL)	Assumed GE's laboratory operations – subsequently renamed Pacific Northwest National Laboratory
1965	July 1	Computer Sciences Corporation (CSC)	Computer services	New scope
1965	August 1	Hanford Occupational Health Foundation	Industrial Medicine	Assumed GE's industrial medicine role
1965	September 10	Douglas United Nuclear	Single pass reactor operations & fuel fabrication	Assumed part of GE's reactor operations
1966	January 1	Isochem	Chemical processing	Assumed GE's chemical processing operations
1966	March 1	ITT Federal Support Services, Inc.	Support services	Assumed
1967	July 1	Douglas United Nuclear	N Reactor operation	Assumed remainder of GE's reactor operations
1967	September 4	Atlantic Richfield Hanford Company	Chemical Processing	Replaced Isochem
1967	August 8	Hanford Environmental Health Foundation	Industrial Medicine	Name change only
1970	February 1	Westinghouse Hanford Company	Hanford Engineering Development Laboratory	Spun off from PNL with mission to build the Fast Flux Test Facility
1971	September	ARHCO	Support Services	Replaces ITT/PSS
1973	April	United Nuclear Industries, Inc.	All production reactor operations	Name change from Douglas United Nuclear only
1975	January 1	Energy Research and Development Administration (ERDA)	Lead U.S. Government entity	Replaced AEC – managed site until October 1, 1977

Year begun	Month	Organization	Responsibility	Remarks
1975	October 1	Boeing Computer Services (BCS)	Computer services	Replaced CSC
1977	October 1	U.S. Department of Energy (DOE)	Lead U.S. Government Agency	Replaced ERDA – manages site presently
1977	October 1	Rockwell Hanford Operations (RHO)	Chemical Processing & Support Services	Replaces ARCHO
1981	June	Braun Hanford Company (BHC)	Architect & Engineering Services	Replaces Vitro
1982	March	Kaiser Engineering Hanford (KEH)	Architect & Engineering Services	Replaces BHC
1987	March 1	KEH	Construction	Consolidated contract includes former J.A. Jones work
1987	June 29	WHC	Site management & operations	Consolidated contract includes former RHO, UNC & KEH work.
1996	October 1	Fluor Daniel Hanford, Inc. (FDH)	Site management & operations	FDH is integrating contractor with 13 subcontracted companies
2000	February 7	Fluor Hanford	Site cleanup operations	Transition to site cleanup (13 Fluor subcontractors held various roles)
2000	December 11	Bechtel National, Inc.	Engineering, construction, and commissioning of the Waste Treatment Plant	
2008	October 1	Ch2M Hill Plateau Remediation Company	Central plateau cleanup and closure	
2009	April 8	Washington Closure Hanford	River corridor cleanup and closure	
2009	May 26	Mission Support Alliance	Site infrastructure and services	Consolidated services contract
2009	October 1	Washington River Protection Solutions	Tank Farm operations	

Other divisions of the site (historical)

- Plutonium Finishing Plant (PFP) – made plutonium metal for use in weapons^[97]
- B Plant, S Plant, T Plant – processing, separation, and extraction of various chemicals and isotopes^{[98][99]}
- Health Instruments Section – an attempt to keep workers and the environment safe^[99]
- REDOX Plant / C Plant – recovered wasted uranium from World War II processes^[99]
- Experimental Animal Farm and Aquatic Biology Laboratory^[99]
- Technical Center – radiochemistry, physics, metallurgy, biophysics, radioactive sewer, neutralization, metal fab, fuels manufacturing^[99]
- Tank Farms – storage of liquid nuclear waste^[99]
- Metal Recovery Plant / U Plant – recover uranium from tank farms^[99]
- Uranium Trioxide Plant (aka Uranium Oxide Plant aka UO₃ Plant) – took output from other plants (i.e. liquid uranyl nitrate hexahydrate from U plant and PUREX plant), made uranium trioxide

powder^{[98][99][100][101][102][103][104]}

- Plutonium-Uranium Extraction Plant / PUREX Plant – extracted useful material from spent fuel waste (also see the PUREX article)^{[98][99]}
- Plutonium Recycle Test Reactor (PRTR) – experimented with alternative fuel mixtures^{[97][99][105][106]}
- Plutonium Fuels Pilot Plant (PFPP) – see PRTR

Historic photos



Cooling water retention basins at the F-Reactor



Underground tank farm with 12 of the site's 177 waste storage tanks



Inside one of the waste storage tanks



Inside the PUREX facility



View of the central plateau from Rattlesnake Mountain



The government town of Richland in the early days of the site



Hanford workers lining up for paychecks



Hanford scientists feeding radioactive food to sheep



Testing a sheep's thyroid for radiation



Cold War-era billboard



"Atomic Frontier Days" parade in Richland



The Fast Flux Test Facility

See also

- Black Ops 2 (Green Run location)
- Fernald Feed Materials Production Center
- Harry Shearer's Le Show— a weekly radio show and podcast featuring "Clean, Safe, Too Cheap to Meter", a series of regular updates on the Hanford Site, and nuclear power news around the world.
- Idaho National Laboratory
- James Acord
- Lists of nuclear disasters and radioactive incidents
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Paducah Gaseous Diffusion Plant
- Pantex Plant
- *Plutopia*
- Radioactive contamination from the Rocky Flats Plant
- Rocky Flats Plant
- *Safe As Mother's Milk*
- Sandia National Laboratories
- Savannah River Site
- Timeline of nuclear weapons development

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Further reading

- John M. Findlay and Bruce Hevly. *Atomic Frontier Days: Hanford and the American West* (University of Washington Press; 2011) 368 pages; explores the history of the Hanford nuclear reservation and the tri-cities of Richland, Pasco, and Kennewick, Washington

External links

- Official Hanford website (<http://www.hanford.gov/>) Department of Energy.
- Washington Department of Ecology – Nuclear Waste Program (<http://www.ecy.wa.gov/programs/nwp/>) State agency that regulates Hanford cleanup.
- U.S. Environmental Protection Agency (<http://yosemite.epa.gov/R10/CLEANUP.NSF/sites/Hanford>) Federal agency that regulates Hanford cleanup.
- Hanford Challenge (<http://www.hanfordchallenge.org/>) Hanford watchdog group, based in Seattle.
- Hanford News (<http://www.hanfordnews.com/>) Current news from the *Tri-City Herald*.
- Hanford Site Environmental Report (<http://hanford-site.pnl.gov/envreport/>) Detailed annual report on radioactive concentrations measured at the Hanford Site.
- Atomic Heritage Foundation (<http://www.atomicheritage.org/>) Historic Preservation of Manhattan Project Sites at Hanford.
- "Ranger in Your Pocket" Online tours of Hanford's Manhattan Project sites (<http://www.atomicheritage.org/tours>) Atomic Heritage Foundation
- B Reactor Museum Association (<http://www.b-reactor.org/>) A collection of Hanford-related documents from a group fighting to preserve the B-100 Reactor at Hanford.
- Contaminated US site faces 'catastrophic' nuclear leak (<http://www.newscientist.com/article/mg19926642.900-contaminated-us-site-faces-catastrophic-nuclear-leak.html?full=true&print=true>) 2008 *New Scientist* report.
- Heart of America Northwest (<http://www.hoanw.org/>) Hanford watchdog group, based in Seattle.
- The Alsos Digital Library for Nuclear Issues (<http://alsos.wlu.edu/qsearch.aspx?browse=places/Hanford,+Washington>) Annotated bibliography for the Hanford Site.
- A Review of Data Triples Plutonium Waste Figures (<http://www.nytimes.com/2010/07/11/science/earth/11plutonium.html?hp>) Matthew L. Wald, *The New York Times*, July 10, 2010
- Washington River Protection Solutions (<http://www.wrpsoc.com/>) Hanford environmental remediation contractor.



Wikimedia Commons has media related to ***Hanford Site***.

- Safe as Mother's Milk: The Hanford Project (<http://www.hanfordproject.com/>)
- Hanford (<http://www.opb.org/television/programs/oregonexperience/segment/hanford/>) Documentary produced by Oregon Public Broadcasting

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