The Early Hanford Reactor Site: Disposal Methods and Social Impact

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Introduction

Communities struggling with a legacy of nuclear waste are often connected to weapons development. Whether it is Hanford in the United States or Mayak in Russia, the rushed production at such sites led to simple disposal schemes, releasing large quantities of radioactive material. Hanford acted as a "company town", in which the actions of the facility and its contractors were not to be questioned. Additionally, the limited research on the environmental impact of radiation was rarely shared between Hanford and other Manhattan Project sites, leading to a culture of hurried decisions with little consideration as to their broader impact.

The plutonium found in nuclear weapons, plutonium-239, has a half-life of 24,100 years.[1] Its production requires the bombardment of uranium-235 atoms by a barrage of neutrons generated by the decay of other uranium-235 atoms. Only a portion of the uranium in a pile will decay into plutonium-239. The mixture of untouched uranium-235, plutonium-239, and many other daughter products must then be chemically processed to yield tiny amounts of plutonium, resulting in the creation of massive quantities of radioactive waste.[2]

The race to create and use atomic weapons led to difficult cost-benefit calculations. With the United States facing an existential threat, nearly any action could be justified through the fog of war. Urgency drove decision-making. The environmental cost was not the Army's priority. Army brass needed a site that could cope with the environmental consequences of supporting plutonium production reactors. It needed a desolate landscape, access to water, electricity, and geographic isolation from high-population areas. That, the Army reasoned, would limit the collateral damage.

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[1] "Backgrounder on Plutonium", U.S. Nuclear Regulatory Commission

[2] "Seaborg and Plutonium Chemistry", Department of Energy

When Army brass chose Hanford as the site for its production reactors to support the atomic weapons program, it saw a vast expanse of scrubland nestled along the Columbia River. In this place, where they saw nothing, they would create a vibrant community of engineers, scientists, and professionals. The Army would also attempt to erase the indigenous people and farmers who called the area home for decades.[3]

The damage caused by the site is long-lived. Since the final reactor went offline in 1987, environmental concerns have abounded. The cost of remaining cleanup is projected to be $9 billion per year at peak cost and the cleanup will continue until 2078. The low-range total estimate for the remaining cleanup is $323.2 billion.[4] The high-end estimate is $677 billion. The slow seepage of wastes dumped on the Hanford site, the poor record-keeping at the site, and the potential for catastrophic events continue to lengthen the timeline. By the current estimated timetable, the cleanup will take generations, if not longer. But Hanford does not stand alone. Defense-based weapons facilities in the United States have contaminated approximately 40 million acres of land (an area slightly larger than the state of Florida).[5] Hanford is just one example of a much larger problem.

The Hanford site's wartime origins shaped its environmental legacy. The primary motive of production over caution led to shortcomings in safety considerations, with the lack of foresight also stemming from a broader culture of workplace safety that existed in the 1940s. Though the first contractor, DuPont, prioritized worker safety, it did so with limited scientific information from other Manhattan Project sites. This lack of information in turn caused DuPont to utilize questionable disposal methods under the assumption that dilution of radioactive

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[3] Bruce and Hevly, 15-25

[4] *2019 Hanford Scope, Schedule, and Cost Report*, P-1

[5] Lustgarten, 2017

particles with another solution would reduce the environmental impact of radioactive emissions. These methods included: venting airborne radioisotopes into the atmosphere, dispersing radioactive particles in the Columbia River, and dumping diluted chemical wastes onto and into the ground. These central factors, the production motive, limited scientific information about the impact of radiation, and the workplace safety culture of the 1940s, all resulted in the release of significant levels of radioactivity both over the lifetime of the facility and long after its decommissioning. The site also deeply impacted the nearby communities of Richland, Pasco, and Kennewick, forming a science and engineering-oriented company town.

World War II Production

The story of Hanford begins with World War II. The United States believed itself to be in a deadly race with Germany to build the atomic bomb. On September 18, 1942, General Leslie Groves was given the charge of overseeing the Manhattan Engineer District, or the Manhattan Project.[6] Groves immediately pushed for the acquisition of a site in Oak Ridge, Tennessee to process uranium and directed Dr. Robert Oppenheimer to find a suitable site in the southwest for building and testing a bomb.[7] Groves also directed a team led by Colonel Franklin Matthias to search for a site to refine uranium into plutonium due to its potential use in another type of atomic bomb.[8]

Col. Matthias began his search near the Grand Coulee area in Washington state along the Columbia River. The area was attractive not only for the easy accessibility of cold water to cool the refinery, but also due to the abundance of hydroelectricity nearby to power water pumps and

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[6] Bird, Loc. 3807

[7] *Ibid.*, Loc. 3807

[8] Findlay and Hevly, 18

other machinery.[9] When Matthias' team looked at the Hanford site in eastern Washington, they quickly discovered the region's benefits: the area was sparsely-populated, provided easy access to gravel on-site for rapid building, and provided seclusion for a top-secret matter of national security.[10] The army announced that it would condemn nearly 3,000 tracts of land owned by approximately 2,000 individuals in February 1943, thus creating the Hanford Reservation. The federal government only permitted them 30 days to leave and provided the minimum amount of compensation necessary to secure the land.

With the site in hand, the federal government needed an experienced contractor to oversee production. Eventually, Gen. Groves tapped DuPont Chemical to oversee the new facility. Within their contract, DuPont instituted a corporate payscale for its employees due to fears that the company could not attract skilled laborers and engineers.[11] Their fears would later be proven true: Matthias reported that the early phases of the project were characterized by a monthly employee turnover rate of 10 percent.[12] DuPont's experience as a weapons manufacturer also informed its safety practices, which relied upon keeping the facilities a safe distance from inhabited areas.[13]

The Hanford Engineering Works were meticulously planned with the plutonium production cycle in mind. The three production reactors, B, D, and F consisted of the same basic plan: a grid of graphite bricks with holes bored down the middle (see **Figure 1** on next page).[14] The holes held uranium fuel rods (uranium pellets encased in aluminum), control rods (to regulate the speed of the chain reaction), or safety rods (designed to halt the chain reaction).

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[9] *Ibid.*, 18
[10] *Ibid.,* 19
[11] Findlay and Hevly, 23
[12] *Ibid.*, 25
[13] *Ibid.*, 24
[14] Gerber, 33

Once the fuel was spent, it was pushed out of the back of the graphite matrix into a pool of water to cool. After cooling sufficiently, the fuel was taken by a remote mechanical device to chemical separation facilities, where the plutonium was dissolved from unconverted portions of the fuel rod.[15] This stage presented the greatest overall environmental risk due to the impact various solvents had upon the adsorption rates of various radioactive byproducts.[16] The effluent, or cooling water, produced by the Hanford "100 area" was held for a short amount of time before being returned to the Columbia River (see Figure 1 for a reference map). This water was filled with over 60 different radionuclides.

Figure 1: Basic Design of B, D, and F Reactors

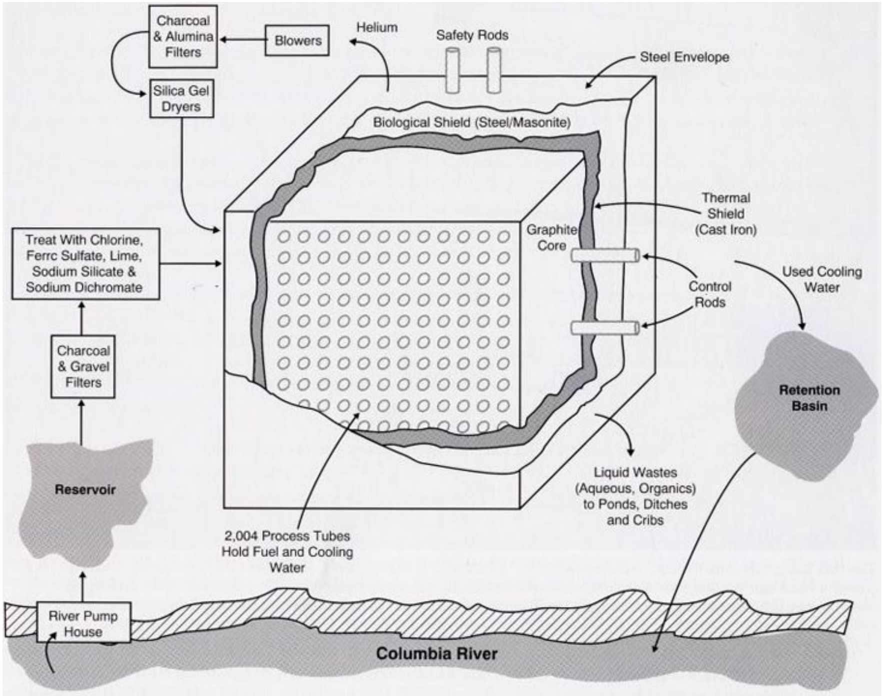

Figure 1 illustrates the basic design of the original plutonium production reactors at Hanford. These were clustered in the 100-area of the reservation (see **Figure 2**).

Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to their Environmental Consequences. 1997. United States: Department of Energy. 164. http://catalog.hathitrust.org/Record/003180782.

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[15] *Ibid*., 34

[16] *Ibid*., 35

Figure 2: Map of the Site

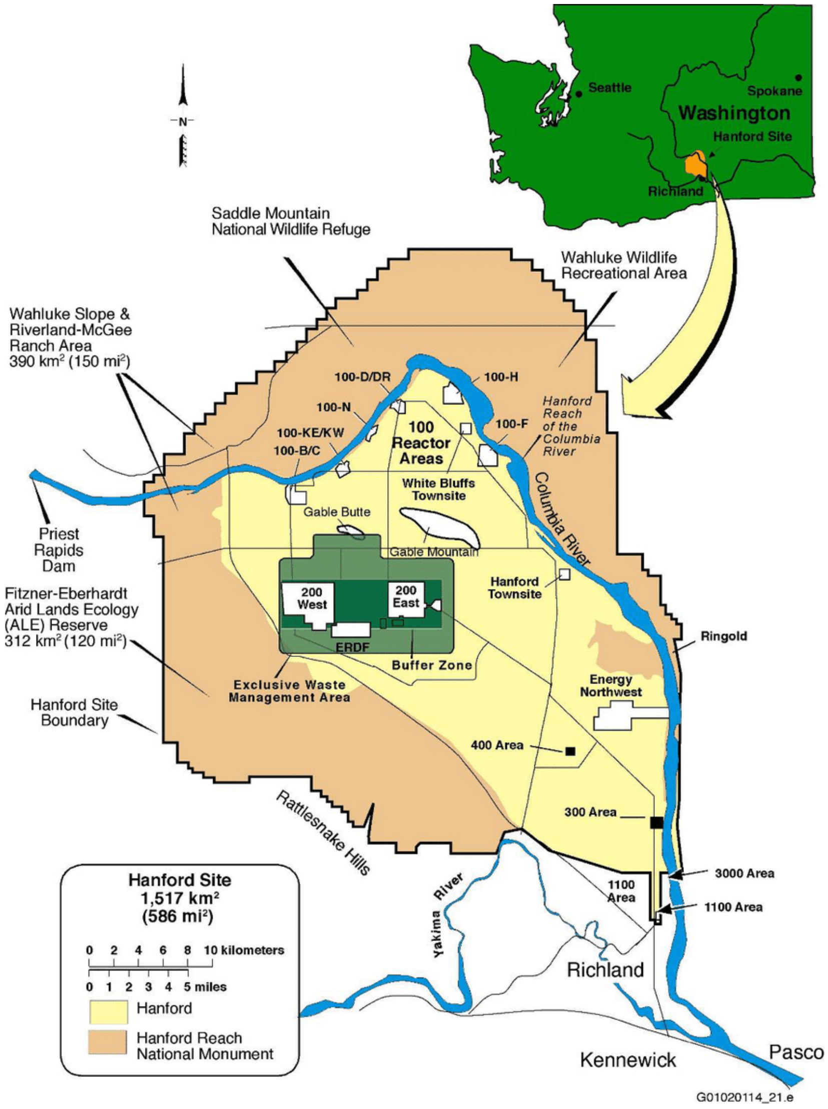

Figure 2 demonstrates the main difficulty facing DuPont and the Army Corps of Engineers: controlling large-scale operations across a massive area. Note: The original boundaries of the reservation are in yellow.

Williams, Mark, Brad Fritz, Donaldo Mendoza, Mark Rockhold, Paul Thorne, Yulong Xie, Bruce Bjornstad, et al. 2008. *Interim Report: 100NR2 Apatite Treatability Test: Low Concentration Calcium Citrate-Phosphate Solution Injection for in Situ Strontium90 Immobilization*. doi:10.2172/969183.

The war characterized the creation of the Hanford facility: speed was paramount. The rapid pace of building paved the way for hasty decisions. The damage to the site began with demolition of the existing farms and infrastructure. Though Hanford was already a desolate landscape, the Army Corps of Engineers exacerbated the problem. The Corps bulldozed the landscape flat, removed the topsoil, and replaced it with silt from the Yakima River.[17] According to a scientist moving to the area, "When the wind blew[,] you wouldn't be able to see across the street."[18] Late in 1943, Col. Matthias gave orders to the government's contractor, DuPont, to install water treatment safeguards on the second reactor, but not the first to allow the first reactor to begin plutonium production.[19] The breakneck pace of building was then concentrated on the amenities needed to lower the staff turnover rate.[20] The entire project was viewed through the prism of war and production.

The first production reactor to be completed, B reactor, was built in 15 months from June 1943 to September 1944.[21] The Hanford Engineering Works would gain two additional reactors and two chemical reprocessing plants by February 1945. All three reactors were simultaneously running at their designed power levels by March 18, 1945. In anticipation of a Nazi surrender, the Army and DuPont kept up a barrage of propaganda to maintain the frenzied pace of production and deploy the bomb before the end of the war.[22] Hanford produced its first shipment of fissionable material on February 2, 1945. It produced the quantities of plutonium necessary for both the Trinity nuclear test and the 'Fat Man' bomb in a span of approximately 7 months.

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[17] Findlay and Hevly, 21
[18] *Ibid.*, 19
[19] *Ibid.*, 24
[20] *Ibid.*, 25
[21] *Ibid.*, 34
[22] *Ibid.*, 35

Waste: Early Concerns and Long-Term Trends

From the beginning of the project, DuPont and the Army expressed concerns over the waste produced at Hanford. An early memo from DuPont in 1942 estimated that the production of one gram of plutonium would result in 8,000 gallons of "hot" material.[23] The Army commissioned studies to determine if winds would dilute and carry away dangerous atmospheric emissions. A subordinate of Gen. Groves, Lt. Col. Kenneth D. Nichols, wrote of the study: "Decision relative to acquiring the site is held up pending results of the meteorology study being made by Dr. Compton's group. Upon the completion of this study, DuPont will make its recommendation *and the site will be acquired*" (emphasis added).[24] Under pressure from Groves and the Army, scientists conducting the study determined that the production schedule could be coordinated with wind patterns, lessening the overall concern.[25] Instead, plant operators pushed to meet the delivery schedule for Los Alamos, speeding up the process by making atmospheric releases when the winds were poor and failing to let fuel rods cool for the correct amount of time. The result was that Hanford routinely released radiation well in excess of the calculated maximum of one curie per day set by Hanford's chief health physicist, Herbert Parker.[26] The chemical separation facilities in Hanford's 200-area primarily released iodine-131, releasing 420,000 curies of radiation in the first two years of operation (an average of more than 500 curies per day). Iodine-131 is dangerous due to its affinity for bonding inside human and animal thyroid tissue, where it can cause cancer.

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[23] *Ibid.*, 37

[24] Nichols qtd. in Findlay and Hevly, 37

[25] Findlay and Hevly, 38

[26] Gerber, 78

The surrounding area quickly showed signs of contamination from radioisotopes of iodine-131 and similar emissions. The chemical dissolution of the first fuel charge resulted in an emission of 1,700 curies (composed of radioactive xenon and iodine) being released into the atmosphere.[27] In spring of 1945, DuPont began to track deposits of these emissions near the stacks and inside the chemical processing facilities, with some radioactive deposits peaking at more than 100 times the acceptable value. DuPont began conducting thyroid checks to track worker inhalation of iodine-131. The emissions were not just being deposited over a great distance. Instead, they were also being concentrated on-site. Contaminated vegetation was found nearly 70 miles away in Walla Walla and Pendleton by December 1945.[28] In response, and due to the decreased demand for production following the Japanese surrender, DuPont increased the cooling time for spent fuel rods, thereby decreasing the emissions of radioactive byproducts into the atmosphere. This held until 1949, when the first Soviet atomic explosion inspired the "Green Run" experiment at Hanford. In the experiment, a plume of radioactive isotopes was released and tracked across the landscape to help calculate estimated Soviet production.[29] The Soviet test caused production to increase once more.

Though strides were being made to limit atmospheric emissions, little was initially done to prevent radioisotopes from entering the Columbia river and being carried downstream. The first eight reactors built from 1943 to 1955 were designed as "single pass" systems, intaking water from the Columbia to cool the reactor, holding it for a few hours, and discharging it into the river.[30] Since little data on the impact of radiological emissions on aquatic ecosystems

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[27] *Ibid.*, 82
[28] *Ibid.*, 83
[29] Brown, 168
[30] Gerber, 115

existed, the Army commissioned a study with the help of Dr. Lauren Donaldson of the University of Washington.[31] Early findings in 1946 indicated that radioactive isotopes were concentrated within fish at a level from 6 to 30 times greater than the water.[32] Of the young fish raised in effluent from the reactors, nearly 99 percent died. In December 1946, scientists estimated that nearly 40,000 curies of radiation had entered the Columbia River (peaking at 900 curies per day in summer 1945). Further studies illustrated the biological magnification problem in the Columbia: even plankton and algae concentrated radioactive isotopes at a factor more than 2,000 times that of the river water.[33]

The first Soviet test in 1949 brought with it a new era of production and increased waste. River radioactivity entered a new phase in 1950. Channeling effects concentrated radioactive isotopes in ever changing-areas along the river. The beta radiation measured at the Richland Dock (an area with the largest population in the surrounding area) doubled from the year prior.[34] As the Cold War intensified and plutonium production increased, so too did the levels of radiation introduced to the water. By 1952, the radioactivity levels measured in the effluent were 20 times the amount measured in 1947.[35] This corresponded with decreased effluent holding times. In 1945, the Hanford Engineering Works held effluent for eight hours on average, providing enough time for radioisotopes with shorter half-lives to decay. By 1946, effluent would be held for 4 to 6 hours. By 1960, effluent holding times would be a mere 30 minutes to 3 hours, releasing nearly the full amount of short-lived isotopes of concern (namely arsenic-76 and phosphorus-32).[36] These practices resulted in steadily-increasing levels of radiation from August

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[31] *Ibid.*, 114
[32] *Ibid.*, 117
[33] *Ibid.*, 120
[34] *Ibid.*, 121
[35] *Ibid.*, 124
[36] *Ibid.*, 125

1957 to 1959, climbing at a rate of nearly 4,000 curies per day. By 1963, the average release rate of beta emitters had climbed to 14,500 curies per day.

The final vector for radiological contamination occurred via groundwater. The long-term storage of Hanford's high-level wastes posed the lowest risk. Instead, the most significant risk to groundwater came from the *deliberate* use of injection wells and "open-bottomed" holes/cribs to "store" large quantities of acidic radioactive wastes from the chemical processing facilities at the 200-area.[37] Scientists at Hanford believed this practice to be safe due to ion exchange between the soil and wastes. This practice resulted in the following radionuclides being present in Hanford's groundwater (in addition to several others): strontium-89 and 90, cobalt-60, cesium-137, plutonium-239, and iodine-129 (which has a half-life of several million years). The use of cribs, or ditches, was of early concern. The practice of allowing wastes to evaporate at ground level meant that winds could pick up the dried waste and disperse it.[38] Reverse wells (dry shafts with holes at the bottom) were used to prevent the creation of surface deposits but placed wastes in immediate contact with groundwater. A U.S. Geological Survey study of Hanford found that wastes from the chemical processing facility slowly inched toward the Columbia River.[39]

Origins and Context of Disposal Methods

The choice of DuPont as the first contractor at Hanford would inform the facility's disposal practices and safety procedures for years to come. DuPont's prior experience in munitions and chemical processing influenced its choices and priorities. Common practice in the 1940s and 1950s was to develop disposal methods through "an amalgam of science and

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[37] Stenehjem, 107
[38] Gerber, 147
[39] Gerber, 150

engineering mixed with heavy doses of convenience and expediency."[40] With the added pressure of wartime, DuPont and the Army failed to conduct early research on the relationship between radiation and the natural world, opting instead to prioritize the health and safety of its workers over the broader ecological effects of radiation upon the environment.[41] DuPont failed to see the broader impact of its disposal schemes.

Outwardly, Hanford was evaluated to be a simple ecosystem primarily composed of scrubland. By the Army's evaluation, the land was "practically worthless."[42] The site's remoteness justified the lack of care given to disposal methods. DuPont and the Army focused upon tracking the danger posed by radiation to workers at the jobsites and imposing strict limitations on exposure.[43] To achieve these limits, it was believed that the impact of radiation could be lessened through dilution, primarily accomplished through introducing radioisotopes to air or water. Management's focus upon worker safety and misguided belief in dilution as a cure-all resulted in disposal policies that produced the largest releases of radioactivity across the history of the site.[44]

DuPont designers were most short-sighted in the disposal schemes they devised for the byproducts of chemical separation after the fuel was recovered from the reactor. It elected to store corrosive byproducts (a combination of bismuth phosphate, uranium, and other radioisotopes) in steel containers capped by concrete due to steel shortages during the war.[45] The plans only provided enough of these tanks to store a year's supply of byproducts. Additionally,

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[40] Colten and Skinner, Ch. 3
[41] Stacy, 415
[42] *Ibid.*, 418
[43] *Ibid.*, 419
[44] *Ibid.*, 419
[45] *Ibid.*, 422

the tanks only held the most dangerous byproducts. The overwhelming majority of the chemical baths used to dissolve the aluminum casings around fuel slugs were deposited in the ground around the 200-area.[46] The institutional habits created by these large-scale policies would be slow to change.

Such protection schemes did little to protect workers. In part, this stemmed from the institutional directive given to the Medical Section within the Manhattan Project. According to Hymer Friedell, the division's chief medical officer, "the services of the medical organization are an accessory function. The primary interest is to maintain the health of the operators at a level which will in no way interfere with operations."[47] As such, military brass directed the scientists of the Medical Section to perform studies that would protect the Army from legal action.[48] When DuPont inquired into the results of impact studies, the Army routinely deflected. Ultimately, DuPont established its own research program focused upon the impact of Hanford upon the ecology of the Columbia River.[49] While DuPont began researching the ecological impact of radiation and ways to minimize its impact, the Army began researching secondary uses for the Hanford waste in weapons.[50] The Army was well aware of the potential impact of radioactive waste, but the siloed nature of information in the Manhattan Project meant that DuPont executives would remain in the dark.

Despite such shortcomings, Hanford and its overseers in DuPont were viewed as overly cautious in respect to safety measures. A regime change would ultimately upend the comparative culture of caution promoted by DuPont. After the war, Methods division head Herbert Parker

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[46] *Ibid.*, 422
[47] Friedell qtd. in Brown, 51
[48] Hales, 281
[49] Brown, 52-53
[50] Brown, 54

was criticized by Los Alamos scientists for the sensitivity of the methods used to detect contamination of workers by plutonium.[51] This sense of relative conservatism was not without boundaries. In 1947, radioactive particles were found on the ground near the 200-area stacks. Attempts to control the dispersal of radioactive particles on the reservation with new ductwork and sand filters appeared promising until new data illustrated that particles were traveling as far away as Spokane.[52] Parker ceased dissolving operations in the 200-area on October 25, 1948. The Atomic Energy Commission, which gained control of federal activities at Hanford in 1947, only permitted this to continue for six weeks before production resumed. The habits had been set.

A Company Town: Social Impact

From the start, Hanford reshaped the surrounding communities of Richland, Pasco, and Kennewick. A community of farmers was razed to the ground to make way for the facility. In its stead, DuPont built company houses in nearby Richland to support the scientists and engineers needed to staff the site.[53] As a result, Richland was a "model community" built to serve white, middle-class engineers, administrators, and operators.[54] Matthias instructed DuPont to set rental rates high to discourage laborers from living in the town.[55] Due to its production goals, the Army did not want to risk racial conflict. Richland's planning was the product of compromise between economic efficiency and DuPont's vision of middle-class life.[56] The town plan was balanced

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[51] Stacy, 425
[52] *Ibid.*, 427
[53] Findlay and Hevly, 21
[54] *Ibid.,* 81
[55] *Ibid.*, 82
[56] *Ibid., 86*

between boosting morale and minimizing cost. The Army and DuPont reversed roles when considering how Richland would be operated. The Army believed that more social services were necessary to support residents while DuPont intended to place its corporate culture on the town.[57]

By contrast, the Hanford Camp was constructed for laborers and their families. Due to the labor shortage, its population included African American and Hispanic workers.[58] This minority-based community was inherited by Pasco and Kennewick after the temporary Hanford Camp was dismantled in 1945. Hispanic and African American populations mostly lived in a now-crowded Pasco, the only nearby city in which they could be housed.[59] The federal government had assumed that the small towns near the project could provide essential services necessary to maintain construction and production. Instead, Col. Matthias soon noted that the project had placed an "unbearable load on the facilities, both social and law-enforcing, of the Pasco area."[60]

The site altered the fabric of the surrounding communities. It brought a group of scientists and engineers as well as African American and Hispanic laborers. The early site was also characterized by a lack of autonomy for Richland; the town had no local elections or local government.[61] However, this was out of necessity, as the communities of Richland and the other Tri-Cities were not self-sustaining, relying heavily upon funding from the federal government. In 1948, General Electric and the Atomic Energy Commission hired a firm to create a new master plan for Richland. This plan was adhered to due to the town's lack of "politics as usual".[62]

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[57] *Ibid.*, 89
[58] *Ibid.*, 27
[59] *Ibid.*, 83
[60] Matthias qtd. in Findlay and Hevly, 84
[61] Findlay and Hevly, 89
[62] *Ibid.,* 92

The facility also shaped the new scientific community it created, as is evident in the early career of William Bair. William Bair received his undergraduate degree in chemistry from Ohio Wesleyan University. On a whim, he applied to the University of Rochester for a graduate degree in radiological physics, where he became the first person to receive a PhD in radiation biology.[63] Bair arrived in Richland in September 1954. After two years spent working on basic mutagenesis research (the mechanism by which radiation causes genetic changes), he was selected to run the inhalation toxicology lab at General Electric in 1956.

The inhalation toxicology lab was born out of the need for understanding the effects of inhalation of radiological materials on animals, particularly humans. Prior studies on the biological effects of plutonium in the body utilized injection as their form of delivery, a poor analog for inhalation. The Air Force contracted Bair's division to study the effects of plutonium inhalation in beagle dogs. Bair found that dogs exposed to an aerosol of plutonium-239 oxide tended to retain plutonium-239 primarily in the lungs and excrete the plutonium at five times the rate of intravenous injection.[64] Gradually, the plutonium moved to the lymph nodes, thus protecting the lungs from further harm. No evidence of cancer was found in the lymph nodes.

Hanford continued to be the catalyst for further radiobiological research. Bair mainly focused on developing biokinetic models for the distribution of radionuclides throughout the body (which organs are most impacted and the biological mechanisms of travel between organs).[65] General Electric commissioned studies focused on the adsorption of plutonium in the digestive tract and explored the mechanisms for removing plutonium from the body

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[63] "Interview with William Bair," *Hanford History Project*
[64] "Retention, Translocation, and Excretion of Inhaled $Pu^{239}O_2$", July 1962, T.2016.004.001b, Folder: Inhalation Toxicity Meeting, William Bair Collection, Hanford History Project, Richland, WA.
[65] "Interview with William Bair," *Hanford History Project*

("decorporation"). This line of research ultimately produced a drug, DTPA, to treat exposure to heavy radioactive elements (such as plutonium).

Bair's story illustrates the profound impact of the Hanford reservation upon the communities around it. The entire scientific community came to Richland and the Tri-Cities with a distinct purpose: studying the impact of the new atomic frontier or aiding in its creation. That sense of purpose altered the essence of the Tri-Cities and directly influenced the decisions made by scientists and engineers like William Bair. His early focus upon inhalation toxicology and biokinetic models for the adsorption of radioactive material in the body were the direct legacy of the early waste disposal techniques used by DuPont and the contractors that followed.

Conclusion

Hanford's environmental legacy is the direct result of its wartime origins. The context of the war placed production as the primary focus above all else. Decision-making processes were also steeped in the workplace safety culture of the 1940s and 1950s, narrowing the scope of safety discussions. Attempts to make the facility safe did so with limited scientific information about the ecological impact of radiation and focused on providing the level of safety needed to ensure production. This informational deficit and organizational flaw led DuPont and future contractors to spew wastes into the air, send them into the Columbia River, and deposit them in the earth beneath the site.

These disposal practices ultimately harmed the ecology of a significant geographical area and have necessitated a dangerous cleanup process that will take decades to complete. The cleanup process creates its own share of dangers. Though workers are monitored for exposure to radiation, they are also exposed to other toxins. The vapors emitted by the tank farms are known to contain chemicals linked to brain and lung damage.[66] The wellbeing of those cleaning up the facility is imperiled by the scope of the environmental damage.

Socially, Hanford created a new community of scientists and engineers. It also created three cities with deeply-engrained racial and class boundaries. The surrounding communities were financially-dependent on the site during its operation and continue to depend on it in the present day. These communities were built due to federal spending and rely on it to keep their citizens employed. Despite the hazards posed by the site, the Tri-Cities need Hanford. Without the site and its environmental impact, the area would be a simple farming community. Instead, it is a community forever marked by nuclear research.

Similar military sites have exposed countless Americans to toxic waste through disposal of munitions and other chemical compounds. The Pentagon estimates that nearly 40,000 known and suspected toxic sites exist on current and former Department of Defense properties.[67] Their disposal schemes, particularly open burns, continue unabated. Like Hanford, we do not yet know the scale of their impact. Their current and future disposal practices will determine that scale.

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[66] Farrow and McHugh, 2016

[67] Lustgarten, 2017

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