



Cold War, Hot Mess

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After decades of mismanaging its nuclear waste, the US Department of Energy wrestles with its toxic legacy.

In August 2015, Abe Garza and a small crew of technicians headed out across the scrub plains of the Hanford Nuclear Reservation, which sprawls over hundreds of square miles in eastern Washington. They were planning a routine inspection of the site's holding tanks, which contain millions of gallons of nuclear waste, created over decades as the site produced two-thirds of the country's plutonium. Garza's job was to calibrate the tanks' monitoring equipment, a task he'd performed countless times in his nearly three decades working at Hanford. Shortly after he arrived at the work site, his nose started bleeding, and wouldn't stop. Another crew member complained of a terrible headache. A third said he could smell something like onions. (Previous chemical exposures at work had destroyed Garza's ability to smell.) Garza knew right away something had gone wrong, but it was already too late: A potentially lethal cloud of chemicals was sweeping over them. "It's like it consumes you," says Nick Bumpaous, Political Action Committee Chairman at Local Union 598, who's counseled many Hanford workers after these kinds of exposures. "You can't get out of it, and you don't know which way to run, and you can't breathe. They're leaned over puking, and their nose is bleeding, and their eyes are just watering like nobody's business."

The particular underground tank Garza's crew was working on was about the size of an elementary-school gym and contained what he calls a "witches' brew"—radioactive substances mixed with other highly toxic heavy metals, such as mercury and beryllium. There are 177 of these tanks at Hanford, and their slurry forms bubbles, like juice under a pie crust. Over time, toxic vapors seep up into the pocket of air at the top of the tank, along with hydrogen and oxygen, both highly flammable gases. These vapors are carefully ventilated to relieve pressure and mitigate the danger of tank explosions. As Garza later discovered, another team had been working on a nearby tank, disturbing its slurry and releasing this toxic mix into the air before his own unsuspecting crew arrived.

After the men recovered enough to leave, Garza reported his vapor exposure to his supervisor. (Several colleagues who were new to Hanford and afraid of losing their jobs chose not to.) At

home, he couldn't get rid of a strange, metallic taste. His wife, Bertolla Bugarin, tried to get him to go to the hospital, but it wasn't until the next morning, when he woke up with his lungs crackling, that he finally agreed. When they arrived at the emergency room, Garza's oxygen levels were dangerously low. After being stabilized, he was released, but his difficulties were just beginning. Over the next several months, various specialists eventually diagnosed Garza with occupational asthma, heavy-metal poisoning, and toxic encephalopathy—a degenerative neurological condition that is often associated with dementia and is frequently fatal.

Garza's experience is common among Hanford workers; in July 2021, a new state report found that a shocking 57 percent of Hanford workers have reported exposure to hazardous materials. But as dangerous as they are, the toxic vapors Garza's crew encountered aren't necessarily the tanks' worst hazard. It wouldn't take much for a tank to fuel a massive explosion, one that Tom Carpenter, executive director of the watchdog group Hanford Challenge, says could spread radiation over a staggering area: Washington, Idaho, Oregon, "probably Utah and maybe Canada, depending on the wind direction and speed." And some of the tanks at Hanford reached the end of their design life during the Vietnam War. As the site's infrastructure ages, it's hard to overstate the danger. Carpenter warns that the consequences of a tank fire would be on the order of Fukushima. (Dan Serres, conservation director of Columbia Riverkeeper, points toward Chernobyl.)

The Department of Energy (DOE) has adopted a closed-door approach to managing nuclear sites, which exacerbates anxieties over these risks. (The DOE declined multiple requests for interviews during the reporting of this article.) "It's fine to have autonomy for a program that needs a certain amount of secrecy," says Mark Henry, the section manager for radiological emergency preparedness at the Washington State Department of Health. "But radioactive material getting into the general public does not need autonomy." As the local newspaper, the *Tri-City Herald*, reports, this has happened multiple times in the last five years, such as when a building demolition released plutonium dust that blew for miles, or when plutonium and americium particles contaminated workers' cars, including a rental later returned to the company.

This string of mishaps is compounded by extraordinary pressure on the DOE's budget, which requires congressional approval every year, and has not grown in proportion to costs. In a 2019 report, the DOE extended its timeline for cleaning up Hanford's waste until 2100; meanwhile, its aging infrastructure has only heightened safety concerns and escalated expenses. In 2018, the DOE's own estimates of their financial liability grew by \$110 billion—almost a fifth—primarily due to an increase in the cleanup budget at Hanford.

In the face of these rising costs, the DOE announced in 2019 that it would redefine what constitutes "high-level radioactive waste" under federal law, which would allow it to leave additional waste in place, rather than transferring it to safer, long-term storage. The DOE estimates that this relabeling could save the agency between \$73 and \$210 billion. When applied to Hanford, it would allow the tanks holding nuclear waste to be filled with concrete and left where they are, after which the DOE has promised a 100-year-long monitoring period.

A century of monitoring might seem sufficient, but the timeline of nuclear contamination is measured on a different scale. Even after the monitoring period, some of Hanford's waste will

still be radioactive. One of plutonium's isotopes has a half-life of 24,100 years; other radioisotopes, such as iodine-129, are around for much longer than that. "If you inhale strontium-90," Carpenter said, referring to a radioactive particle widely found around Hanford, "and it kills you, and you're buried in the ground, those radionuclides will persist around your grave." He added: "They can get into food supplies again. They essentially never go away."

For critics, these long-term consequences raise concerns about the agency's priorities. "The DOE is both paying for the cleanup and determining how much is good enough," says Jeff Burright, a nuclear waste remediation specialist at the Oregon Department of Energy. "This creates an institutional conflict of interest."

This new approach to waste management could have a profound impact on the environment, as well as human health. If Hanford's tanks are left in place, it is likely that their radioactive pollutants and heavy metals will contaminate one of the country's largest rivers, the Columbia. David Trimble, of the Government Accountability Office, describes this decision-making as "DOE has got the steering wheel from Mom and Dad and are now running for the highway."

Considering the stakes, the sheer number of missteps at Hanford are troubling, and the DOE's response to injured workers like Garza raises serious questions about its commitment to public safety. "In my opinion, the worst thing is that they haven't admitted there's a problem out there," Garza says.

Hanford is home to the world's first production-scale nuclear reactor, built in Washington's high desert during World War II, under top secrecy. The site itself sits along the cold waters of the Columbia River, where Rattlesnake Mountain knuckles along a sprawling plain that was once the traditional winter home for several Native American tribes, who still maintain treaty rights to hunt and fish along the river. To Colonel Franklin Matthias, the Army officer in charge of scouting potential nuclear sites, the land seemed empty and remote, and the sparkling river provided easy access to water, ideal conditions for a clandestine project of this scale. In 1943, the Army evicted the handful of settlers who'd made a home there, and broke the Treaty of 1855, informing the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and Wanapum that their hunting and fishing rights would be restricted.

At the time, nuclear science was still largely untested. In 1942, the physicist Enrico Fermi had quietly built an ad hoc nuclear experiment in a squash court in Chicago's Hyde Park, hoping his calculations were accurate enough to optimize an atomic chain reaction, what's known as "going critical." To help prevent a thermonuclear explosion, Fermi had an assistant stand in the court's balcony with an ax, with instructions to cut down a rather makeshift emergency control rod if the reaction got out of hand. From the very beginning, as the official historians of the Atomic Energy Commission later noted, nuclear technology was a "gamble."

Out among the sagebrush, workers hurried to build a larger version of Fermi's Chicago experiment, constructing a 120-foot-tall cylinder of concrete and steel. Within months, two more reactors and four chemical-separation facilities were underway, as the nuclear reservation grew to about half the size of Rhode Island. The plateau turned into one of Washington's largest cities

as people arrived from around the country to work. Because of the project's highly sensitive nature, scientists and construction workers were sworn to silence and warned that passing on classified information was a capital crime, punishable by death. Information about the project was compartmentalized, which meant that many on the site didn't actually know what they were building.

One of the scientists recruited for the project was a chemical engineer named William Mobley. In 1940, the war wasn't going well when the twenty-two-year-old engineer was asked to work on a clandestine project by his boss at DuPont. Mobley soon left Oak Ridge, Tennessee, in a Chevy with extra gas-ration coupons and a map that got him to Washington. There wasn't much there when Mobley arrived. In an unpublished account of his work that he left to his children, Mobley recalls playing poker on the long bus rides from worker housing into the site, where punishing winds whipped the soft volcanic soil. "In a few seconds, the dust was so thick you couldn't see," he recalled. Nicknamed "termination winds," the storms drove many workers to quit. But Mobley stuck it out. The night the first reactor went critical, he made and won a bet on how fast he and his team could load the fuel rods. After the destruction of Nagasaki, Japan, in August 1945, the local newspaper proclaimed, "Peace! Our bomb clinched it!" Mobley and his wife framed the front page and hung it on their wall.

That sense of victory didn't last long. By 1949, the Soviet Union had conducted their own atomic trials in Kazakhstan, with the incredible heat from the blasts transforming pieces of the grassland into jade-colored glass. Anxious to know how much nuclear material the Soviets had developed, the Atomic Energy Commission and the US Air Force began planning a secret test, nicknamed the Green Run. They ordered Hanford operators to match the Soviet plutonium processing conditions, prematurely processing "green" fuel rods rather than allowing them to cool as usual. Their goal was to measure the radioactivity released in order to make educated guesses about how far the Soviet program had evolved. Normally, Hanford's reactors used scrubbers to minimize radioactive gases; for the Green Run test, the scrubbers were never activated, exposing local populations to radioactivity that exceeded the site's own safety limits. At the time, Hanford scientists claimed they did not realize the risks of these adjustments, and that the release was predicted to be within prevailing standards for human exposure.

Mobley was the plant manager on duty when the Green Run began one Saturday in 1949. He was monitoring the experiment when it became clear that the gases being released were about three times as radioactive as anticipated. To make things worse, the notorious winds began to blow, and an unexpected temperature inversion held the radioactive gas low to the ground. Monitors began reporting high radiation levels on workers' clothes. Mobley shut the plant down and called his supervisors. "No one was at home," he recalled. "I was on my own." It was near the end of the day, and the day shift was getting ready to leave. Mobley knew that everyone there was likely contaminated, and so he instructed workers to shower and change clothes. Meanwhile, radioactive gas drifted toward nearby Richland—a small town populated primarily by Hanford workers, where Mobley's wife and young children lived—then farther east, across the state and into Idaho. Altogether, the experiment released an estimated eleven thousand curies—more than twice what they predicted, America's largest intentional release of radiation. In nearby Kennewick, levels of iodine-131, which causes thyroid cancer, were reported in vegetation samples at a thousand times higher than the legal limit. Physicists would later learn that livestock

grazing on these contaminated pastures would eventually transfer the radioactive iodine to people through milk and meat.

Yet the Green Run accounts for only a small part of the radiation people around Hanford were unwittingly exposed to. As the world's first plutonium factory, in its initial three years of operation, Hanford released over 685,000 curies of radioiodine; in its first decade, an estimated 120 million gallons of tank waste was simply discarded on the ground or covered with dirt, contamination that soon spread into the groundwater. In the Columbia River, algae, which are at the bottom of the aquatic food chain, were found to have radionuclides at one hundred thousand times the amount in the river water itself. Fish, which feed on the algae, were in turn exposed to even higher concentrations, and so on up the food chain in a process known as bioaccumulation.

Until 1971, Hanford's radioactive reactor effluent was discharged straight into the Columbia River, which has long been a vital waterway to the nearby towns of Richland, Pasco, and Kennewick, referred to today as the Tri-Cities. People fished in it, and unsuspecting bathers swam in it, attracted to the warmer water near the reactors, where the temperature rose by as much as five degrees. The towns still rely on the river for drinking water. Altogether, 110 million curies went into the Columbia; the site's unofficial motto was "dilution is the solution to pollution." From World War II to the 1970s, the Oregon Public Health Division called the Columbia the most radioactive river in the world. Yet for decades, the general public was unaware of the scope of Hanford's contamination. Classified documents later released by the DOE show that biologists considered that it "may be necessary to close public fishing" at certain parts of the river, but public-relations and security concerns prevented them from speaking out. Local tribes, whose diets were rich in fish from the Columbia River, were particularly exposed. Ultimately, as many as two million people were exposed to Hanford's toxic waste.

Hanford stopped producing plutonium in 1989, but the region continues to be affected by its pollution. Plumes of strontium-90 and heavy metals leaked into the groundwater, and trace amounts of tritium have been found in local milk and wine. The weight of this contamination sits heavily with Robert Franklin, an archivist at Washington State University. "If we'd stopped producing in 1945, we'd have a minuscule amount [of radioactive waste] compared to what's out there in those tanks now," Franklin says. Standing in a warehouse filled with relics gathered from Hanford's past, he describes the common narrative of World War II as a story of progress and triumph. "Why build it? Why use it? Those are pretty simple questions: We were at war." The harder question, he says, is why the mindset of wartime secrecy is still being applied to its cleanup.

Hanford's problems, large as they are, aren't isolated. In order to decentralize its nuclear-weapons program, the US built thirteen other nuclear defense sites across the country. Some locations processed uranium, some stored nuclear arsenal, and others were focused on research and development of nuclear technology, including testing ranges for bombs. Across the country, there are now ninety million gallons of high-level nuclear waste from different defense sites, along with around twenty-one million gallons from civilian power plants, all waiting for a permanent solution. The specific hazards vary by site, but they share a common problem: From conception to cleanup, the American nuclear-weapons program has lacked effective oversight.

There are three types of radiation known to be a danger around Hanford. At its most basic, ionizing radiation occurs as a result of an unstable atom, which releases particles and energy as its nucleus breaks down. This energy can be emitted in the form of high-energy waves called gamma rays that can penetrate the human body, damaging DNA and any tissue they come across like a deadly cellular tsunami. If the atomic nucleus is unstable enough, it emits alpha particles, which are heavy and can only travel short distances. They can be stopped by as little as a sheet of paper; if ingested, however, they can cause cancer. Atoms can also emit beta particles, which can pass through skin but which also primarily cause harm when ingested. All three types of radiation are invisible, odorless, and impossible to detect without special equipment. You could easily receive a harmful dose without knowing it.

Whereas high levels of radiation are widely considered dangerous, the risk posed by chronic, low-level exposure to radiation is hotly debated. That's the question that haunts Tri-City residents like Joe Ford, who was a child living there during the Green Run. On a walk through Richland on a crisp fall day, Ford pointed out his childhood home, a bungalow still painted the daisy yellow his mother picked out when she and her husband moved there in 1943. As Hanford employees, they rented their home directly from the US government, which owned nearly all the real estate surrounding the town. Richland was one of the country's first planned communities, built by General Electric to house thousands of Hanford's workers. The company controlled the new city down to the architecture, with initially just a handful of floor plans to choose from. Ford recalled that, periodically, someone would come and leave a milk bottle on the front porch, "but it wasn't really [for] milk." His parents were expected to urinate in the bottles and put them back on the porch so they could be taken to a lab and tested for radioactivity. "My mother feared that she'd been irradiated," Ford said. "They understood what they were doing was dangerous."

Ford's parents both died of cancer, a fate common enough among nuclear-site workers that it prompted Congress to approve the Energy Employees Occupational Illness Compensation Program in 2000, which pays a settlement to nuclear workers or their survivors. "They pay you \$150,000 per deceased parent," Ford said, adding that he'd put several friends in touch with an advisor to help guide them through the byzantine application process. He himself had recently been diagnosed with non-Hodgkin's lymphoma; he couldn't help but wonder if it was related to his exposure during the Green Run. Every family in Richland knew there were trade-offs to living there, he said, standing in front of his mother's rosebushes. "I don't know if they were worth it."

Although there are fences and warning signs around the nuclear reservation, questions about the extent of Hanford's health impacts continue. Lonnie Rouse, who worked at Hanford for decades, explained how he would be sent out with a can of spray paint and a dosimeter to find radioactive tumbleweeds, which regularly absorb radiation from waste leaked into soil, and travel widely as part of their lifecycle. "We'd spray them pink to watch and record how far these things went," he said. Pink tumbleweed kept showing up in Richland. "People started freaking out, so we quit painting them. But that doesn't mean the radioactivity stopped."

Hanford has an entire Biological Control program dedicated to handling what they call "vectors" that spread radiation off the site, including fruit flies, wasps, pigeons, swallows, and mice. Some of the stories beggar belief—a badger, for example, dug into a waste pit, after which rabbits got

into the hole. The site spent \$300,000 trying to track bunnies spreading radioactive poop over 2,500 acres.

Just how worried one should be about radioactive rabbits depends on who you ask. In one major 1994 study called the Hanford Environmental Dose Reconstruction, researchers tried to calculate how much radiation people might have been exposed to from the 1949 Green Run. They analyzed wind patterns, home locations, and children's diets during the Green Run itself, but they didn't take into account any other chronic contamination from the site. Surveying 3,440 people born near Hanford between 1940 and 1946, they found what a scientific reviewer described as a "surprising amount of thyroid disease," with high levels of cancer, and hypothyroidism in over a quarter of the women. But the study didn't have a control group, and only focused on diseases in connection to an estimated radiation dose from the Green Run—not from Hanford's decades of operations. In the end, researchers were unable to draw statistically significant conclusions.

Owen Hoffman, president emeritus of Oak Ridge Center for Risk Analysis, has spent his career studying radiation epidemiology, and was one of many independent scientists who took issue with the conclusions of the Dose Reconstruction study. Hoffman calls it "simply inconclusive. It was not proof that there was no harm, it was simply an underpowered study." Most epidemiological studies, he explains, need ten thousand or more subjects. And because so much time had elapsed, the study had to use mathematical models, rather than taking environmental measurements, to estimate radiation doses. "In Chernobyl," Hoffman says, "environmental measurements and actual measurements of peoples' necks are very conclusive that exposure to iodine-131 leads to thyroid cancer." Other studies around Hiroshima, Nagasaki, Chernobyl, the Marshall Islands, and the Nevada nuclear test sites, for example, have all found increased rates of cancer.

But in the nuclear world, you learn quickly that most statistics are debated. Industry experts often claim that the nuclear accident at Chernobyl killed just twenty-eight people. The Chernobyl Forum, a collection of eight different UN specialized agencies, suggests that Chernobyl could be responsible for more than four thousand deaths. The National Commission for Radiation Protection in Ukraine, meanwhile, claims that as many as half a million people have perished from Chernobyl's radiation exposure. Yelena Burlakova, former chairwoman of the council on Radiobiology of the Russian Academy of Sciences, disparages the lower fatality predictions tallied by the International Atomic Energy Agency, telling the scientific publication the *Lancet*, "The IAEA is just a lobby group for the nuclear industry, which is interested in showing there were no serious consequences." Assessing non-fatal impacts is even trickier: Research published in the medical journal *Pediatrics* in 2010 found that in parts of Ukraine still contaminated with low levels of cesium-137, a type of neural tube birth defect is almost two and a half times Europe's average. Scientists also found in 2018 that milk in parts of Ukraine still has radioactivity levels twelve times the country's safe limit for children, and a UN report that same year found a dramatic increase in childhood thyroid cancer in exposed populations.

Generally, cancer rates worldwide are increasing, and it is often difficult to even measure radiation exposure, much less establish causation with low-level doses. Yet for those who believe their illnesses stem from radiation, this kind of official uncertainty can feel insulting. At

Hanford, these debates have stymied lawsuits seeking damages for exposure. More than five thousand cases of so-called Downwinders—people who believe Hanford was responsible for their illnesses—were consolidated into a class-action lawsuit that was settled in 2015. Hoffman, who was called as an expert witness during the trial, remembers his frustration with the use of science in the lawsuit. Despite what he saw as the inconclusive nature of Hanford’s Dose Reconstruction study, its results had a definitive legal impact: For one plaintiff, the study calculated that the likelihood Hanford had caused her cancer was 35 percent. “But the uncertainty [of that figure] was greater than 50 percent,” Hoffman says. Few Downwinders received settlements; the *Tri-City Herald* reported that the sum paid to Downwinders paled in comparison to what the DOE spent on its own defense.

Bruce Amundson, vice president of Washington Physicians for Social Responsibility, who helped conduct the Dose Reconstruction study, says it had another unintended result. “It closed the door on the possibility of any other epidemiological study,” he says. “It also curtailed interest in funding at a federal level on studies at other nuclear weapons labs where releases were less dramatic.” The scientists running the study were surprised by the vitriol their results prompted among the community. Having to deal with the criticism, Amundson says, “dampened enthusiasm of other radiation epidemiology elsewhere, even if there had been funding.”

Nuclear physics and epidemiology are complex, and talking to people in Richland, it can be hard to get a sense of which of their concerns can be verified. Linda Coldiron, for example, grew up in Richland and recounted taking what she was told was a polio vaccine on a sugar cube as a kid. When she started working at Hanford years later, they oddly already had her personal information, including her social security number. She conjectured she’d been part of a secret radiation experiment. This sounded far-fetched; then I stumbled across a report by the Energy Department’s Office of Human Radiation Experiments, which describes “an effort to summarize over 400 human radiation experiments associated with DOE and its predecessors.” The report details testing on more than nine thousand Americans. I found no evidence one way or the other of Coldiron’s sugar cubes, but one of the more notable experiments included secretly dosing eight hundred pregnant women with radioactive iron. Other research involved irradiating the testes of inmates at the Oregon State Penitentiary, and feeding young boys with disabilities radioactive iron and calcium while they were enrolled in so-called nutritional studies. These secret experiments continued well into the 1980s. An investigation into these unethical practices resulted in an extensive report on decades of questionable research. The report didn’t draw much attention, as it was released on October 3, 1995—the same day as the verdict in the OJ Simpson trial.

This long history of secrecy and mistrust makes an already difficult science harder for the public to understand, or for policymakers to address. Though there are many unresolved scientific questions, the Environmental Protection Agency has long operated under the general assumption that there is no risk-free level of radiation. But in 2018, under President Trump, radiation regulations were quietly weakened, allowing for additional exposures in workplaces and homes. Supporters of the change suggest, despite mainstream scientific consensus, a little radiation might actually be good for you.

Hoffman scoffs at the notion. “There’s no level at which the risk of radiation is zero. It just means that epidemiology has a limit of detection. The risk may still be there.”

This complexity has helped the Department of Energy evade responsibility when it comes to Hanford employees whose health has been compromised at work. Garza’s years-long effort to receive compensation for his injuries demonstrates the barriers many workers face. First, he filed a claim with the Washington Department of Labor and Industries, which Penser North America, the contractor running Hanford’s workers’ compensation program, disputed. Over the next two years, Garza was sent to nine different independent medical examiners selected by Penser, none of whom had access to Garza’s medical records or even the results of past examinations, as part of Penser’s policy.

The process has been plagued by bizarre occurrences. At one point, he says, records of his exposures on the tank farm were altered. Files show that six micrograms of mercury—well above the permissible limit—was changed to nanograms, a smaller unit that Hanford normally does not use to measure mercury. (An emergency-room technician at Kadlec Hospital, where Garza was initially admitted, told me that when an injured Hanford employee comes in, the protocol is to call Hanford, and that doctors are often asked not to run certain time-sensitive tests, such as those for mercury or lead toxicity.) At one doctor’s appointment, a stranger burst into Garza’s exam room and confronted him about a late income tax payment; later, a woman claiming to be working for the Census Bureau repeatedly visited his home, asking questions about his medical history, until Garza’s wife finally called the police.

Other bureaucratic barriers make it exceedingly difficult to file these kinds of compensation claims. Until 2018, the DOE required anyone filing a claim related to exposure to identify the specific substance responsible for their illness in order to qualify for compensation. Garza had clearly been exposed to something, but the tanks hold more than 1,800 identified chemicals, along with many that haven’t been identified. As to what those substances might be, “the people most able to speculate won’t,” says union representative Nick Bumpaous.

“It’s a lonely world for a sick Hanford worker,” one home-aid caregiver, who agreed to speak on condition of anonymity, told me. She mentioned how, when she reported what she saw as discrepancies with another injured Hanford employee’s medical records to a DOE medical-benefits examiner, she was threatened with violating federal law for interfering. “I’m not sure whose side we’re on here,” she said. “It seems like we should be fighting for the patient.”

In the meantime, Garza’s life has been upended. He used to love books, keeping Shakespeare volumes in his office; after his exposure, reading became all but impossible. “By the time I got to the end of the paragraph,” he said, “I’d have to re-read it.” He had short-term memory loss, seizures, and delusions; after one doctor’s appointment in Seattle, driving back to Richland with his wife, he got turned around, claiming a whole town must have moved. “Abe, we just came through here yesterday,” she said. “Nobody moves a town.” To this day, despite well-documented workplace exposures and tens of thousands of dollars in medical bills, Garza still hasn’t received permanent disability status.

More than one hundred thousand workers have developed illnesses because of their employment at nuclear-weapons facilities, enough that entire cottage home-health-care industries have sprung up around nuclear sites. Yet despite efforts like the congressional compensation program of 2000, worker claims have been denied at a troubling rate. Seattle TV station KING 5 has found that Hanford workers' claims have been denied at a rate 52 percent higher than other self-insured companies in Washington.

Like Garza, Lonnie Rouse, the nuclear-process operator who tracked tumbleweed, was also diagnosed with toxic encephalopathy when he was in his mid-forties. Over the last three years, his dementia has worsened, and he now has a noticeable speech pathology. Though disabled by a degenerative disease, his attempts to file for compensation have been impeded, delays that have left his family without his income as medical bills pile up. His wife took a second job, but the family still had to file for bankruptcy, and nearly lost their house. One of their sons started standing by the garbage at school, asking his classmates for food, spurring the family to seek out the local food bank. Rouse said that his condition is common among Hanford workers. "Most of the people I started working out there with are dead," he said.

In March 2018, Washington State passed Substitute House Bill 1723, with the intention of making it easier for Hanford workers to receive compensation for workplace injuries without having to prove that they were caused by their employment. The Department of Labor and Industries must now presume that if a Hanford employee has certain illnesses—from respiratory diseases to many types of cancer—it was the result of an exposure at the site. The Department of Labor must prove otherwise in order to deny the claim.

But three years after the bill's passage, Penser has continued to fight Hanford workers' claims. People like Garza and Rouse—and the lawyers they've hired—report that despite the new law, Penser still regularly misses deadlines for deciding on claims, requires workers to submit documentation the law deems unnecessary, and frequently requests additional time to search for evidence. Even when a claim has been approved, Penser has stalled actual payments. After some of his conditions were approved for compensation, for instance, Rouse was informed that his deposit was being withheld pending outstanding litigation. For some of his other covered diagnoses, Penser has also denied him permanent-disability status, which means that for ongoing conditions, Rouse only receives payments a few weeks after a doctor's appointment, then nothing until he sees the doctor again.

The state has yet to step in and force Penser to comply with the law or impose penalties. In December 2018, the DOE filed a lawsuit against the state of Washington, claiming that the new law discriminates against the agency by requiring it to do things other employers don't, in addition to alleging that Hanford is exempt from the state law due to its status as a federal facility performing federal functions. Governor and former presidential candidate Jay Inslee vowed to fight the case, saying, "The people who fought communism shouldn't have to fight their federal government to get the health care that they deserve." Washington won on appeal with the Ninth Circuit last summer, but people like Garza and Rouse still haven't gotten paid. (In 2017, after local media criticism, the DOE said they would not extend their contract with Penser when it expired; in 2019, they quietly awarded the company a new multimillion dollar contract.)

“It costs money to fight the government,” Bugarin says. Conversely, any judgments Hanford pays its workers is funded by taxpayers like Garza and Rouse. DOE contractors are themselves often indemnified, although a report by the International Union of Operating Engineers shows that this provides “disincentives to safe engineering.” In 2018, the DOE’s own Inspector General found that the “Department does not have effective processes, procedures, and controls over the Workers’ Compensation Program at the Hanford site.”

On a practical level, this means that nuclear workers’ injuries don’t receive sufficient oversight from either the federal Occupational Safety and Health Administration or the Nuclear Regulatory Commission. George Smith knows the problems this causes all too well. Sitting beside his daughter on a couch piled with cushions during a video call, he spoke in a rasp that was difficult to interpret. He’d worked at Hanford for decades before developing an onslaught of cancers—kidney, bone, bladder, skin, and, finally, in his vocal cords. His voice box was removed in 2017. Even though his illnesses should have been legally covered by the DOE, he’s spent years struggling to qualify for compensation.

In 2015, Bob Ferguson, the Washington Attorney General, filed a lawsuit against the DOE for exposing its workers to harm. (Each of Washington’s last three attorneys general—Republicans and Democrats—have sued the DOE.) Separately, Ferguson also filed a lawsuit over the DOE’s lack of accountability and delays in cleanup. US District Court Judge Rosanna Malouf Peterson returned an unusually scathing assessment, criticizing the agency’s “total lack of transparency.” In an agreement in September 2018, the DOE agreed to increase worker-safety measures to try to prevent exposures like Garza’s.

“The government didn’t do right by those workers, to put it very mildly,” Ferguson says of Hanford’s sickened employees. “It’s hard to imagine a case in my entire career that angers me more than this one.” Sitting in his sunlit corner office in Seattle, the gritty realities of Hanford felt far away, which, to Ferguson, was part of the problem. “If Hanford were in Virginia, I would not have had to file a lawsuit.” Despite his efforts, the legal victories have yet to materialize into real-life improvements. Garza worries that the settlement’s lack of firm timelines has allowed Hanford to continue exposing its workers to unsafe working conditions. In June 2021, nine workers were evaluated after digging in soil where tank waste had previously leaked or spilled, three of whom were ultimately hospitalized. “You just grin and bear it and keep going,” Bugarin says.

Hanford employees and their families have been left to fumble forward, Bumpaous said in his office at Union 598. “Everybody is trying to make a living.” He got up and walked into the union hall, where the names of workers who’d died had been etched into bricks that encircled the room. Each brick had life dates inscribed on them, and it was hard not to notice that many of the workers had died young. “It’s not a job to most people, it’s—we’re serving the national mission,” Bumpaous said, clearly frustrated. He stood in the middle of the room, turning slowly to read the names.

“You should come home in the same way that you went to work,” he said. “When one day at work changes the trajectory of your entire life—somebody should be held accountable for that.”

These broken promises raise alarms about the DOE's current proposal to reclassify nuclear waste. Its motivations for doing so are viewed skeptically by watchdogs and activists. It's actually not the first time this relabeling has been proposed; in 1999, under pressure to clean up increasingly decrepit and expensive waste tanks, the DOE attempted to reclassify waste at three nuclear-weapons facilities, which would have reduced the amount of waste it had to pay to put in long-term storage by as much as 75 percent.

Russell Jim, a Yakama elder who managed the Yakama Nation's Environmental Restoration and Environmental Cleanup program at the time, was horrified. "Rather than reveal to Congress and the public the actual costs of restoring the environment, DOE seems to think that 'what they don't know won't hurt them,'" Jim said in one of his many speeches on Hanford. Several tribes—including the Yakama Nation, Nez Perce, Confederated Tribes of the Umatilla Indian Reservation, and the Wanapum—have had access to sacred sites and burial grounds at Hanford restricted, while bearing the brunt of its pollution. A study conducted by the EPA in 2002 reported that tribal children from the Hanford area have an extremely elevated risk of immune diseases, and a tribal member's risk of developing cancer from eating locally caught fish was estimated at one in fifty. Jim noted that these results—as well as a US Geological Survey study finding adverse health effects in salmon near Hanford due to hexavalent chromium, the chemical Erin Brockovich brought to fame—went unmentioned in the DOE's environmental-impact statement. Jim insisted that an analysis of waste needed to be fully independent to ensure "transparent and credible information" before any reclassification.

In 2002, the Yakama Nation, along with the Natural Resources Defense Council (NRDC), the Snake River Alliance, and the Shoshone-Bannock Tribes, sued the DOE over its reclassification initiative, with Washington, Idaho, Oregon, and South Carolina filing "friend of the court" briefs in support. A federal district court judge in Idaho ruled in their favor, finding that the DOE did not have the authority to make this change. The DOE appealed the decision to the Ninth Circuit. (The DOE would ultimately prevail a few months later.) The agency also lobbied members of Congress, who, after a fight on the floor of the Senate that ended in a one-vote margin, added a rider to the next defense-authorization bill, allowing the DOE to reclassify waste in the states of Idaho and South Carolina, but not in Washington or New York. Geoff Fettus, the senior attorney at NRDC's Nuclear Climate & Clean Energy program, who argued the case, says, "Let's say we fought to a draw."

Now in 2021, there's a rematch brewing. "They can't say they've emptied the tanks, there's always some [waste] left in there. So they say 'retrieved,'" says Randy Bradbury, a recently retired communications manager at the Washington Department of Ecology Nuclear Waste Program. To better understand Hanford's risk, I filed a Freedom of Information Act request for its general hazard assessment reports, and was told such documents were unable to be located. But an identical Washington state records request returned fourteen files detailing potential risks around the site, in some cases to the general public. The amount of high-level waste currently in just one of Hanford's hundreds of tanks would cover a football field to a depth of one foot. More than a third of the single-shell tanks have already leaked. One of the double-shell tanks, into which waste was moved after concerns over leaks, has also failed. In late April of 2021, news broke about a new leak in one of the single-shell tanks, which is estimated to be spilling nearly 1,300 gallons a year.

It's difficult to plumb the true depths of the hazards at Hanford. John Brodeur, an environmental engineer and geologist who worked at Hanford in the 1990s, wrote that the DOE's leak-detection method is "not only flawed, but designed to avoid finding leaks." In 2008, the DOE announced that it had reclassified waste that had leaked or been spilled from Hanford's tanks. "That was kept a secret," Carpenter says. "Nobody knew it, not even the state." From these leaks and spills—and places where waste was intentionally dumped—plumes of hexavalent chromium, as well as cyanide, uranium, strontium-90, technetium-99, and iodine-131, are all now in the groundwater, at risk of being joined by radiation from waste left in the tanks. Whether these plumes reach the river depends on what happens next.

Despite the profound consequences, the DOE's decisions about waste management have been approached without nearly enough buy-in from local and regional parties. "If you were talking about any other industry, and a company was making a mess, the EPA or the state can come in and tell you to clean it up to specific standards. That can't happen at DOE sites," Fettus says.

One could view DOE's approach to its reclassification efforts as a deliberate move to limit its exposure to oversight: Not only will the proposal ease its cleanup burden by simply defining the problem away, the department is charged with the task of policing itself on how well it adheres to standards—ones the agency devised in the first place. "They don't have anyone looking over their shoulder," Andrew Fitz, senior counsel for the Ecology Division of the Washington State Office of the Attorney General, says, speaking about the nature of the agency's self-regulation under the Atomic Energy Act. Expanding certain laws, such as the Resource Conservation and Recovery Act (RCRA) would incorporate a system of checks and balances that would, among other things, allow the EPA and Washington State a greater role in assessing what counts as safe and clean—and what does not.

In February 2021, the Washington Department of Ecology, the state's attorney general, the Confederated Tribes and Bands of the Yakama Nation, the NRDC, Hanford Challenge, and the Columbia Riverkeeper sent a request to the Department of Energy to rescind its 2019 waste reclassification, saying "it lays the groundwork for the Department to abandon significant amounts of radioactive waste." They cited the lack of independent regulatory oversight, and pointed to President Biden's January 20 executive order that requires a review of all agency actions that might be inconsistent with protecting public health and the environment. It's an unusual coalition, striking in its diversity. In May 2021, the DOE announced it would be reviewing the decision. Fettus says his goal is to encourage the Biden administration to work with the state and the tribes, and to finally ensure that environmental laws apply to nuclear waste. "The good news or bad news," Fettus says, "is that the half-lives we're talking about means this fight will be relevant for thousands of years."

Nuclear accidents in the past have demonstrated the consequences of not having regulatory oversight. In 1957, a waste tank similar to those at Hanford overheated and exploded in Russia's Ural Mountains. The explosion propelled a mushroom cloud of deadly cesium, strontium, and smoke half a mile high. In less than an hour, an odd black ash began to rain down over the Techa River. Historian Kate Brown recounts in her book *Plutopia: Nuclear Families, Atomic Cities, and the Great Soviet and American Plutonium Disasters* that the government response took days: Workers refused to enter the contaminated area, and soldiers were conscripted to run in, a few

minutes at a time, to bury the site. No one knows the number of people injured or killed as a result, but eyewitnesses reported overflowing hospitals and clinics. Ultimately, the accident polluted nine thousand square miles. (The area remains closed to the public.)

At Hanford, overlooking risks has already resulted in crisis. In May 2017, a tunnel at Hanford containing flammable uranium, plutonium, and mercury collapsed. Approximately three thousand workers rushed into buildings and shut the ventilation off, waiting to hear what had gone wrong—and what might happen next. If the collapse sparked a fire, then the tunnel’s twenty-one thousand curies could mingle with the smoke and spread on the wind. A second tunnel, full of even more dangerous material, was belatedly judged a “high potential collapse hazard.” Reports emerged that the DOE had known for years the tunnels were at risk. In April 2021, the DOE had to work to stabilize two additional underground structures at risk of collapsing, which also could have released radiation into the air. As with the tunnels, the DOE filled the structures with grout.

The pattern of overlooking risks distresses Steve Lijek, a former environmental engineer for the Washington State Department of Ecology, who’s had to live with its consequences. He resigned after disagreeing with his boss over whether measures to detect leaks in the tanks were adequate, but has struggled to find another job. “There’s an extreme amount of power with money,” he says, referring to the rampant corruption he says he witnessed at Hanford while working there as a consultant for various companies contracted to the DOE in the 1990s. “I think a lot of people were compromised working there. In a sense, I think the whole state was compromised.” Lijek admits that, while at Hanford, he issued permits for work on the tanks he knew could expose employees to dangerous conditions. Once, a friend of his, a single father with two kids, needed a tank-farm air permit, which allowed a project to move forward, and without which he would have been fired. “What am I supposed to say?” Lijek asks. He gave his friend the permit. He regularly encountered these kinds of dilemmas on the job, and they continue to haunt him, even years later. “I always thought of Hanford as a giant, juggernaut monster machine moving forward,” he says. “No one can stop it. If you get in front of it, it’ll run you over.”

On a Friday night before the pandemic, people crowded into the football stadium at Richland High School, where girls with yellow ribbons in their hair wore “Bomb Squad” T-shirts. Parents wore sweatshirts with the slogan “Proud of the Cloud.” Many of the families on the bleachers worked at Hanford, where the mission has changed, but the commitment to the importance of the work hasn’t.

Down the road, the festivities continued in the Red Lion Hotel’s garden, where people mingled in the awkward dance of a fifty-fifth high-school reunion. One man had tattooed a mushroom cloud in the school’s colors onto his calf. As dusk fell, fireflies sparked around a miniature replica of the Fat Man bomb dropped on Nagasaki, another piece of school memorabilia. The next morning, in the hotel lobby, people gathered at the coffee station and traded notes on their kids’ accomplishments, as well as how to register deaths with the Energy Employees Occupational Illness Compensation Program. Outside, the early fall sunshine burned brightly.

Parts of the nuclear reservation are now considered clean enough for residential use. The former mayor, John Fox, who was on the planning commission, says he isn’t worried about residual

radioactivity. The Washington State Department of Ecology says that building multifamily units on parts of the site would be deemed safe, though future residents would not be allowed to mow their own lawns or otherwise disturb the soil.

It's an example of how the term "cleanup" is a bit of a misnomer. The United States still doesn't have a long-term plan for its nuclear waste. High-level waste is required by law to be vitrified—turned into glass logs for storage—and then stored in a geologic repository. But nine different reactors made plutonium at Hanford, using at least five different chemical processes, so the waste currently stored in the tanks has been mixed and comingled over time. Construction on a vitrification plant at Hanford began in 2002. Since then, the estimated cost has tripled, and the completion date has been pushed back by almost two decades. A contractor who suggested the plant design has unresolved safety issues was retaliated against after voicing his concerns, and the DOE settled a lawsuit with him.

Assuming these kinks get sorted, the glass logs will be shipped to a deep geologic repository for high-level nuclear waste, whenever and wherever that gets built. Construction of Yucca Mountain Nuclear Waste Repository in Nevada—selected in a highly controversial process as the country's long-term nuclear-waste site—has permanently stalled, and no state has volunteered an alternative. No Hanford tank waste has yet been vitrified. In the meantime, radioactive waste continues to be stored in the aging tanks. This spring, the DOE and its regulators proposed extending the timeline for moving its plutonium-contaminated waste off the site another twenty years.

Some of Hanford's non-high-level waste has been shipped to the Waste Isolation Pilot Plant—currently the country's only deep geologic repository—in a salt deposit in Carlsbad, New Mexico. In 2014, a thermal explosion occurred there after the type of kitty litter being used to soak up liquids was switched. That such small changes can trigger emergencies highlights the moral dilemma of long-term nuclear-waste storage: Twelve thousand years ago, agriculture was a new idea. In less than the half-life of plutonium, who knows how New Mexico will have transformed?

There's simply no way to tidy high-level nuclear waste. Technetium-99 has a half-life of 211,000 years. You can only try to keep it where it does less harm. To mark a future repository's hazards, researchers have suggested everything from building larger-than-life statues of giant thorns to genetically modifying cats to change color near radioactivity and seeding myths about them. "No one wants to talk about it," says Jennifer Richter, a professor at Arizona State University. "But if we're going to mark a site for ten thousand years, who was our audience?" She says the shadow of the United States' inevitable future collapse falls over the whole conversation. "What is our moral obligation to people who aren't us?"

It's a question that already applies to where nuclear sites have been placed. Western states—home to Los Alamos, Hanford, the Nevada testing sites—have often been considered sufficiently remote to minimize harm. "But it turns out the empty West is never as empty as people like it to be," Richter says. She points to Eastern states' successful rejection of a deep geologic repository. "You're not looking for empty land, you're looking for people who are dispossessed of power."

Cleaning up Hanford will take several generations, which makes it even more important to build structures of accountability. The first step would be for Congress to revisit its regulatory authority over nuclear waste. “We are consigning [these spaces] to not being livable for the rest of human existence,” says Richter. Historically, she says, the DOE has been “really bad at managing those kinds of decisions.”

One former Hanford worker, who asked to speak anonymously, has felt the pain of this mismatch personally. After getting sick from vapor exposure, he wanted to help educate other workers of the tanks’ dangers, showing up at town-hall meetings and speaking with Attorney General Ferguson. “I even got a group together and went and stood on the side of the road with signs,” he said. “I thought I was doing something that mattered.”

Eventually, the inertia got to him. “It’s a job where everything is gray,” he said. “The people that are writing the regulations and the rules have no idea what’s going on in the field, and you cannot follow what they legally want you to do. So you kind of just make up a lot of stuff. At some point, I guess things just stop bothering you.”

About fifteen thousand years ago, as the Ice Age waned, a massive lake in what is now the western United States broke through an ice dam that had been holding it in place. Within days, hundreds of cubic miles of water spilled over the Pacific Northwest. This flood shaped eastern Washington into what it is today. You can still see its path on the land, in strange islands of sediment and the fossils of the mammoths and other animals that perished. This catastrophe, which is passed down in the Nez Perce’s oral tradition, is within the half-life of plutonium-239.

Anthony Smith, an environmental specialist and a member of the Nez Perce (though he emphasizes he doesn’t speak on behalf of the Nez Perce tribe), says the tribe is intimate with the land. “You have to be picking berries, digging roots,” he told me, “to get knee deep or belly deep in water to go fishing—to be immersed in it.” He questioned whether the scientific community was familiar enough with tribal life to make accurate risk assessments, adding, “It’s rare to see an all-inclusive analysis.” And he wondered how anyone could place a dollar figure on losing access to a way of life and sacred places. “We were created here. This identifies us as much as we identify it.” He chose his words carefully. “Everybody else that comes here can just pick up and go somewhere else. But we don’t have that option. This is our home.”

Policymakers are incapable of predicting what hazards might encroach on the site in the next fifteen thousand years. But there are plenty to choose from: Since Hanford was built, seismic technology has improved, and newly discovered geological faults have dramatically increased our knowledge about the likelihood of large quakes—the kind that could crack concrete pools, like the ones extremely hot cesium and strontium capsules are sitting in at Hanford, where, as they decay, they turn the water a glowing, electric blue. These capsules contain over a third of the total remaining radioactivity on the site; the structure is ten years past the end of its design life and is considered one of the site’s worst hazards.

Geologists have also found that the power plant at Hanford—which stores spent fuel rods in pools similar to the Fukushima reactor—is at risk of experiencing seismic activity two to three times stronger than it was designed to handle. If power supplies failed, “it would take about a

day for enough water to evaporate [from the pools] to cause a catastrophe,” Carpenter, of the watchdog group Hanford Challenge, said over lunch one day, just a few miles from the site. The waitress delivered a salmon wrap; it was hard not to think about radioisotopes creeping into the Columbia. If even a tiny fraction of the strontium-90 and cesium in the capsules were to leak, well—“There’s probably no level of strontium that is safe, because it acts like calcium and goes to the bone, to all the systems where calcium goes.” He picked up his fork and took a bite.

In the timescale of Hanford’s nuclear waste, one of the Cascades’ many volcanoes might erupt, jamming critical air ventilation, or a terrorist could decide to fly a plane into the tank farm. As the West gets hotter and drier, wildfires are increasing. In 2011, Los Alamos, a nuclear research site in New Mexico, was almost overrun by a wildfire, threatening the lab and forcing an evacuation of twelve thousand people. Floods could also rewrite all calculations about what contamination makes it off the site, into the river or groundwater. Even if none of these worst-case scenarios happen, cutting corners during the cleanup will be dangerous enough.

As the site’s risks balloon, workers and policy-makers are being forced to confront Hanford on a human scale. People with firsthand knowledge of activities around the site are retiring. Others who tried to hold the government accountable, like Russell Jim, have passed away. President Biden has made environmental issues a focus, but his administration has shepherded through a budget for Hanford for this year that’s \$900 million short of what’s needed. The idea that Hanford is a problem has itself become part of the problem. Local reporters have faithfully catalogued Hanford’s accidents and consequences, so no one seems shocked when a new scandal there arises; the fresh angles on abuse of power have run out. But injustice doesn’t seem to be sufficient—broader attention requires some degree of novelty.

But the stakes couldn’t be higher, for the region or the people who call it home. Though Smith spent years working on the impacts of Hanford’s contamination, he was at first reluctant to talk to me, apprehensive of being misrepresented. “Even the smartest people in the world have no idea how to understand the magnitude of issues with contamination at Hanford,” Smith says, adding that it’s a lot like asking your kid to clean up their room, only to find they’ve pushed the mess under the bed. “That’s not clean, that’s only changing the appearance of the mess—it’s still there.”

Sitting in a Days Inn, across from a strip mall in a region where his tribe used to travel widely to hunt and fish, he pauses for a long moment. “All along the way, we’ve always maintained we want it clean. We also understand that expectation, it’s pretty far out. Now the question that we have to ask ourselves is if we agree to accept anything else—is that something we can live with? Knowing our connection, our history with the land?”

“If things continue to go like they’re going, everything will be taken from us.” He drums his fingers against the table, marshaling the words.

There’s a long quiet. He works to collect himself. “But what do we say to our grandchildren? That we were tired? That we gave up?”