HOT WATER

Groundwater Contamination At The Hanford Nuclear Reservation

A report on the history of Hanford, previous and current releases of contaminated materials, and the independent study of researchers Norman Buske and Linda Josephson

By Tim Connor

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Illustrations

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INTRODUCTION

This is actually a story within a story. At one level is about the enormous radioactive and toxic chemical drainfield being created on the banks of the Columbia River by Hanford. At another level, it offers an intimate glimpse of the attitude held by the individuals to whom the American people have entrusted Hanford's management.

Future investigations may reveal that at the heart of this subject lies a kind of fraud, for there is evidence suggesting that government officials should have long been aware that continuation of Hanford's waste-dumping practices pose far greater risk to the Columbia River than they've admitted. Reviews already completed indicate that at Hanford and similar facilities, management of U.S. nuclear weapons construction programs has been characterized by a potentially deadly combination of incompetence and indifference. Tennessee and Ohio have already sued the federal government for damages resulting from nuclear weapons construction, and similar litigation in Washington State may not be far away. Meanwhile, several Congressional leaders are demanding a new accountability on the part of those who supply the nation's nuclear arsenal.

In April of 1985 Ohio's Senator John Glenn asked the General Accounting Office—the investigative arm of the U.S. Congress—to begin a study of the U.S. Department of Energy's management of the nation's nuclear weapons facilities. Senator Glenn's request was based on the alarming conditions he discovered at the Fernald plant in his own state.

On September 25, 1986 Senator Glenn released the fourth in the series of special GAO reports compiled at his request. He announced that the report "surveys the extent of soil and groundwater contamination at nine DOE facilities located at seven sites around the nation. And the facts revealed in this report are both shocking and revealing." The Senator then proceeded to summarize evidence that staggering contamination is being inflicted on America by its own nuclear weapons production—contamination that is occurring without a single enemy nuclear weapon ever being fired in anger against the United States.

"What these figures show, said Senator Glenn, "is that the Department of Energy and its predecessors have been carrying out their mission to produce nuclear weapons with an attitude of neglect bordering on contempt for environmental protection. What they've said, in effect, is 'we're going to build bombs—and the environment be damned.'"

Senator Glenn concluded his remarks by expressing frustration that legislation he has introduced that would end DOE's self-regulation at nuclear weapons facilities like Hanford is being ignored. Said the Senator: "Unfortunately, my bill has gone nowhere. It's still bottled up in Committee, while these DOE facilities continue to poison our soil and groundwater. Frankly, I don't know what the problem is.

"But there's one thing I <u>do</u> know. I know we better wake up in this country; we better wake up before it's too late and we find ourselves with an environmental disaster that makes the Chernobyl accident look tame. If I sound angry, it's because I am. If I sound worried, it's because we should <u>all</u> be worried. And if what I've said sounds frightening, it's because I believe it's absolutely crucial that someone shake the Congress and the Administration out of their lethargy and info some meaningful action on this issue."

Less than two months later, on November 18, 1986, Rep. Mike Synar of Oklahoma released still another GAO report blasting the energy department for its management of Hanford. That report, compiled by the House Government Operations Subcommittee on the Environment, Energy and Natural Resources, concludes that a dangerous guessing game exists at Hanford; DOE's research has been so haphazard as to make it impossible to know how much of the facility's wastes are entering the groundwater, thereby threatening the Columbia River. The report also suggests that Hanford's managers have for five years consciously ignored the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Hanford has admitted to having 337 waste sites subject to the law, but GAO said the true number may exceed 750. At the same time, the GAO found that Hanford waste practices are violating portions of the 1976 Resource Conservation and Recovery Act which DOE's own managers appear to acknowledge must be obeyed.

Rep. Synar said the GAO report supports his own view that "DOE has an abysmal track record in managing its waste" and that the record is not improving despite promises from DOE Secretary John Herrington that the weapons agency would start obeying the nation's environmental laws. In addition, Synar seemed to raise the possibility that key DOE officials had either perjured themselves or didn't know what they were talking about in testimony given to Congress last summer about Hanford's hazardous waste dumping practices. Since the two officials were Mary Walker, DOE's Assistant Secretary for Environment, Safety and Health, and Ron Gerton,

Hanford's director of the same post, Synar's criticism underscores the growing opinion that DOE decision-making is mired in deceit, incompetence, or both.
Historically, the Department of Energy and its predecessor the Atomic Energy Commission, have argued that the Atomic Energy Act exempts the government from having to obey human health and environmental protection laws in the construction of nuclear arms. The latest GAO report on Hanford says that the Congress must now decide whether to continue tolerating this position, a position that allows activities that amount to outlaw practices at the nation's nuclear weapons facilities.

Inevitably, this will be one of the most difficult issues Congress has ever had to face; the foreign policy implications are immense. At the bottom of the GAO's recommendation is a gut-wrenching question: is it possible for a constitutional nation to own nuclear weapons without sacrificing the very principles of lawfulness that make its orderly existence possible? In a sensitive 1981 report titled "Some Political Aspects of Special Nuclear Materials [bomb material] Production" DOE analyst A.T. Peaslee, Jr. in effect warned the Reagan Administration that obeying human health and environmental protection laws would lead to the "effective curtailment" of nuclear weapons production in America.

Such reasoning implies a bleak definition of national security, one that suggests that the terms of nuclear protection may be far more punitive than the American people ever knew. This report by Tim Connor offers a detailed look at how those terms appear to be operating at Hanford.

—Larry Shook

Chapter 1

Hanford History:
The White Bluffs Military Project

The first and most important chapter in the history of the Hanford Reservation is illustrated on the north wall of the Hanford Science Center. Between the front door and a gumball machine that dispenses irradiated glass beads ("Atomic Marbles") for a dime each, is a series of black & white photographs that tells the story. In early 1943 three small Washington towns—Richland, White Bluffs, and Hanford—and some 6,000 people working the land along the 45-mile Hanford reach of the Columbia River found themselves squarely in the tracks of history. In one frame is a photograph of the Planters Hotel at pre-war Hanford. A few feet away is a reproduction of the August 6, 1945 front page of the Richland Villager newspaper announcing "It's Atomic Bombs!" The time lapse is 567 days. A caption on the wall explains: "Many had said, 'What we make is a mystery to us but we know it must be important to the war effort.'"

The closest thing to an environmental appraisal for what was originally called the "White Bluffs Military Project" is in the handwritten notes of Lt. Col. Franklin T. Matthias of the Army Corps of Engineers. In 1942 Matthias' job was to visit sites in the western United States that might be suitable for the "Manhattan Engineering District" (MED) plutonium production complex. Although the criteria for a site included such vital considerations as the availability of water and

electricity, it was the compelling need for open space that sent Matthias on a whirlwind tour of the west coast. Originally, the project planners intended to build a "semi-works" prototype facility in the Argonne Forest near Chicago, then locate a full-scale production complex at Oak Ridge, Tenn., where uranium enrichment plants were already underway. On the recommendation of a top staffer, however, the Manhattan Project's leader, General Leslie R. Groves, changed his mind.

"The loss of life and damage to health might be catastrophic."

"If because of some unknown and unanticipated factor a reactor were to explode and throw great quantities of highly radioactive materials into the atmosphere when the wind was blowing toward Knoxville," Groves wrote in his memoirs, "the loss of life and damage to health in the area might be catastrophic."[1]

This fear of a disastrous accident is clearly reflected in Matthias' journal entry of December 16, 1942, the day he left headquarters in Wilmington, Del., for Pasco. In the middle of the single-page entry is a diagram not much bigger than a matchbook cover. It is an outline of the clearance MED engineers thought necessary for what Groves referred to as "the hazardous manufacturing area."[2] The dimensions Matthias outlined totaled 560 square miles, almost exactly the size of what was to become the Hanford Reservation. For Matthias, Hanford was but one stop on a two-week expedition that look him to Spokane, Grand Coulee, Ellensburg, Yakima, Portland, Sacramento, Los Angeles, and Blythe, Calif. before returning east to Washington, D.C., to meet with Groves on New Year's Eve. Groves was predisposed to a site in the Pacific Northwest to begin with, and Matthias' endorsement of Hanford supported the general's inclination. Real estate appraisal of the land to be condemned at Hanford began just a week later; Groves himself toured the site and approved its selection on January 16,1943.

"The suitability and the exact boundaries of the site were studied as thoroughly as time permitted during January," wrote Groves. "It was essential that there be no afterthoughts, for once the actual purchasing or condemnation of a particular parcel of land was started, it would be confusing and expensive to make changes."[3]

It was not until a full month after the first Hanford worker arrived, that Matthias phoned the Corps of Engineers' Seattle office to request a report on "subsurface conditions and groundwater location" at Hanford.[4]

There is nothing in Matthias' journal or Groves' memoirs to suggest either man was thinking of Hanford beyond the Manhattan Project or World War II. Although the simultaneous construction at the site of three reactors and three chemical processing plants was extraordinary, the object was to do the least work necessary to produce and recover enough plutonium for use in a few bombs. When, in July 1944, it became evident to MED physicists at Los Alamos that plutonium, if it were useful at all, would be needed in relatively small amounts, there was even some discussion of stopping work on one of the Hanford reactors.[5] Likewise, Hanford's builders. E.I. Dupont de Nemours & Company, insisted from the start that their contract at Hanford would end with the war. It did.

Five months after V-J Day, Hanford was all but deserted. The lull did not last long, however. In June 1946, the War Department announced General Electric would replace Dupont as contractor at the site. By August the production of plutonium had resumed in earnest. Next came a major expansion. In December 1948 David Lilienthal, the first chairman of the Atomic Energy Commission (AEC), announced that Hanford would become the site of "the largest peacetime construction job in American history."[6] This expansion, which continued to the completion of the Hanford PUREX plant in 1956, added five plutonium production reactors to the three built during the war, and three chemical processing plants to the original three. Hanford was going to be around awhile.

{Insert Figure 1}

Figure 1: **Hanford and Chemical Processing Areas:** Plants for the recovery of plutonium and uranium are located on seven square miles in the center of the Hanford Site known as the "200" Areas. Today, irradiated fuel from the Hanford "N" Reactor is shipped by train to PUREX in the 200 East Area where uranium and plutonium are separated from highly radioactive fission products. Uranium is converted to oxide power and plutonium oxide to metal at plants in the 200 West area.

Chapter 2

The Atomic Landfill

From the beginning, the Hanford plutonium factories have affected the Northwest environment in several ways. Water to cool the first eight production reactors was drawn directly from the Columbia River, piped once through the reactor cores, impounded briefly in riverside holding ponds, then released to the river. In 1964, the amount of radioactivity injected into the river was such that nearby residents could have received a 4-millirem dose to the gastrointestinal tract by drinking a mere 7 ounces of water a day, less than a cup, for a year.[1] This level of radioactivity existed in the sanitary waters of Pasco, a city 30 miles downstream from the Hanford reactors. A 4-millirem dose is the current drinking water limit recommended by the U.S. Environmental Protection Agency.

Air vented to the atmosphere from both reactors and chemical processing plants has also carried harmful amounts of radionuclides, particularly radioactive iodine-131 which, judging from dose estimates provided the recently convened Hanford Health Effects Panel, may have resulted in thyroid injuries throughout the Inland Northwest.[2] Both kinds of discharges have imposed health risks upon people living downwind and downstream of Hanford. There is a debate now about the magnitude of these risks and whether a pattern of deaths and/or illnesses, traceable to the releases, can be established. But that is another story.

The contamination of Hanford soil and groundwater is yet another chapter, because the consequential environmental harm threatens to escalate with time, perhaps dramatically. To begin to explain why the contamination seeping from the Hanford aquifer into the Columbia River today may be an early warning of a growing problem, it helps to look at how the Hanford factories work.

Sluicing Plutonium

Like uranium-235, the material used in the Hiroshima bomb, plutonium-239 is a reluctant volunteer for a nuclear warhead. To make a nuclear explosion one needs a bundle of atoms that are both unstable (radioactive) and "fissile"—releasing both energy and subatomic particles (neutrons) when they are struck by other neutrons. If each atom which is struck by a neutron releases several neutrons, then a nuclear chain reaction can be sustained if there are enough atoms close enough together in the bundle.

Uranium-235 was a logical first choice because it is found in nature wherever the much more abundant uranium-238 is found. The problem is, the two isotopes are chemically identical—to separate one from the other requires an incredibly laborious, energy-consuming process. The only other choice in 1943 was plutonium-239.

This too was a difficult choice. Plutonium is essentially non-existent in nature. It can be artificially produced, however, and in a way that avoids the painstaking isotopic separation process necessary to pull meaningful bits of U-235 out of veritable mountains of natural uranium. Plutonium's appeal to Manhattan Project physicists was that the fissile isotope, Pu-239, so predominates over the non-fissile plutonium isotopes that the material can be used straightaway to make bombs. The technologies to separate U-235 and Pu-239 are very different. But that does not imply that producing and separating plutonium is actually simple and thrifty. It's not. Uncertain as to which process and which material would ultimately prove most useful in making atomic bombs, MED leaders pursued the development of both.

Hanford got the plutonium mills. Plutonium would first be produced by irradiating U-238 in a reactor. Then it would be chemically separated from uranium and the so-called "fission products" of the irradiated uranium. It is this second step, the actual recovery of plutonium from irradiated uranium, that makes Hanford and its sister facility, the Department of Energy's Savannah River Plant (SRP) in South Carolina, distinct among American nuclear facilities. It is also this process "reprocessing," which has been responsible for some of the worst environmental contamination. Society is now faced with the task of spending untold billions of dollars to begin cleaning up both these sites.

Reactors at Hanford and SRP, like most other reactors, use slightly enriched uranium as fuel. Uranium fuel rods are only slightly radioactive when unsexed into a reactor. When they are discharged, however, they are fiercely radioactive, containing hundreds of synthetic radionuclides in addition to most of the U-238 and U-235 originally present in the raw fuel. About one percent of the irradiated "spent" fuel consists of plutonium-239 which is created when atoms of uranium-238 absorb neutrons and, through a "decay" process lasting a day or more, become atoms of the new element.[3] Thus, plutonium is not only present in the irradiated fuel of Hanford and SRP reactors but in the spent uranium fuel in commercial power reactors as well. The difference is that what to the commercial nuclear power industry is a dangerous and troublesome waste, is at Hanford a raw material for nuclear warheads.

The chemical recovery of plutonium and uranium from spent reactor fuel is known as "reprocessing." In most basic terms, reprocessing involves the disintegration of irradiated fuel rods, the dissolving in highly acidic solution of the fuel contents and the chemical separation of plutonium from uranium and uranium fission products.

This needn't be done on a large scale, but at Hanford it is. The end result doesn't look like much. An operation that requires 570 square miles, $5 billion in facilities, thousands of employees, and several hundred millions of dollars, gravitates in one way or another toward a surprisingly cramped, stuffy room in the bowels of the Hanford PUREX (Plutonium-URanium EXtraction) plant known as "N" cell. There, a mere handful of workers in baggy white coveralls "load out the product" as they say—pack powdery plutonium oxide into metal containers the size of large soup cans. If this seems incongruous, such is the nature of plutonium. Even when the PUREX plant operates, as it did in 1984, at about half its present capacity, the workers of N cell "loadout" about one metric ton of plutonium a year, enough for a Nagasaki-sized bomb every two days.

Even though PUREX employs the third and most efficient process that has been used at Hanford to recover plutonium from irradiated fuel, its use still involves contaminated discharges to at least 17 so-called "waste streams," 14 of which are liquid streams containing varying quantities of radioactive and chemical wastes.[4]

Looking just at the recovery of plutonium (an additional facility is used at Hanford to complete the recovery of uranium), for every kilogram (2.2 lbs.) of plutonium extracted at PUREX—the results of a typical eight-hour work shift at the plant there results:

- *More than 340 gallons of liquid high-level radioactive wastes in a mixture with hazardous chemicals.*[5]

- *More than 55,000 gallons of low to intermediate level wastes disposed to "cribs," or gravel-lined pits (Enough to fill a municipal swimming pool).*[6]

- *More than 2 1/2 million gallons of potentially contaminated cooling waters disposed to ponds. (Enough to float a small ocean-liner in 30 feet of water).*[7]

The above numbers may seem staggering. But to get a true picture of the wastes discharged at Hanford on an average day, you must multiply them by three.

The Glamourless Profession

The contamination that exists today at Hanford is partly due to the fact that the early processes were not nearly as efficient as PUREX. Just as the Hanford reactors were expansions on a grand scale of the crude "pile" used by physicist Enrico Fermi to conduct his famous experiment in late 1942, the first Hanford reprocessing plants were colossal enlargements of laboratory processes which, theretofore, had recovered mere specks of plutonium.[8]

"The designers of the chemical separations plants at Hanford recognized that the technological innovations required for conducting chemical operations by remote control behind thick concrete walls were demanding enough," wrote chemist William P. Bebbington in 1976, "without trying to achieve such niceties as the optimization of the process."[9]

One of the niceties dispensed with in the original "bismuth-phosphate" process used at Hanford (the term refers to the chemical compound used to separate out the plutonium) was the recovery of uranium, essentially all of which was allowed to pass through to the waste tanks and cribs. The performance of these first reprocessing plants so exceeded expectations (they were able to capture better than 95 percent of the plutonium) that only two of the three built for plutonium recovery were actually used for that purpose. Yet, however efficient these "reprocessing" plants were at distilling plutonium, they still discarded a huge volume of extremely dangerous wastes. Despite improvements in efficiencies this paradox persists up to the present day at Hanford. A performance standard for recovering plutonium in no way guarantees environmental protection.

"Even in my day in the Atomic Energy Commission," wrote former AEC General Manager Carroll L. Wilson in 1979, "we spent $250,000 a month sinking steel tanks in the desert to hold high-level waste which remained after the plutonium had been extracted from the fuel elements of Hanford reactors. Now, thirty years later, these tanks are very old. I wonder what their half-life is!

"Chemists and chemical engineers were not interested in dealing with waste. It was not glamorous, there were no careers, it was messy. Nobody got brownie points for caring about nuclear waste. The Atomic Energy Commission neglected the problem."[10]

Though Wilson was writing about the earliest years of operations (1946-1950), the problem he cites persisted as further improvements in plutonium recovery were pursued at Hanford. In rapid succession, second and third generation reprocessing plants were built. The Hanford REDOX (REDuction OXidation) plant began operating in 1951. Finally, the PUREX (Plutonium URanium EXtraction) plant started up in 1956. In these plants organic solvents were employed to separate plutonium and uranium from the other radioactive byproducts. While this technique gradually reduced the volumes of waste it did not in the least affect the manner in which the wastes were disposed.

The classification of Hanford wastes to general "low," "intermediate," and "high" level categories was apparently well established by 1959.[11] These levels were: greater than .1 curie per liter (Ci/l) for high-level waste, from 10^{-8} Ci/l for intermediate level, and less than 10^{-8} Ci/l for low-level.[12]

High-level wastes were clearly the biggest problem, because workers coming in direct contact with them for any length of time would suffer from acute radiation exposure. These wastes then, as now, were routed to underground storage tanks. Wilson was correct that the tanks would not last. By 1980, there was either evidence or suspicion of leaking in 58 of the 149 single-wall steel tanks.[13] Although some 500,000 gallons is thought to have leaked into the ground, Hanford officials say they believe none of the leaked waste has thus far penetrated to the water table.

Essentially all other liquid wastes were and, for the most part, still are dumped right into the ground. In basic terms, the Hanford plutonium and waste storage operations "perspire" heavily, and do so as a routine consequence of normal operations. Ponds—or "swamps" as they were originally known—form where large volumes of often-contaminated cooling waters are discharged. Cribs, glorified trenches, have been constructed to dispose annually of hundreds of millions of gallons of "process condensates" containing chemical and low-level radioactive wastes.

Still another category exists for the millions of gallons of wastes resulting from accidents or unusual accumulations that have been dumped into the ground at Hanford. Until 1958, for example, several trenches and pits were used as "specific retention basins" to dump "marginal" wastes, some of which had originally been stored as high-level waste in tanks.[14] In 1958, two Hanford scientists finally called for an end to this practice except for emergencies. Their report is forthright in stating that the reasons for the practice were expedience, cost-savings, or both.

The largest recorded instance of such operations began in August 1956 and involved the disposal to trenches "immediately south of the 200 East Area" of million gallons of recycled high-level waste. This housecleaning was intended to release an estimated three to four year capacity of tank storage space" for future wastes from the then-new Hanford PUREX plant.[15] Some of the waste disposed in this manner, the authors reported, contained levels of strontium-90 "that frequently are 10,000 to 100,000 times the local limit for release to the public domain." From 1951 to 1957, an estimated 26.7 million gallons of waste was disposed to the environment this way. The report notes that waste was similarly disposed in earlier years, but volumes and contents were not noted in records kept during that period.

These "specific retention basins" were additions to the more common practice of using simple "trenches" to dump smaller volumes of intermediate to high-level wastes. Trenches were used when the wastes did not fit the schemes or criteria for tank or crib disposal. Although trench disposal has been restricted since 1957, by that time they had accounted for nearly 30 million gallons of intermediate-level radioactive wastes.[16]

Still other wastes, including wastes containing plutonium, were injected deep into the ground via so-called "reverse wells." The Department of Energy has identified at least ten such sites.[17] Reverse well disposal resulted in the first contamination of Hanford groundwater.[18] In one such well, from 1945 to 1947, over 4 kilograms of plutonium, 75 curies of stronlium-90, and 80 curies of cesium-137 were disposed.[19]

The extent to which the reprocessing plants have relied upon the surrounding environment as a blotter for radioactive wastes is illustrated at the Hanford "B" plant. One of the original plutonium recovery plants, the "B" Plant has since been converted to recover and store radioactive byproducts. Over the course of its 42-year-life, wastes from "B" plant have been sent to nearly 70 ground disposal sites (ponds, cribs, trenches, etc.)[20] In early 1985 the cumulative volume of liquid wastes discharged to the environment from Hanford reprocessing plants surpassed 200 billion gallons—enough fluid to cover the isle of Manhattan to a depth of over 40 feet. Consequently, a Hanford contractor estimated in 1985 that there remains in Hanford soil some 22,600 curies of strontium-90, 24,600 curies of cesium-137, 192 kilograms of

plutonium and 142,000 kilograms of uranium.[21] The extent to which the ground at the reservation is already being relied upon as a huge sponge is illustrated by the fact that it would take an amount of water equal to 25 years of Columbia River flow (as measured at Hanford) to dilute the above sum of strontium-90 to the Environmental Protection Agency's standard for drinking water.

{Insert Figure 2}

Chapter 3

The Pasco Gravels

There is nothing on the west bank of the Columbia River, one mile south of the old Hanford townsite, that looks very alarming. Tumbleweeds are piled almost neatly at the high water line, wild asparagus spears poke through knee high grass, there are songbirds in the brush and larger fowl gliding in the thermals high overhead. Unless you knew what you were looking for you would have a hard time spotting the small jets of water kicking up puffs of silt and sand, beneath the surface of the river just offshore. The water flowing out of these springs the size of half dollars comes from Hanford waste ponds and cribs six miles away.

Although it appears pure enough to drink, the water contains telltale chemicals and radionuclides that leave no question about its origin. Spokesmen for the Department of Energy and Battelle Northwest Laboratories, the contractor charged with environmental monitoring at Hanford, insist the contamination is negligible. They assert the public health is not threatened because the contaminants are quickly diluted to "acceptable" levels by the flow of the Columbia. Norm Buske argues such claims may be true, but are beside the point. The water, he says, has an important story to tell and one Hanford scientists seem determined to ignore. Buske and his wife, Linda Josephson, are a team of scientific consultants whose firm, SEARCH Technical Services of Davenport, Washington, has performed over 600 technical investigations since the two of them teamed up in Portland, Oregon eight years ago. Since last fall, Buske and Josephson have been investigating groundwater discharges into the Hanford Reach of the Columbia River, an endeavor they began as science advisors to the environmental group Greenpeace.

If there is an alarming story that Buske and Josephson's detective work calls our attention to, it is a story which has its beginning in recent geologic history. The reason this is so is that 12,000 years before Hanford was quickly consigned to be the largest nuclear materials production complex in the world, it rather suddenly became a large gravel dump.

Hanford's 570 square miles all but fill the western half of the Pasco Basin, a large, saucer-like depression in the thick sheets of basalt that underlie virtually all of the Columbia River Basin. It is both the location and shape of the Pasco Basin that would have made the crest of Rattlesnake Mountain, the 3,500 foot slope along Hanford's southern boundary, an excellent vantage point to have witnessed the great floods set loose upon eastern Washington at the end of the last ice age. As the continental ice sheet withdrew northward, an ice dam holding some 500 cubic miles of water in ancient Lake Missoula was breached perhaps as many as seventy times.[1] The immense

force of the resulting floodwaters across three states is most visible upon the stark terrain of eastern Washington's channeled scablands.

"Like roads to Rome," wrote geologist J. Harlen Bretz in 1959, "all scabland rivers led to the Pasco Basin."[2] The Lake Missoula waters boiled upon Hanford by at least two routes, one marked by the Koontz coulee some five miles north of the Washington Public Power Supply System's #2 reactor, the other following the Columbia River valley and entering from the west. When this happened, geological evidence suggests, the Pasco Basin became an immense funnel, forcing waters pouring into it from the west, north, and east through the notch of Wallula Gap. At this site southeast of Pasco there are scars marking the floods' passing etched upon the cliff walls 800 feet above the present level of the Columbia River. Whereas the Lake Missoula floods left to other parts of the scablands such striking features as Grand Coulee and the massive dry cataracts of the Quincy Basin in Grant County, the floods bestowed upon Hanford two massive bars of gravel.

It is atop the larger of these bars, what geologist Bretz referred to as the "Cold Creek bar," that the Corps of Engineers began building the Hanford plutonium processing plants in 1944. And it is in the basalt floes beneath Cold Creek bar that a high-level nuclear waste repository would be built should Hanford finally be selected to host that scheme.

Gravel doesn't hold water very well. The cribs used at Hanford for the disposal of large volumes of liquid low-level radioactive chemical waste "work" as well as they do because the ground beneath them is able to drain the liquids very rapidly. Visitors to Hanford's "200" Areas, where the huge Hanford reprocessing buildings stand like aircraft carriers on a sea of sagebrush, can spend the day with their guides without seeing so much as a patch of damp soil. To illustrate the ability of Hanford soil to absorb water, a National Academy of Sciences panel reported in 1978 that had the water dumped at Hanford not percolated into the ground it would, by then, have covered the 200 Area dumpsites to a "phenomenal" depth of 1,800 feet.[3] But, because the ground at Hanford drains water so rapidly, it gives Hanford managers the ability to conduct a large scale dumping operation without getting their feet wet.

The Ringold

The water table at Hanford resides almost entirely within the so-called "Ringold Formation." As opposed to the "Pasco gravels" that lie above it, and into which the Hanford waste waters are poured, the Ringold testifies to a relatively quiet geologic interlude between the last of the Columbia Basin lava (basalt) floes some 8-9 million years ago and the Lake Missoula flooding. The Ringold, simply, is a mixture of compressed and layered sediments deposited by the ancestral Columbia River as it made its way through the Pasco Basin for several million years. With the uplifting of the Horse Heaven ridge to the south, the evidence suggests the river's flow was impeded for a good length of time. This natural dam formed a lake that filled the basin until the waters carved through the ridge at Wallula Gap. Thus the Ringold underlies nearly all of the Pasco Basin and is present everywhere beneath Hanford except where the underlying, older basalt protrudes above it at Gable Mountain and Gable Butte.

The Ringold is important in the Hanford waste picture because it catches and tries to absorb Hanford waste water draining from the cribs and ponds 300 feet above. But the Ringold has to drain too. This is where bad news begins because the Ringold moves the water eastward, toward the Columbia River. For the following reasons, however, there's more to it than that:

- *The Ringold Formation is naturally saturated with groundwater. The overlying Pasco gravels, with few exceptions, are above the water table and therefore naturally dry.*

- *All things being equal, groundwater flows much more rapidly through the Pasco gravels than it does through the denser sediments of the Ringold.*[4]

- *When the waters filling the Pasco Basin receded, the Ringold Formation was exposed. Consequently, it had become extensively eroded prior to being smothered by the Pasco gravels. Thus, there are "channels" where the surface of the Ringold is scarred, allowing the overlying gravels to backfill <u>beneath</u> the surface of the water table.*[5]

The last two points are especially important for they show how wastes heading down the country road of the Ringold toward the Columbia can suddenly come upon a freeway of Pasco gravels.

The U.S. Geological Survey, in a 1972 report, warned of just such a possibility: "If radioactive waste is disposed to groundwater that is rising [above the Ringold] into or traveling in the glaciofluviatile and fluviatile deposits [Pasco gravels], the waste can be flushed to the Columbia River in about one-hundredth of the average time of travel for a similar distance in the Ringold conglomerate."[6]

The message, simply, is that if you contaminate Hanford groundwater you'd hope that the contaminated water does not wander out of the Ringold and into the Pasco gravels.

The first reports handed Hanford managers on subterranean conditions were highly optimistic. Not only would contaminated waste water percolate quickly and deeply into the ground, but upon reaching the water table in the Ringold formation it would then disperse and seep slowly toward the Columbia. This initial optimism, which Hanford spokesmen are still in no hurry to abandon, is reflected in two reports prepared by General Electric Company scientists at Hanford in the 1950s. The first, in 1953, reported a "minimum time" of not <u>less</u> than 50 years for groundwater to flow from beneath the disposal sires in the 200 Areas to the Columbia River.[7] Another, prepared in 1959, calculated a "travel time" to the Columbia River between 175 to 180 years.[8]

Both were wrong by quite a margin. Contaminated groundwater was first detected beyond the boundary of the 200 East Area in January 1956. By 1963 radioactive tritium levels at monitoring wells nine miles away at the river began to rise dramatically. The forecast in the 1959 report was for the waste water to follow a looping, southeasterly path covering some 20 miles at an average flow rate of less than two feet per day. What the Hanford scientists recorded, instead, was that the leading edge of the contamination plume had taken a much shorter easterly path to the river of only nine miles and arrived in seven years. This surprising development was discussed in a 1963 report, which was among the recently released Hanford historical documents.

"Earlier estimates of groundwater travel time from the 200 Areas to the Columbia River were based on a limited amount of monitoring data, pumping tests, and tracer studies. As more of these observations were made, refinements in the travel time estimates were also made. Current estimates of travel time are based on the appearance time of gross beta-emitters (Ru^{106}-Rh^{106}) [ruthenium-rhodium] and fission product tritium in monitoring wells located at various distances from liquid waste disposal sites."[9] This was a way of saying, of course, that what had actually happened was quite different from what had been predicted. The tritium discharged from PUREX had reached the river, as had the slightly slower-moving ruthenium.

Thus: An <u>average</u> travel time of from 7-8 years is estimated for Ru^{106} contamination in the groundwater to move from the PUREX plant site southeast to the Columbia River. A period of time only slightly less, 6-7 years is indicated for tritium following the same path."[10] These 1963 observations would seem to have settled the issue. They did not. When one reviews the Hanford literature what one finds is that estimates of groundwater travel time since the 1963 report have actually *multiplied*. A 1977 DOE report on waste storage at Hanford cited a computer model as predicting a "<u>minimum</u>" travel time for radionuclides dissolved in groundwater beneath the 200 East Area [where PUREX is located] at 43 years."[11] Another report, issued in 1982 just prior to the restart of PUREX operations cited a "measured" travel time of 23 years but a "predicted" travel time, based again on a computer model, of 27 years.[12] (The authors of the 1982 report, alert to the fact that readers would be confused by this disparity, explained that the difference between what was "measured" and what the computer had forecast was "within the uncertainties of modeling accuracy."[13])

When these discrepancies were questioned during a DOE-sponsored workshop last May, the reply from Battelle hydrologist Dr. Michael Graham was that there really were no discrepancies. His reasoning was that Hanford scientists have done a poor time communicating to the public what they mean by "travel time." The Hanford scientists, he said, do not now mean for travel lime estimates to represent situations like that reported in 1963, when a leading edge of contamination is detected. Rather, he said, travel time should stand for the movement of a "peak" of contamination from one point to another. This, said Graham, is what Hanford scientists use now when they refer to "travel time."

Clearly, however, the use of this definition in documents written specifically for public review is very misleading. The suggestion that contaminants are only available to harm the public and the environment at the end of such an artificially long travel time is illogical. It is also a clear departure from the "conservatism" Hanford officials claim they've employed in providing the public with estimates of risks associated with Hanford waste discharges.

{INSERT FIGURE 3}

Figure 3: Pasco Basin and Hanford

{INSERT FIGURE 4}

Figure 4: Hanford Flow System

Contaminated groundwater at Hanford follows natural flow to the Columbia River. The above diagram is based on a 1979 document prepared under contract for Rockwell Hanford Operations.

Chapter 4

The Case of the Missing Water

When he is feeling whimsical on the subject, Norm Buske will brim with one-liners about what he regards as Hanford's institutional amnesia. ("A lot was known about Hanford before the present time." "Next year we expect they'll locate the aquifer.") Buske does not put a lot of faith in the forecasts of Hanford model-makers to begin with. One does not volunteer to spend nights in early winter in a wetsuit on a small raft anchored in the Columbia, waking up hourly to take water samples, without good reason. Buske makes no bones about this: he thinks the idea of bringing tens of thousands of tons of additional high-level radioactive waste to Hanford and storing it in the basalts beneath Cold Creek bar is a bad idea.

Buske, who holds a masters degree in physics from the University of Connecticut and a masters degree in oceanography from Johns Hopkins University, was working on nuclear energy-related projects for the Coalition for Safe Power and Physicians for Social Responsibility before he and his wife Linda Josephson, a former college mathematics instructor, moved their technical consulting business from Portland to Davenport, Washington in 1981. Shortly after the December 1984 draft "Environmental Assessment" for the prospective Hanford "Basalt Waste Isolation Project" (BWIP) was distributed by the Department of Energy, Buske was asked to participate, as a technical reviewer, at a gathering of Northwest citizens groups concerned about BWIP. His initial and foremost concern about the assessment, he says, was that "the Columbia River is something they [the Department of Energy] were carefully not looking at."

In March 1985 Buske published a critique of the DOE document. In it he took aim at what he and other reviewers regard as a major flaw in Hanford's promotion as a potential high-level waste site, its suspect "geohydrology" or groundwater movement characteristics.

In addition to the aforementioned water table which is the uppermost aquifer, Hanford is known to have several "confined" aquifers where groundwater has infiltrated, like frosting between layers of a cake, to saturate "interbeds" among the several basalt floes. As seen in the exposed basalt in innumerable eastern Washington road cuts, basalt is prone to fractures. Thus, groundwater has ample pathways within basalt to migrate.

In order to qualify as a repository site, the evidence must show that groundwater encountering the repository caverns would not migrate to the "accessible environment" for 1,000 years.[1] Buske argues that the evidence shows otherwise, and that a travel time from the "reference" repository site 3,000 feet below Cold Creek bar to the Columbia River would be closer to 300 years. Hanford, he concludes, should be eliminated from further consideration in accordance with DOE's own guidelines.[2]

This was not Buske's first look at Hanford. In 1983, working with the environmental group Greenpeace, he and Josephson collected samples of Hanford springwater infiltrating to the

shoreline of the Columbia. The samples were then sent, unlabeled, to a state Department of Social and Health Services (DSHS) laboratory. The analysis showed that a sample drawn from a shoreline spring near a retired Hanford reactor contained nearly twice the amount of beta (radiation) activity allowed by EPA for drinking water.

Greenpeace's subsequent announcement of the findings was noteworthy because neither the energy department, Battelle, nor the state of Washington had paid much attention to the groundwater seeping into the Columbia from Hanford shoreline springs. It was only in the fall of 1982, for instance, that Battelle (DOE's environmental surveillance contractor) made a comprehensive effort to identify and take samples from the springs. The state Department of Social and Health Services (DSHS), for its part, devotes less than a paragraph to the Hanford springs in its most recent annual report on environmental radiation, cites no spring samples, says its groundwater monitoring well data at Hanford was "inadvertently not being submitted," then concludes that "seepage...into the Columbia River...pose(s) no threat to public health."[3]

For Buske and Josephson the exercise was intended to illustrate just how intimately Hanford operations and the Columbia River are bound to each other and how the law and Hanford's managers have obscured that reality. The public laws governing Hanford operations have created a double standard. DOE's Hanford plants are involved in the production of nuclear weapons. This means their radioactive emissions are shielded by the Atomic Energy Act of 1954. Yet, because Hanford discharges to the Columbia are regulated by EPA in accordance with the Clean Water Act, this results in a rather peculiar state of affairs. The Clean Water Act requires EPA to govern the discharge of all pollutants into the nation's waterways. But because Hanford is a nuclear weapons facility, the Atomic Energy Act prevails over the Clean Water Act, thereby exempting Hanford radioactive wastes from the requirement of the discharge permits. Thus, the requirements of the National Pollutant Discharge Elimination System (NPDES) permit issued for Hanford by EPA, restricts such things as suspended solids, acidity, oil and grease, and even temperature, but simply omits radioactive material.

Buske and Josephson pointed out another loophole. The present Hanford NPDES permit cites eight specific discharges to the Columbia at three general locations along the river. One of them is the so-called "SP-1 Spring" (see chapter 5) which is located less than a quarter mile from a trench where waste water from the Hanford N-Reactor's core cooling system and fuel storage basins is discharged. The effluent passes through the bottom of the trench down to the water table, then follows the groundwater flow to the riverbank, emerging at SP-1.

"They still want to argue that there are just eight discharge points to the river including the N-Reactor springs," Buske says. "We wanted to show there are just oodles of springs with no permits. It [the 1983 venture] was really a questioning of their credibility.

Buske and Josephson, again with backing from Greenpeace, returned to the Hanford reach of the Columbia in the summer of 1985 with a plan that, had it succeeded, would have added a new chapter in the annals of citizen oversight. The researchers were faced with the problem of not being able to go very far ashore at Hanford to collect samples; the N-Reactor bristles with concertina wire and the Hanford Patrol carries Israeli-made Uzi machine guns and grenade launchers. So Buske and Greenpeace planned to fly a miniature, remote-controlled helicopter

from a boat and hover it above the N Reactor trench long enough to lower a device that would take a bottom sample, then fly the machine back to the boat. The helicopter had been purchased and the sampling device perfected when, in July, Hanford manager Mike Lawrence announced DOE would cooperate with Greenpeace and the states of Washington and Oregon in a joint sampling program along the Hanford reach of the Columbia.

After first being thwarted by untimely high water, which temporarily blocked spring flows, samples were obtained from springs on the Hanford shore. They showed measurable amounts of uranium, tritium, and non-radioactive nitrate as expected. The ensuing debate was not over the measurements (there were no substantial differences in the lab results) but over their significance. While Greenpeace pointed to the results as further evidence of Hanford operations contaminating the Columbia, DOE and Battelle cited them as confirming their previous position that contamination levels in the seeps were so low as to pose no significant threat to the river itself.[4] As for the permit issue, DOE-Richland Director of Environment, Safety, and Health Ron Gerton told the press that none were required, because the contamination was being carried to the river by groundwater, and the law "is not built to handle Mother Nature; it's meant to handle man's activities."[5]

Buske had a different view: "First, what they're doing is not responsible waste management. The second thing is, it does tell you something about BWIP. There you would have a public health problem. What they're proposing to stick into that sieve is incredibly toxic. You really do want to isolate it. You're just not going to find out for a while whether you were successful or not."

The Missing Water

In the search for springs to sample along the Hanford Reach (the 44-mile-length of the Columbia River through Hanford), Buske and Josephson realized there was another question, this one stemming from the premise that what goes in must come out. In simple terms, they knew the Hanford plants atop Cold Creek bar imported and disposed of enormous sums of water. They knew from technical descriptions of the aquifer that the waste water then followed the natural Hanford groundwater flow to the Columbia River. And yet the few and relatively small springs they'd observed along the Columbia shoreline could not nearly account for the volume of waste water that should be returning to the river. Where was the water going?

Their theory was that the water had to be returning to the river by submerged, hidden springs. Thus, while shoreline spring water was being sampled at the respective laboratories, Buske and Josephson were out on the river searching for submarine springs that could tell them more about how Hanford groundwater interacts with the Columbia. The irony in this is hard to miss. Battelle, which receives $2.8 million annually to do groundwater studies at Hanford, had never attempted to look for submerged springs in the river. By late October, the duo from Davenport, working on days off with modest financial support from Greenpeace for field equipment, had located and marked two areas of underwater springs. They did not tell anybody at first.

When Buske and Josephson attended the second meeting of the joint group on October 17, 1985 they brought with them a proposal for DOE and Battelle to join them in a search to identify and

sample underwater springs in the Columbia. Response to the recommendation by the Battelle scientists at the meeting, they say, was anything but enthusiastic.

Buske and Josephson based their proposal on a 1983 Battelle report which estimated Hanford groundwater flow into the river at "less than" 100 cubic feet per second (cfs). Yet, they reasoned, the water flowing from the observable springs into the river clearly did not amount to anything near 100 cfs. The question was: where was the remainder of the water returning to the river? This is what Buske and Josephson proposed to investigate.

Unbeknownst to Buske and Josephson, however, Battelle scientists had drastically altered their estimate since 1983. They had narrowed their focus from the entire 44-mile stretch of shoreline to a four-mile stretch just south of the Hanford townsite where the main branch of the contaminated groundwater plume from PUREX intercepts the river. Here, Battelle now estimated, 3 cfs were entering the river.[6]

When Buske offered his proposal, which included Battelle's earlier 100 cfs estimate, he and Josephson say they were quickly informed by the Battelle scientists at the meeting that their proposal, because it relied on the 100 cfs estimate, was flawed. It was then that they learned of Battelle's new number.

Buske says he immediately dismissed the 3 cfs estimate. In marking one of two areas where he and Josephson had earlier located underwater springs, the two had done a quick "seat of the pants" estimate. The quick calculation, based on measurable nitrate concentrations upstream and downstream from the marked area, indicated 10 cfs of groundwater were entering the river, just in that one immediate area.

The October 17th meeting ended, they say, with Ron Gerton, the Department of Energy's top environmental officer at Hanford, ordering reluctant Battelle scientists to cooperate on a joint field effort for the following day. According to Buske and Josephson, the field trip was a disaster. After the Battelle boat was abandoned because of equipment problems, the team traveled over land to one of the areas where Buske and Josephson had marked underwater springs. There the team discovered the river level was higher than normal, the increased pressure from high water blocking the normal flow of groundwater from the springs in the river bottom.

State officials from Washington and Oregon left the October 17th meeting satisfied that contaminated groundwater seepage into the Columbia posed no immediate public health concerns.[7] These reassurances, along with the scuttled field trip the following day, left Buske and Josephson alone with their concerns about the ramifications of contaminated groundwater seepage to the Columbia at Hanford. Unable to convince the Department of Energy and its top environmental contractor at Hanford of the need to do a follow up study, they would proceed to do it themselves.

Chapter 5

Hanford Time Bombs

Buske and Josephson's weekend detective work is akin to what a paleontologist would attempt after finding a heretofore unknown and small bone beneath an old rock. The water they retrieve from the tiny "sand fountains" just off the Hanford shore may contain as many clues as the smallest shards of prehistoric animals that can be the keys to reconstructing the anatomy of an extinct dinosaur. The difference, of course, is that while the paleontologist looks to bones to tell stories of bygone eras, the duo from Davenport look at Hanford spring water for clues as to how the Columbia may ultimately be affected by the nuclear wastes that continue to pile up at the reservation.

The Hanford wastes are a large part of what the construction industry journal Engineering News Record recently termed an "environmental time bomb that is ticking in the soil around the federal government's weapons plants."[1]

The most knowledgeable critic of the waste practices which have contributed to this problem at Hanford and other DOE nuclear weapons facilities is William Lawless. Now an assistant professor of mathematics at Paine College in Augusta, Georgia, Lawless was a senior project engineer in radioactive waste management for the Department of Energy until 1983 when he resigned in protest. Since then he has written and testified extensively about DOE waste practices.

Lawless's message is a simple one: "It may be theoretically correct that [the storage of] nuclear wastes is safe, but the reality is quite different than what nuclear scientists and engineers predict."[2]

Lawless draws most of his examples from his service at Hanford's sister facility, DOE's Savannah River Plant (SRP) in South Carolina. As at Hanford, SRP plants produce and separate plutonium from irradiated uranium. As at Hanford, liquid high-level radioactive wastes are stored in temporary underground storage tanks. As at Hanford, the management of low-level radioactive wastes still involves dumping the waste liquids, often mixed with hazardous chemicals, directly into the ground.

It should be noted that conditions at SRP are exacerbated by a much wetter climate (SRP receives nearly eight times as much rain as Hanford does). Still, the episodes Lawless cites where managers have badly misjudged the behavior of contaminants in the environment are no less troubling. In one instance, strontium-90 discharged to a "seepage basin" was measured entering a nearby creek at concentrations more than 40,000 times the EPA drinking water standard.[3] In 1982 turtles contaminated with strontium-90 were found at a commercial hog farm about one kilometer from the SRP site boundary. In July 1981 chlorinated hydrocarbons (organic compounds that are suspected carcinogens) were found to have contaminated on-site drinking water.[4] They had been discharged to a seepage basin and penetrated the Tuscaloosa aquifer, a regional source of drinking water.

As alarming as the instances of contamination is Lawless's first-hand criticism of the way the agency has undermined its in-house environmental protection program. Lawless has continually insisted the Department employs good, competent people. Yet, the bureaucracy in which they

work, he contends, lacks the direction and will to solve the problems it faces and "seems more often concerned with image than substance."[5]

"The Department of Energy," Lawless has written, "often uses antiquated technology in its radioactive waste management, often covers up significant technological problems, has inferior regulations compared to NRC regulations, and has not demonstrated an effective environmental program at Hanford or at any other DOE nuclear waste dump in the United States."[6]

Theory

Hanford scientists have known for nearly 30 years that wastes dumped into the ground at the PUREX plant and the other plutonium and waste processing facilities were traveling to the Columbia River.[7] Concerns about this connection to the Columbia from the dumpsites atop Cold Creek bar are reflected in at least two papers prepared at the Hanford laboratories in the 1950s.[8] Yet, expressions of concern are exceptions.

More typical are assurances such as the following from a 1957 General Electric Company document entitled "The Hanford Atomic Project and Columbia River Pollution":

"In percolating through the soil, most of the radioactive material is more-or-less permanently absorbed or held sufficiently long for radioactive decay to reduce the contamination to insignificant levels. The water which passes on to the water table some 200 feet below then flows slowly with the groundwater toward the Columbia River."[9]

Although this statement was written six years before Hanford scientists confirmed contaminated groundwater from PUREX had reached the river, it is essentially the same as the statements still issued annually, almost three decades later, by Battelle.[10]

Leaving aside for the moment the question of significant as opposed to insignificant contamination, there is basis for the above assurance. Any number of Hanford studies have shown that *most* of the radioactive material disposed to the environment at Hanford is "more-or-less" held by the soil it is dumped into. Plutonium, for example, is so readily filtered by soil under normal conditions that nearly all of it is captured by the first few feet of ground.[11] This is also true, to a somewhat lesser degree, for the worrisome fission products strontium-90 and cesium-137.[12] The question is whether the soil can hold the waste permanently or at least long enough for the radioactivity to decay. (Plutonium remains deadly for 240,000 years.)

The ability of soil to hold nuclear wastes is dependent upon a number of factors. The solubility of a radionuclide often depends upon the chemical ion or compound that it is a part of. Generally more important than solubility in holding a radionuclide in soil, however, is an electrical phenomenon known as "sorption" or "ion exchange."[13] Basically, ions in solution will bind to charged soil particles by the exchange of similar electrical charges. It is this same phenomenon, for instance, that allows the absorption in soil of water soluble fertilizers.[14] The disposal of radioactive and chemical wastes is a deliberate decision to contaminate soil. It also involves the gamble that the physical, chemical, and ion exchange character of the soil will support the burden of the nuclear waste being put into it.

The outcome of this gamble is dependent upon a variety of factors, not all of which can be anticipated. Hanford laboratory and field research established early on that the ion exchange properties of Hanford soil were by and large favorable.[15] But researchers also observed that the acidity of the waste, the presence of salts (PUREX and the other chemical processing plants consume tons of sodium annually), the presence of organic complexants (such as those used as solvents in the reprocessing operations), and even temperature significantly affect the migration of radionuclides in the environment.

To begin to appreciate the unknowns as to how disposal practices at Hanford will eventually affect the environment, consider the preliminary findings of the Hanford Comprehensive Environmental Response, Compensation and Liability Act program (CERCLA) which has, to date, identified 337 inactive waste sites at Hanford, *not including* waste tanks or the soil contaminated by the 150 known instances of accidental ground contamination.[16] Of the 337 sites, 250 were used to dispose of liquid wastes.[17] All told, nearly all of the wastes (84%) were mixtures of radionuclides (an estimated 90,000 curies) and chemicals (an estimated 75,000 metric tons).[18]

If, merely to simplify matters, the above factors were removed, ground disposal of radioactive wastes would still be risky. This is because the ion exchange "barrier" itself is prone to sudden "breakthrough" when the mass of soil reaches equilibrium (an electrical balance) with the wastes it is receiving.[19]

Reality

Since the Hanford N-Reactor started up in 1963, water from its primary coolant loop and fuel storage basins has been discharged to the so-called "1301-N crib." Once discharged to the crib, the waste water percolates 50 feet down to the water table and then a minimum of 800 feet to the riverbank spring known as SP-1.[20] Among the radionuclides routinely discharged to the 1301-N crib over the years is strontium-90. Ion exchange with soils between the crib, the water table, and the river was supposed to prevent significant levels of the radionuclide—a beta radiation emitter with a half-life of 28 years—from reaching the river.[21]

The soil guarding the river from the radionuclides discharged to the 1301-N crib is quickly losing its ability to hold back strontium-90. In 1973, 16 curies of strontium-90 were released to the crib.[22] Over the course of the same year, spring samples indicated about a third of a curie of stronium-90 made it through to the river. Since then discharges of strontium-90 to the crib increased dramatically as irradiated fuel piled up in the reactor's storage ponds. Evidence of a breakdown in the soil's ability to hold strontium began to show up in 1977 when releases from the spring to the river tripled in the space of 12 months.[23]

The response of the Department of Energy was not to stop using a crib. Instead, it dug a new one (the 1325-N crib) 1,300 feet further from the river and, in October 1983, began diverting most of the reactor's waste water (by now laden with over 300 curies of strontium-90 annually) to the new site.[24]

This dubious solution was too late for the problem. The new crib failed soon after being brought on line, prompting a lengthy redesign while, for several months, waste water was routed back to the old crib.[25]

Thus, strontium-90 continued seeping to the river at an increasingly high rate. Between 1983 and 1984 releases of strontium-90 from the riverbank spring nearly doubled, rising from 4 to 7 curies.[26]

By 1985, according to a report by UNC Nuclear Industries, the contractor that operates the N-Reactor, the average concentration of strontium-90 in the riverbank spring water during 1985 was 4,500 picocuries per liter—exceeding by over 560 *times* the EPA drinking water standard and by more than 15 times the Department of Energy's own concentration guide for releases to uncontrolled areas.[27] Thus, even as discharges of strontium-90 to the soil declined to 240 curies during 1985, releases from the spring rose another 25 percent to 8.7 curies.[28]

The radioactive discharges from N-Reactor, and their consequences, exemplify how the Department of Energy can ignore standards of environmental protection that are well recognized and mandatory in the commercial nuclear industry. Even the DOE's predecessor, the Atomic Energy Commission, recognized the long-term dangers of using the ground for liquid waste disposal when it published an operating manual 13 years ago.

"As soon as technically and economically practical," the AEC said, "the use of natural-soil columns (such as cribs, seepage ponds, and similar facilities) for liquid streams that exceed established standards for release of radioactivity to uncontrolled areas shall be replaced with other treatment systems. It should be recognized that liquid waste which meets established standards and is released to soil columns still may result in a buildup (at a slower rate) of radioactivity in the soil column."[29]

The AEC, ERDA, and DOE simply disregarded the policy. Only now that the 1301-N crib failed are Hanford officials pursuing funding to stop liquid discharges to the ground at N-Reactor.[30]

The failure of the N-Reactor crib (or, more accurately, a crib and a chunk of riverbank over two football fields in length) illustrates how quickly a natural barrier can fail as the ion exchange and other holding capacities of the soil are overwhelmed.

The ground of Cold Creek bar is a larger, more complicated kettle of wastes. While the water table beneath it has been monitored since the 1950s, there are several factors that complicate forecasting the behavior of wastes over the centuries length of time they will remain harmful.

First, forty years is insufficient time to learn enough about the way Hanford's long-lived wastes will behave in the 20-foot-thick layer of soil, sand and gravel—the so-called "vadose" or "unsaturated" zone—above the water table. The recently published draft environmental impact statement on the Hanford wastes offers the following blunt, though clumsily phrased, assessment: "Data do not exist to validate long-term transport predictive models at the Hanford site. Monitoring of the unconfined groundwater aquifer at Hanford is limited to approximately 40 years. Transport times in the vadose zone will significantly exceed this length of time;

therefore, monitoring transport only in the unconfined aquifer is not sufficient from a predictive model validation point of view."[31]

Early attempts to understand what was happening to radioactive waste between points of discharge and the water table were undertaken at the Hanford laboratories in the late 1950s and early 1960s. These involved sticking radiation probes down wells used to monitor the groundwater beneath cribs and measuring how the radioactivity was spreading.

"The vertical extent of radionuclide migration beneath 200 Area waste disposal sites varies from shallow depths, directly under some facilities, to complete penetration where the entire soil column is contaminated from crib bottom to water table," Hanford scientists wrote in a 1964 report summarizing the field work. "Horizontal spread varies from a few feet from the edge of the crib, trench or cavern to several hundred feet from the disposal site. The concentrations of radioisotopes in the soil vary from below detection threshold to beyond the maximum range of the scintillation [radiation detection] probe."[32]

The report not only points out that migration of wastes is often difficult to predict, it also documents instances where measurements of waste sites revealed far more radioactivity present than could reasonably be accounted for from the records of wastes discharged at the specific site.[33] In some instances the authors conclude that waste disposed at some sites had migrated laterally to intercept the "soil columns" beneath others. In at least one other instance, the authors' inference is that the records are suspect.[34]

This points to a second area of concern: Hanford records *are* suspect. The historical documents reviewed for this report clearly show that it was only after the Hanford expansion was well underway that the long-term consequences of waste discharges and storage began to be considered in any substantive fashion.

For example, a 1954 document co-authored by three scientists in the Hanford Radiological Sciences Department, reports that "few data are on record regarding the quantities of long-lived radioactive isotopes which entered the grounds in liquids sent to cribs since 1944. The report noted a 1951 internal memorandum citing the "need for a complete audit of cribbed wastes…following the realization that disposal of such liquid wastes would probably continue indefinitely."[35] Yet, no audit had been done.

Likewise, when an independent reviewer of Hanford groundwater management visited the site in 1974 he found to his exasperation that: "The program to measure the concentration of radionuclides in the groundwater has been continuous since 1947. Unfortunately, to obtain original data is virtually impossible. Data for the period 1947 through 1966 are apparently filed haphazardly in the 'archives.'"[36] Finally, the same problem exists for solid wastes that may, in some circumstances, pose a threat to groundwater as well. The waste material contents (including radionuclide activity) of the burial grounds are not well known for all burial grounds, because precise records of disposed material were not kept until recent years," a U.S. Geological Survey team of investigators reported in 1975.[37]

Given these uncertainties it is not hard to imagine scenarios at Hanford where hazardous and radioactive wastes sit dormant in the ground for years, decades, or centuries before a sequence of unforeseen events lights the fuse that launches them into the groundwater and on their way to the Columbia River. In fact, there's no need to imagine such events. At least one has already happened.

{INSERT FIGURE 5A}

Figure 5A: **Theory**
The practice of dumping intermediate and low-level wastes into the ground at Hanford is based on the assumption that the soil will, with the exception of tritium and ruthenium, filter the long-lived radioactive wastes. This display, taken from a 1973 Hanford document, illustrates the concept.

{INSERT FIGURE 5B}

Figure 5B: **Reality**
The above panels, taken from a 1975 Energy Research and Development Administration report, show field measurements of contamination beneath two of Hanford's more than 300 "cribs." The two cribs (216-S-1&2) received wastes from the Hanford REDOX plant between 1952 and 1956. The study showed substantial migration of cesium-137 and strontium-90 toward groundwater in the ten years *after* waste discharge had ceased. (Illustration based on ERDA-1538, Vol. II, p. II.1-C-50)

Chapter 6

A Symphony of Bad News

In 1984 they buried the "U-Pond" at Hanford. The 14-acre hole in the ground located in a corner of the 200 West Area had, since 1944, received process and cooling waters from several 200 West facilities, including those devoted to plutonium processing and uranium recovery. A testimony to the ability of Pasco gravels to suck up waste water is that U-Pond was able to absorb well over 1 billion gallons a year (more than 3 1/2 million gallons a day), some 95 percent of which percolated into the ground before evaporation claimed the remainder.[1]

After 40 years of use, however, U-Pond presented Hanford waste managers with a Catch-22. Over the years it had received an enormous amount of radioactive material, including 82 kilograms of plutonium, and nearly 5 1/2 metric tons of uranium.[2] Even though the pond's full capacity was no longer needed, it continued to receive over 500 million gallons a year, most of which was "make up" water.[3] The extra water was needed to keep the pond's contaminated sediments wetted, so they would not dry out and be blown about by the wind.[4] Even with the pond wetted, said Rockwell-Hanford waste program manager Bill Heine, radiation monitors stationed near the pond routinely registered the highest levels measured anywhere on the Hanford site.[5]

Continued use of U-Pond, however, was posing yet another problem. The percolating water was driving uranium in the pond's sediments down to the water table in increasing amounts. Uranium concentrations in one of the groundwater monitoring wells near the pond had reached 28 picocuries per liter, exceeding both Rockwell's internal guidelines of 4.8 pci/*l* and the EPA drinking water standard of 15 pci/*l*.[6] The decision was made to drain and bury the pond.

With U-Pond due to go out of commission in September 1984, process and cooling waters from the Hanford Uranium plant (which resumed operating in tandem with the PUREX plant the year previously) were routed to a new crib beginning in July. The stage had thus been set for a sort of Rube Goldberg environmental calamity.

The new crib [the U-16 crib] was built 265 feet away from two much smaller cribs used during the 50s and 60s when the U-Plant was recovering uranium from stored high-level waste discharged by the original Hanford reprocessing plants. Rockwell later estimated the cribs had received 4,000 kilograms of uranium during that time, plus a "small quantity of acidic decontamination waste."[7] Although the uranium in the groundwater beneath the cribs—at close to 500 pci/*l*—was already very high even by Hanford standards, the levels had appeared to be stable.[8]

Rockwell's Heine explains what happened next: "Along about February 1985, suddenly we started seeing increased uranium activity in some groundwater wells over here [near the abandoned cribs]. These old cribs had not operated for 20 years or more, and we've been monitoring these wells and not seeing any uranium. And suddenly we started seeing uranium."

And how. In three months between quarterly samples uranium concentrations in the groundwater beneath the cribs had jumped from less than 500 pci/*l* up to 85,000 pci/*l*. As Heine admitted at the time, Rockwell officials were mystified.[9]

What had gone wrong? In simplest terms, Hanford's present had collided with Hanford's past in a big way. Rockwell officials and investigation reports offer the following explanation:

Water discharged to the U-16 crib had percolated downward in the Pasco gravels more than 100 feet. Past that point but still 100 feet above the water table, the water's downward movement was impeded by a layer of silt and clay backed by a layer of "caliche," a dense crust of calcium carbonate that occurs irregularly throughout the Pasco basin as pan of a transition zone between the Pasco gravels and the Ringold Formation. The caliche layer thus acted as a dam, causing water percolating down to move horizontally. The U-Plant water, which Heine described as "essentially clean," thus spread laterally over 250 feet until it intersected the contaminated soil beneath the abandoned cribs.

The episode involved contamination from an old crib, discharge water from a new crib, a small geologic surprise with the caliche layer, a small man-made surprise in the forgotten reverse well, a chemical reaction with the acid, and a natural reaction with the calcium carbonate at the caliche layer.

Originally, according to a Rockwell investigation report, the uranium disposed in the two old cribs remained "distributed mostly near the original discharge level" and owed its immobility to the low solubility of the waste solution containing the uranium.[10] The dumping in the same cribs of the acidic decontamination wastes in 1967, however, "partially dissolved" the uranium compounds. This can hardly be written off as ignorance on the part of past Hanford managers. The effect of acidic solutions in mobilizing wastes such as that discharged to the cribs in 1967 was well understood by 1954.[11] As the acidic uranium solution moved downward to the caliche layer it became even less stable because some of the uranium was converting to "poorly sorbed" carbonate complexes.[12]

It was this perched "cloud" of mobile uranium, then, that the spreading plume of water discharged from the new U-16 crib intercepted. This took place some 50 feet or more above the water table. Although an April 1986 Rockwell report speculates that the contamination plume may have hit the water table through a "window" in the caliche layer, the prevailing theory among the Rockwell investigators is that the window to the water table was man-made. This was in the form of an old reverse well on the other side of the two cribs, over 300 feet from the U-16 crib. Significantly, Rockwell had no record of the well's existence.[13] The contamination plume is thought to have followed the old reverse well's fractured casing the remaining distance to groundwater.

Thus, the episode—which Heine characterized as a "very unique situation" and "a very interesting case"—involved contamination from an old crib, discharge water from a new crib, a small geologic surprise with the caliche layer, a small man-made surprise in the forgotten reverse well, a man-made, complicating chemical reaction with the acid, and a natural complicating reaction with the calcium carbonate at the caliche layer.

It is a telling insight into Hanford science that the most thorough account of this severe contamination episode appears not as an accident report, but as a report on the cleanup effort, an effort Heine confided to this reporter that Rockwell was very proud of. Heine and others at Rockwell assured the public that the uranium contamination posed no threat to the Columbia River. The cribs are seven miles from the river, and calculations provided Rockwell by Battelle estimate the plume will arrive at the river only after 200-600 years and by then diluted "well below" DOE guidelines.[14] Despite this assurance, Rockwell began pumping out contaminated groundwater and channelling it to an ion exchange column to remove the uranium, which was then put in an underground tank.[15]

A Rockwell press release explained: "DOE and Rockwell Hanford elected to reduce the uranium in the groundwater in keeping with ALARA (as low as reasonably achievable) principles, even though the uranium posed no significant environmental or health hazards."[16] The decontamination effort, Heine said, cost "about a million" dollars. When pumping concluded, the uranium contamination had been reduced to 20,000 pci/*l*, still more than 1,300 times above the EPA drinking water standard.[17]

Early Warnings

"Geology holds the key to waste disposal to the land environment. Unfortunately the desired degree of reliability of determination of the geologic parameters is not amenable to precise definition. Generally it can yet be based only upon seasoned judgment and experience. We dare not compromise radiological safety. Until the geologic parameters can be defined far more quantitatively than now, waste disposal to the ground must not become a widely used method of disposal."
—Hanford Laboratories scientist Randall E. Brown in a paper based on the Hanford waste experience, submitted for an International Atomic Energy Agency-sponsored forum on radioactive waste disposal in Monaco November 1959.[18]

What is disturbing about the U-cribs episode and the strontium-90 breakthrough at the N-Reactor crib is the particular pitfalls involved in both incidents have long been recognized by Hanford scientists and others who've reviewed Hanford waste management. The limitations of ion exchange and the effects of even subtle soil chemistry changes on the mobility of radioactive wastes were amply demonstrated both in the laboratory and by field observations at Hanford in the 1950s. The presence of "Palouse soil" and impermeable layers of caliche beneath the 200 West Area, where U-Plant is located, was also well known.[19] Each element, in itself, may not seem to be much cause for alarm. Bring three or more together and still there may be no warning. Add a fourth and suddenly you have a problem, perhaps a very big one.

Brain teaser for today: How big a problem can a problem at Hanford be?

The question that is not easily answered is: How big a problem can a problem at Hanford be? Although there have been some simplified "worst case" analyses (i.e. dumping the contents of one stabilized waste tank into the Columbia River[20]) the Department of Energy has yet to address that question forthrightly, at least in the open literature. Moreover, surprises like the U-cribs contamination episode are warnings that the ability of Hanford scientists to predict the behavior of these wastes in the environment, even in the short-term, is questionable. Yet, those wastes continue to pile up.

A reasonable place to begin, then, is to look at what is known about Hanford's present burden and prospects for the near future. The quantities of radionuclides in the soil at Hanford are extraordinary. These wastes are only the tip of the iceberg when viewed as part of the total amount of waste that is stored above the water table at Hanford. All of what is stored at Hanford now, is similarly dwarfed by what the total radioactive burden at Hanford will be when, and if, Hanford becomes a commercial high-level waste repository site.

To give a very rough picture of how this escalates, one can single out cesium-137 and strontium-90, two dangerous uranium fission products with half-lives of just under 30 years. The values are curies.

Soil[21]	Tanks[22]	Repository[23]
STRONTIUM-90		
22,600 Ci	120 Million Ci	2.65 Billion Ci

CESIUM-137

26,400 Ci 120 Million Ci 3.7 Billion Ci

Assume the bottom line for groundwater and river water for each of these radionuclides is the present EPA drinking water standard. A simple measure of the task involved in waste isolation is the amount of water necessary to dilute a single curie to the EPA limit. With strontium-90 the standard is 8 trillionths of a curie (8 picocuries) per liter.[24] Thus, to dilute a single curie of strontium-90 to the EPA standard would require 125 billion liters, or approximately 30 billion gallons. The drinking water standard for cesium-137 is 200 picocuries per liter,[25] thus diluting a curie of it to the EPA standard would require a mere billion gallons.

It is thus no wonder that scientific debates about the feasibility of storing nuclear waste are conducted in a language in which honest disagreements range over several "orders of magnitude"—powers of ten. The enormous absolute risk involved is such that even being just a bit off, relatively speaking, may ultimately spell the difference between what is "acceptable" and what is ruinous.

"The moral of Hanford," says former Rockwell waste manager Steve Stalos, "is that one-tenth of 1 percent of a whole-hell-of-a-lot amounts to something."

Stalos, whose allegations of mismanagement and coverups of Hanford waste tank surveillance deficiencies prompted an internal DOE investigation, resigned his post in 1978. Among the formal complaints he later filed with the agency was that the model and methods it had used to predict consequences from a hypothetical major waste tank leak were "not conservative."

"Even so," he wrote, "the MPC (maximum permissible concentration) for water, for one radionuclide was exceeded. Do we really know the microgeology of the Hanford Reservation so well that we can preclude a large amount of strontium or cesium from reaching groundwater?"[26] Stalos has referred to Hanford as a "time bomb."

For the record, it is important to note that the Department of Energy has updated the 1973 AEC directive ordering that "as soon as technically and economically practical," the discharge of low-level liquids to the ground should be halted. In February 1984 DOE issued a new Radioactive Waste Management order. Operations such as the Hanford cribs and trenches that involve low-level waste discharge directly to the environment "shall be replaced" by other methods, DOE directs, "unless specifically approved by Heads of Field organizations."[27] In other words, low-level liquid discharges at Hanford can now continue for as long as the Hanford manager routinely exempts the discharges from DOE policy.

The failure of the agency to fund substantial improvements in nuclear waste management over the past decade, however, has put it on a crash course with Congress and the State of Washington over landmark legislation whose intent is to head off environmental tragedies like those at Love Canal, New York and Times Beach, Missouri. U.S. Senator John Glenn recently referred to the agency's attitude as "We're going to build bombs—and the environment be damned."[28] An

example of that attitude is the agency's current battle over a law known as the Resource Conservation and Recovery Act.

{INSERT FIGURE 6}
Figure 6: Uranium contamination episode, February 1985

Chapter 7

Pick Your Poison

"We don't see a big threat from having RCRA [the federal Resource Conservation and Recovery Act] imposed on us, that this is going to shut PUREX down and prevent this 'nasty polluting machine' from working. That'll never happen. If people understand the defense minds in this country, there is nothing that stops them. They just fix what little you might have shown them is bad or broken at the time. And so the system works. If you want PUREX shut down you're going to have to go to Congress and convince them they don't want to run it. You're not going to do it environmentally. They'll just throw money at that. Want $100 million to fix it? Big deal. That's academic. That won't shut down PUREX, if they want that material [plutonium]."
—DOE Richland Director, Division of Safety and Quality Assurance Ronald E. Gerton, in an interview with the author, Nov. 18, 1985.

"The range of remedial actions that EPA (Environmental Protection Agency) or a state could require are almost beyond the imagination."
—DOE -Richland attorney Robert M. Carosino, in a memorandum concerning the Resource Conservation and Recovery Act (RCRA) to DOE Assistant General Counsel Henry K. Garson, Jan. 15, 1985.

The sprawling complex known as "Y-12" at the Department of Energy's Oak Ridge, Tenn., site is Hanford's oldest sister facility. It is where most of the uranium for the Hiroshima bomb was purified and is where, since the early 1950s, materials for American hydrogen bombs have been produced. In post-war years, the processes involved at Y-12 demanded tons of mercury. In the rush to produce this material for H-bombs, Y-12's operators flushed huge amounts of the toxic, heavy metal from the plant. Much of it, an estimated 120 *tons*, seeped into a nearby creek, contaminating an entire 20-mile stretch of the stream to where it enters Tennessee's Clinch River.[1] When information about the extent of the Y-12 mercury discharges came to light as a result of a 1982 Freedom of Information Act request, The Tennessee-based Legal Environmental Assistance Foundation (LEAF) and the Natural Resources Defense Council (NRDC) filed suit. Because Y-12's operators continued to discharge mercury and other hazardous wastes without federal and state permits, the two environmental groups argued, DOE was violating the law.

The Y-12 lawsuit was the first volley in a legal battle that has served to illustrate two things. The first is the irony that many of the plants DOE operates to supply the Pentagon with nuclear materials for state-of-the-art weapons systems are themselves so antiquated they can only operate in violation of state and federal environmental laws. The second is that despite assurances about striving to meet the letter and spirit of these laws, the agency's top lawyers and bureaucrats have

worked tenaciously to mute the laws' effects and to avoid regulation, whenever possible, by the Environmental Protection Agency and the states. The next round in this battle is already being fought at Hanford, where Washington state officials are trying to enforce upon the Energy Department the idea that it is no longer acceptable to use Hanford groundwater as a cesspool.

In the name of national security, the Atomic Energy Act allows no room for the enforcement of federal, state and local health, safety and environmental laws.

A License to Pollute

The facts in the Y-12 case are bitter testimony to the government's poor stewardship at Oak Ridge. But what was really on trial was the Department of Energy's protected operations under the Atomic Energy Act of 1954 (AEA), the law which the government invoked in its defense. In passing the AEA, Congress said that military use of the atom was "the paramount objective" of the nation's atomic energy program. But the AEA is more than that, for in the specific provisions of the law Congress went much further. It exempted nuclear weapons production plants from all federal and state licensing requirements and gave to the Atomic Energy Commission—the Department of Energy's predecessor—sole authority to regulate its own operations. In the name of national security, the Atomic Energy Act allows no room whatsoever for the enforcement of federal, state and local health, safety, and environmental laws. Thus, when confronted in the Y-12 case, the Department of Energy had a simple reply. The agency said, in a nutshell, that it could not be in violation of laws which it did not have to obey.

The issue before the judge in the Eastern District of Tennessee would have been simple, and weighed to DOE's favor, if the decision were based solely on the AEA. No matter the extent of contamination around Oak Ridge there was no case to make against DOE's operation of Y-12 under the Atomic Energy Act. Instead, the two environmental groups—they were joined as plaintiffs by the state of Tennessee—brought suit against the agency under the 1976 Resource Conservation and Recovery Act (RCRA).

Between a Bomb and a Hard Place

RCRA is part of a slate of laws passed by Congress in the 1970s to deal with the growing incidence of soil and groundwater contamination resulting from careless disposal of solid and hazardous liquid wastes. It gives to the Environmental Protection Agency *and* respective states (with EPA approval) the authority to set and enforce requirements for the safe treatment, storage and disposal of such wastes. RCRA, however, applies only to chemical, non-radioactive wastes. Had Y-12 been releasing tons of deadly plutonium to the environment instead of non-radioactive mercury, LEAF and NRDC would have had no case under RCRA. This is because RCRA specifically yields to the Atomic Energy Act—and thus to DOE's authority—where radioactive materials from government weapons plants are involved.

In the Y-12 case, the government argued RCRA was inconsistent with the AEA because, among other things, it would allow state and local agencies to have access, and regulatory authority, at DOE facilities, something the AEA prohibits. But the federal government lost this argument.

Notwithstanding the language in the 30-year-old Atomic Energy Act, federal Judge Robert Taylor ruled, Congress intended that the new law (RCRA) should apply "to the extent that (it) is not inconsistent" with DOE's authority (inherited from the Atomic Energy Commission) to self-regulate radioactive discharges.[2] Judge Taylor's ruling confronted the Department of Energy with a dilemma that threatened the pace, if not the scale, of the current nuclear weapons build-up. Simply, the agency could not operate huge and aging nuclear facilities and also comply with current environmental laws. In the opinion of former DOE waste manager William Lawless, none of the agency's nuclear weapons plants could fully comply with federal and state environmental statutes *if* those laws were allowed to be enforced. When asked during a Congressional hearing last April if Lawless's assertion was correct, J. Winston Porter, EPA assistant administrator for solid waste, concurred: "I think none would meet full requirements."

An investigation by the Congressional General Accounting Office (GAO) found that of 20 DOE facilities inspected in 1985, 14 wore found to be in violation.[3] Significantly, facilities at Hanford and the Savannah River Plant, were not among those inspected by GAO for the aforementioned report. Lawless considers Hanford and Savannah River Plant to be the worst offenders.

With facilities like Hanford s PUREX already struggling with maintenance downtime and other problems to meet production quotas clearly the last thing the agency was bargaining for was an environmental law with teeth in it and independent inspectors who would use it.

Mr. Lawrence, Meet Mr. Stanley

Prior to the Y-12 case, Hanford's managers had no reason to expect a challenge to their authority by the State of Washington. What presence the state had at Hanford was essentially limited to the Department of Social and Health Services (DSHS) Radiation Control Section which, though collecting a modest amount of water and air samples, had neither the authority nor the initiative to be an effective watchdog. This state of affairs was outlined in a June 14, 1984 memo from Terry Strong, head of the Radiation Control Section to state Division of Health director Dr. John Beare. DSHS authority at Hanford, Strong explained, was limited to monitoring at the WNP-2 reactor, operated by the Washington Public Power Supply System and at the state-licensed commercial low-level waste burial ground operated by a private company called U.S. Ecology. As for DOE facilities like PUREX, however, Strong wrote: "In the absence of an invitation from U.S. DOE to work with them, we cannot conduct a monitoring program."[4]

The basis for Strong's explanation was the state nuclear energy code. (In July 1985 the code was toughened considerably.) Originally adopted in 1961, the law was, in many ways, a timid reflection of the federal Atomic Energy Act of 1954. Among its provisions were that state radiation inspectors could enter the Hanford Reservation "only with the concurrence of the federal government."[5]

Roger Stanley, however, was not restrained by this law. Even before Judge Taylor handed down his ruling in the Y-12 case, Stanley had greeted DOE-Richland officials with the disturbing news that *his* employers in state government did regard Hanford as part of Washington state.

Stanley is a veteran supervisor in the industrial section of Washington's Department of Ecology.

Because the ecology department is charged with policing the disposal of hazardous, *non*-radioactive wastes it has statutory authority under Washington law that DSHS's Radiation Control Section does not. In 1982 the state adopted hazardous waste regulations closely resembling RCRA and in 1983—months before Judge Taylor's decision—Stanley and the Ecology department began to try to look at Hanford.

The DOE-Richland office had taken a first step, albeit a very small one, toward RCRA compliance even before the Y-12 ruling by filing a waste permit application with EPA in November 1980. This was surprising, because it was still the position of DOE Headquarters that RCRA did *not* apply to its facilities. In other words, the Richland office had broken ranks with headquarters. Citing EPA documents obtained under the Freedom of Information Act, the Portland Oregonian reported that in 1982, Robert Carosino, the attorney for DOE's Richland field office tried to withdraw the application, explaining to EPA that officials at the DOE-Richland office had disobeyed headquarters when they submitted the application because "they felt they should."[6]

Still, it was not as though the rebel bureaucrats at Richland had given away the store. The 1980 permit application listed only a single waste disposal site and, as the Oregonian reported, DOE officials moved quickly to correct any notion that DOE would actually allow RCRA or the state's hazardous waste laws to be enforced at Hanford. State inspectors were still barred from the reservation and information exchanges with the state were regarded by DOE as mere courtesies.[7] Then came the showdown in Tennessee.

"Application of the RCRA rules could involve very large expenditures to alter existing facilities..."

In the weeks following Judge Taylor's ruling, the State of Washington issued an order requiring DOE to comply with the state's dangerous waste regulations and filed a notice of intent to bring suit if the agency continued to prohibit formal site access to state inspectors. On the second point, DOE finally acquiesced. Stanley was escorted onto the Hanford site in June 1984, and in a short inspection identified twenty specific violations of state law including failure to notify the state of hazardous waste activities, use of unpermitted facilities and failure to install required groundwater monitoring systems.[8]

The dilemma for DOE was obvious. "Application of the RCRA rules could involve very large expenditures to alter existing facilities, time to obtain money and construct facilities and would subject existing radioactive waste disposal facilities to RCRA rules even though DOE under its AEA authority has determined those waste management practices are acceptable," wrote DOE-Richland attorney Carosino in early 1985. "The range of remedial actions that EPA or a state could require are almost beyond the imagination."[9]

In the midst of one of the largest nuclear weapons construction campaigns in U.S. history, how was DOE to deal with public officials outside the nuclear weapons bureaucracy? The answer was simple. If it could not obey the law, the agency would simply rewrite it.

The Nuclear Midas Touch

There was no disputing that Judge Taylor's ruling had gotten EPA and the states in the door at DOE weapons plants. In his Y-12 decision the Judge wrote: "The Court concludes that the most reasonable reconciliation of the RCRA and the AEA is that AEA facilities are subject to the CRA except as to those wastes which are expressly regulated by the AEA: *nuclear and radioactive materials*." (emphasis added)[10]

As noted earlier, however, the waste systems at many DOE weapons plants—including nearly all at Hanford—were designed to dispose of hazardous chemicals and radioactive wastes as mixtures in the *same* waste streams. This raised the spectre of regulation by EPA and the respective states, something DOE clearly seeks to avoid.

DOE's decision not to appeal Judge Taylor's decision, a top agency official told the McGraw-Hill Newsletter Inside Energy, was based on the recognition by the agency that Taylor was "probably as favorably disposed" to DOE's position as any federal judge.[11] The DOE legal staff had a remarkable solution for this dilemma. The Court had ruled there must be a compromise between the Atomic Energy Act and RCRA. So, DOE would—with EPA acquiescence—take the lead in constructing that compromise.[12] To clarify the situation, DOE then proposed new federal rulemaking, not under RCRA, but under the Atomic Energy Act.

Again, RCRA is about hazardous chemicals. Congress was clear in saying that RCRA does not apply to "Source, Special Nuclear, or Byproduct Materials" as defined in the Atomic Energy Act. In other words, RCRA may not be interpreted to allow EPA and state regulation of the radioactive wastes, including uranium, plutonium, and fission products, that result from nuclear weapons production.

But what happens, as at Hanford's PUREX plant, when strontium-90 and other "byproduct" radionuclides are in solution with non-radioactive, hazardous chemicals? This is where the agency's new rulemaking came into play. And the answer, by DOE's rules, was simple: the *entire* waste stream "even those (materials) that would otherwise qualify as hazardous under RCRA" would be classified as "byproduct material" and thus wholly exempt from state and EPA regulation.[13]

Translation: DOE was proposing something akin to a jurisdictional Midas touch. So long as a waste stream was contaminated, however slightly, with radionuclides resulting from nuclear weapons production, DOE could assert absolute jurisdiction under the Atomic Energy Act and prohibit EPA and state regulation.

Now you see it...Now you don't

An indication of the depth of negative reaction to DOE's proposal is that even its sister agency, the Nuclear Regulatory Commission (NRC) said it had "serious reservations" and strongly questioned its legality.[14] The state Department of Ecology was more outspoken, calling the proposal "environmentally unsound," and "arbitrary." If the proposed rules went into effect, the Natural Resources Defense Council protested, "DOE is led with absolute discretion to determine

which of its wastes will be regulated by RCRA."

This point was borne out in a matter of days at Hanford. Those seeking to comment on DOE's proposed rules were quite naturally interested in how the "byproduct rule" would apply to specific facilities. They were referred to a color-coded manual which displayed each facility's waste streams and how these streams would be regulated under the new guidelines.[15]

In classifying the waste streams at the Hanford site, said Ron Gerton, the top environmental and safety officer for DOE's Richland office, "what became very obvious to us is that anything we dumped in the ground is a damn good candidate to have state and EPA overview because that ought to bother them."[16]

Indeed, the document Gerton provided seemed to represent what would have been half a welcome mat to EPA and the state. It identified 66 Hanford waste streams. Thirty-seven of the streams were categorized as "candidate mixed waste streams." This was the term chosen for wastes that could potentially carry both radioactive and hazardous chemical wastes but since the radioactive materials in them were considered by DOE to be an "indirect" rather than "direct" consequence of making bombs, these would be candidates for EPA and state regulation under RCRA. The remaining 29 streams, because they were deemed to contain "byproduct" waste, or plutonium itself, were to remain off limits.

As Gerton himself acknowledged, of most concern to Stanley and the state ecology department were those liquid waste streams that discharge directly to the environment. There are 24 such streams, and they represent the nitty-gritty of the RCRA issue at Hanford. DOE had identified 6 of the 24 as "byproduct streams," off-limits to state regulation under DOE's proposed rules. Yet, these six streams, by DOE's own account, carry roughly 8 times the volume of wastes as the remaining 18. (Curiously, the waste stream volumes reported by DOE were for 1982, the year *before* PUREX restarted.)

A month after DOE made public its proposed rules, Gerton notified the author by mail of the following development: "On the basis of engineering studies, process flow sheets, process flow computer modeling, analyses of chemical usage, and a review of existing waste characterization data, all candidate [mixed waste] effluent streams going to cribs, ponds and ditches, have been classified as non-RCRA."[17]

In other words, DOE had used its arcane rulemaking—ostensibly to *comply* with RCRA—to put a new lock on the Hanford gate. Of the 24 liquid waste streams that discharge directly to the ground at Hanford—none were to be regulated by EPA and the State of Washington.

The Backlash

The agency's contorted "compromise" further aggravated what was already a credibility crisis. Not only does Washington's ecology department have similarly impatient counterparts in other states with DOE weapons facilities, but members of DOE's Congressional oversight committees were becoming increasingly critical and outspoken about what they regard as the agency's inability to demonstrate it can effectively regulate itself. What now added to the hemorrhaging

of DOE credibility was the Department's own inflated rhetoric and timing.

Shortly after replacing his predecessor Donald Hodel, Energy Secretary John Herrington commissioned Deputy Associate Secretary James S. Kane to review the effectiveness of DOE's Office of Environment, Safety and Health (ES&H). ES&H is the agency's in-house environmental policeman and, because of the Atomic Energy Act's exclusion of outside oversight, the public's sole guardian when it comes to nuclear weapons production operations. Kane's findings were devastating:

"The current state of ES&H is a disgrace," he reported back to Herrington. "It is widely perceived as having 'no clout', and of being ignored by senior management unless a crisis develops. Morale is low, and as successive reports recommending action are followed by no action, it sinks further. It is not an office that would be attractive to aggressive young people on the way up. In spite of dedicated efforts by many of its staff, it has become a toothless watchdog guarding the safety and environmental integrity of one of the potentially most hazardous undertakings in the world."[18]

Thus, scathing criticism from inside the agency was an echo of that coming from outside DOE. Herrington's answer came in January of this year in the form of a new DOE environmental policy statement that committed DOE to conduct its operations "in compliance with the letter and spirit of applicable environmental statutes, regulations and standards," and promoted the head of the ES&H office to the position of assistant secretary.[19] This position had been filled in September 1985 by Mary L. Walker, a former Justice Department attorney who, though recruited by the Reagan Administration in 1982, had only been with DOE since June 1985.

Walker's job was to begin to salvage public and Congressional confidence in DOE's much-maligned self-regulating scheme. The RCRA controversy and, specifically, DOE's proposed "byproduct rule" became the instant litmus test.

Internal DOE memoranda obtained through the House Subcommittee on Energy Conservation and Power, reveal that Walker and her staff were shaken by the overwhelming negative response to the "byproduct rule." They wanted to modify it, but Walker did not have the power to veto it. While the Secretary had elevated the status of her office, he had not given her the right to overrule the Secretary, let alone the other top DOE bureau heads. In other words, the "toothless watchdog" had a new bark, but not a new bite.

Walker laid out her case in a March 27, 1986 memo to J. Michael Farrell, DOE's General Counsel. Her purpose, she wrote, was "to initiate a thorough policy review of the current status and future direction" of DOE's proposed rules to assure that they and "all related actions by the Department are consistent with the Secretary's Environmental Policy Statement of January 8, 1986."

Her reasoning was straightforward. Reviewers of the proposed rules had so roundly criticized the Department's approach that even "Congressional supporters" of the agency had "strongly encouraged the Department to fix the problem...'or somebody else is going to do it for you.'"[20]

The response from Farrell and his staff was that, if anything, DOE's proposed rules were *too* lenient an interpretation of the Atomic Energy Act. Had DOE taken a "mechanical and literalist approach," he wrote, the agency "could conclude in effect that any waste whatsoever stemming from processes involving production or utilization of [bomb material] constitutes exempt byproduct material." This approach, however, "did not seem to be the choice closest to both 'the letter and spirit of RCRA.'

"Instead, the memo continued, "the policy choice reflected in the proposed rule is intended to afford the broadest RCRA jurisdiction over waste streams at our facilities that the statute [the Atomic Energy Act] *and underlying engineering reality will sustain*."[21] (emphasis added)

This, of course, was exactly what one Department's critics were alleging had happened. Rather than appeal the Y-12 decision, DOE's lawyers had gone back to the Atomic Energy Act to construct rules to ensure that the "underlying engineering reality," the archaic dumping practices, would remain off-limits to EPA and the states. As to Walker's reasons for wanting to put the brakes on now, Farrell replied, "none of them persuades me that the Department should refrain from proceeding to adopt a final rule."[22] Another example of the resistance Walker's office was encountering is contained in a March 21, 1986 memo from Henry K. Garson, DOE's Assistant General Counsel for Environment to John R. Barker, director of DOE s Office of Environmental Audit and Compliance. At this time Barker was apparently trying to advance a more conciliatory DOE position by acknowledging a state's right to regulate "mixed waste" streams. He presented the proposal as "an attempt to implement the new direction in this area that Mary Walker has been eluding [sic] to in her press conferences."[23]

Garson's reply was that Barker's trial balloon "continues to reflect an incomplete understanding of the legal and policy issues associated with the mixed waste question" and "would represent a significant departure from current DOE policy."[24] Specifically, Garson wrote, DOE had to avoid any suggestion that it acknowledged the rights of states to regulate mixed wastes at DOE weapons plants. Garson then reiterated that DOE policy was to work with states "so long as DOE does nothing to suggest acquiescence to state jurisdiction over mixed waste."[25] This bureaucratic foot-dragging is reported here to illustrate that the spirit of Herrington's "new" environmental policy is hardly infectious within DOE. Reality had preceded the rhetoric: the operation of DOE's aging bomb plants and compliance with RCRA were irreconcilable. This had been the message from DOE field officers to DOE legal officers at work trying to pick up the pieces after the Y-12 verdict.[26]

The legal office then went back to the Atomic Energy Act to draft rules that would allow DOE to effectively dictate what could and could not be looked at by EPA and the states at the bomb plants. This became a new policy which, when all was said and done, was not much different from the old policy Judge Taylor had struck down.

Walker, at least according to her March 27th memo, was nervous about the clamor of protest over the policy she had inherited, which came right on the heels of the fanfare associated with Herrington's environmental policy statement and her own promotion to assistant secretary. But neither she nor any other DOE officials were prepared to repudiate the policy nor publicly propose a different one. The message this sent to the growing ranks of DOE critics was that,

despite all the hoopla, the agency was still much more interested in protecting its powers under the Atomic Energy Act than in protecting the environment. In the Senate, Sen. John Glenn of Ohio—where uranium recovery operations at DOE's Fernald plant near Cincinnati have contaminated air and groundwater—proposed legislation that would give complete jurisdiction over mixed wastes to EPA.
The same bill had been introduced by Rep. Tom Luken of the Ohio delegation to the House of Representatives. Rep. Ron Wyden of Oregon was a co-sponsor with Luken of the above bill and had also proposed yet another bill that would require EPA to set standards for radioactive as well as non-radioactive emissions from DOE weapons plants.

Wyden was particularly outspoken about waste dumping practices at Hanford. "While the Nuclear Regulatory Commission forbids the commercial nuclear industry from using such disposal practices," Wyden complained, "the DOE at Hanford is not only failing to deal with this dangerous legacy head on, it is, incredibly, spending more public funds to continue the dumping of these deadly liquids into the soils of Washington state."[27]

As Walker sought to review DOE policy with regard to RCRA, the House Subcommittee on Energy Conservation and Power scheduled hearings on the Luken and Wyden bills. In addition to seeking testimony from Walker and Admiral Sylvester Foley, the DOE Assistant Secretary for Defense Programs, the subcommittee invited a panel of DOE critics including Bill Lawless, Roger Stanley, Lisa Crawford (whose family's drinking water well was contaminated with uranium from DOE's Fernald, Ohio plant), Virginia Aveni, deputy director of the Ohio Environmental Protection Agency, and the author, who represented HEAL.

Part of the purpose of the hearing was to have the Department answer its critics on DOE dumping practices. This did not happen, however. When time came for testimony from the panel of critics, Walker and Foley, over repeated objections from the subcommittee, led a walkout of more than 50 top DOE officials, including Hanford manage Mike Lawrence, from the hearing room. This episode, while it visibly angered Wyden, probably did not hurt the changes of his and Luken's bills which, because they threaten the Atomic Energy Act and its understandably broad legions of constituents, already have an uphill climb ahead of them.

As much as Congressional critics are zeroing in on DOE waste practices, perhaps the greater threat to the agency are state hazardous waste programs. This is because Judge Taylor's ruling, by upholding RCRA, let both EPA and the states in the door at DOE weapons plants.

The agency's response to this, as Walker made clear in her testimony, was to adopt a policy where it would only recognize state regulation of mixed wastes where state inspection had specifically been certified by EPA. At the same time, DOE has tried to persuade EPA to restrain state agencies, like Washington's Department of Ecology, that in many instances are the lead enforcement agencies for both state *and* federal environmental laws.

"The major issues are related to state programs," wrote John Lehman, EPA's director of waste management and economics in a July 1985 memo about DOE and EPA negotiations after the Y-12 decision. "Where DOE requests a variance from RCRA rules for radiological reasons, DOE wants EPA to make the decision [not the states]. DOE also wants to block the States from

having more stringent State rules than EPA determines are necessary at the Federal level."[28]

In this way, RCRA and the Y-12 decision have become an acid test for EPA as well. Will the agency side with its more power federal brethren or the state agencies it works with most often and closest with?

Wayne Pierre of EPA's Region X office in Seattle often accompanies Washington's Roger Stanley on Hanford inspection tours. These inspections resulted, last February, in a finding of five hazardous waste violations at Hanford and a joint order from EPA and the state ecology department demanding compliance. The State of Washington also levied a $49,000 fine. DOE appealed the fine to the state Pollution Control Hearing Board while, according to Washington state Assistant Attorney General Kathleen Mix, representatives from the state, EPA and DOE began negotiations.

"We were working it out," Mix says, "then lo and behold, Energy called one day near the end of the negotiations to say they could not concede that EPA could order them to do anything."

Pierre confirms this. In the months since the joint order, he said, EPA Region X had made considerable progress working with DOE field teams at the Idaho National Engineering Laboratory and Hanford. They were "with a few specific exceptions" near agreement, Pierre said, when, in July, the DOE Office of General Counsel pulled the rug out.

"The reason I sound cynical," Pierre said, "is that we overcame almost all those [technical] issues. It came down to them saying, constitutionally, they would not be subject to EPA." The issue, he says, has now "gotten very convoluted" and passed on to review by the Justice Department while EPA's enforcement effort at Hanford is, consequently, "on ice." The Department of Energy did sign an agreement with the state on October 1, 1986 to comply with the state order of last February. It has not, as yet, agreed to pay the $49,000 fine which the state is continuing to try to collect.

What is telling about the resistance to this first EPA/Washington state test run at bringing Hanford operations into compliance with RCRA and state hazardous waste laws is that the February 5th order involved *none* of the active "mixed" and "byproduct" streams at Hanford that are culpable for the continuing widescale contamination of Hanford groundwater.

"Those are next," says state attorney Mix. "We are still trying to get their [EPA's] blessing, but we're also taking to position we can go ahead. Somebody's got to clean them up."

Observes Bob Alvarez, a veteran watchdog of DOE weapons plants for the Washington, D.C. Environmental Policy Institute: "I think DOE despises state regulators more than they hate the Russians."

Chapter 8

Garbage in,

Garbage Out

The Case of the Missing Water, Revisited

By the winter of 1985 Norm Buske and Linda Josephson's research had led them to the first of several disagreements with Hanford scientists about the nature of Hanford groundwater flow to the Columbia River.

As reported earlier, Buske and Josephson concluded from their surveillance of the Hanford Reach in the summer and fall of 1985, that there was nowhere close to being a "balance" between the 100 cfs estimate Battelle cited in 1983 and the relatively sparse *observable* flow from Hanford's shoreline springs. They surmised from this that the preponderance of the estimate 100 cfs flow was entering the river beneath the surface of the water via submarine springs. They offered, in support of this hypothesis, the springs they had located and photographed on the Columbia river bottom.

This discovery was a first. After four decades of official scientific investigation of the Hanford environment there was no previous attempt to locate and study underwater springs in the Columbia through which groundwater discharges into the river.

It was their position that the need to investigate these springs is self-evident: *if* Hanford contamination poses an increasing threat to water quality in the Columbia, the springs at the river may offer an early warning of that problem. Buske and Josephson reasoned that if the springs could be located and sampled, analysis of the water might provide important information about its source and path to the river.

The research the Department of Energy has been funding at Hanford relies heavily on test wells that tap Hanford aquifers in order to gather such information. The merits of using wells for such research are indisputable. What Buske and Josephson were arguing is that the Columbia springs can provide a different and potentially valuable perspective.

The conflict with Hanford science arose from Buske's proposal that the Department of Energy fund further studies of groundwater flow into the Columbia River. To support this proposal he'd referenced Battelle's 100 cfs estimate in making the following argument: 1) groundwater flow into the Columbia along the Hanford reach is substantial but, 2) the springs that are visible and which Battelle had identified could not even account for most of the reported flow, therefore 3) the bulk of the flow was underwater and a program to locate and characterize underwater springs is overdue.

Beginning with its 1984 reports, however, Battelle chose to address groundwater flow into the river only along a four-mile stretch of the Hanford reach just downstream of the old Hanford townsite.[1] This stretch is indeed of interest because Battelle's groundwater monitoring system shows it to be the area where the highest concentration of contaminants in the "plume" originating at PUREX discharges into the river.

Citing a computer model of the Hanford unconfined aquifer called the "Variable Thickness

Transient" (VTT), Battelle reported that groundwater flow into the river along this four-mile stretch was an estimated 3 cfs. The net result was that 97 cfs of water had vanished, at least on paper. This left Buske in the sudden and seemingly ridiculous position of asking DOE to allot tax dollars to look for water that no longer officially existed. The rug had been pulled from beneath his argument; it effectively killed his proposal. It also gave him something to do over the winter.

Algebra 1

The evidence for questioning the accuracy of Battelle's computer-generated number came from PUREX. Using portable field equipment, Buske and Josephson were able to measure concentrations of non-radioactive nitrate (the most common chemical pollutant discharged from PUREX) in river water upstream and downstream of where they had marked the underwater springs.

Using practical algebra, they designed their own problem analysis. They knew what the approximate flow of the river past the springs was and what the approximate concentration of nitrate was in groundwater entering the river. By looking at the upstream/downstream difference in nitrate concentration they then could attempt to deduce the volume of flow entering the river in the area of the spring. Again, it was a rough calculation. Buske estimated there were about 10 cubic feet per second of groundwater entering the river in the immediate area of the marked underwater spring. While the estimate could be consonant with Battelle's previous 100 cfs estimate for the entire Hanford reach, it clearly did *not* square with the new 3 cfs number meant to represent just the four-mile stretch of shore southeast of the Hanford townsite.

Buske thought he and Josephson had found a flow of about 10 cfs within a stretch that Battelle was now estimating a mere 3 cfs. This was the first discrepancy.

{INSERT FIGURE 7}

Algebra 2

To this point, at least, the joint sampling pact initiated by Greenpeace and agreed to by Hanford manager Mike Lawrence had worked out rather well for the Department of Energy. When Buske and Josephson—representing Greenpeace—and representatives from the two states, Battelle, and DOE met on October 17th, 1985, there was good agreement among the laboratory results. Moreover, the representatives from the states of Oregon and Washington came away not only convinced of no immediate public health threat but publicly confirming DOE's contention that the Columbia was a much "cleaner" river today than it was during Hanford's heyday, when eight reactors discharged primary cooling water directly back to the river.[2] This did not deter Buske and Josephson's interest in further study. A reactor can be turned off tomorrow. Contaminated groundwater seeping or flowing into the river cannot be.

Within days of the meeting, Buske set forth what he regards as one of the strongest arguments against Battelle's estimate. He argued that Battelle shouldn't be measuring substantially more contamination in the Columbia than it says Hanford operations are putting into the river. And

yet it is.[3] This inconsistency, he says, is the first piece of evidence suggesting the existence of a groundwater channel flowing from PUREX, or thereabouts, to the Columbia River.

The evidence for this comes from tritium measurements in Columbia River water. Tritium—the radioactive isotope of hydrogen—is the most prevalent radioactive contaminant in Hanford groundwater. Buske's argument was that Battelle's new 3 cfs estimate of groundwater flow into the river near the Hanford townsite was simply unreasonable given the concentrations of tritium Battelle was measuring with its river water sampler at the Richland drinking water intake just downstream of the reservation.

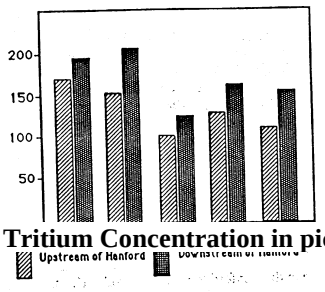
Battelle's explanation: "The calculated concentration of tritium front 100 N [N-Reactor] releases was much less than the monitored downstream concentration, *indicating tritium was being added to the river by groundwater seepage.*"[4] (emphasis added)

But where? Battelle, in the same report, identified the main source of tritium as the "plume" of contaminated groundwater migrating from the Hanford 200 East Area, where PUREX is located. It even pointed to the path of the plume by reporting that "(t)he movement of the tritium plume has reached the river adjacent to the Hanford townsite..."[5]

Further, Battelle reported that "except for some small zones around the 100 [reactor] Areas *groundwater from the Hanford Townsite area represented the highest probable tritium concentration entering the Columbia River.*"[6] (emphasis added)

So far so good. To this point Buske and Battelle were essentially in agreement: the monitoring results clearly indicated a source of tritium other than N-Reactor; the source implicated was the tritium plume emanating from the Hanford 200 East Area and entering the Columbia River along the four mile stretch of river near the old Hanford townsite. The catch was: with Battelle discarding its 100 cfs estimate in favor of the new 3 cfs estimate along this stretch, the math no longer made any sense.

Figure 8: Upstream—Downstream Measurements of Tritium in Columbia River Water. (Source PNL-5817, Environmenta1 Monitoring at Hanford for 1985, p. 111.23



Using Battelle's 1984 data, the measured increase in tritium concentration (multiplied by the annual flow of the Columbia past Hanford) comes to about 4,000 curies of tritium added to the river by Hanford operations. Battelle reported that N-Reactor discharges could account for 140 curies. Battelle then calculated that the main branch of the tritium plume was adding a mere *450 curies* of tritium per year to the river—still not much of a dent in the total upstream/downstream

difference of 4,000 curies.[7] Again, the pieces did not fit.

The Tritium Surplus

Within a week of the October 1985 meeting Buske offered Battelle the following, straightforward analysis: either the contractor's published 3 cfs estimate of flow from the main branch of the tritium plume into the Columbia was off by about 8 times *or* his and Josephson's preliminary flow estimates in that area were wrong "and there is a 3,400 Ci/year unidentified source of tritium into the Hanford Reach."[8]

By press time (November 1986) Battelle had not yet replied in writing to these points in Buske's October 21, 1985 letter. On December 23, 1985, the author put the question both to Don Elle, Chief of Radiological Safely Branch at DOE-Richland, and to Paul Eddy, head of the Hanford groundwater monitoring program at Battelle.

Elle began by saying the model which had generated the 3 cfs number "has been used here historically" and that "we believe it is pretty good." As for the upstream/downstream difference in tritium, Elle said: "My understanding is that the other 35 [picocuries per liter] is a contribution from other 100 [reactor] areas, including some from N-Reactor as well as the error terms of the upstream/downstream measurements."

When asked specifically about Buske's interpretation, Elle said, "I don't have a clear answer. I can't say that Norm is wrong, or that we're wrong." To which he added, "I do believe that when Norm gets the [additional] information he may come up with a different conclusion. There is information he didn't have access to." Elle, however, conceded that he was unable to describe, exactly, what that information was. "PNL [Battelle]," he explained, "is the technical staff."

"The reason I did that is that it matched to the model."

Eddy was able to be more helpful. Asked why Battelle, in a report of which he was the principal author, had gone from using the 100 cfs to the 3 cfs estimate in the Hanford townsite, he said, "The reason I did that is that it matched to the model."

Eddy, however, acknowledged that the change to conform with Battelle's computer model had thrown his program out of balance with the measured upstream/downstream difference. Simply, the meager flow generated by the computer model for the area of the Hanford townsite had created a problem for Eddy, who was then left to try to explain where the remainder of the tritium might be coming from. But he could not.

Because of this, he said, he would now have cause to look more closely at the 100-B reactor area and 100-N reactor area. This, however, implied a very large source of previously undetected tritium, rather unlikely because UNC Nuclear Industries was directly monitoring discharges in the 100-N Area. Eddy's program had, for the past two years, sampled and found only moderate tritium concentrations in several wells in the 100-B Area where past activities involving tritium discharges had taken place.

Finally, Eddy conceded: "I don't like the 3 cfs going out there either. If I can't account for it in other sources then I'm forced to go back and say it [the extra tritium] is coming out of there [Hanford Townsite.]"

In other words, Eddy, who is responsible for Battelle's groundwater surveillance program but not responsible for Battelle's groundwater models, was not able to balance his observations in the field with what Battelle's model was saying. Although the debate between Buske, Josephson and Hanford has traveled on to public forums, neither DOE nor Battelle has yet offered competing evidence to explain where the additional 3,400 curies per year of tritium is coming from. Moreover, as the following chart from Battelle's most recent environmental monitoring report shows, the measured upstream/downstream difference in the tritium concentration of Columbia River water has been consistently elevated between 25 and 60 picocuries per liter (2,400 to 4,800 curies) over the past five years, with the difference the last two years being 40 pci/*l* (3,850 Ci).[9]

What this means, in a nutshell, is that Battelle does not have the field observations to corroborate its computer model. In Buske's mind it was actually worse than that: Battelle's field measurements were contradicting its computer model. With characteristic pluck, Buske asked the scientists at Battelle to send him information about the VTT groundwater model, so that he could find, and show them, their mistakes.

The Channel Theory

It wasn't until the first of this year (1986), Buske says, that the idea of a groundwater channel linking Cold Creek bar and the Columbia River near the old Hanford townsite occurred to him. What prompted the idea was a third piece of evidence from Battelle's own published field data. He'd had the information for a year and had gone back to reexamine it.

Between the fall of 1982 and 1983, a five person team from Battelle had, for the first time, surveyed and taken samples from shoreline springs along the Hanford Reach. One of the areas they looked most closely at was a six-mile stretch of shore near the old Hanford townsite where the contamination "plume" from PUREX reaches the river. What the Battelle team found—but curiously chose not to comment on—was that tritium concentrations in springs along this stretch of shore are anything but uniform.

Data from Battelle's groundwater monitoring well system suggests that contaminated groundwater is traveling in a several-mile-wide plume to the river, then narrowing to a four-to-six mile neck and, presumably, seeping into the river. Yet what the Battelle surveyors documented was that extremely high concentrations of tritium are found in three springs within one mile of each other, with concentrations 20 times *lower* found in springs along the remainder of the stretch.[10]

Bustle says he'd looked at the numbers in the Battelle report before. But now, several months later, they gave him his concept: a groundwater channel about 7,000 feet across was entering the river some 28 miles downstream from Vernita Bridge.

This was an important point. Up to this juncture Buske and Josephson had been arguing their case based upon their own observations and Battelle's observations *at* the river. The feature Buske and Josephson were describing was not to be found in the hydrology data Battelle was feeding into its VTT model. In other words, information Battelle did not put into its model could not be considered.
The immediate problem for Buske and Josephson was that by now it was the middle of winter, not a good time for doing the field work needed to confirm their preliminary finding. In the meantime, Buske went to work on the three-volume text to the VTT computer model which the Battelle Earth Sciences Department had sent to him. Given the tritium concentrations in groundwater near the old Hanford townsite, Buske had calculated that an inflow of 28 cubic feet per second (cfs), where Battelle was estimating 3, would basically explain the upstream-downstream difference in Columbia River tritium concentrations. He says he even thought the error might be as simple as a misplaced decimal point, someone punching "3" instead of "30."

Somewhat to his surprise he quickly concluded that the structure of the model was basically sound. It looked to him very much as though the model was capable of rendering a fair picture of reality. Within 72 hours of receiving it, he'd used the model to calculate a 15 cfs inflow near the old Hanford townsite.

He had, however, erred. After consulting with a member of Battelle's technical staff, he corrected his math (he'd neglected to include a factor in his equations) and became convinced that, given the data and other factors entered into the VTT model, it did indeed render 3 cfs along the stretch near the old Hanford townsite.

Still, Buske could not accept this result. If the model was indeed delivering a mere 3 cubic feet per second near the Hanford townsite then, in his opinion, there really was a problem within the model. He would look harder for it.

"Getting into the model in more detail," he wrote in a January 16, 1986, letter, "I noticed that the hydraulic conductivities are critically important. Thus, the method of their calculation is worth a look. That is a routine in the model, which was not provided with my info (from Battelle)."

What Buske was missing was a part of the model which dealt with differences in how readily soils of the Hanford site allow groundwater to pass through them. The reason this is crucial is that differences in conductivity (the rate at which soil will allow water to pass through it) along a horizontal groundwater flow path at Hanford can easily vary by 100 fold, or more. This, of course, is precisely what Hanford scientist Randall Brown was alerting Hanford managers to with his 1960 report about erosional channels in the Ringold Formation, and what U.S.G.S. investigators had noted, in a more general way, in 1972. It is worth noting, too, that at the time he postulated his channel theory, Buske was unaware of either paper.

The Hands in the Machine

The part of the puzzle Buske saw he was missing was the so-called "Transmissivity Iterative Routine" or TIR. The TIR was devised to allow Hanford hydrologists to incorporate the above-described differences in conductivities into the VTT model so that a continuous scheme

can then represent how groundwater will behave along all flow paths at Hanford. As Buske underscored in his January 16th letter, how these differences were accounted for was everything, because the end result is what a Hanford hydrologist would use to explain Hanford's groundwater movement to the rest of the world.

Particularly interesting to Buske was whether or not the TIR could, in theory, account for a groundwater channel such as he was describing. Equally important, how easily could such a channel escape the attention of the model builders, or simply be left out on purpose? What Buske found was that the TIR, like the VTT, was sound in principle, but in practice demanded especially attentive and scrupulous model builders. Otherwise, it could yield a distorted—perhaps wildly distorted—picture of reality.

The Hanford scientists who authored a written description of the TIR immediately acknowledged the problem: 1) Hanford's unconfined aquifer is "extremely heterogeneous" and, 2) The "classical approach" to thoroughly documenting such differences in an aquifer as complex as Hanford's poses high costs and very difficult technical problems.[11]

A Hanford hydrologist has ample freedom to insert information into the model without actually having the field data to corroborate it.

The solution to this, the authors concede, is a number of compromises with the "classical approach."

"The method, as used in the application to the Hanford unconfined aquifer," they write, "is *very subjective* and allows the hydrologist to use his knowledge on the hydrology of the aquifer in determining the hydraulic conductivity distribution."[12] (emphasis added)

In other words, a Hanford hydrologist has ample freedom to insert information into the TIR without actually having the field data to corroborate it. In Buske's opinion it is worse than this. The text to the TIR, he asserts, indicates that Hanford scientists could not get the model to run well using typical values for "storage coefficient" at 20 percent. (Storage coefficient is a measure of how water permeates rock; generally, the higher the percentage, the more mobile the groundwater. These values are an important part of the equation to determine how fast groundwater moves. They can be measured using test wells. The test results, though, may only be valid for a small area of the aquifer being studied.) Plugging 20 percent into the model led to calculations along certain flow paths (known as streamtubes) where the computer registered "negative transmissivities"—water running uphill! Consequently the storage coefficient was reduced to 10 percent. This, Buske says, got rid of the negative transmissivities, but did not necessarily result in a truer picture of reality.

In 1973, Dr. Raul Deju, then a consulting hydrologist contracted by the Atlantic Richfield Hanford Company, conducted a review of the Hanford hydrologic program. In his report, Deju noted several problem areas with the TIR, among them:

- a 50 percent error in storage coefficient leads to a 100% error in hydraulic conductivity at the end of a streamtube calculation;

- the value of the storage coefficient was set *somewhat arbitrarily* at .1 [10 percent] to reduce the occurrence of negative transmissivities;

- a comprehensive error analysis of model input and output was not conducted; and

- *because of the high sensitivity of travel times to accurate effective porosity data, results may be largely in error*.[13] (emphasis added)

Thirteen years later, Buske is making much the same criticisms. His look at the VTT tells him that the Hanford hydrologic models are capable of showing a groundwater channel. However, much depends on the investigative skills of the hydrologists who gather field data and feed it into the computer. If the data that might show a channel have not been gathered and entered into the machine, or if the "knowledge on the hydrology of the aquifer" that can be substituted for field data in the VTT does not include knowledge of a channel, the model will not show the channel. It's that simple.

Battelle insists that the groundwater model at Hanford is constantly being improved and refined. Prior to a meeting with Buske and Josephson at Hanford in January 1986, two staff members of Battelle's hydrology section agreed to recalculate groundwater flow to the Columbia River near the Hanford townsite. They based their calculations not on the VTT model, but on two hydraulic conductivity measurements taken in July 1978 at a well only a mile from the river and less than a quarter mile from where Buske projected his channel passes on the way to the Columbia River. Depending on which measurement they used in their equations, the resulting calculations were 11.9 cubic feet per second or 21.4 cubic feet per second-*four to seven times higher* than what Battelle, citing the VTT model, had estimated for the same stretch in its 1985 environmental reports.[14]

Seven weeks later, Battelle provided more estimates in a letter from Walt Haerer, the Manager of Hanford Environmental and Occupational Health Programs for the contractor. Using the model, he wrote, the estimated discharge from the unconfined aquifer into the river along the entire Hanford Reach was 43 cubic feet per second. "Hand calculation" methods, however, resulted in a high estimate of 72 cubic feet per second and a low estimate of 49 cubic feet per second.

"The discharge to the river, estimated with the Hanford groundwater flow model, is outside the range predicted by hand calculation," Haerer conceded. But, he added, "Regarding the correct method for determining groundwater discharge to the river, with the Hanford groundwater model or by hand calculation, *both supply only estimates and at best can only be used to bound the possible range of groundwater discharge*."[15] (emphasis added)

This is not exactly a rousing defense of the VTT model. Up to this point Buske was using an array of technical arguments to show how the model could fail to account for a groundwater channel, about a mile wide or less, that could be bringing a much greater flow of tritium and nitrate contaminated groundwater to the river than Battelle was estimating. But now the

argument was to be reversed. Battelle was through trying to defend its model. It would now ask Buske and Josephson to defend their theory.

"We feel that the evidence you have called to our attention does not indicate the presence of a high-conductivity channel from the 200-East Area to the Columbia River," Haerer wrote. "While each individual piece of information...may suggest the presence of high hydraulic conductivity sediments [Pasco gravels] below the water table on portions of the Hanford site, the data considered together do not support a continuous channel from the 200-East Area to the Columbia River."[16]

Rivermile 28

Up to this point, Buske and Josephson had been handicapped in that they could only base their arguments on data collected by Battelle and other Hanford contractors. The monitoring wells at the site are the windows which allow Hanford scientists to view the extent of groundwater contamination and the various hydrologic features of the aquifer itself. Where to place these windows, when to look through them, and what to look for, are all subjective decisions that an investigator would like to control.

{Insert Figure 9—Rivermile 28}

"We really like wells," Buske said once in a meeting at Hanford, "other than the fact that we can't get to them."

Using recent measurements of water table elevations at a series of wells east of PUREX, Buske has recontoured the slope of the water table in a way that suggests the signature of a continuous groundwater channel. The evidence would be all the more clear, he believes, if a few more wells had been drilled closer to where he thinks the channel lies. Yet, he and Josephson have neither the access nor the resources to go onto the Hanford site, drill wells, and decide what to look for.

They did what they could do. They went back to the underwater springs they'd marked near the old Hanford townsite where they believed the channel entered the river. They wanted to further test their "seat of the pants" ten cubic feet per second estimate of groundwater flow from the previous fall. And when they looked more closely at Battelle's 1984 shoreline spring study, two other oddities appeared.

The first concerns the presence of radioactive iodine-129 and technetium-99 at Spring 28-2. Both I-129 and Tc-99 are extremely long-lived radionuclides discharged in wastes from Hanford reprocessing plants. Both are measurable throughout the Hanford unconfined aquifer in patterns that basically resemble the distribution of tritium and nitrate.

Spring 28-2 lies in the same area where they'd tagged the underwater spring in the fall of 1985. When Battelle surveyors sampled springs along a 15-mile stretch of the river on September 11, 1983, the sample they took from spring 28-2 contained, by far, the highest concentrations of tritium, technetium, and iodine-129 measured anywhere along the Hanford Reach.[17] The nearest spring sampled for all three radionuclides was spring 27-1, a little over a mile to the northwest

and still well within the four mile stretch Battelle focused upon in its 1984 environmental reports. Compared to the sample from 27-1, the sample from spring 28-2 contained nearly 400 times more tritium and I-129, and nearly 900 times more Tc-99.[18]

To Buske, it wasn't just that 28-2 looked to be, by Battelle's own data, an especially "hot" spring. Measurement technology developed and used at Hanford is extremely sensitive to I-129, so much so that even though it is present in the Columbia at levels far less than a trillionth of a curie per liter, Hanford's contribution to the river—based on upstream and downstream measurements—is discernible. This did not escape Buske's attention, nor his calculator. Battelle, he noted, had already concluded in its reports that the I-129 being added to the river was coming from the aquifer. Further, he wrote in an April 9, 1986 letter, "the Iodine-129 added to the Hanford Reach would be accounted by Spring 28-2 flowing at an average volume rate of about 10 cfs."

The second thing that caught Buske's eye was that Battelle had made a seemingly minor error in how it presented the sample data in its report. In a graph display it had inadvertently flip-flopped the location of spring and river water sample points near Rivermile 28. This made it appear, to the casual reader, that the river water sample with the highest concentration of tritium (60,600 picocuries per liter) was downstream from spring 28-2. Battelle's data log, however, shows the opposite to be true. Spring 28-2 is indeed adding a lot of tritium to the river, but the river water sample with the highest tritium concentration was collected just offshore right at Rivermile 28, indicating to Buske that the center of his channel was actually entering the river a short distance *upstream* of Rivermile 28. (Although the Battelle surveyors noted a spring near Rivermile 28 they apparently did not collect a sample from it.)[19]

Buske and Josephson were back to Rivermile 28 in mid-March. By mid-April they were prepared for their study. They would look at a stretch of shore just over a sixth of a mile in length at this particular spot on the river.

Their observations were conducted over a three-day period. The length of time was needed primarily to observe and account for a "bank storage" effect whereby the Hanford shore actually absorbs river water when the Columbia is at a higher than normal level. Thus, when the river drops, the water flowing from the springs is, at first, less contaminated and flowing at a higher rate than actual groundwater itself. To observe and account for this, Buske and Josephson arranged with the operators of Priest Rapids dam to have the river held at a constant flow rate for the duration of the study.

Other than having to correct for the bank storage phenomenon, the study Buske and Josephson conducted was basically simple. Using their portable nitrate sampler and a flow meter they were able to measure nitrate concentrations in offshore river water both upstream and downstream of a 852 foot length of Hanford shoreline. By repeated measurements this gave them an estimate of the amount of nitrate entering the river. By simultaneously measuring the nitrate concentration of groundwater flowing into the river through the springs, they could then estimate the volume flow of groundwater from the springs to the river.

Their preliminary findings, based on the nitrate measurements, were published in their Spring

1986 Data Report. The average discharge along the 852 foot section, they reported, was over 6 cubic feet per second—twice the flow predicted by Battelle for the *entire* 4 mile stretch of shore near the Hanford townsite which includes the section Buske and Josephson studied. After receiving the results of DOE's laboratory analysis of river and water samples for tritium and doing a more thorough review of their study design, Buske and Josephson have since published a second report listing a conservative estimate of 7 cubic feet per second, with a best guess of 10.[20]

{Insert Figure 10}
Figure 10: Buske's Channel
One of the points Norm Buske and the Battelle scientists agree upon is that if there is a channel of fast-flowing groundwater connecting the Hanford 200 Areas with the Columbia River, it should show up in measurements of the water table. The bottom panel shows how Hanford hydrologists have contoured the surface of the aquifer. The top panel is Buske's contouring, using the same data, showing where he believes a channel filled with Pasco gravel lies.

So great a flow in such a concentrated area, they insist, is simply inconsistent with Battelle's "seepage model" of groundwater flow. They believed this finding supported the concept of a channel in the Ringold Formation, filled with Pasco gravels, connecting the 200 East area with the Columbia River. The consequence of such a channel, they argue, is that the travel time of waste water to the river could be as much as ten times less than what the model predicts. Also, because boulders and gravels filling the channel confront radioactive wastes with much less surface area than other, finer soils, the potential for filtering of the wastes is so much less that some contaminants may migrate through the aquifer to the river 10,000 times faster than Hanford scientists have previously estimated.[21]

Welcome to G-53

In the months before doing their field work at Rivermile 28, Buske and Josephson had dealt with no fewer than six Battelle scientists and managers. For a month after they'd provided the Department of Energy with their April 27, 1986 report on their findings, there was no reply. The first semblance of a response came, not to them, but to a panel of Northwest dignitaries appointed by Hanford Manager Mike Lawrence to review DOE's Defense Waste disposal program at the site. It was delivered, orally, by Dr. Michael Graham, the head of Battelle's hydrology section at Hanford, who'd not previously been involved in the discussions or correspondence between Buske and Josephson and DOE and Battelle.

Buske appeared at the invitation of the panel when it met in Spokane on May 5th to present his and Josephson's findings. Among those present on the panel for Buske's presentation was Dr. Leonard Palmer, a geologist from Portland State University. Noting that he'd done very similar studies using very similar procedures to characterize marine springs in Hawaii, Palmer said that in looking into Hanford literature he'd been "amazed" to find that studies like Buske and Josephson's had not been done previously.

"If we were to compare the number of dollars spent by the other side and by you," Palmer continued, "the credibility would weigh heavily on their side. This raises very grave doubts about motivation and perhaps words like honesty, if I hear you correctly."

Buske replied that he had been heard correctly.

Hanford's response to Buske's presentation was included in Graham's appearance before the same panel [absent Palmer] on May 27th in Portland.

The following is the essence of Graham's rebuttal: "We agree that channels exist on the Hanford Site. We have known about them since the 1960s, we have considered them in the modeling. We have done more to characterize those channels, but we don't see a channel such as the one proposed by SEARCH (Buske and Josephson) existing at Hanford."[22]

In a telephone interview with the author, Graham said his presentation did not constitute a formal reply to Buske and Josephson's study and referred further questions to a DOE public affairs officer.

Buske, upon learning of Graham's remarks, wrote Battelle's Haerer to demand a better explanation.

"You seem to be saying that you don't see anything really intolerably wrong with the VTT model, and it doesn't show a channel, so it isn't there," Buske wrote. "Now let's get down and shoot it out. Do you agree that models are required to agree with data? Do you agree that the data presented in our Spring 1986 Data Report are inconsistent with a seepage flow as predicted by the VTT model? Are you arguing that data which disagree with the VTT model are suspect? I don't think I'm being argumentative. But I am annoyed. I think your arguments are circular. And then your [March 13th] summary, *"While each individual piece of information…may suggest the presence of high hydraulic conductivity sediments..., the data considered together do not support a continuous channel from the 200-East Area to the Columbia River"* does not seem to make sense technically. Surely you aren't saying the more information proving the existence of a channel-type flow, the less it is to be believed?"

The shootout was a meeting chaired by DOE-Richland director of Environment, Safety and Health Ron Gerton and attended by representatives from Oregon, Washington, the USGS, Greenpeace and others, including the author. It took place the morning of July 29, 1986 in a cramped meeting room known as G-53 in the basement of the Richland Federal Building. The format of the meeting was for Buske and Josephson to present their findings. Dr. Graham, from Battelle, was on hand to offer rebuttal.

Graham's principal argument during the three hour meeting was that Battelle had a thorough, peer-reviewed groundwater program at Hanford and while it had identified channels of fast-flowing groundwater at Hanford, it did not see the particular channel that Buske and Josephson addressed. Graham said before the meeting that his critique of the Buske-Josephson research was not based on a technical review of their findings. The sum of his arguments at the July 29th meeting was that: "What you're proposing is inconsistent with the thinking of the technical community."

"Excellent," Buske replied. "Now we have a distinction. What we're proposing *is* inconsistent with the thinking of the technical community."

The outcome of the meeting was never much in doubt.

"We're not totally sure what the issue is," Gerton said in a telephone interview the week before the meeting. "I'm having trouble seeing a difference between what PNL is saying and what Norm [Buske] is saying." To which he added: "Norm's got to convince us. I cannot go spend taxpayers' money unless it's pretty obvious there's a benefit to the taxpayer."

Gerton's claim to be unsure of the issue, two and a half months after Buske and Josephson had presented their findings appears to indict either his candor or his competency. Still, his statement was both precise and telling. It was not just that the burden was upon Buske and Josephson to prove a groundwater channel existed (as opposed to DOE and Battelle having to prove that it did not), it was also their duty to convince DOE that it mattered. Yet, in retrospect, this was impossible.

The reason can be found in the three tests Gerton applied at the outset of the July 29th meeting.

1) "One of the things we do agree with...is that there does not appear to be any health and safety issues connected to this channel."

2) "We really wonder how you can draw the conclusion that you did relative to BWIP (the proposed Hanford high-level waste repository known as the Basalt Waste Isolation Project) that this channel somehow impacts or affects that program."

3) "We do not see where the channel, whether it exists as you describe it or not, has any impact on (Defense Waste) EIS work."

The first test was not really a test at all. Buske and Josephson had actually gone out of their way to say the channel posed no immediate threat to public health. The issue was whether such a channel posed a long-term environmental and public health concern.

The other two tests rely on technicalities that stem from the methodology DOE is using to look at BWIP and the defense waste disposal program. Gerton's argument here is actually twofold: although both BWIP and the defense waste "in-place disposal option" involve the danger that wastes will migrate to the unconfined aquifer and then on to the Columbia River, the approach DOE is using to address the safety of either scheme looks almost entirely at other things—migration upward through the basalt for the repository, and downward through the soil for the defense wastes—to assess the dangers. Thus, says Gerton, a dispute over the travel time of contaminants in Hanford's uppermost aquifer is trivial because the Department of Energy "does not rely on travel time [of contamination] in the unconfined aquifer" in weighing the risks of either waste project.[23]

This is akin to the safety officer of an ocean liner saying that the safety of the passengers does not rely on lifeboats because the law prohibits the company from setting sail with a vessel designed to sink. Moreover, by Gerton's logic, the millions of tax dollars currently being spent to continue monitoring and studying the contamination and groundwater flow in the Hanford

unconfined aquifer are for no obvious benefit either.

The bottom line of the meeting in G-53, as clearly recorded in Gerton's minutes of the session is that the decision had been made by DOE "(not) to spend any more time or money on the channel issue" even before DOE's single-page technical critique of Buske and Josephson's work, provided on August 8th, had even been composed.[24]

Concerns

Norm Buske and Linda Josephson fully expected that their work would have more meaning than the sum of its parts. Their challenge of Battelle's published understanding of Hanford groundwater flow tests the credibility of the Department of Energy and Battelle as custodians for the Hanford site.

l) The field work performed by Buske and Josephson along with the shoreline spring data Battelle itself has published supports the presence of a groundwater channel entering the Columbia at Rivermile 28. It clearly warrants follow-up study to explain what, if not a groundwater channel, is causing the phenomenon they and Battelle investigators have observed. The most substantive of the objections Battelle/DOE offered was to suggest that the flow Buske and Josephson measured at Rivermile 28 "would be mostly river water stored in the bank from the high river stages prior to the study."[25]

This objection was cited in an August 8, 1986 letter from DOE's Ron Gerton to Buske. Gerton's comment ignores the fact that Buske and Josephson anticipated, measured, and controlled for this phenomenon in their study design. Nor does Gerton explain the extraordinarily high tritium concentrations (at or above 100,000 picocuries per liter) present in samples collected from Rivermile-28 springs the afternoon of April 21, 1986 and present, as well, in samples the Battelle team collected from springs at Rivermile the morning of September 11, 1983.

Here the Battelle data—from samples collected September 11, 1983—is particularly instructive because it shows that at about a half mile either way from Rivermile-28, tritium concentrations fall off sharply by a factor of about 100.[26]

DOE and Battelle officials should have had the integrity to concede, by now, that something peculiar is happening at RM-28, even if they don't wish to call the public's attention to it.

Buske and Josephson provided the author with a more thorough technical review of the SEARCH study by the United States Geological Survey. (A copy of which, along with Buske's reply, are available from HEAL.) The reviewer concluded, among other things: "Even though the study results are questionable, they do raise questions about previous studies. I think it would be worthwhile to do some geologic explorations to verify or disprove the existence of a buried river channel."

2) Battelle, without fanfare, has stopped using the 3 cubic feet per second flow estimate (attributed to the VTT model) for the Hanford Townsite area that Buske and Josephson challenged. At the July 29, 1986 meeting the author asked Battelle's Dr. Graham about this. His

reply: “We included the 3 cfs because someone was interested in what kind of discharges we had along the Hanford Reach so that they could calculate tritium loading into the river and see that that’s a very difficult thing to do as Mr. Buske points out. It’s very difficult to measure exactly how much flow is going into a river and where it is happening. So we didn’t attempt to do that this year.”

In fairness to Buske, he and Josephson have never characterized their study as something that is technically very difficult. What they have said, from the beginning, is that Battelle’s 3 cfs flow estimate was much too low to account for the amount of tritium Battelle is measuring being added to the river by Hanford. This raises the next point.

3) Buske and Josephson continue to insist that the measured upstream-downstream Columbia River difference in tritium concentration is among the strongest arguments for the channel they propose. Their point is that no other known mechanism or feature at Hanford can account for the consistently high disparity. Paul Eddy, the head of Battelle’s groundwater monitoring program, seems to agree with this view.

Gerton rests his case against Buske and Josephson on two points: A) The measured downstream tritium concentration at the Richland drinking water intake is not “an adequate representation of the actual downstream river tritium levels” and B) Because the levels of tritium measured upstream and downstream “are so small and have a significant analytical variability to them...US DOE *disagrees that accurate conclusions can be made* about the actual level of tritium added to the Columbia River by the Hanford Site.”[27]

The problem with Gerton’s argument is obvious. Hanford officials cannot use data to support impressions favorable to their interests (i.e. to suggest a relatively slight effect on the river from tritium and other discharges from the N-Reactor), then disavow the *same* data when it is used in ways they consider unfavorable. Yet, this is exactly what has happened.

Moreover, the DOE argument that “accurate conclusions” cannot be made from these measurements is unsubstantiated.

It is hard to escape the conclusion that DOE is using this argument to justify not looking more closely at something it does not want to find.

4) If Buske and Josephson are right about the channel, it clearly could have ramifications for current and future waste management operations and disposal at Hanford. Contaminated groundwater may not behave the way the Hanford model builders might like it to. The danger of a channel such as the one Buske and Josephson propose is that it not only stands to bring a higher volume of water to a given flow path to the river, but because that flow path would be filled with cobbles and boulders rather than sands and clays, the soil’s ability to filter long-lived radionuclides such as plutonium-239, uranium-238, strontium-90 would be greatly reduced.

Unfortunately, there is already indication this is may be happening. The first bit of evidence is a U.S. DOE water sample collected on July 30, 1985 from spring 28-2 which shows a measurement for strontium-90 of .28 picocuries per liter (pCi/*l*) ± .06 By comparison, the

higher of two measurements for strontium-90 in samples of Columbia River water, collected the same day, is reported as .18 pCi/*l* ± .06 (The plus-minus bounds represent two standard deviations.)[28]

Dr. Graham of Battelle argues that the measurement of strontium-90 in the sample from spring 28-2 is "not statistically different, not elevated at all compared to the river samples."[29] Buske disagrees and says there is a 95% confidence that the sample from spring 28-2 shows strontium-90 elevated above background levels in the river.[30]

This may seem to be an esoteric dispute. It isn't. One of the things Hanford officials believe three decades of groundwater research at Hanford have shown is that strontium-90 (with the notable exception of the notorious 1301-N crib at N-Reactor) does not migrate from the immediate areas beneath Hanford cribs and ponds.

For example, responding to the author's question at the July 29, 1986 meeting as to why Battelle does not provide more data and discussion in its annual monitoring reports of the migration of strontium-90 from 200 Area disposal sites toward the river, Graham said the following: "*The reason you don't see it is that we don't see it. We do not see strontium migrate in the system, and there are a lot of reports, and a lot of data have been collected on the Hanford site and we can go back and pull out some references (to show that).*"

Buske and Josephson pressed the issue on strontium-90 as well. The result was that one of the three points DOE and SEARCH reached agreement on, according to Gerton's minutes, was: *"That the presence of Sr-90 at the old Hanford townsite shoreline from the 200 Area would be a significant indication of a channel."*[31]

Graham referred the author to sections of past groundwater monitoring reports published by Battelle that include special analyses for strontium-90 in selected groups of Hanford groundwater monitoring wells. Analysis for strontium-90 in groundwater samples collected away from known Hanford disposal sites do not, as a rule, show strontium-90 to be present.

Unfortunately, this does <u>*not*</u> hold true in the area of the old Hanford townsite in wells miles away from known Hanford dumpsites but very near the channel Buske and Josephson say must exist. Included in the special analyses section of Battelle's 1983 groundwater report are samples from three wells in the Hanford townsite area that not only show strontium-90 to be present but present at levels *above* the EPA drinking water standard of 8 pCi/*l*.[32] In Battelle's 1984 groundwater monitoring report, samples from ten wells near the Hanford townsite were analyzed. Strontium-90 in four of the wells was recorded above the background level of <.4 pCi/*l*.[33] Again, the issue is not whether these measurements pose an immediate health threat. The issue is whether Battelle has failed to either identify or acknowledge a groundwater feature that raises considerable questions about the long-term storage of radioactive wastes at Hanford.

The author included copies of the data, with a request for an explanation, in an August 11, 1986 letter to Dr. Graham. Graham, in a September 16th telephone interview said he did not know about the high strontium-90 measurements near the Hanford townsite when he referred the data to the author.

Then why did he refer to the data? "I referred you *in principle*," Graham said, explaining he knew the samples had been analyzed but did not know what they'd shown. Graham said it looked like there were "some problems" with the data which had been provided by a U.S.G.S. laboratory as part of the Hanford quality assurance program. But, he conceded, "We got no explanation from G.S. [Geological Survey] as to what had happened" (and) "when you have highs and lows you just can't conclude the high numbers are bad." Graham said he would be sending a written response to the author's letter within the week. By press time, November 20, 1986, it had not arrived.

On November 7, 1986, the United States Geological Survey conducted a meeting in Tacoma to begin a technical review of Buske and Josephson's study at Rivermile 28. Amending were Buske, DOE's Ron Gerton, and Battelle's Michael Graham. According to Bill Myer, the Assistant District Chief of U.S.G.S.'s Pacific Northwest Section, an eight-member team of U.S.G.S. scientists will conduct the review.

U.S.G.S. findings and recommendations, Myer said, should be completed by January of 1987. Those findings, he said, will be sent to Oregon Congressman Les AuCoin, who requested the review.

Chapter 9

Conclusion and Recommendations

During the Manhattan Project and for many years following, the Hanford plants were the prototypes for the nuclear age. They were the first of their kinds and they operated for 30 years before the Atomic Energy Commission, under a 1973 court order, made its first attempt to survey the lasting damage the plants' operations were inflicting upon the environment. By that time, the contamination of the soil and subsequent contamination of groundwater at Hanford was extensive. It is still extensive and getting worse.

The practices employed at Hanford, specifically the disposal of liquid radioactive and chemical wastes directly to the environment, are prohibited in the commercial industry. Whereas radioactive and hazardous waste laws enforced by the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) are designed to prevent contamination of groundwater, waste practices at Hanford contaminate groundwater as a matter of course.

The official rationale for allowing plants such as N Reactor and PUREX to operate unfettered by these laws, as prescribed in the Atomic Energy Act of 1954, is national security. Another justification is that current Hanford waste practices, however dirty, are an improvement on past practices which, like it or not, have already contaminated more than 300 acres of land and 100 square miles of groundwater. One of the Hanford officials interviewed for this report offered yet another rationalization. Hanford waste practices, he said, are comparable to speeding on a rural highway at a time when there is no traffic. While they may technically violate the law, the result is inconsequential because the possibility of anybody getting hurt is essentially nil, or at least far less than the speed limit—the law—contemplates.

This is the same defense offered when Hanford officials publicly dismiss the flow of contaminants into the Columbia River at Rivermile 28, six miles from the Hanford PUREX plant. Nobody drinks water from these springs and the Columbia River greatly dilutes the contaminants before they reach the nearest drinking water intake downstream. Hence, the argument follows, it is okay to continue polluting the aquifer that feeds the springs.

The fallacy in this argument seems obvious when one considers that many of the pollutants stored or discharged at Hanford will remain dangerous for thousands and even millions of years to come, long after the Hanford Patrol will be around to shoo visitors off the 560 square mile reservation, and long after Hanford scientists can assure the public, as many have, that they would not work at Hanford, nor drink the water downstream in Richland, if they thought it was harmful to them or their children.

The existing slate of state and federal environmental laws, by and large, incorporates the ethic that dangerous waste disposal must protect future as well as present generations. The failure at Hanford, as at other Department of Energy nuclear weapons plants, is that forty years after V-J Day no substantive change in priorities has occurred. Despite the assertion from DOE officials that they would not operate these plants in an environmentally unsound manner, the evidence clearly shows otherwise. Plutonium production is still the top priority. In a sense, it is as if the war never ended. The Atomic Energy Act of 1954, while affirming "civilian" control over nuclear weapons production, nevertheless suspended the checks and balances that go with civilian control of other government activities, even those that are not thought of as dangerous. Thus, the Department of Energy has, until now, retained sole authority to determine what are "acceptable" risks and what are "environmentally acceptable" practices. Given the findings of this report, HEAL no longer believes this state of affairs ought to be tolerated by citizens of the Northwest. Fundamental corrections are needed to assure the public that the Hanford wastes will remain safely isolated and ensure the protection of the Columbia River.

HEAL Recommendations

Federal

1) While our report shows that the 43-year-practice of disposing of liquid wastes to the soil is deplorable, and that even stopping today will not solve the continuing groundwater degradation (because of existing contaminants in the soil) we recommend that Congress take action to stop this practice within one year.

2) We recommend Congress hold U.S. DOE accountable to all federal environmental laws, *absent any assertions of Atomic Energy Act exclusions,* and that Congress provide independent oversight to certify DOE compliance.

In this respect, we urge immediate action to compel U.S. DOE to fully comply with:

- **The requirements of the Resource Conservation and Recovery Act (RCRA) of 1976 and its 1984 amendments, for the storage, shipment and disposal of hazardous wastes.**

- **The requirements of 10 CFR Chapter 1, Part 61, of the Code of Federal Regulations (radioactive waste disposal) which require, among other things, the disposal of radioactive wastes in a manner that minimizes their contact with water.**

- **The requirements of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980, including a full assessment of the radioactive and chemical waste sites at Hanford.**

3) We believe the U.S. government has an obligation to totally fund cleanup of contamination at Hanford.

State

1) We recommend that the State of Washington take aggressive action to bring Hanford operations into compliance with all state environmental laws.

2) We recommend the state secure its own sources of funding for monitoring and enforcing compliance with state laws at Hanford.

Federal and State Initiatives

- Language inserted in Congress's 1987 Energy and Water Appropriations bill by Oregon Rep. Les AuCoin requires the Department of Energy, by the spring of 1987, to provide Congress with a schedule for halting the disposal of liquid wastes to the soil at Hanford and instituting alternative methods of disposal. It also requires U.S. DOE to provide Congress a schedule for complying with the same environmental regulations and safety standards applicable to commercial facilities. The language was signed into law in October.

- The "Department of Energy Environmental Compliance Act of 1986" (H.R. 4848 Substitute) sponsored by Oregon Congressman Ron Wyden is a progressive and thorough attempt to require U.S. DOE facilities to comply with Environmental Protection Agency (EPA) and state radioactive and hazardous waste regulations. It would require EPA to set standards for radiation releases from U S. DOE facilities that are no less stringent than those the Nuclear Regulatory Commission (NRC) applies to commercial facilities. It would allow states to apply more protective standards. It would allow EPA to delegate to the states monitoring at onsite stack and effluent discharge streams.

The most recent draft of the bill also incorporates provisions of Ohio Rep. Tom Luken's "mixed waste" bill which gives clear jurisdiction to the Environmental Protection Agency (EPA) to regulate the hazardous chemical component of all Department of Energy mixed wastes. This would formalize into law EPA's own interpretation of its jurisdiction at DOE facilities under RCRA.

Further, the bill would require U.S. DOE to stop the use of soil columns (cribs) as a method for disposing of radioactive and/or hazardous chemical waste no later than a year after enactment.

This piece of legislation, known as the "Wyden Substitute," has been approved by the House Subcommittee on Energy Conservation and Power but has yet to come up before the House Committee on Energy and Commerce.

- In September, Ohio Senator John Glenn introduced a Senate Resolution that would provide, among other things, independent inspection by state agencies of hazardous waste practices at U.S. DOE facilities and require the Secretary of Energy to provide Congress with timelines and cost estimates for bringing DOE facilities into compliance with all applicable environmental laws. Glenn's resolution would also have the NRC conduct independent analysis of the in-house Safety Analysis Reviews U.S. DOE has prepared for major facilities like Hanford's PUREX and N-Reactor. Sen. Glenn's resolution has not been approved by the Senate.

Of the three initiatives, all of which would represent improvements, we believe Rep. Wyden's proposal is the most far-reaching. We encourage its support. Rep. AuCoin's initiative, now law, is obviously the one with the most immediate promise. It requires U.S. DOE to set a date—something it has thus far avoided doing—for the termination of liquid waste discharges to the ground at Hanford. Unfortunately, it stops short of actually requiring U.S. DOE to stop the waste discharges. While it is a commendable step in the right direction, we believe it is important that Congress set specific deadlines for U.S. DOE compliance and ensure the agency adhere to those deadlines.

HEAL would also like to commend Rep. AuCoin for his efforts to enlist the United States Geological Survey in a review of the field study conducted by consulting scientists Norm Buske and Linda Josephson of SEARCH Technical Services of Davenport, Washington.

- HEAL supports Washington Department of Ecology Director Andrea Beatty Riniker, Attorney General Ken Eikenberry, and Governor Booth Gardner in their continued efforts to bring all Hanford operations into compliance with state hazardous waste laws.

At least two sections of state law apply in this regard.

1) The Washington Hazardous Waste Disposal and Hazardous Waste Regulations (RCW 70.105 & 70.105A) orders the Department of Ecology to set and enforce minimum standards for the disposal of hazardous wastes in Washington state. It is under this section of the state code that the Department of Ecology, last February, issued a hazardous waste violation order against the U.S. Department of Energy and levied a $49,000 fine.

2) The Washington Water Pollution Control laws regulate the discharge of pollutants into Washington waters, including groundwater. It authorizes the ecology department to issue permits for discharges and enforce compliance.

According to Department of Ecology industrial section supervisor Roger Stanley, the state plans to enforce both sections of state law at Hanford. The hazardous waste code would be applied to the most concentrated discharges and the water pollution control code will be applied to all other discharges, including Hanford "cribs."

Stanley said the ecology department will also be pursuing regulation of the hazardous chemical portion of the Hanford high-level waste streams and the ultimate disposal of those wastes under the Department of Energy's Defense Waste disposal program. HEAL endorses this approach and further commends Governor Gardner for his insistence that U.S. DOE move "out of the shadow" of the Atomic Energy Act of 1954 to voluntarily comply with RCRA and state hazardous waste laws.

- Enforcement of state radiation protection laws at Hanford is still prohibited by the Atomic Energy Act of 1954. However, with the 1985 amendments to Washington's Nuclear Energy and Radiation code (RCW 70.98) the state Department of Social and Health Services (DSHS) can and should attempt a much more aggressive environmental monitoring program at Hanford than it has in the past. We believe, for example, that DSHS should—independent of the U.S. Department of Energy and its contractors—evaluate the movement of long-lived radionuclides in Hanford soil and groundwater.

Unfortunately, funding for DSHS radiation monitoring and environmental studies at Hanford is currently linked to two activities—commercial low-level waste shipments to Hanford and Hanford's candidacy as host for a high-level waste repository—that have little to do with the cause and continuation of the existing waste problem at Hanford. HEAL regards this as a precarious situation that may not be adequate to independently assess Hanford's present and future effect on the State of Washington. We encourage the state to establish sources of funding such that the monitoring and enforcement of state regulations at Hanford is not heavily dependent on unrelated federal or commercial activities.

Recommendations of Other Organizations

General Accounting Office (GAO)

In the past year, the United State General Accounting Office, the investigating arm of Congress, has issued three reports critical of Hanford waste practices. They are:

Department of Energy's Transuranic Waste Disposal Plan Needs Revision, March 1986.

Environmental Issues at DOE's Nuclear Defense Facilities, September 1986; and

Unresolved Issues Concerning Hanford's Waste Management Practices, November 1986.

The first report, dealing with the Department of Energy's "Defense Waste Management Plan," found that U.S. DOE had not provided Congress with complete inventories, cost estimates, and important environmental and safety information relevant to the permanent disposal of plutonium waste and plutonium contaminated soil. It recommended the Secretary of Energy revise the plan accordingly.

The other two reports offer Congress a clear choice toward correcting the waste management problems at Hanford. The September 1986 report, prepared at the behest of Sen. Glenn, notes that it "could take years before an objective assessment can be made" as to whether the

Department of Energy's elevation of the Office of Environment, Safety, and Health (ES&H) "is sufficiently independent." In the meantime, "problems identified in previous reports—conflicts from program offices in establishing priorities between programmatic goals [i.e. plutonium production] and ES&H activities—can still occur."

Here GAO made two recommendations, both asking for the Department of Energy to solicit independent reviews of its safety and waste management programs.

Unfortunately, HEAL believes these recommendations fall well short of the fundamental problem. Neither would guarantee, for example, that the problems GAO identified in this report—including severe groundwater contamination at N-Reactor and PUREX—would be alleviated by non-binding, independent reviews.

For that reason, HEAL subscribes to the prime recommendation in the November 1986 GAO report, released by Ok1ahoma Rep. Mike Synar, chairman of the House Environment, Energy and Natural Resources Subcommittee of the House Committee on Government Operations:

"Hanford uses RCRA's Atomic Energy Act exclusions to dispose of low-level byproduct [radioactive and chemical] waste in a manner different from what the Resource Conservation and Recovery Act (RCRA) would allow. In view of the potential environmental problems that could result from this difference...GAO believes the Congress should consider whether RCRA's Atomic Energy Act exclusions [for radioactive wastes] are still appropriate."

Hanford Health Effects Panel

The Hanford Health Effects Panel convened by the Washington State Nuclear Waste Board in conjunction with the Centers for Disease Control in Atlanta, made several recommendations HEAL supports. Those relating specifically to soil and groundwater contamination are:

- "The Panel is of the opinion that some areas of Hanford are nuclear and hazardous waste sites. We therefore urge a concerted remedial investigation and feasibility study of the sites together with appropriate federal, state, and local agencies and the Indian Tribes."

- The Panel "encourages the expansion of [soil sampling] as a method of obtaining a measurement of the amount of radionuclides deposited on the Hanford site since the beginning of operations...(and) suggests this sampling and evaluation be performed in coordination with the state of Washington."

- "The Panel is concerned about the advisability of continued soil disposal of chemical and nuclear waste on the Hanford site. Insufficient information was available to allow the Panel to assess the environmental impact of continuation of such disposal practices. Such an assessment should be a priority."

Northwest Citizens Forum on Defense Waste

The forum is a panel of citizens appointed by Hanford Manager Michael Lawrence to review and

advise the Department of Energy on the ultimate disposal of Hanford defense wastes. Of the six main recommendations the panel offered in its August 5, 1986 report, three are of particular note:

- That Congress adopt a "pay as you go" approach to funding the disposal of defense nuclear waste. This recommendation, proposed to the panel by HEAL last May, would require a percentage of the Department of Energy's nuclear weapons budget be dedicated to a "defense waste disposal trust fund" to assure the ultimate disposal of the waste.

- That U.S. DOE conduct a timely, comprehensive analysis of the chemical hazards of the Hanford wastes and commit itself to "substantial compliance" with prevailing environmental and hazardous waste laws. "Informal self-regulation by DOE is not adequate."

- That U.S. DOE demonstrate that decisions made about the commercial high-level waste program do not constrain options being considered for the ultimate disposal of the Hanford defense wastes.

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Chapter 1

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