Chapter
19

Conclusions

The United States is facing a grave, long-term threat: the legacy of its nuclear weapons program. This program has resulted in the contamination of surface and subsurface water throughout the nuclear weapons complex, contamination that is inexorably leaching, migrating, and moving. Particularly where this migration is underground, it is often unpredictable, traveling along inadequately mapped, poorly understood pathways.

Started as a crash program to develop the atomic bomb during World War II, continuing for forty years during the Cold War, and still ongoing today, the nuclear weapons program has left behind a technically challenging and financially daunting project – the cleanup of 13 huge, highly-contaminated sites and scores of smaller facilities. These largest sites, located in 10 states and occupying an area the size of Delaware and Rhode Island combined, threaten important municipal and agricultural water supplies, place major rivers at risk, and are potentially hazardous to the water supply of several large cities.

Rivers and Aquifers at Risk

Some of the major rivers at risk include the Columbia River in Washington, the Clinch River in Tennessee, the Savannah River in South Carolina and Ohio's Great Miami River. Many smaller rivers are also impacted. Dangerous long-lived radioactive pollutants and toxic pollutants have been detected in several important aquifers, including the Snake River Aquifer in Idaho, the Tuscaloosa Aquifer in South Carolina, Ogallala Aquifer in Texas and the Great Miami Aquifer in Ohio. Among the affected cities, whose municipal water supplies are dependent on at-risk rivers and aquifers for all or portions of their municipal water supply, are Richland, Washington, Cincinnati, Ohio and Kingston, Tennessee.

These water contamination problems are particularly acute at a time when periodic droughts, in conjunction with population growth, are severely taxing important water resources. Throughout much of the Southwest and West, multiple years of drought have already drawn down water tables, aquifers and water reservoirs. At the same time these factors are making water scarcer, the nuclear weapons complex is exacerbating the situation by compromising available water supplies with dangerous contaminants.

The problem of contamination has stemmed from the combination of several historical events and misguided long-term DOE waste policies. In the midst of the war-time urgency of the Manhattan project and the continued sense of crisis during the arms race with Russia, the nuclear weapons factories were sited, designed, and operated with little thought given toward waste management. All facilities were located near underground or surface water supplies, which

were needed for production purposes. For example, the Idaho National Engineering Laboratory (INEEL), Hanford and the Savannah River Plant had nuclear reactors that required extensive water for cooling purposes. Thus they were sited adjacent to major rivers. The focus was on production; little thought was given to the ensuing contamination of these bodies of water.

Health Hazards

The health impact of radiation was poorly understood at the time of the construction of the weapons complex. The use of radiation detectors and the idea of health physics were in their infancy when the weapons complex was built. The International Commission on Radiological Protection was officially formed in 1950, several years after Los Alamos and Oak Ridge were built; this commission is the international body that recommends radiation standards. As more information from Japanese bomb survivor data and other sources became available, it was apparent that no radiation dose was too small to cause cancer, that is, no threshold existed. Also, increasing the dose increased the likelihood of developing cancer.

But it was not just ignorance that caused Atomic Energy Commission and Department of Energy to downplay the hazards associated with radiation. It was part of a deliberate policy to keep the public ignorant of the threat posed by nuclear weapons factories. DOE suppressed studies that showed the risk to workers at nuclear weapons factories, cut off funding for important health studies, such as those by Dr. Thomas Mancuso, and frequently failed to release documents showing migration of radionuclides off of the sites. These policies continue to this day.

Similarly, little was known at first about the health hazard of toxic chemicals. Later, critical data was often not released on a timely basis. Many hazardous chemicals, such as mercury, toluene, benzene, arsenic, chromium and trichloralethylene (TCE), were used regularly within the DOE complex. The Environmental Protection Agency only later appreciated the hazard of these materials. Almost all DOE facilities used TCE for degreasing machinery. Because of the large number of motors involved in their operations, the practice was particularly prevalent at the three gaseous diffusion plants in Tennessee, Kentucky and Ohio. Massive amounts of mercury – over 350 tons - were irresponsibly dumped by the Y-12 Plant in Oak Ridge into nearby streams that drained to the Clinch River. Many of these chemicals have since been shown to be carcinogenic, and mercury is known to damage the neurological system.

Reckless Waste Management Policies

At the nuclear weapons factories, immense quantities of radioactive and toxic chemicals were poured directly into the ground. Unbelievable as it seems today, millions of curies of radioactive materials and tons of toxic chemicals were poured into drainage ditches, seepage and evaporation ponds, and unlined burial grounds. This practice continues to the present day at Hanford. From these unstable disposal sites, contaminants have quickly migrated to surface and subsurface water systems. Sometimes these contaminants were even directly poured or injected into underground bodies of water. This was not an accident. It was deliberate government policy that was consistent with the DOE "solution" to radioactive waste management: dilution.

Dilution has always been DOE's preferred method for solving many waste problems. Often concentrations of contaminants in groundwater at the site perimeter are reduced due to dilution. Thus it appears as if the area is not heavily contaminated and makes it easier for a nuclear factory to meet regulatory guidelines regarding off-site emissions. From a public relations standpoint, out-of-sight-out-of-mind is certainly attractive. However, as contamination spreads, more people are affected. According to prevailing scientific opinion, the total dose to the population is the important parameter. The linear no-threshold hypothesis holds that a dose of 100 rems to 100 people (1 rem per person to 100 people) or to 1000 people (0.1 rem per person to 1000 people) produces the same number of fatal cancers. Thus, dilution does not necessarily lead to fewer occurrences of cancer.

Furthermore, dilution does not take into account the fact that diluted radionuclides will travel long distances downstream from the point of release and reconcentrate in mollusks, fish, bird and other creatures that could be subsequently eaten by unsuspecting humans. For example, radioactively contaminated mussels have been found in Oregon, near where the Columbia River empties into the Pacific Ocean, more than 200 miles downstream from the Hanford complex. Neither does dilution address the problem of radionuclides adhering to sediments along waterways such as riverbanks and streams. Subsequently, when water levels drop (for example during a drought) dangerous contaminants can be resuspended and travel in the direction of the prevailing wind.

Contamination of Groundwater

Perhaps nowhere is DOE's dilution policy more alarming than in the contamination of underground water. This is contamination that is almost impossible to map accurately and for which current technology does not allow for the complete cleanup. Yet these aquifers are a vital part of the nation's water supply. Carbon tetrachloride, chromium, nitrates, tritium, iodine-129, uranium, strontium-90 and plutonium-239 and 240 are some of the identified pollutants in groundwater at Hanford. The Snake River aquifer in Idaho has been contaminated with TCE, tetrachloroethene and other hazardous materials. For the first time in 2000, plutonium was also detected in two separate places in the aquifer. Uranium is the principal contaminant found in Ohio's Great Miami Aquifer. This is one of the radionuclides that can be removed by pump-and-treat, but groundwater moving off-site remains a serious concern.

DOE reliance on dilution continued long after information on the harmful effects of radiation was available. At Hanford, DOE estimates over 444 billion gallons of wastes were poured directly into the cribs, ponds, and trenches in the vadose zone beneath the reprocessing areas before this practice was stopped. Since reprocessing operations ceased, an underground mound of contaminated groundwater formed and is now spreading out and migrating out into the environment. Over 200 square miles of groundwater beneath Hanford are now contaminated.

Unfortunately, Hanford's practice was not isolated. Similar practices prevailed at Fernald, Oak Ridge, Lawrence Livermore, Paducah, Portsmouth, Rocky Flats and the Savannah River Site. About 30 million gallons of radioactive wastewater has been discharged annually at the Savannah River Site.[11] At INEEL, starting in 1952 and continuing to mid-1980, six deep wells were drilled into seepage basins into the Snake River Aquifer and wastes were dumped

directly into the aquifer. This unsafe practice continued for thirty years. Three of these wells are known sources of contaminant plumes. Several shallow injection wells were also used to dispose of an average of 360 million gallons per year of contaminated wastewater deep underground. INEEL also operated 8 unlined percolation ponds in which wastes were disposed.

All DOE facilities operated landfills. Most of these landfills were unlined and almost all have leaked into the surrounding environment. At INEEL, more than 6.56 million cubic feet of waste were dumped into 20 pits and 58 trenches. At Los Alamos, more than 18 million cubic feet of radioactive and solid wastes were disposed of onsite since 1943. Much of this plutonium-contaminated waste was buried haphazardly in canyons where flash floods could easily mobilize the waste and carry it down toward the Rio Grande River. At Hanford, more than 21 million cubic feet are buried in landfills, primarily in the 200 Areas where the reprocessing plants are located. At Oak Ridge, some landfills were placed directly in aquifer discharge areas. The US Southern Regional Burial Ground, sometimes called Burial Ground 4, placed waste, including significant amounts of strontium-90, in continuous contact with groundwater.

Water moving through landfills and liquid waste directly dumped into unlined pits, ditches, seepage and evaporation ponds allow radioactive and toxic chemicals to move more easily through the environment. Once dangerous contaminants are released and dispersed within aquifers, containment and recovery becomes much more difficult.

To compound the problem, incomplete records have been kept of much of this dumping. In some cases, records have been sloppily maintained with valuable data either "lost" or burnt up in fires. When the location and boundary of contamination is unknown and the exact composition of the contamination is also a mystery, remediation is greatly complicated.

Inadequate Technology

Unfortunately, the technology to clean up these sites has not been adequately researched and is not fully developed. State of the art approaches are often not used for budget-cutting reasons. Clay liners in use at many DOE sites will degrade, though how quickly is not known. Clay caps crack during dry periods and subsequently erode and allow inflow during wet periods. Vitrification, a method of solidifying high-level waste from leaking high-level waste tanks, has been used at Hanford but it is still not known how long the glass logs produced by this process will maintain their integrity. Though storing solid high-level waste is safer than storing liquid high-level waste, in the last 15 years three major vitrification attempts at Hanford have failed.

Pump-and-treat technology, in use at INEEL, Hanford and Portsmouth, is not removing all the pollutants. Almost without exception, radionuclides are not removed and are disposed of directly into surface waters. The exceptions are uranium removal at Fernald, cesium and strontium removal at Hanford, and technetium removal at Paducah. In some cases, pumps remove contaminants from the plume front and return it to the site at the rear, in a never-ending cycle. Additionally, it is unclear whether sufficiently rigorous standards are being applied to the removal of uranium-contaminated water.

Often where the technological problems seem to be too daunting, DOE has decided to simply leave a major pollutant untouched, for example contaminants that have built up behind dams at Oak Ridge, essentially hoping the earth and its waters will stand still. Yet during heavy rains these contaminants wash over the dams, contaminating the nearby Clinch River.

In order to protect the public, each site will require extensive remediation followed by maintenance, including pump and treat technology, repackaging waste, capping landfills and maintaining burial grounds or landfills. This process will go on for the indefinite future. For example, DOE estimates that at the present pump-and-treat rate, the Snake River Aquifer at INEEL will not be cleaned till the year 2095.

Pumps must draw water back onto DOE sites; contaminated aquifers must be treated to the extent that is possible. The radioactive and hazardous chemicals must be removed, packaged and stabilized. It is obvious that the genie unleashed by the nuclear weapons complex can never be entirely put back in the bottle. But, to the extent that is possible, these cancer-causing materials must be sequestered for their hazardous lives.

Long-term stewardship at the nuclear weapon factories is vital. It entails many activities, such as monitoring of remediated areas, maintaining facilities and vegetated areas, in addition to ensuring the containment of all remaining materials and contaminated areas.

Recommendations

Given the long-term health threat to the biosphere, to humans, animals and the environment, given that the health of future generations is at serious risk, our government and society must act in concert to stop the continued poisoning of vital resources by radioactive and chemical contaminants. To this end, we have the following policy recommendations:

1. There must be full transparency regarding waste management and clean up. All documents, research studies, monitoring reports, public hearing records, minutes of task force meetings, memoranda pertaining to DOE and other federal and state policy decisions regarding contamination at the waste sites and regarding ongoing or proposed clean up must be available for public scrutiny at publicly convenient locations. Previously covered-up, vital reports must be released now. Citizens in a functioning democracy have a right to full and complete knowledge about what materials were handled at each of the sites, what contamination levels still exist, what health risks are present, and what will be done.

2. Adequate monitoring of both operating and recently closed sites must continue for the indefinite future. Location and depth of monitoring wells, types of contaminants being monitored, frequency of sampling, and full disclosure of monitoring results must be available at public document rooms in the vicinity of each weapons factory, on the web, and, since many of these DOE sites are on the Superfund list, at the Environmental Protection Agency in Washington, DC. This information should be made available on a quarterly or semi-annual basis. DOE must be required to install legally adequate groundwater monitoring systems at the point of compliance (facility or unit edge) for soil units. This must be done on an enforceable schedule. Further, DOE must be required to meet "early detection" standards to detect releases before they hit groundwater through soil monitoring (vadose zone).

3. *The public must be actively involved in the clean up of DOE sites.* Public hearings on proposed remediation plans must be held at convenient locations and times. The public has a right to share in the responsibility for protecting their communities by setting cleanup standards, choosing remediation plans, establishing zoning restrictions, and evaluating monitoring technologies. Technical assistance grants to help citizens review highly technical and complex

programs and hire outside independent experts must be allocated. Unfortunately, DOE has increasingly opted for short term rather than comprehensive, solutions, to contamination at DOE sites. Characterization and remediation alternatives have been limited and DOE has reduced the use of public meetings to gather input. Public meetings have become information sessions.

4. ***Sufficient funding for DOE clean up must be provided.*** Particularly during times of economic downturn and/or periods of war, there will be a strong temptation to cut back on the funding for the environmental remediation program. Funding for cleanup cannot be subject to political whims. However, monies should not just be thrown at the same set of contractors who have historically worked for DOE, a policy that, in the past, has resulted in scandalously wasteful policies. Congress should begin to exercise its rightful authority over DOE programs.

5. ***Adequate research monies must be allocated to develop fail-safe technologies for clean up.*** In particular effective, safe, long-term stabilization methods must be developed for high-level waste stored in aging and leaking underground tanks. Pump-and-treat technologies must be developed to handle the full spectrum of radionuclides and toxic chemicals that are now polluting aquifers at nuclear weapons factories.

6. ***Unsafe disposal practices must be halted at once.*** Dilution of pollution can no longer be seen as the solution. Dumping into aquifers, creeks, streams and rivers can no longer be tolerated. Dumping into cribs and seepage ponds is not acceptable. Burial in unsafe landfills must be abandoned. In the case where leaking burial grounds cannot be stabilized they should be exhumed with full and careful protection afforded to workers involved in this process.

7. ***All federal and state environmental laws, regulations and legally binding clean-up agreements must be adhered to throughout the nuclear weapons complex***. Any attempts by DOE to avoid compliance with these requirements must be halted. Efforts by DOE to exempt certain wastes from current laws must be resisted. Attempts to redefine radioactive wastes so they appear to present less of a hazard to people and the environment in order to allow less stringent guidelines for management and disposal must also be stopped. The public must remain alert to block proposals that would weaken the National Environmental Policy Act, the Clean Water Act or the Clean Air Act.

8. ***The goal must be to remove all contamination sources from intimate contact with aquifers and groundwater systems***. All wastes must be sequestered on DOE sites. While high-level waste presents the greatest potential risk, the most immediate danger often comes from waste materials that are in contact with groundwater systems and migrating both on and off-site. In any instance where high-level waste is in contact with groundwater then the highest priority must be assigned to clean up.

9. ***The intention of DOE to return any part of nuclear weapons sites to industrial and/or recreational uses must be carefully investigated on a case-by-case basis.*** The temptation for DOE to use site transformation as a public relations stunt will be grave. When Rocky Flats is converted to a functioning "wildlife refuge," a term which evokes ideas of pristine natural habitats, who will feel that the site is still seriously contaminated and in need of remediation? Given widespread contamination elsewhere on a site, the probability of contaminants traveling by air or wind to those released areas, thereby putting workers at a new factory or recreationists at risk, will be high.

- Both soil and groundwater must be remediated to the extent that available and developing technology allow in order to meet the same cleanup requirements that apply to other hazardous waste sites in the affected states. The goal must be to meet the health risk (and ecological-risk) standard allowing for future public use to be unrestricted due to contamination for as much of the site and groundwater as is possible.
- The groundwater strategy goal for each site must be to clean up (remediate) the groundwater to restore the highest potential beneficial uses, presumed to be drinking water and irrigation, in keeping with Environmental Protection Agency and state legal requirements.
- US DOE must be held to the same legally applicable standard for groundwater to be cleaned up to allow future beneficial use and to prevent surface water contamination as all other hazardous waste sites. Where technology does not allow this, long-term stewardship must be applied as well as focused research and technology development efforts.

10. ***DOE, policy makers and the public need to accept that significant portions of the nuclear weapons complex are so contaminated that they will have to remain off limits for hundreds of years.*** Access to thousands of acres of land will need to be restricted for the indefinite future.

11. ***Long-term stewardship at these sites is vital.*** The underlying idea behind long-term stewardship is to restrict access to contaminated areas while monitoring the residual contamination in order to protect human health and the environment. In addition to continual maintenance, there must be ongoing research and review to ensure that proper practices are in place and being implemented.

12. ***Long-term stewardship must not become long-term neglect.*** Given DOE's track record of rosy pronouncements regarding the success of clean up strategies, even when there is substantial residual contamination, there is always the danger that "remediated" sites will, in fact, not be fully cleaned. Long ignored nuclear weapons sites may eventually disappear from the public's radar screen. As a result, future generations may feel less impetus to fund ongoing decontamination and monitoring at these facilities. Personal and institutional memory is short, much shorter than the extraordinarily long lives of these radioactive and toxic materials.

The continued vigilance of an informed citizenry is necessary to assure that a comprehensive cleanup of the DOE weapons complex is achieved.

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[1]Coyle et al. *Deadly Defense: Military Radioactive Landfills*, 1988:97.