NEAR SURFACE DISPOSAL FACILITY (NSDF)

IAA REF# 80122

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Comparative Study of NSDF Reference Sites

PREPARED ON BEHALF OF NORTHWATCH

AWMA

RADIOACTIVE WASTE MANAGEMENT ASSOCIATES

Section 1 - Introduction

Canadian Nuclear Laboratories is proposing to construct and operate what they have named a "Near Surface Disposal Facility (NSDF)" at the Chalk River Laboratories (CRL) site. [1]

The Chalk River Laboratories site is situated on the Ottawa River on unceded Algonquin territory approximately 200 km west of Ottawa, approximately equidistant between Ottawa, Ontario and North Bay, Ontario.

The Proponent

The proponent operates as Canadian Nuclear Laboratories and is described as a private-sector company that is contractually responsible for the management and operation of nuclear sites, facilities and assets owned by Atomic Energy of Canada Limited (AECL).[2]

Atomic Energy of Canada Limited (AECL) is a federal Crown corporation responsible for the long-term, contractual arrangement with Canadian National Energy Alliance (CNEA) for the management and operation of Canadian Nuclear Laboratories (CNL) under a "Government owned, Contractor operated (GoCo) model". This follows the announcement by the Government of Canada in June 2015 of the selection of CNEA through a competitive procurement process.[3]

Canadian Nuclear Energy Alliance is a "engineering and technology companies" consortium consisting of Jacobs, Fluor, and SNC-Lavalin Inc. CNEA was formed to respond to the Government of Canada's procurement for the"Management and Operation of Atomic Energy of Canada Limited's (AECL) Nuclear Laboratories."[4]

Project Summary

The stated purpose of the NSDF Project is to "provide the permanent disposal of current and future low-level waste at the CRL site, as well as a small percentage of waste volume from off-site locations, in a manner that is protective of both the public and the environment. The practice of continuing to build additional temporary storage systems at the CRL site for low-level waste is not consistent with modern waste management principles. Further, the NSDF Project would enable the remediation of historically contaminated lands and legacy waste

[1] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-1
[2] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-1
[3] AECL Web site printout, dated 2016-06-22
[4] Canadian Nuclear Energy Alliance as found at http://www.cnea.co/about-us/, 2022-03-03

management areas, as well as the decommissioning of outdated infrastructure to facilitate the CRL site revitalization".[5]

The NSDF Project is proposed as a waste disposal facility which will utilize an engineered containment mound design built at ground surface and intended to hold up to 1,000,000 cubic metres (m3) of low-level waste. According to the 2021 version of the Environmental Impact Statement, the facility will feature 10 waste disposal cells, built in two phases.

The engineered containment mound, if approved and constructed as proposed, would include a multilayer base liner and cover system, where waste will be placed in between. The waste in each cell would be covered after the cell is full.[6] Purportedly, the NSDF would include only "low-level waste which contains primarily short-lived radionuclides with a restriction on waste containing long-lived radionuclides" with the supposition that this material will require isolation and containment for only up to a few hundred years. The engineered containment mound design life of 550 years would allow for radiologic decay of the waste inventory.[7] The waste types include contaminated soils from remediation activities, demolition debris from decommissioning work and general waste such as used personal protection clothing or equipment. The May 2021 EIS states that "the NSDF will primarily contain waste currently in storage at the CRL site, waste generated during environmental remediation and decommissioning activities now underway, as well as future waste that is expected to be produced as a result of on-going nuclear science and technology activities. A small percent of the waste volume will come from other AECL-owned sites (e.g., Whiteshell Laboratories), or from sources such as hospitals and universities." [8]

The facility's long term safety performance relies on a series of engineered barriers, including a base liner system comprised of a primary and secondary liner, a final cover system, and a perimeter berm. The base liner and final cover systems are composed of a combination of natural materials (e.g., compact clay liner) and synthetic materials (e.g., high density polyethylene geomembranes). The perimeter berm is constructed exclusively from natural materials. The proposed project design includes leachate collection and treatment systems. After treatment, the effluent will be discharged to ground via an exfiltration gallery.[9] When that system lacks sufficient capacity (e.g., under spring conditions), treated effluent will be discharged untreated directly to Perch Lake.[10]

The CRL site is located within the Canadian Shield, with bedrock outcrops throughout the region. Groundwater table depth varies significantly throughout the NSDF Project site and changes with the seasons. The average groundwater depths range from approximately 0.06 m

[5] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-1
[6] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-2
[7] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-3
[8] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021 ES-4
[9] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-4
[10] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-5

in the vicinity of the wetlands to 15.95 m in the northern section of the study area, which corresponds to the thickest overburden. Groundwater flow from the NSDF Project site is to the adjacent wetlands, and ultimately discharges into the Ottawa River via Perch Lake and Perch Creek.[11] The NSDF Project will alter the local hydrogeology, and groundwater levels and flows will be changed due to the construction of the NSDF Project. [12]

[11] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-9
[12]NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004, Revision 3, May 2021, ES-10

Purpose of the Comparative Sites Study

In their May 2021 Environmental Impact Statement, CNL argued that "the preferred option for disposal of low-level waste (LLW) is near surface disposal facilities (IAEA 2001)" and positioned their proposed Near Surface Disposal Facility as one such facility.

CNL went on to opine that "the effectiveness of such facilities for disposal of LLW has been demonstrated as illustrated through the following near surface facilities currently in operation in North America" and went on to describe projects within Canada that CNL is in the process of implementing in Port Hope and Port Granby Projects, referencing selected examples of NSDFs for LLW as provided in Table 2.5.2-1 of the EIS.

The referenced table provides a summary of information about a short list of facilities. In addition to the Port Granby and Port Hope sites, the table lists the Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility, the Portsmouth On-site Waste Disposal Facility, and the Fernald On-site Disposal Facility.

The Canadian sites are owned by the federal government and are the responsibility of Atomic Energy of Canada Limited but managed by Canadian Nuclear Laboratories. The U.S. sites are also owned by the federal government and managed by the Department of Energy under a variety of contractual arrangements.

Table 2.5.2-1: Attributes of Selected Near Surface Facilities in Canada and USA for Long-Term Management of Low-Level Waste

Facility	Location	Built	Status	Capacity (m3)	Waste Type	Climate	Annual Precipitation	Terrain	Distance to Nearest Surface Water Body
Proposed CNL Near Surface Disposal Facility	Ontario, Canada	Proposed	Proposed	1,000,000	LLW from past operations, environmental remediation and decommissioning	Wet	87 cm	On a ridge	~0.35 km to Perch Creek, 1.2 km to Ottawa River
Port Granby Long-Term Waste Management Facility	Ontario, Canada	2017	In Operation	774, 000	LLW, hazardous and mixed waste from uranium processing and environmental remediation	Wet	83 cm	Flat	0.7 km Lake Ontario
Port Hope Long-Term Waste Management Facility	Ontario, Canada	2017	In Operation	1,200,000	LLW, hazardous and mixed waste from uranium processing and environmental remediation	Wet	83 cm	Flat	0.1 km to Brand Creek, 3 km to Lake Ontario
Oakridge National Laboratories, Environmental Management Waste Management Facility	Tennessee, USA	2002	In Operation	1,300,000	LLW, hazardous waste from environmental remediation and decommissioning	Wet	140 cm	On a ridge	0.5 km to Bear Creek & Clinch River
Hanford Environmental Restoration Disposal Facility	Washington, USA	1996	In Operation	16,800,000	LLW, hazardous and mixed waste from environmental remediation and decommissioning	Arid	16 cm	Flat	12 km to Columbia River
Portsmouth On-site Waste Disposal Facility	Ohio, USA	Under Construction	Under Construction	1,000,000	LLW, hazardous and mixed waste from uranium processing	Wet	102 cm	On a ridge	2.4 km to Sciota River
Fernald On-site Disposal Facility	Ohio, USA	1996	Closed	2,250,000	LLW and mixed waste from uranium processing	Wet	105 cm	Flat	~1 km to Great Miami River

Similarly, in their 2016 Project Description,[13] CNL had stated that "the design of the NSDF is currently under development. It will be designed as an engineered mound, built at near-surface level on the CRL property, and resembling the plan for the Port Granby Project and licensed waste landfills established on many US Department of Energy sites; e.g., Idaho CERCLA Disposal Facility, Fernald On Site Disposal Facility and the Oak Ridge Environmental Management Waste Management Facility."

Northwatch's comment on the 2016 Project Description included the observation that while the project description referenced one Canadian project and three American projects stating that they "resemble" the not yet developed design of the NSDF, it provided no description of those projects, no analysis of similarities or differences in terms of waste volumes and characteristics and/or physical settings and did not even include references to these projects or source materials.

The purpose of this comparative sites study undertaken for Northwatch is to examine the validity of the statements made by CNL with respect to a) the effectiveness of the referenced facilities in isolating radionuclides from the environment, b) the relevance of the example facilities for review and consideration of the Near Surface Disposal Facility as an option for the long term management of radioactive wastes at the Chalk River site, and c) the alignment of this project with IAEA guidelines, as referenced by CNL.

[13] NSDF Project Description, 2016, as found at https://www.ceaa-acee.gc.ca/050/documents/p80122/114475E.pdf

Section 2 – Comparative Study

Section 2.1 Overview

As noted in the previous section of this report, in their May 2021 Environmental Impact Statement, CNL stated that the effectiveness of a facility such as the Near Surface Disposal Facility proposed for the Chalk River site has been illustrated by facilities currently in operation, including the Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility, the Portsmouth On-site Waste Disposal Facility, and the Fernald On-site Disposal Facility.

The four U.S. sites referenced - Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility, the Portsmouth On-site Waste Disposal Facility, and the Fernald On-site Disposal Facility – are all part of the the legacy of the U.S. nuclear weapons program, but each addresses only a portion of the contamination issues at its respective host site.

The nuclear weapons production complex is vast and includes 13 nuclear weapons sites located in 10 states. These sites include hundreds of factories, very large acreages, and are highly contaminated. They were created as the production sites for the uranium, plutonium and tritium used in atomic bombs, but they also produced a wide range of dangerous contaminants, including poisonous radionuclides and toxic chemicals which contaminated surface and subsurface water in the nuclear weapons complex and in many if not most cases the contamination migrated, moving off site. The contamination has threatened important municipal and agricultural water supplies and has placed major rivers at risk as well as being potentially hazardous to the water supply of several large cities.

Cleanup has been underway at the 13 nuclear weapons factories run by the Department of Energy (DOE) over the last few decades, and the four facilities cited by CNL in the 2021 EIS for the proposed Near Surface Disposal Facility are part of this cleanup effort.[14]

Nuclear Weapons States - the Challenge of Cleanup

The prestigious National Academy of Sciences in a 1999 report, *Groundwater and Soil Cleanup*, warns, "The Department of Energy faces monumental challenges in restoring the environment at installations that were part of the U.S. nuclear weapons production complex." The National Academy adds, "Despite the large amount invested in DOE environmental management, progress on groundwater and soil remediation has been slow."[15]

[14] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

[15] National Research Council, *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants,* National Academy Press, Washington, D.C. 1999.

Eight years earlier, in 1991 the respected US Office of Technology Assessment also sounded an alarm about contamination levels in the nation's nuclear weapons production complex. In their detailed report, *Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production,* the agency says: "Contamination of soil, sediments, surface water, and groundwater throughout the weapons complex is widespread."

The report goes on to say: "Almost every facility has confirmed groundwater contamination with radionuclides or hazardous chemicals."[16]

History of the Nuclear Weapons Complex

In the early 1940s, the Atomic Energy Commission (AEC), later known as the Department of Energy, opened factories across the nation to design, construct and test nuclear bombs for use in World War II. The Manhattan Project, as this project was initially called, was run as a top-secret operation. The factories were typically sited near a river or lake or directly above ground water. At the time a water-rich location was seen as a plus because the nuclear reactors and other processes required large amounts of water. This plus has now become a terrible detriment as pollutants have migrated to these bodies of water and contaminated them, making cleanup exceptionally difficult.

On August 6, 1945 the US dropped an atomic bomb on Hiroshima, Japan, followed by another bomb dropped on Nagasaki three days later. Nuclear weapons production continued even after the war to build a stockpile of weapons as a part of the United States' military policies. By 1967 this arsenal totaled 32,000 nuclear weapons. Since then the arsenal has been reduced to approximately 10,000 long-range nuclear weapons.

In the 1980's the US stopped producing plutonium and tritium and started to shut down some of the nuclear weapons factories. This change was a result of the Cold War's end, new disarmament treaties and a shift towards recycling plutonium out of old, dismantled weapons.[17]

Spreading Contamination

Both surface and subsurface water systems are at risk from the DOE nuclear weapons factories. 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. Other smaller rivers are also impacted. Pollutants have been detected in several important aquifers, including, but not limited to, the Snake River Aquifer in Idaho, the Tuscaloosa Aquifer in South

[16] US Congress, Office of Technology Assessment, *Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production*, 1991, p.23.
[17] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

Carolina, Ogallala Aquifer in Texas and the Great Miami Aquifer in Ohio. (An aquifer is a permeable, water-bearing unit of rock or sediment that yields water in a usable quantity to a well or spring.) The contamination in these vital water systems includes dangerous long-lived radioactive pollutants and toxic chemicals. Among the affected cities, 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.

Contamination has traveled from the DOE sites to the groundwater via many different routes. Precipitation and surface water are methods of recharge for aquifers. As precipitation encounters surface contamination it can percolate through the soil, carrying the pollutants down towards the aquifers. And as surface water flows, it carries contaminants from the surface further from their source and may spread the contamination into nearby streams and rivers, municipal reservoirs, as well as further offsite. Injection techniques, unlined landfills, trenches and pits, degrading waste containers, breaks in pipelines, or deliberate dumping also cause the spread of contaminants into the subsurface as well.[18]

Health Hazards

The health impact of radiation was poorly understood at the time of the construction of the weapons complex. Indeed, 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.

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. 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.

From the beginning, dilution was the DOE's 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

[18] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

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, over 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.

Perhaps nowhere has DOE's dilution policy been 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.[19]

The Chalk River Connection

The Chalk River nuclear laboratories site shares this regrettable legacy of atomic weapons program with its American counterpart sites.

The British government began to plan a nuclear weapons research project in 1940, and in 1942 Canada accepted a British request to relocate the research project, first to the "Montreal Laboratory" based at McGill University and the Université de Montréal, and relocated to Chalk River just a few years later.

In 1943 Britain and the United States merged their nuclear weapons research program and the joint effort - agreed to at a Quebec conference - would later become the notorious Manhattan Project, to which Canada made three main contributions: Canada supplied and processed the uranium that the Americans used to research and then develop atomic bombs; Canada played a major role in researching the extraction and production of plutonium; and Canada provided many researchers and scientists, as well as key facilities for research and production, including and in particular the research facilities established in Chalk River in 1944.[20]

[19] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

[20] "Canada and the Manhattan Project", by Taylor C. Noakes, Published Online August 21, 2020, Last Edited October 29, 2020 by the Canadian Encyclopedia, as found at

The ZEEP, housed in Chalk River, Ontario, was a small prototype reactor constructed to prove that natural uranium and heavy water could be used to create and sustain nuclear fission (also known as achieving "criticality"). The reactor was also used to demonstrate the design's potential to generate plutonium – an artificially created fissile material that can be extracted chemically from irradiated uranium fuel – for the Allies' military programs. The first reactor to achieve criticality outside the U.S. (in September 1945), the ZEEP served as the basis for the design of the NRX (National Research Experimental) reactor.

After the Manhattan Project was terminated in 1946, Chalk River Laboratories focused its efforts on medical and industrial applications of nuclear technology. A laboratory to extract plutonium from irradiated fuel rods from the NRX was developed and operated until 1954.

Between 1959 and 1964, about 252 kg of plutonium contained in used nuclear fuel was exported to the U.S. The material was transferred from Chalk River Laboratories to the Savannah River Site in South Carolina, where it was processed and blended with the remaining U.S. nuclear weapons program inventories.[21]

Chalk River was the site of two nuclear accidents in the 1950s. The first incident occurred on December 12, 1952, when there was a power excursion and partial loss of coolant in the NRX reactor, which resulted in significant damage to the core. The control rods could not be lowered into the core because of mechanical problems and human errors. Three rods did not reach their destination and were taken out again by accident. The fuel rods were overheated, resulting in a meltdown. The reactor and the reactor building were seriously damaged by hydrogen explosions. The seal of the reactor vessel was blown up four feet, and 4,500 cubic metres (1,200,000 US gal) of radioactive water were found in the cellar of the building. This water was dumped in ditches around 1,600 metres from the Ottawa River and an estimated 10 kilocuries (400 TBq) of radioactive material was released.[22]

A flatbed truck used to haul the intensely radioactive core to a nearby burial site was manned by a relay team of drivers, each spending just a few minutes behind the wheel before running away to limit their exposure to lethal radiation. A portion of the road was buried as radioactive waste. Thousands of litres of radiotoxic water and other contaminated reactor wreckage were put in sandy trenches. Radioactive wastes from the NRX accident remain a significant contributor to the immense toxic and radioactive legacy handed down from decades of nuclear research and nuclear materials production at the Chalk River Laboratories.[23]

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https://www.thecanadianencyclopedia.ca/en/article/canada-and-the-manhattan-project#:~:text=In%201943%2C%20the%20British%20nuclear,became%20the%20Chalk%20River%20Laboratory.

[21] Canada's historical role in developing nuclear weapons, May 28, 2012, Canadian Nuclear Safety Commission, as found at https://nuclearsafety.gc.ca/eng/resources/fact-sheets/Canadas-contribution-to-nuclear-weapons-development.cfm

[22] Jedicke, Peter (1989). "The NRX Incident". Canadian Nuclear Society. Retrieved 19 December 2021.

[23] Chalk Rivers toxic legacy, by Ian MacLeod, published by the Ottawa Citizen, Friday, December 16, 2011

The second accident, in 1958, involved a fuel rupture and fire in the National Research Universal (NRU) reactor building. Some fuel rods were overheated. With a robotic crane, one of the rods with metallic uranium was pulled out of the reactor vessel. When the arm of the crane moved away from the vessel, the uranium caught fire and the rod broke. The largest part of the rod fell down into the containment vessel, still burning. The whole building was contaminated. The valves of the ventilation system were opened, and a large area outside the building was contaminated. The fire was extinguished by scientists and maintenance men in protective clothing running along the hole in the containment vessel with buckets of wet sand, throwing the sand down at the moment they passed the smoking entrance.[24]

Both accidents required a major cleanup effort involving many civilian and military personnel and contributed significantly to the contamination at the Chalk River site. The 37-square-kilometre site along the Ottawa River harbors 70 per cent of all the radioactive waste ever produced by Atomic Energy of Canada Ltd. (AECL) and its predecessor, the National Research Council of Canada.

Like its DOE counterparts struggling to clean up U.S. nuclear weapons complex sites, Atomic Energy of Canada launched a multi-billion dollar multi-decade federal cleanup effort of its "legacy" wastes in 2004. More than half of the federal nuclear legacy liabilities are the result of Cold War activities in the 1940s, '50s and '60s, when the risks of atomic waste were not well known, and regulations were less stringent. The rest is from research and development for nuclear reactor technology, medical isotope production and national science programs.

The cleanup includes: the Chalk River Laboratories, the former Whiteshell Laboratories (and nearby Underground Research Laboratory) in Manitoba, two closed heavy water plants and three partially decommissioned prototype power reactors at Rolphton located 30 kilometres northwest of Chalk River, Douglas Point on the eastern shore of Lake Huron in Bruce County, and the WR1 reactor on the Winnipeg River in Manitoba. As Canada's primary nuclear science establishment since the 1940s, Chalk River poses the most complex cleanup.[25]

Just as the four U.S. sites referenced - Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility, the Portsmouth On-site Waste Disposal Facility, and the Fernald On-site Disposal Facility – will address only a portion of the contamination issues at each respective host site, CNL's proposed Near Surface Disposal Facility will address only a portion of the contamination issues at the Chalk River Site.

[24] The Canadian Nuclear FAQ What are the details of the accident at Chalk River's NRU reactor in 1958? Archived 2009-01-30 at the Wayback Machine

[25] Chalk Rivers toxic legacy, by Ian MacLeod, published by the Ottawa Citizen, Friday, December 16, 2011

Section 2.2.1

Oakridge National Laboratories Environmental Management Waste Management Facility

The Oakridge National Laboratories Environmental Management Waste Management Facility was one of four U.S. nuclear waste management facilities identified in CNL's May 2021 Environmental Impact Statement as examples of the effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility.

As outlined in the previous section of this report Oakridge National Laboratories Environmental Management Waste Management Facility is part of the the legacy of the U.S. nuclear weapons program – in this case, the Oak Ridge Reservation – but the facility addresses only a portion of the contamination issues at its host site.

The Oak Ridge Reservation is located in eastern Tennessee. The site is comprised of three major industrial complexes: Oak Ridge National Laboratory, Oak Ridge East Tennessee Technology Park, and the Nuclear Weapons Components. Weapons production activities at this site have included enriching uranium at the gaseous diffusion plant and producing machined components for nuclear weapons assembly.

The Knox Aquifer is the main aquifer located beneath the site and it has been contaminated with mercury, strontium, and thorium. There is an abundance of surface water onsite and contamination has traveled into the aquifer via surface water. Cs-137 and Hg were released from the White Oak Dam and are present in sediments in the downstream Watts Bar reservoir. The causes of the pollution have also included deep injection, unlined pits, deliberate releases into onsite streams, leaking waste burial grounds, waste storage tanks, spill sites, seepage ponds, contaminated inactive facilities, and hydrofracturing. Hydrofracturing is a waste disposal "technique" through which fractures are made by pumping fluids under great pressure into boreholes, after which wastes encased in cement are placed in the enlarged fractures.

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.[26]

Environmental Management Waste Management Facility

In May 2002, the Department of Energy (DOE) opened the Environmental Management Waste Management Facility (EMWMF), a multi-celled, above grade disposal facility located on the Oak Ridge National Laboratory Reservation (ORNL) near the Y-12 facility in Oak Ridge, Tennessee. The facility was

[26] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

part of an accelerated cleanup program to provide disposal of waste from DOE burial sites at the Oak Ridge Reservation, which includes multiple facilities and waste areas.

The Environmental Management Waste Management Facility was constructed as a series of waste disposal cells. The design included stormwater being diverted around the disposal cells, and rainwater that fell on the cells being pumped to one of four contact water ponds. The contact water ponds were expected to be tested to assure the level of contaminants met the release levels outlined in protocols and, when full, would be pumped to a sediment basin where it would be held allowing the suspended solids to settle out before being released into Bear Creek.

Each contact water pond could hold 350,000 - 400,000 gallons of water and all were synthetically lined to prevent seepage. This water was to be managed for both radioactive contaminants and chemical constituents for the known waste streams accepted.

DOE contracted with Bechtel-Jacobs Company (BJC) to operate the facility. Bechtel Jacobs Company LLC is a limited liability company owned by Bechtel and Jacobs Engineering Group that served as the primary contractor to the U.S. Department of Energy (DOE) for waste management and environmental remediation activities on DOE-managed federal government properties in Oak Ridge, Tennessee.

While Bechtel-Jacobs Company held the contract with DOE, BJC subcontracted actual landfill operations and management to Duratek Federal Services (DFS), the company that was later charged with environmental violations at the EMWMF.

Bechtel Jacobs was established as the environmental management contractor for DOE's Oak Ridge operations (including sites in Paducah, Kentucky and Piketon, Ohio, in addition to Oak Ridge) in 1997, when a $2.5 billion management and integration contract was issued to the company. In 2003, Bechtel Jacobs was awarded a new 5-year cost-plus-incentive-fee contract with an estimated value of $1.8 billion.[27] Bechtel Jacobs was replaced as the environmental remediation contractor for the Portsmouth Gaseous Diffusion Plant site in Piketon in 2005,[28] and their involvement at the Paducah Gaseous Diffusion Plant site ended in 2006[29] after DOE entered into contracts with other service providers. Bechtel Jacobs' role in Oak Ridge ended in 2011 after the environmental management contract for DOE properties there was awarded to a different company.[30]

Jacobs, a partner in Bechtel Jacobs, is also one of three corporations that comprise Canadian Nuclear Energy Alliance; as previously noted in this report, CNEA is the operator of Canadian Nuclear Laboratories under a Government-owned / contractor-operated business arrangement between AECL and CNEA.

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[27] U.S. Department of Energy Awards Portsmouth Remediation Contract To LATA/Parallax; $141 Million Small Business Contract Runs Through September, 2009 Archived 2009-04-12 at the Wayback Machine, U.S. Department of Energy press release, January 10, 2005

[28] LATA/Parallax Portsmouth, LLC website Archived 2008-07-04 at the Wayback Machine

[29] Joe Walker, DOE plant site gets new cleanup firm; Shaw Environmental and Infrastructure and Portage Environmental will replace Bechtel Jacobs at the Paducah Gaseous Diffusion Plant, Paducah Sun, December 28, 2005

[30] Frank Munger (May 23, 2011). "The UCOR era begins in Oak Ridge". Atomic City Underground. Knoxville News Sentinel. Archived from the original on February 16, 2013.

Environmental Concerns

The Southern Environmental Law Center, acting on behalf of several public interest groups in the area, has set out a list of environmental concerns related to the EMWMF to the U.S. Environmental Protection Agency in several communications, including:

- Water pollution is occurring as a result of the operations at the Environmental Management Waste Management Facility.
- he EMWMF has been discharging radionuclide pollution into Bear Creek for many years.
- There are no real limits on the discharges of radionuclide pollution into Bear Creek
- the radionuclide pollutants include chemicals that are known to cause cancer and are bio-accumulative, meaning they will continue to build up in waterways, fish and other wildlife over time.
- The contamination will have a major impact on communities that fish and enjoy Bear Creek and the Clinch River; signs installed in 2016 told people not to eat the fish in an area downstream from the EMWMF.
- The contact water holding ponds at the existing EMWMF have come close to failing in the past during heavy rain events, and as a result, thousands of gallons of untreated wastewater containing radionuclides and other hazardous pollutants have been discharged from EMWMF into Bear Creek.[31]
- Contact water holding ponds at the existing EMWMF have come close to failing in the past during heavy rain events, and as a result, thousands of gallons of untreated wastewater containing radionuclides and other hazardous pollutants have been discharged from EMWMF into Bear Creek.[32]
- The EMWMF was not always operated consistently with federal law; for example, there is no authorization for discharge of landfill wastewater to surface water, but an EMWMF contractor had an unauthorized release of landfill wastewater containing radionuclides to Bear Creek during 2002 to avert a pond failure (see next section on Environmental Violations).
- EMWMF wastewater has been discharged to Bear Creek surface water for over 18 years without the necessary authorization to discharge landfill wastewater with radionuclides in the absence of legally compliant and protective discharge criteria.
- The EMWMF WAC included a limited set of radionuclides and are likely not protective of human health associated with future groundwater use.

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[31] "Environmental group has concerns for future landfill", by Benjamin Pounds, Oakridger dated as found at https://www.oakridger.com/story/news/2022/03/02/environmental-group-has-concerns-future-landfill/9047743002/

[32] *See, e.g.,*Att. 2, Plea Agreement, *United States v. Duratek Federal Services*, No. 3:06-cr-00172-CCS (E.D. Tenn. 2006); Att. 3, Factual Basis at 2–3, *United States v. Duratek Federal Services*, No. 3:06-cr-00172-CCS (E.D. Tenn. 2006).

- Unlimited amounts of radionuclides without WAC may be disposed and those radionuclides are not tracked and used to determine if the landfill is in overall compliance with waste acceptance criteria.
- Even though EMWMF has released contact water to Bear Creek since 2003, fish samples from Bear Creek and lower East Fork Poplar Creek were not being analyzed to evaluate levels of radionuclides in fish that people may eat from 2003 through 2019, and the frequency of radionuclide analysis and radionuclides to be analyzed in future fish sampling remains unclear.[33]

As of July 2021 the EMWMF was at 78% capacity. A second similar facility, the Environmental Management Disposal Facility (EMDF) is being proposed for a nearby and similar location. The second facility will be for similar waste types, described by the Department of Energy (DOE) as "soil and soil-like materials" and demolition debris from ongoing clean-up efforts at Y-12 and ORNL (both are part of the Oak Ridge Reservation). Local conservation groups are opposing the construction of the next landfill, arguing for alternate proposals which would see the waste managed in a different and drier location. [34]

Environmental Violations

The following statements are excerpts directly from the Agreed Factual Basis in the case of the United States District Court Eastern District of Tennessee versus Duratek Federal Services:

- Samples of the contact water in the ponds was expected to be collected by DFS and sent to a designated lab for analysis.
- Prior to water being released from the ponds the water must meet DOE Order 5400.5 and Tennessee Department of Environment and Conservation (TDEC) Rule 1200-4-3 Water Quality Criteria.
- The procedure (DFS-OP-009) in place at the time of discharge did not allow the use of annual averaging of the concentration of radiological constituents.
- Once water is ready for release it was to be pumped into the east/west diversion ditch to a sediment basin that holds up to 1.5 million gallons and then to the north tributary (nt 5) that empties into Bear Creek.
- If the analysis exceeded release criteria, the water in the contact water ponds was supposed to be pumped to a Leachate Tank and shipped to the ORNL Waste Water Treatment Plant, treated and then released at ORNL.
- In mid-August 2002, STL Richland Lab, Richland, Washington, received water samples from DFS which were analyzed and found to contain radiological constituents.
- DFS was notified the results were above release criteria for one of the ponds. The ponds were full due to heavy rains in the area that had occurred in July that year.

[33] Southern Environmental Law Center, Attachment to 11/4/2021 Letter to EPA Administrator Michael S. Regan
[34] "Environmental group has concerns for future landfill", by Benjamin Pounds, Oakridger dated as found at https://www.oakridger.com/story/news/2022/03/02/environmental-group-has-concerns-future-landfill/9047743002/

- On September 22 and 23, 2002, heavy rains from the remnants of Hurricane Isadore filled the waste cells and the contact water ponds.
- The storm caused the cell walls to breach allowing cell one storm water to commingle with cell two.
- On September 23, 2002, the landfill manager, David Williams, learned from weather reports that another heavy rainfall was imminent. The landfill manager determined that if the water in the cells was not pumped off the cells, it would breach causing a complete failure of the disposal cells which would destroy the disposal cells, damage downgradient features, and allow the buried waste to be exposed and wash into waters of the United States.
- The landfill manager determined that the leachate tanks would not contain the amount of water from the cells and contact ponds.
- To avert this potential disaster, the landfill manager met with BJC officials on September 24, 2002, to discuss measures that could be employed to address the water in the cells and the ponds.
- The landfill manager was aware that one of the two ponds exceeded release criteria as set out in the protocols existing at that time. Because there was nowhere for the water in the cells to be pumped, the contact water ponds needed to be emptied to accommodate the anticipated volumes of water from the cells. As such, the landfill manager began pumping the ponds to the sediment pond.
- During the night of September 24, 2002, the landfill manager became concerned that the water in the contact ponds was not being pumped rapidly enough to beat the impending storm. In order to speed up the process, the landfill manager, without notification to or consultation with any Duratek management, decided on his own to use a portable pump to pump the water in one of the ponds into a drainage ditch which ran directly into Bear Creek, bypassing the sediment basin and the established treatment procedure and protocols.
- As a result, the landfill manager allowed 350,000-400,000 gallons of contact water containing radionuclides to bypass the sediment basin and the water was discharged directly into Bear Creek.[35]

A Plea Agreement was reached between the U.S. Attorney for the Eastern District of Tennessee and the defendant Durateck Federal Services, and the defendant agreed to plead guilty to the misdemeanor violation outlined in the agreed upon facts and to pay a combination of fines and fees amounting to $300,000. [36]

Three observations directly relevant to the CNL claim that the Oakridge National Laboratories Environmental Management Waste Management Facility provides an example of the

[35] Agreed Factual Basis in the case of the United States District Court Eastern District of Tennessee versus Duratek Federal Services

[36] U.S. Attorney for the Eastern District of Tennessee v. Durateck Federal Services, Case 3:06-cr-00172-CCS Document 2 Filed 12/14/06

effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility can be drawn from this violation, including the related Agreed Factual Basis and the resultant settlement:

- The operation of the EMWMF does not demonstrate the effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility.
- The contractor Bechtel Jacobs Limited was made aware of the situation and the associated risks to the environment prior to the events.
- The environmental violations resulted from a combination of design and operational failures: There was insufficient water storage capacity as part of the facility design and there were operational decisions made which resulted in environmental harm as a result of those design limitations

Section 2.2.2 Hanford Environmental Restoration Disposal Facility

The Hanford Environmental Restoration Disposal Facility was one of four U.S. nuclear waste management facilities identified in CNL's May 2021 Environmental Impact Statement as examples of the effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility.

As outlined in the previous section of this report the Hanford Environmental Restoration Disposal Facility is part of the the legacy of the U.S. nuclear weapons program, but the facility addresses only a portion of the contamination issues at the larger host site.

The Hanford Nuclear Reservation is the most contaminated site in the United States. The site includes 56 million gallons of radioactive waste being stored in old, leaky underground tanks just a few miles from the Columbia River. There is a plan to clean up this 56 million gallons of waste, at a cost of $2.4 billion per year, but after more than 20 years, none of the worst waste has been cleaned up.

Hanford is located in Southeastern Washington state and is 586 square miles. The Department of Energy owns the Hanford Site and controls major cleanup decisions and priorities, but contracts private sector operators —like Bechtel, AECOM, and CH2MHill—to do the actual cleanup.
Along the river, there are nine old nuclear reactors. The Central Plateau, located in the center of the site, is where the tank farms, the worst of the waste is located, along with a Waste Treatment Plant designed to turn the liquid waste in the tanks into a solid glass (a process called vitrification), with a longer-term intention to bury the vitrified waste in a hypothetical deep geological repository.[37]

The site was originally established as part of the Manhattan Project to support the nuclear weapons program with missions that included reactor operations, chemical separations,

[37] "What is Handford?", produced by Hanfordchallenge.org as found March 2022 at https://www.hanfordchallenge.org/whatishanford

fabrication, and research. It was this mission that left a legacy of contaminated sites along a major waterway, the Columbia River.[38]

At this site in south-central Washington, nearly two-thirds of the nation's inventory of high-level waste is stored in massive tanks, 68 of which are known or suspected to have leaked over a million gallons. Hanford reprocessed nuclear fuel and produced plutonium. Carbon tetrachloride, chromium (vi), nitrates, tritium, iodine-129, uranium, strontium-90 and plutonium-239 and 240 are some of the identified pollutants in groundwater at Hanford. Cesium-137 and technetium-99 have been found deep underground beneath the high-level waste tanks and are moving towards the Columbia River.[39]

During production years, more than 100 billion gallons of waste water were discharged to the ground, contaminating it, the groundwater below, and often reaching the Columbia River. The most hazardous and radioactive waste, 56 million gallons, was stored in 177 underground tanks. Boxes and barrels containing chemical and radioactive waste were dumped in unlined trenches. Large pieces of contaminated equipment were buried underground in rail cars. Items dumped in unlined trenches included lab materials, liquids, solids, office waste, etc., and were radioactive or hazardous.[40]

An underground mound of contaminated groundwater formed has been spreading and migrating out into the environment since reprocessing operations ceased. Over 200 square miles of groundwater beneath Hanford are contaminated. The 200-Area, where reprocessing and waste disposal took place, will be restricted forever.[41]

Hanford Environmental Restoration Disposal Facility

ERDF accepts only Hanford waste including low-level radioactive, hazardous, and mixed wastes. Today the landfill has taken in more than 18 million tons of waste and has a capacity of about 20 million tons.

The Environmental Restoration Disposal Facility (ERDF) is a waste disposal facility located in Area 200 at the Hanford Nuclear Reservation. ERDF is a large, multi-cell CERCLA waste disposal facility located just southeast of the 200 West Area on the Central Plateau. ERDF was

[38] HANFORD ENVIRONMENTAL RESTORATION DISPOSAL FACILITY: AN OPERATION AND PRIVATIZATION SUCCESS Joel A. Eacker, Waste Management Federal Services, Inc, as found March 2022 at http://archive.wmsym.org/1998/html/sess19/19-06/19-06.htm

[39] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

[40] Hanford Overview, Department of Ecology, State of Washington, as posted March 2022 at https://ecology.wa.gov/Waste-Toxics/Nuclear-waste/Hanford-cleanup/Hanford-Overview

[41] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003

constructed using a double liner and a leachate collection system and is used to dispose of hazardous and dangerous waste, low-level radioactive waste, as well as mixed waste that meets, or has been treated to meet, land disposal restrictions, and ERDF waste acceptance criteria.[42]

Built in 1996, ERDF accepts low-level radioactive waste, mixed waste, and other hazardous materials that are generated at Hanford. The main storage facilities consist of single layer tanks that hold in all more than 17 million tons of nuclear waste. As of 2011, two new “super tanks” which hold double the amount of the single layer tanks were installed. Liners were previously installed to collect liquid released by the tanks or rain water that may seep in. The ERDF does not accept liquid waste, but water that seeps into the landfill is treated to keep the surrounding environment safe.[43]

The Hanford Site's Environmental Restoration Disposal Facility (ERDF), operated by contractor CH2M HILL Plateau Remediation Company, receives low-level radioactive, hazardous, and mixed wastes that are generated during cleanup activities at Hanford.[44]

Wastes at the ERDF vary dramatically in quantities, characteristics and contaminants of concern. Generating sites include reactor complex areas, chemical treatment facilities, liquid waste disposal sites, solid waste disposal sites, research facilities, and various miscellaneous clean-up efforts. A reactor complex, as an example, produces a large variety of wastes from the actual reactor structure, primary coolant systems and piping, secondary systems and piping, fuel storage basins, laboratories, and ancillary equipment needed to operate the reactor. Wastes produced at such a site include bulk soils, demolition debris, contaminated equipment, stabilized/treated sludge, irradiated hardware, and numerous types of scrap steel, piping, and other miscellaneous materials. [45]

Contaminants of concern also vary greatly based upon the original function of the generating site. Radioactive isotopes include alpha, beta, and gamma emitting isotopes from nuisance levels to contamination and direct radiation levels that require special handling and protective equipment. Hazardous constituents include RCRA listed wastes, RCRA characteristic wastes, toxic substances, and mixed wastes. This wide spectrum of anticipated contaminants was a significant factor in developing the facility design and providing the appropriate operational controls to ensure worker safety.

[42] Hanford Site Third CERCLA Five-Year Review Report, page 83-84, DOE/RL-2011-56, Rev. 1, Date Published March 2012 Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management
[43] "Environmental Restoration Disposal Facility - Hanford Site". hanford.gov. Retrieved 2016-11-01.
[44] https://www.facebook.com/HanfordSite/photos/the-hanford-sites-environmental-restoration-disposal-facility-erdf-operated-by-c/10156491574171330/
[45] HANFORD ENVIRONMENTAL RESTORATION DISPOSAL FACILITY: AN OPERATION AND PRIVATIZATION SUCCESS Joel A. Eacker, Waste Management Federal Services, Inc, as found March 2022 at http://archive.wmsym.org/1998/html/sess19/19-06/19-06.htm

Bulk soils represent the vast majority of the waste forms and are handled through dumping, placement by bulldozers, and compaction in place to meet structural requirements. Water or recycled leachate is used for both compaction purposes and dust control. The arid Hanford environment has made optimum water moisture in materials critical in achieving design compaction.

Special wastes at ERDF are those that require handling by other equipment and/or special procedures to ensure worker safety or prevent release of contamination to the environment. Large equipment including fans, piping, tanks, and other miscellaneous hardware have required some form of stabilization to ensure compaction in the landfill. A common waste from the decontamination and decommissioning efforts at the site have led to the use of grout, contaminated fill, or sand to prevent differences in subsidence in the landfill. [46]

Since beginning operation on July 1, 1996, more than 10.2 million tons (9.25 million metric tons) of remediation waste has been disposed of at ERDF. Approximately 12.6 million gallons (47.7 million liters) of ERDF leachate have been treated or recycled, and approximately 82.45 tons (74.8 metric tons) of waste has been treated at ERDF prior to disposal. The two initial disposal cells reached their operational capacity in August 2000 and an interim cover was installed. In 2009, the initial interim cover was extended 500 feet (152.4 meters) to the east. Six additional disposal cells have been constructed, all of which have been placed into operation.[47]

The Facility is one of 45 different projects, project areas or defined waste areas delineated within the Hanford Nuclear Reservation.[48]

Project Irregularities

Project activities at Hanford have received media attention because of the high costs, missed deadlines, and design flaws. For example, a vitrification plant was originally supposed to cost a little over $4 billion dollars and start making glass in 2008, but the latest estimate for treating dangerous waste is 2036 and will cost more than $16.8 billion dollars.[49]

An independent technical review investigated operational irregularities at the Environmental Restoration Disposal Facility (ERDF) and found the irregularities included (i) failure to recognize that pumps for the leachate collection system were not functioning for an extended period and (ii) falsification of compaction data by a technician responsible for monitoring waste placement

[46] HANFORD ENVIRONMENTAL RESTORATION DISPOSAL FACILITY: AN OPERATION AND PRIVATIZATION SUCCESS Joel A. Eacker, Waste Management Federal Services, Inc, as found March 2022 at http://archive.wmsym.org/1998/html/sess19/19-06/19-06.htm

[47] Hanford Site Third CERCLA Five-Year Review Report, page 83-84, DOE/RL-2011-56, Rev. 1, Date Published March 2012 Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management

[48] https://www.hanford.gov/page.cfm/ERDF

[49] “What is Handford?”, produced by Hanfordchallenge.org as found March 2022 at https://www.hanfordchallenge.org/whatishanford

in the ERDF. Other issues related to compaction of the waste were also considered during the independent technical review.[50] A number of important lessons were learned as part of this review. These lessons are summarized below.

In May 2006 an incident affected the pumps that are designed to operate automatically when the level of leachate exceeds prescribed settings. The contractor did not discover the inoperable leachate pumps until December 2006 – a full seven months later - although technicians were aware of the lack of flow from the pumps and have even documented it.

This circumstance sparked an investigation which revealed another irregularity: some of the waste compaction test data did not correspond to the Radiological Control Technician records of entry into the contaminated area where compaction tests are performed. Upon investigation, it was discovered that the technician who was responsible for taking the compaction tests had not performed the tests and had been fabricating the test data since June 2005.

The response from DOE and the US Environmental Protection Agency (EPA) upon being notified of the operational breaches was to place the ERDF in standby mode from January 12th until EPA issued a consent to resume waste placements a week later in an area that had not yet been used.

An independent technical review team to assess the impacts of these operational irregularities was established, carried out a site visit in March 2007, met with EPA staff involved with oversight of the ERDF and received a detailed briefing from the ERDF operations staff, and reviewed extensive technical documentation regarding the design and operation of the ERDF after the site visit and facility tour. The review team pursued seven different lines of inquiry; their review generated the following findings:

- Root cause analysis of why the falsification of compaction data went undetected for several months included shortcomings in past procedures, a lack of accountability of the subcontractor and lack of visual verification of testing.
- The root cause analysis did not address factors contributing to failure of the leachate pumping system or the contractor's inability to identify that pumping was not occurring for an extended period; the reason for the pump failure remains unknown.
- Analyses indicated that the problem would have been noticed had the pumping rate been regularly compared to historical pumping rates.
- Analysis of the impacts of the excessive leachate level did not assess the most significant impact associated with the elevated leachate level, i.e., whether the excessive leachate level cause additional leakage from the ERDF.
- The most significant issue regarding waste compaction is whether the compacted waste fill in the ERDF will provide adequate support for the final cover. The analysis conducted by the contractor indicated that results of waste compaction testing between January

[50] C.H. Benson, Wisconsin Distinguished Professor, et al, "Evaluating Operational Irregularities at Hanford's Environmental Restoration Disposal Facility", WM2008 Conference, February 24-28, 2008, Phoenix, AZ

2002 and January 2007 were questionable given that a considerable portion of the data was falsified, and in many cases where measurements were made, the technician was re-doing tests to find an area that met the compaction criteria and both of these actions cast considerable doubt on the reliability of the density testing during this period.

- The ITR team concluded that the density methodology that has been used to evaluate compaction at the ERDF has many technical flaws and is of questionable value.
- Documentation was not available to confirm that the 3:1 ratio (soil to debris), or the number of containers over which this ratio can be averaged (24), was adequate to support the final cover for the ERDF.
- The ITR team concluded that additional information or demonstrations are needed to verify that the compaction criterion is adequate.
- The team determined that the soil pressure requirement has not been directly related to the compaction criterion.
- The ITR team also concluded that the information currently available is insufficient to confirm that the existing compaction specification and compaction methods are adequate to ensure that the waste will provide a stable foundation for the final cover to be placed on the ERDF.[51]

Interestingly, despite these project irregularities, the CERCLA 5 Year Report for the period of 2005 to 2011 simply reported the ERDF as "operating as required to meet the objectives outlined in the ROD for disposing of waste from all Hanford CERCLA activities".[52]

Project Evolution

Hanford's massive landfill, known as the Environmental Restoration Disposal Facility (ERDF), is located in Hanford's 200 area and was originally constructed in 1996. Since being built, ERDF has seen four major expansions.[53]

The Environmental Restoration Disposal Facility was authorized in January 1995 to provide waste disposal capacity for cleanup of contaminated areas on the Hanford Site. The first ERDF Record of Decision provided the overall plan for construction of the facility and disposal of remediation waste from the Hanford Site.

Since that initial approval, there have been multiple amendments to the project authorization, and so to the project itself. These include but are not limited to:

- allows for the disposal of investigation-derived waste; D&D waste; waste from RCRA past-practice OUs and closures; and non-RCRA waste from inactive TSD units

[51] C.H. Benson, Wisconsin Distinguished Professor, et al, "Evaluating Operational Irregularities at Hanford's Environmental Restoration Disposal Facility", WM2008 Conference, February 24-28, 2008, Phoenix, AZ
[52] Hanford Site Third CERCLA Five-Year Review Report, Executive Summary Page iii and
[53] Hanford Overview, Department of Ecology, State of Washington, as posted March 2022 at https://ecology.wa.gov/Waste-Toxics/Nuclear-waste/Hanford-cleanup/Hanford-Overview

- authorizing the conditional use of ERDF leachate for dust suppression and waste compaction
- authorizing expansion of the facility by constructing two new disposal cells and to allow for limited waste treatment at ERDF
- authorizing the delisting of ERDF leachate; this was done to “allow for implementation of more cost-effective and appropriate leachate handling techniques”.
- authorizing the second ERDF expansion to disposal cells 5 through 8, and allowed the staging of remediation waste at ERDF while awaiting treatment
- authorizing disposal of certain Hanford Site waste in storage and created a 'plug-in' approach of Hanford-only generated waste in storage for ERDF disposal Hanford Site
- authorizing super cells 9 and 10, including modification of the cell design to allow a single 'super cell' to be used in place of the double cell side-by-side configuration described in the initial ROD
- authorizing the addition of future ERDF cells upon EPA approval through the issuance of a fact sheet by DOE, rather than using the ROD amendment process required by the original ERDF ROD[54]
- authorizing ERDF leachate to be transferred to either the ETF located in the 200 East Area or the 200 West Area P&T for treatment; previously, excess leachate from ERDF operations was collected and transferred by pipeline to the ETF.
- authorizing placement of certain long, large, and/or heavy hazardous waste items in an ERDF trench prior to completing the required land disposal restriction treatment because treatment prior to placement results in greater risk to human health and the environment.[55]

Observations

Three observations directly relevant to the CNL claim that the Hanford Environmental Restoration Disposal Facility provides an example of the effectiveness of a facility such as CNL’s proposed Near Surface Disposal Facility can be drawn from the irregularities and the project evolution observed at the ERDF:

- In the GOCO model in place at the Hanford Environmental Restoration Disposal Facility, a lack of oversight from both the contractor and the site owner was observed, which allowed key equipment failures to continue undetected for seven months and a falsification of documents to be carried out over a period of years.
- Government agency oversight reports failed to note even such significant failures as those noted immediately above.

[54] Hanford Site Third CERCLA Five-Year Review Report, page 83-84, DOE/RL-2011-56, Rev. 1, Date Published March 2012 Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management
[55] Hanford Site Fourth CERCLA Five-Year Review Report, page 3-39, Date Published March 2017, Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management

- The initial authorization for the facility changed significantly even in the first decade of operation. It began with an expansion of the acceptable wastes in the first year after initial authorization and an expansion of the size of the facility the following year; multiple additional expansions to the authorization have continued throughout the operating period.

Section 2.2.3 Fernald On-site Disposal Facility

The Fernald On-site Disposal Facility was one of four U.S. nuclear waste management facilities identified in CNL's May 2021 Environmental Impact Statement as examples of the effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility.

As outlined in the previous section of this report cleanup work at the Fernald On-site Disposal Facility is part of the the legacy of the U.S. nuclear weapons program – in this case, the former Fernald Feed Materials Production Center – but the facility addresses only a portion of the contamination issues at the larger host site, with some wastes shipped off site as part of the site closure and remediation program.

The former Fernald Feed Materials Production Center, now named the Fernald Preserve, is a 1,050-acre site located near Cincinnati in southwest Ohio. It is a former uranium foundry that produced high-quality uranium metals for the nuclear weapons complex.[56]
Titled the Feed Materials Production Center, it was situated on 1050 acres and near the community of Fernald. It employed 2800 individuals and produced most of the uranium used in US Nuclear Weapons production. [57]

Over a period of nearly 37 years, from 1952 to 1989, the Fernald Feed Materials Production Center produced over 500 million pounds of high-purity uranium metal products for the U.S. nuclear weapons program. These operations generated over 6 million tons of liquid and solid wastes and emitted over 1 million pounds of uranium into the atmosphere. [58] When operations ceased in 1989, they left a legacy of radioactive and hazardous wastes, nuclear product, aging facilities and site infrastructure, contaminated soil and a uranium-contaminated groundwater plume.[59]

Controversy struck the site when, in 1984, a faulty dust collector at one of the plants released nearly 300 pounds of enriched uranium oxide into the environment. It was also revealed at that time that uranium had contaminated three off-site wells just three years earlier (nearby wells contained uranium at levels 180 times the federal safety standard [60]). Since the community sits above the Great Miami Aquiver, one of the largest drinking water aquifers in the country, these revelations caused great concern and anger. The community filed a class action lawsuit against the Department of Energy (DOE, previously known as the AEC) and five years later received

[56] https://www.nga.org/wp-content/uploads/2021/03/2019_FFTF_Ohio.pdf
[57] https://participedia.net/organization/4852
[58] https://www.fluor.com/projects/fernald-environmental-remediation
[59] https://www.fluor.com/projects/fernald-environmental-remediation
[60] "Toxic legacy of the Cold War", Ralph Vartabedian, published Oct. 20, 2009 in the Los Angeles Times at https://www.latimes.com/archives/la-xpm-2009-oct-20-na-radiation-fernald20-story.html

compensation of $73 million[61] to local residents and to the state of Ohio and agreed to allow the state to oversee its waste disposal activities. [62]

During site investigations prior to and during the cleanup operations, uranium was found to be the principal contaminant in Ohio's Great Miami Aquifer. This aquifer is located directly underneath the Fernald plant and provides water to the city of Cincinnati. Uranium is one of the radionuclides that can be removed by pump-and-treat, but the fact that the contaminated groundwater is moving off-site is of serious concern.

The aquifer is also contaminated with radium and thorium. A local stream, Paddy's Creek, served as a recharge area for the Great Miami Aquifer and carried uranium below ground to the aquifer. In 2003, uranium concentrations in groundwater ranged from 500 to 800 ppb, well above the 30 ppb required to meet EPA regulations. Major municipal water intakes from the Great Miami Aquifer are located just ¾ mile from the site's east boundary.[63]

Fernald On-Site Disposal Facility

The clean-up strategy for the Fernald site included small volumes of more-radioactive waste material being shipped to licensed offsite disposal facilities; the more highly radioactive material, consisting of high-purity former Belgian Congo uranium ore and tailings, was hauled away. It was deemed too dangerous to leave in the rainy Ohio climate. Ultimately, it was mixed with cement and cast in 3,776 steel containers that were sent to a privately owned dump in west Texas. [64] The much larger volumes of low-level radioactive materials remain at Fernald, encapsulated in the On-Site Disposal Facility (OSDF).

The OSDF was completed in 2006 and contains nearly 3-million cubic yards of low-level waste consisting of 85 percent soil and 15 percent building debris. The facility is 800-feet wide, 3,700-feet long, and 65-feet high.

It has a multilayer cap-and-liner system that encapsulates waste material and an engineered system that collects liquid that drains from the waste and conveys it to the Fernald wastewater treatment facility.

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[61] https://participedia.net/organization/4852
[62] https://participedia.net/organization/4852
[63] *Danger Lurks Beneath*, prepared for the Alliance for Nuclear Accountability (ANA) by Dr. Marvin Resnikoff and the research staff of Radioactive Waste Management Associates, 2003
[64] "Toxic legacy of the Cold War", Ralph Vartabedian, published Oct. 20, 2009 in the Los Angles Times at https://www.latimes.com/archives/la-xpm-2009-oct-20-na-radiation-fernald20-story.html

The OSDF is covered with a prairie grass mix that serves the dual purpose of controlling erosion and providing habitat for a variety of grassland birds and raptors. DOE monitors the performance of the OSDF and performance reports are provided each year in the Site Environmental Report. More detailed information, including a cross-sectional model of the OSDF, is available for viewing at the Fernald Preserve Visitors Center. [65] The large mound sits on the eastern edge of the Fernald Preserve.[66]

Engineered as above-grade waste disposal facility for low level radioactive waste (LLRW) and treated mixed LLRW generated during Decommissioning and Demolition (D and D) and soil remediation, the OSDF is engineered to store 2.93 million cubic yards of waste derived from the remediation activities. The OSDF is intended to isolate its LLRW from the environment for at least 200 years and for up to 1,000 years to the extent practicable and achievable. Construction of the OSDF started in 1997 and waste placement activities were completed and the final cover (cap) placement over the last open cell was in place in Spring 2006.[67]

Ongoing activities at the site include continuing groundwater remediation, surveillance and monitoring of the on-site disposal facility, institutional controls implementation and other aspects of the remedy. Ohio settled litigation regarding natural resource damage that focuses primarily on contamination and lost use of a portion of the Great Miami Buried Valley Aquifer.[68] Original projections estimated the Fernald cleanup would take 30 years and cost $12 billion.

The $4.4-billion cleanup transformed Fernald from a dangerously contaminated factory complex into what many would consider to be an environmental showcase. However, the site is “clean” only by the terms of a legal agreement. Its soils contain many times the natural amounts of radioactivity, and a plume of tainted water extends underground about a mile. Federal scientists say that no one could ever safely live on the site, and the site will have to be closely monitored essentially forever.[69]

Although the cleanup officially ended at Fernald in 2006, long-term groundwater testing will continue at this site “probably into the late 2030s, and there might always be some level of water treatment needed at the site.” The “plume” - the area of affected groundwater, or the sphere of contamination - is down to about 100 acres now.[70]

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[65] https://www.energy.gov/sites/prod/files/2020/04/f74/Fernald%20Preserve%2C%20Ohio%20On-Site%20Disposal%20Facility.pdf

[66] https://www.energy.gov/sites/prod/files/2020/04/f74/Fernald%20Preserve%2C%20Ohio%20On-Site%20Disposal%20Facility.pdf

[67] Lessons Learned from the On-Site Disposal Facility at Fernald Closure Project, Kumthekar, U A; Chiou, J D, as found at https://www.osti.gov/biblio/21210731-lessons-learned-from-site-disposal-facility-fernald-closure-project

[68] https://www.nga.org/wp-content/uploads/2021/03/2019_FFTF_Ohio.pdf

[69] “Toxic legacy of the Cold War”, Ralph Vartabedian, published Oct. 20, 2009 in the Los Angles Times at https://www.latimes.com/archives/la-xpm-2009-oct-20-na-radiation-fernald20-story.html

[70] “What Lies Beneath the Fernald Preserve”, Jenny Wohlfarth, as published in the Cincinnati Magazine on June 7th, 2019, as posted at https://www.cincinnatimagazine.com/citywiseblog/what-lies-beneath-the-fernald-preserve/

An Energy Department agency, the Office of Legacy Management, has been created to monitor the weapon sites after closure and decommissioning. A warehouse in West Virginia will hold millions of records in perpetuity, detailing how the cleanups were conducted and where the toxins are buried. In the case of Fernald, the records will note the location of the radioactive mound, and will show how the basements of the former manufacturing buildings became storage ponds and how for hundreds and possibly thousands of years workers will have to trap groundhogs so they don't burrow through the barriers keeping radioactive waste from leaching into groundwater. [71]

Citizen Engagement

While the DOE communicated with the local community according to the minimum regulatory requirements during the initial period of closure planning, the residents insisted on having a much greater involvement in the project.

In response, the Environmental Protection Agency (EPA) established a forum called the Federal Facilities Environmental Restoration Dialogue Committee (FFERDC), which would provide a blueprint for stakeholders engagement. DOE managers at the Fernald site decided to implement this approach, which led to the establishment of the Fernald Citizens Task Force in 1993 (which became the Fernald Citizens Advisory Board in 1997). It met over a 13-year period in order to provide recommendations for the better management of the remediation process.[72]

Conclusions and demands of local citizen groups, the US and Ohio EPA and the DOE managers at Fernald, all of whom were concerned about reducing the human health risk and environmental damage in the area, led to the creation of the Fernald Citizens Advisory Board (FCAB) in 1993.
FCAB was established in order to provide policy and technical advice regarding important clean-up decisions to the regulated and regulating agencies. In 1995, it was deemed that over 3 million cubic yards of waste and contaminated material would need to be removed from the site. [73]

The Department of Energy estimated that the Fernald Citizens Advisory Board (FCAB) recommendations saved the taxpayers more than $2 billion over the lifetime of the project. This substantial savings is partly due to FCAB's call for the acceleration of cleanup efforts (to be completed by 2006 instead of the DOE's original 2020 goal). The amended cleanup estimate of $2.9 billion – $4.3 billion, billions less than the original $7.2 billion estimate resulted from years of savings in building maintenance expenses, salaries for workers and a number of other expenses. FCAB also saved a significant amount by recommending that 80% of the FEMP site's

[71] "Toxic legacy of the Cold War", Ralph Vartabedian, published Oct. 20, 2009 in the Los Angles Times at https://www.latimes.com/archives/la-xpm-2009-oct-20-na-radiation-fernald20-story.html
[72] https://participedia.net/organization/4852
[73] https://participedia.net/organization/4852

waste remain on-site, and that off-site disposal be limited to 20% of the waste. Since it would have cost three times more to ship the waste than to construct the on-site disposal facility, an additional $700 million was saved[74]

Observations

Three observations directly relevant to the CNL claim that the Fernald On-site Disposal Facility provides an example of the effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility can be drawn from even the summary account provided above. Those observations are:

- The degree to which the Fernald clean-up operations were successful relied on several critical factors, including and particularly that the remediation activities followed closure, rather than running concurrent with continued waste generating and contaminating activities co-located on the site.
- Citizen engagement was a priority, and citizens occupied a central role in decision-making, communicating with the public, priority setting.
- Perpetual care was embedded as a project expectation, and the oversight agencies have a known and seemingly reliable plan for long term record keeping and retention of institutional memory.

[74] https://participedia.net/organization/4852

Section 2.2.4. Referenced Sites Not Included in this Comparative Study

In their May 2021, Environmental Impact Statement CNL referenced “selected examples of NSDFs for LLW” including the Port Granby and Port Hope sites, the Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility, the Portsmouth On-site Waste Disposal Facility, and the Fernald On-site Disposal Facility.

This study of comparative sites examined the Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility and the Fernald On-site Disposal Facility.

This study did not examine the Port Granby and Port Hope sites or the Portsmouth On-site Waste Disposal Facility as these projects are still in the early implementation stages and provided insufficient operational experience or observation of outcomes for this studies purpose.

Section 2.2.5 Alignment of the Project with IAEA Guidelines

In their 2021, Environmental Impact Statement CNL makes the claim that the NSDF Project has been specifically designed as a permanent solution to reduce environmental risk and achieve isolation and containment of the sources of contamination for a sufficiently long period, and that this is in accordance with the requirements set out in the International Atomic Energy Agency (IAEA) Disposal of Radioactive Waste Specific Safety Requirements No. SSR-5 (SSR-5; IAEA 2011).[75]

CNL further claims that "the IAEA definition of a near surface disposal is the placement of solid, or solidified, radioactive waste in a disposal facility located at or near the land surface (IAEA 2014). The preferred option for disposal of LLW is in near surface disposal facilities (IAEA 2001). [76]

In their 2017 review of International Atomic Energy Agency guidance relevant to the Near Surface Disposal Facility, Concerned Citizens of Renfrew County and Area concluded that the NSDF proposal advanced by Canadian Nuclear Laboratories (CNL) would not meet IAEA guidance on several counts, including:

- The approach would place large quantities of radioactive waste with longer lived hazards in in a landfill-type facility suitable only for very low level waste.
- Long-lived radionuclides in the NSDF would be highly vulnerable to human intrusion in the post-closure period.
- Radioactive exposures to humans as a result of intrusion would exceed currently allowed limits by a large margin.
- Acceptance of the proposed NSDF project by Canadian regulatory authorities would violate international safety standards for radioactive waste disposal.[77]

The 2021 EIS states that, "To meet the requirements of IAEA's SSR-5, CNL has defined the near surface disposal within its Integrated Waste Strategy as the primary disposal path for LLW that meet the Waste Acceptance Criteria."[78] However, a fundamental issue with the NSDF is continued uncertainties with respect to the radioactive waste inventory and the characterization of the radioactive wastes which CNL may deposit in the NSDF. Until such issues are resolved, there can be no reliable determination made as to whether the wastes being placed in the NSDF meet IAEA guidance.

Further, the IAEA guidelines set out that a near surface disposal facility is not appropriate for Very-low-level waste. But CNL has determined that "the development of a VLLW disposal facility does not meet the NSDF Project purpose which recognizes the need for an LLW disposal

[75] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004 Revision 3, 2021, Page 2-7
[76] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004 Revision 3, 2021, Page 2-16
[77] "International Atomic Energy Agency guidance relevant to the Near Surface Disposal Facility", Concerned Citizens of Renfrew County and Area, July 2017, as found at https://www.ceaa.gc.ca/050/documents/p80122/119397E.pdf
[78] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004 Revision 3, 2021, Page 2-15

facility and a VLLW disposal facility is not considered technically feasible”[79] and therefore intends to utilize NSDF capacity for the disposition of VLLW.

Disposal of Radioactive Waste

The International Atomic Energy Agency says that the “specific aims of disposal” are to:
(a) contain the waste;
(b) isolate the waste from the accessible biosphere and to reduce substantially the likelihood of, and all possible consequences of, inadvertent human intrusion into the waste;
(c) inhibit, reduce and delay the migration of radionuclides at any time from the waste to the accessible biosphere;
(d) ensure that the amounts of radionuclides reaching the accessible biosphere due to any migration from the disposal facility are such that possible radiological consequences are acceptably low at all times.[80]

The NSDF has not demonstrated as being capable of meeting these “specific aims”.

Near Surface Disposal Facilities for Radioactive Waste

The International Atomic Energy Agency assumes that member states intending to pursue an option of near-surface disposal of radioactive waste will do this in accordance with national policy. It says:

> *“Within the framework set by the national policy for near surface disposal of radioactive waste, the operator, in consultation with the regulatory body, should set out elements of the national policy in a formal safety strategy document that is produced as early as possible in the disposal program and is updated periodically. The safety strategy is the high level integrated approach adopted for achieving safe disposal. It should include strategies to select a site and to design, construct, operate and close a disposal facility. In addition, it should include recommendations for the preparation and maintenance of the safety case for use in decision making and procedures for regulatory approval for the assumed duration of the period of institutional control.”*[81]

Canada’s current radioactive waste policy, the 1996 Radioactive Waste Policy Framework, does not provide this policy direction. Nor does the draft policy released by Natural Resources Canada on February 1, 2022 for public comment.

[79] NSDF ENVIRONMENTAL IMPACT STATEMENT 232-509220-REPT-004 Revision 3, 2021, Page 2-21
[80] IAEA 2010. Disposal of Radioactive Waste. Specific Safety Requirements No. SSR-5, p. 3
[81] IAEA 2014. Near surface disposal facilities for radioactive waste. Specific Safety Guide No. SSG-29., p. 16

Section 3.0 Conclusions

The purpose of this study of comparative sites undertaken for Northwatch is to examine the validity of the statements made by CNL with respect to a) the effectiveness of the referenced facilities in isolating radionuclides from the environment, b) the relevance of the example facilities to the review and consideration of the Near Surface Disposal Facility as an option for the long term management of radioactive wastes at the Chalk River site, and c) the alignment of this project with IAEA guidelines, as referenced by CNL.

In carrying out the study, the report authors examined the three examples sites which have sufficient operational experience that are far enough along in implementation to provide a basis for consideration, i.e. the Oakridge National Laboratories Environmental Management Waste Management Facility, the Hanford Environmental Restoration Disposal Facility and the Fernald On-site Disposal Facility.

Each of these facilities and their operating experience was unique, but each provided insights and observations which were relevant to CNL's proposed Near Surface Disposal Facility at Chalk River. Some experiences were common across the three, which are directly relevant. In particular, all three operate under the GOCO model, and two of the three have contractors which are partners in the Canadian Nuclear Energy Alliance (operator of CNL). All three examples appear to be effectively reducing the footprint or the extent of radio-contaminants but none are successfully isolating the radio-contaminants from the environment. And, all three are facilities whose operations were part of the nuclear weapons complex; similarly, the origins of the Chalk River nuclear laboratory site are with the Canadian contribution to nuclear weapons development.

The Oakridge National Laboratories Environmental Management Waste Management Facility does not provide an example of the effectiveness of a facility such as CNL's proposed Near Surface Disposal Facility. What it does provide is an example of how a lack of oversight and/or commitment to operational safety can result in violations of operating protocol and subsequently, environmental violations. The environmental violations resulted from a combination of design and operational failures in that there was insufficient water storage capacity as part of the facility design and there were operational decisions made which resulted in environmental harm as a result of those design limitations. The responsibility chain went from site owner to contractor to sub-contractor and was broken.

The Hanford Environmental Restoration Disposal Facility further demonstrates how irregularities in project delivery and the project evolution can emerge under the operating model. In the GOCO model in place at the Hanford Environmental Restoration Disposal Facility, a lack of oversight from both the contractor and the site owner was observed, which allowed key equipment failures to continue undetected for seven months and a falsification of documents to be carried out over a period of years. Government agency oversight reports failed to note even such significant failures as those noted immediately above. In addition, a form of “ authorization creep” emerged, with the initial authorization for the facility changing significantly over even the first decade of operation, beginning with an expansion of the acceptable wastes in the first year after initial authorization and an expansion of the size of the facility the following year and multiple additional expansions to the authorization continuing throughout the operating period.

The Fernald On-site Disposal Facility provides an example of several elements which do not appear to be in place in the case of CNL’s proposed NSDF, but were important to the Fernald project. In particular, the degree to which the Fernald clean-up operations were successful relied on several critical factors, including and particularly that the remediation activities followed closure, rather than running concurrent with continued waste generating and contaminating activities co-located on the site. Citizen engagement was a priority, and citizens occupied a central role in decision-making, communicating with the public, and priority setting. Finally, perpetual care was embedded as a project expectation, and the oversight agencies have a known and seemingly reliable plan for long term record keeping and retention of institutional memory.

In conclusion, rather than providing examples of success, the observations from the Oakridge National Laboratories Environmental Management Waste Management Facility, Hanford Environmental Restoration Disposal Facility and Fernald On-site Disposal Facility operating experience provide caution warnings.

Appendix A – Report Authors

Dr. Marvin Resnikoff is an international consultant on radioactive waste issues.
A nuclear physicist and a graduate of the University of Michigan, Dr. Resnikoff has worked on radioactive issues since his first project at West Valley, New York in 1974. Throughout his career, he has assisted public interest groups and state and local governments across the US, Canada and England.

His recent research focus has been on the risk of transporting and storing radioactive nuclear reactor fuel, decommissioning nuclear facilities and the health impact of radioactive waste from oil and uranium production.

This report relied extensively on research completed by RWMA over a number of decades, which integrated studies prepared by contractors managing the US weapons complex, research reports and books written by independent engineers, scientists, and epidemiologists, and research information developed by public interest groups. Finally, the full text and individual chapters were painstakingly reviewed by an extensive list of public interest groups located in the vicinity of each of the nuclear weapons factories

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