Naval Reactors Facility

ENVIRONMENTAL MONITORING REPORT

Calendar Year 2023

Prepared for the U.S. Department of Energy
By Fluor Marine Propulsion, LLC

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Prepared for the US Department of Energy by
Fluor Marine Propulsion, LLC
Naval Reactors Facility
Idaho Falls, Idaho
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LIST OF ACRONYMS

A1W	Large Ship Reactor Prototype
ACM	Asbestos Containing Material
CAA	Clean Air Act
CAP-88	Clean Air Act Assessment Package-1988
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO	Carbon Monoxide
Corps	US Army Corps of Engineers
CWA	Clean Water Act
D&D	Decontamination and Decommissioning
DLC	Decision Level Concentration
DOE	US Department of Energy
DOE-EM	Department of Energy Office of Environmental Management
E. coli	Escherichia Coli
ECF	Expended Core Facility
EHS	Extremely Hazardous Substance
EPA	US Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERA	Environmental Resource Associates
FFA/CO	Federal Facility Agreement and Consent Order
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HAP	Hazardous Air Pollutant
HEPA	High Efficiency Particulate Air
IDEQ	Idaho Department of Environmental Quality
INL	Idaho National Laboratory
IPDES	Idaho Pollutant Discharge Elimination System
IWD	Industrial Waste Ditch
LDR	Land Disposal Restrictions
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MDL	Minimum Detection Level
MSDS/SDS	Material Safety Data Sheet/Safety Data Sheet
NAICS	North American Industry Classification System
NEPA	National Environmental Policy Act

LIST OF ACRONYMS (Cont.)

NIOSH	National Institute for Occupational Safety and Health
NNPP	Naval Nuclear Propulsion Program
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NO_X	Nitrogen Oxides
NRF	Naval Reactors Facility
O&M	Operation and Maintenance
OSLD	Optically Stimulated Luminescence Dosimeter
Pb	Lead
PCB	Polychlorinated Biphenyl
PCE	Perchloroethylene (Tetrachloroethylene)
PCM	Phase-Contrast Microscopy
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers
PM_{10}	Particulate Matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers
QAP	Quality Assurance Program
RWMC	Radioactive Waste Management Complex
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
S1W	Submarine Thermal Reactor Prototype
S5G	Advanced Water Cooled Natural Circulation Submarine Prototype
SI	International System of Units
SMCL	Secondary Maximum Contaminant Level
SO_2	Sulfur Dioxide
STP	Site Treatment Plan
SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TEM	Transmission Electron Microscopy

LIST OF ACRONYMS (Cont.)

TLD	Thermoluminescent Dosimeter
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage, and Disposal (Facility)
US	United States
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WERF	Waste Experimental Reduction Facility

COMMON ABBREVIATIONS

Bq	Becquerel
Ci	Curie
km	kilometer
lbs	pounds
mg/l	milligrams per liter
mrem	millirem
pCi	picocuries
pCi/filter	picocuries per filter
pCi/g	picocuries per gram
pCi/kg	picocuries per kilogram
pCi/l	picocuries per liter
pH	potential for hydrogen
ppb	parts per billion
ppb_v	parts per billion based on volume
rem	Roentgen equivalent man
$\mu g/m^3$	micrograms per cubic meter
μmho/cm	micromhos per centimeter

EXECUTIVE SUMMARY

This report presents the results of the radiological and non-radiological environmental monitoring programs for 2023 at the Naval Reactors Facility (NRF). Current operations at NRF are in compliance with applicable regulations governing use, emission, and disposal of solid, liquid, and gaseous materials. A conservative assessment of radiation exposure to the general public as a result of NRF operations demonstrated that the maximum potential dose received by any member of the public was well below the most restrictive dose limits prescribed by the United States (US) Environmental Protection Agency (EPA), the US Department of Energy, and the US Nuclear Regulatory Commission. The results obtained from the environmental monitoring programs verify that releases to the environment from operations at the NRF did not have any adverse effect on the environment or the health and safety of the general public.

Specific site historical information from the NRF Environmental Summary Report has been added to this report. This key information will provide the reader with a historical perspective of NRF operations.

The results of the radiological and non-radiological environmental monitoring programs for NRF are summarized below.

Definitions for technical terms used in this report can be found in the Glossary.

LIQUID RELEASES (OTHER THAN TO SANITARY SEWER)

Approximately 10.5 million gallons of water were released to the environment via the Industrial Waste Ditch. No radioactivity attributable to operations at the NRF site was detected in any of the environmental samples from these releases. Radioactivity concentrations were typical of natural background levels in water from the Snake River Plain Aquifer. Monitoring data for chemical and radiological constituents of liquid wastewater effluents continued to demonstrate compliance with the Department of Energy (DOE) and other applicable Federal and State regulations.

SANITARY SEWER DISCHARGES

All sanitary effluents are discharged to evaporative sewage lagoons at NRF. No radioactivity attributable to operations at the NRF site was detected in any of the environmental samples of sanitary waste. All wastes discharged to the sanitary system were in compliance with all applicable regulations.

DRINKING WATER MONITORING

Analysis of water from drinking water wells collected on-site did not detect any radioactivity in excess of natural background levels. All required non-radiological drinking water monitoring results were below regulatory limits, demonstrating compliance with all applicable regulations.

GROUNDWATER MONITORING

Strontium-90 and program-specific gamma emitting nuclides measured in samples collected from designated groundwater well groups located on-site and off-site were typical of natural background levels. Measurements for tritium radioactivity were orders of magnitude below drinking water standards. All of the (monitored or target) non-radiological constituent concentrations were below primary drinking water standards. Groundwater monitoring wells are not used for drinking water supply; therefore, drinking water standards are used as references or guidelines only. Monitoring data continues to demonstrate compliance with all applicable regulations.

SOIL GAS MONITORING

Results from the soil gas analysis for volatile organic compounds indicate that several constituents were detected at or above the laboratory sample quantitation limit. These constituents are within the range of previously detected concentrations. Based on risk assessments performed for these sites under previous Comprehensive Environmental Response, Compensation, and Liability Act investigations, the levels detected for all constituents do not pose a significant threat to human health or the environment.

AIRBORNE EMISSIONS

Airborne radioactivity in NRF emissions was controlled using high efficiency particulate air filters and, in some cases, charcoal filters to maintain particulate and gaseous radioactivity releases as low as reasonably achievable. The results of airborne radiological emissions monitoring at NRF have shown that the amount of radioactivity released was too small to result in any measurable change in the background radioactivity levels in the environment. Therefore, the concentrations of the particulate and gaseous radioactivity released from the NRF site were well within the applicable standards for radioactivity in the environment. Monitoring data continues to demonstrate compliance with all applicable regulations.

Emissions of non-radiological air pollutants were calculated and recorded according to the Idaho National Laboratory (INL) Permit to Construct with Facility Emissions Cap. No emissions were observed above regulatory limits. All emissions of non-radiological air pollutants were well below applicable EPA and State of Idaho standards.

SOIL AND VEGETATION MONITORING

Although some low levels of radioactivity are present in the soil at some localized areas at NRF as a result of past operations, this radioactivity does not present a significant risk to on-site personnel, the general public, or the environment. These areas were monitored on a routine basis to verify that radioactivity is not migrating and to ensure that the risk remains insignificant. Therefore, NRF operations did not contribute to any measurable increase in the radioactivity of the surrounding environment.

CONTROL OF WASTES

Hazardous wastes were generated during site operations. On-site wastes were handled, controlled, and stored by trained personnel. Off-site disposal was arranged with licensed treatment, storage, and disposal facilities. The volume of solid, low-level radioactive waste generated was minimized by limiting the type and amount of materials that could become radiologically contaminated. All radioactive, hazardous, mixed, polychlorinated biphenyl, and asbestos wastes generated by NRF and shipped off-site by NRF were packaged in containers meeting US Department of Transportation requirements. Procedures and practices for controlling wastes continue to ensure compliance with all applicable regulations.

RADIATION MONITORING

Both NRF and the INL independently performed measurements of radiation levels along the NRF perimeter. NRF also performed background thermoluminescent dosimeter measurements at non-developed locations five to ten miles away from the NRF perimeter. A comparison between the average perimeter reading and average background reading indicates that NRF did not contribute to a detectable increase in off-site radiation levels. Additional independent monitoring performed by the INL also indicated that radiation levels surrounding NRF were comparable to natural background levels at distant off-site communities. Monitoring data continues to demonstrate compliance with all applicable regulations.

RADIOLOGICAL DOSE ASSESSMENT

The only potential radiation exposure to the public from NRF operations in 2023 was from airborne releases from normal operations. As such, effective dose equivalent to any member of the public is estimated using the CAP-88 (Clean Air Act Assessment Package-1988) (Reference 1) computer code, which is an EPA-approved modeling software.

In 2023, the resultant evaluation of airborne releases conservatively estimated an effective dose equivalent of 0.000093 millirem (mrem) per year to an individual off-site. This is well below the EPA airborne radiation exposure limit of 10 mrem per year (Reference 2). It is also well below the radiation exposure limit of 100 mrem per year established by the DOE and the Nuclear Regulatory Commission (References 3 and 4). The 100 mrem per year standard includes all potential exposure pathways.

Further, the dose is negligible when compared to the naturally occurring background radiation dose of approximately 366 mrem per year for residents of southeast Idaho. The dose is also much less than the approximate three mrem that an individual would receive from a single cross-country airplane flight.

CONCLUSION

Operations at the NRF site during 2023 did not have any adverse effect on human health or the environment at the site or at surrounding communities.

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INTRODUCTION

BACKGROUND

The Idaho National Laboratory (INL), which includes the Naval Reactors Facility (NRF), is owned by the United States (US) Department of Energy (DOE) and the Naval Nuclear Propulsion Program (NNPP). NRF is currently operated by Fluor Marine Propulsion, LLC. NRF has been operated for the NNPP since the inception of NRF in 1949. In 2016, the NNPP began using "Naval Nuclear Laboratory" to refer to the collective operations of the four DOE sites that perform NNPP work and the personnel operating at the associated locations. NRF is located on the INL site 6.3 miles from the nearest INL boundary (Figure 1). The developed portion of the facility within the security fence (the NRF Industrial Complex) covers approximately 89 of the 4,400 acres under the cognizance of NRF. The remaining 4,311 acres comprise the NRF Administration Area. Most of the INL site, including NRF, is a secure facility, which is not accessible to the general public. NRF provides the NNPP with unique capabilities for research and development of advanced naval nuclear propulsion plants

NRF has had environmental control programs in place since prototype operations began in 1953. The objective of these programs has been to meet or exceed the requirements of laws and regulations applicable at the time.

For many years, NRF and INL subcontractors have conducted environmental monitoring to demonstrate that NRF is being operated in accordance with environmental standards. The results have been published in the NRF and INL publicly available annual reports provided to Federal, State, and local officials. Historically, the monitoring results confirm compliance with environmental standards.

NRF's performance in radioactivity control has established and maintained levels of control that are equal to and in many cases more stringent than applicable requirements. The maximum possible annual dose to a member of the public resulting from NRF operations is calculated by using conservative assumptions of release and human uptake.

There are isolated areas at NRF where controlled releases of low-level radioactive liquids were made prior to 1979. Members of the public cannot come in direct contact with any of the small amounts of residual radioactivity still present at NRF.

Current NRF practices for handling chemical wastes conform with applicable Federal and State requirements, as confirmed by the US Environmental Protection Agency (EPA) and the State of Idaho. In the past, chemical waste disposal was carried out according to industrial practices common to the time; some wastes were sent offsite for disposal and some chemicals were disposed of at NRF. Consequently, some chemical residues containing heavy metals such as chromium, lead, and silver are detectable in isolated areas of soil immediately adjacent to some of the chemical disposal areas. Although hazardous contaminants have been detected in these areas, the levels involved are below regulatory requirements and do not pose a threat to members of the public.

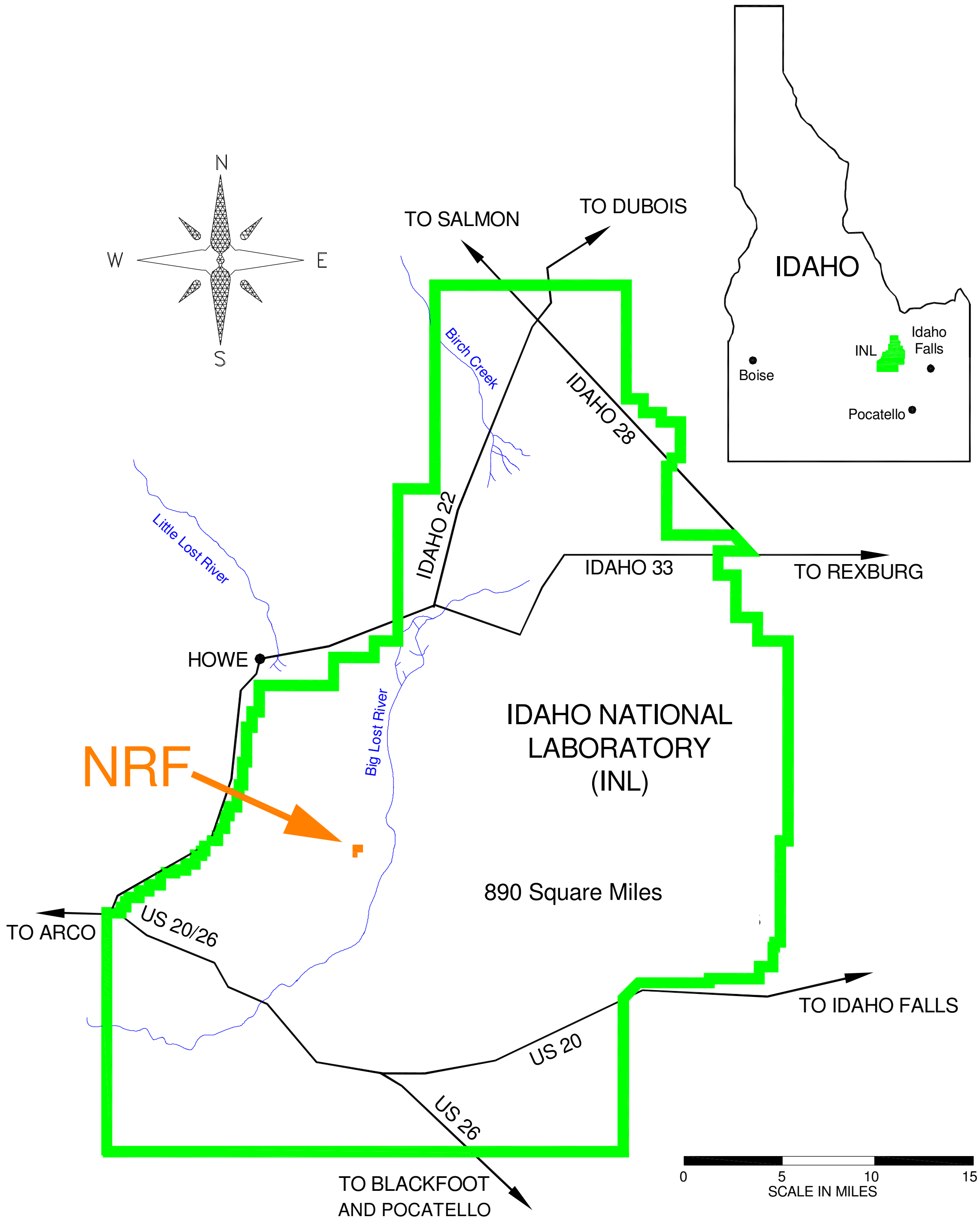

FIGURE 1 – RELATION OF NRF TO THE INL

GEOLOGICAL AND DEMOGRAPHIC SITE DESCRIPTION

The NRF site is located on a 4,400 acre parcel of land within the boundaries of the INL. The INL is comprised of 890 square miles extending across the northeast portion of the Snake River Plain, which covers parts of Butte, Jefferson, Bingham, Clark, and Bonneville counties in Idaho. The Snake River Plain is a U-shaped plateau approximately 300 miles long and 50 to 70 miles wide. Within its land area of 12,000 square miles, the Snake River Plain descends from an elevation of 6,000 feet in the east, near Ashton, Idaho, to 2,300 feet in the west, near Boise, Idaho. The plain is bordered on all sides by mountains, some exceeding 12,000 feet in elevation.

The NRF site is underlain by a succession of inter-layered flows of basaltic lava. These lava flows form layers of hard rock varying in thickness from 10 to 100 feet. These layers are interspersed with layers of sedimentary materials of various thicknesses. The Snake River Plain Aquifer lies approximately 385 feet below the land surface. Groundwater within the aquifer generally flows to the southwest.

Located in a semi-arid sagebrush steppe environment, NRF has an average daily summer temperature of 65.0 degrees Fahrenheit and an average daily winter temperature of 18.7 degrees Fahrenheit. Precipitation at NRF averages 8.4 inches annually, and prevailing winds are out of the southwest (Reference 5).

The largest urban areas surrounding the INL include Pocatello to the southeast and Idaho Falls to the east. Both cities are approximately 50 air miles from NRF. Several small farming communities are located on the western, northwestern, and southeastern boundaries of the INL. Approximately 176,000 people live within a 50-mile radius of NRF according to the 2020 census data.

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NRF HISTORY AND OPERATIONS

SITE HISTORY

The original mission of NRF was to demonstrate the feasibility of propelling submarines and surface ships with nuclear power. Also, the NRF naval nuclear propulsion prototypes served an additional major function as training facilities for Navy nuclear propulsion plant operators.

S1W Prototype Plant. The Submarine Thermal Reactor Mark I, first known as S1W, was the first prototype of a submarine nuclear reactor and the first installation at NRF. In August 1950, construction began on the S1W Prototype whose design eventually propelled the first nuclear powered submarine Nautilus (SSN 571). Initial operation of the S1W Prototype under nuclear power began on March 30, 1953. The S1W Prototype was used throughout its life to test advanced design equipment and new systems for nuclear propulsion projects and obtain data for future generations of nuclear propulsion plants. Support facilities, including a shielded cell, controlled water-shielded fuel handling area, and decontamination facility were constructed within the prototype structure to support the nuclear reactor.

Extensive testing was performed on reactor core components. The tests, conducted according to preplanned procedures and under carefully controlled conditions, yielded a large amount of core performance and survivability data. Use of the support facilities was drastically reduced in 1957, when the Expended Core Facility (ECF) was constructed with an improved capability for work on irradiated core components. After more than 36 years of operation, the S1W Prototype was defueled in 1989 and systems were placed in layup in 1990.

Following the S1W Prototype nuclear propulsion plant, two other prototype nuclear propulsion plants were constructed at NRF.

A1W Prototype Plant. The Large Ship Reactor Prototype (A1W Prototype), built in 1956, demonstrated the feasibility of operating two pressurized water reactor plants to power one propulsion shaft. The concept was then used to power Long Beach (CGN 9), the Navy’s first nuclear powered surface ship, and Enterprise (CVN 65), the Navy's first nuclear powered aircraft carrier. This modification allowed either plant to operate for testing purposes while the other plant was used for the training of Navy personnel, thus utilizing both reactors to their potential. The A1W Prototype continued to test new and advanced reactors for naval applications until its shutdown in 1994. Defueling and systems layup work were completed in 1999.

S5G Prototype Plant. The S5G Prototype, built in 1965, was designed to demonstrate the natural circulation concept for reactor cooling ultimately used in the Narwhal (SSN 671) nuclear powered submarine. This prototype was a pressurized water reactor having the capability to operate in either a forced circulation or a natural circulation flow mode, with cooling flow through the reactor generated by thermal circulation rather than pumps. Similar to the A1W Prototype, the S5G Prototype was shut down in 1995 and defueling and systems layup were completed in 1999

Expended Core Facility. The ECF, built in 1957 and substantially upgraded since then, this examination facility was designed to handle and examine naval nuclear spent fuel and reactor components as well as material and fuel samples irradiated in test reactors at other INL facilities. The tasks are accomplished in controlled water-shielded work areas. After removal from sealed shipping containers, the small samples are transferred into shielded cells for a more detailed examination. The ECF has other related functions: maintenance and repair work on NNPP radioactive material shipping containers and has the capability and equipment to load fuel modules into dry storage canisters for eventual shipment out of the State of Idaho to a permanent repository

The only non-naval fuel examined at the ECF has been the reactor cores removed from the Shippingport Atomic Power Station, the nation's first civilian nuclear power station. In the mid-1950s, the Atomic Energy Commission requested the NNPP to develop Shippingport. The Bettis Atomic Power Laboratory was the prime contractor responsible for this design. In 1987, the ECF examined the final Shippingport reactor core, the Light Water Breeder Reactor design, and provided measurement data that demonstrated a reactor core fueled by uranium-233 and thorium-232 could breed more fuel than was consumed during the life of the core.

SIGNIFICANT ACCOMPLISHMENTS

The technologies developed within the NNPP and tested at NRF are among the most valuable and sensitive military technologies in the United States. They constitute a critical element in the nation's defense system, making possible the extraordinary capabilities of the nuclear powered submarines and surface ships that today comprise more than 40 percent of the Navy's combatant fleet. The S1W plant proved, with its successful simulated non-stop, submerged, full power, voyage from Newfoundland to Ireland in 1953 that reliable nuclear propulsion of submarines was feasible. The A1W Prototype successfully demonstrated that the power necessary to propel a major surface vessel could be attained using propulsion trains, each powered by two reactors working together. As nuclear technology advanced, the S5G Prototype, housing a natural circulation reactor, was built to test a simpler and quieter reactor design. NRF continues to provide the NNPP with unique capabilities for research and development of advanced naval nuclear propulsion plants.

PRESENT OPERATIONS

The primary mission of the NNPP continues to be the design, development, testing, and operational follow of nuclear reactor propulsion plants for naval surface and submarine vessels. Specifically, the NNPP exists to support this nation’s capability to deploy and maintain a modern nuclear Navy. NRF supports the US nuclear fleet operations and development needs by providing the NNPP with unique fuel processing capabilities and accurate and timely nuclear examination data associated with ECF operations.

The major facilities at NRF including the three former naval reactor prototypes and the ECF are located within the NRF security fence (Figure 2).

Currently, construction of the new Naval Spent Fuel Handling Facility is underway. The facility will be a 213,000 square foot, three-story structure to support operations involved in the management of spent nuclear fuel prior to shipment to a permanent Federal repository. The Naval Spent Fuel Handling Facility will incorporate some of the capabilities that currently exist at the ECF and its support facilities as well as additional capabilities for handling spent nuclear fuel received in newly designed shipping containers. Future projects may also include other support buildings and infrastructure to increase efficiency and effectiveness of managing spent nuclear fuel and to support operations at the Naval Spent Fuel Handling Facility. The developed area of the NRF Site (Figure 2) will be updated when the project is completed.

In 2019, an agreement was signed between the NNPP and the Department of Energy Office of Environmental Management (DOE-EM) to perform decontamination and decommissioning (D&D) at the Naval Nuclear Laboratory sites. At NRF, the three nuclear prototypes were identified for D&D The D&D work will be performed by the DOE-EM, Idaho Cleanup Project contractor, over the next several years. This agreement transfers operational, radiological, and environmental responsibilities for the D&D work associated with the three prototypes to DOE-EM as each prototype is ready for D&D.

The D&D of the three NRF prototypes are being performed as Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) non-time critical removal actions, consistent with the 1995 DOE and EPA joint policy for decommissioning DOE facilities. This 1995 policy established CERCLA non-time critical removal actions as the preferred method to remove DOE facilities. An Engineering Evaluation/Cost Analysis was developed for the final end-state of the S1W and A1W prototypes. Details of this evaluation, DOE/ID-12046, and the associated Action Memorandum, DOE/ID-12051, describing the final end state of this project are available at https://idaho-environmental.com/ARIR/.

The S1W Prototype, along with its surrounding and support area, was formally turned over to the DOE-EM contractor on January 27, 2022. On June 5, 2023, the first phase of the A1W Prototype complex was turned over to the DOE-EM contractor for D&D. This first phase of the D&D project included some A1W support buildings, diesel fuel oil storage tank revetment, radioactive water processing system, and various slab/foundations. The second phase of the D&D included parts of the A1W building, including the A1W Prototype, and were turned over on November 13, 2023. The third

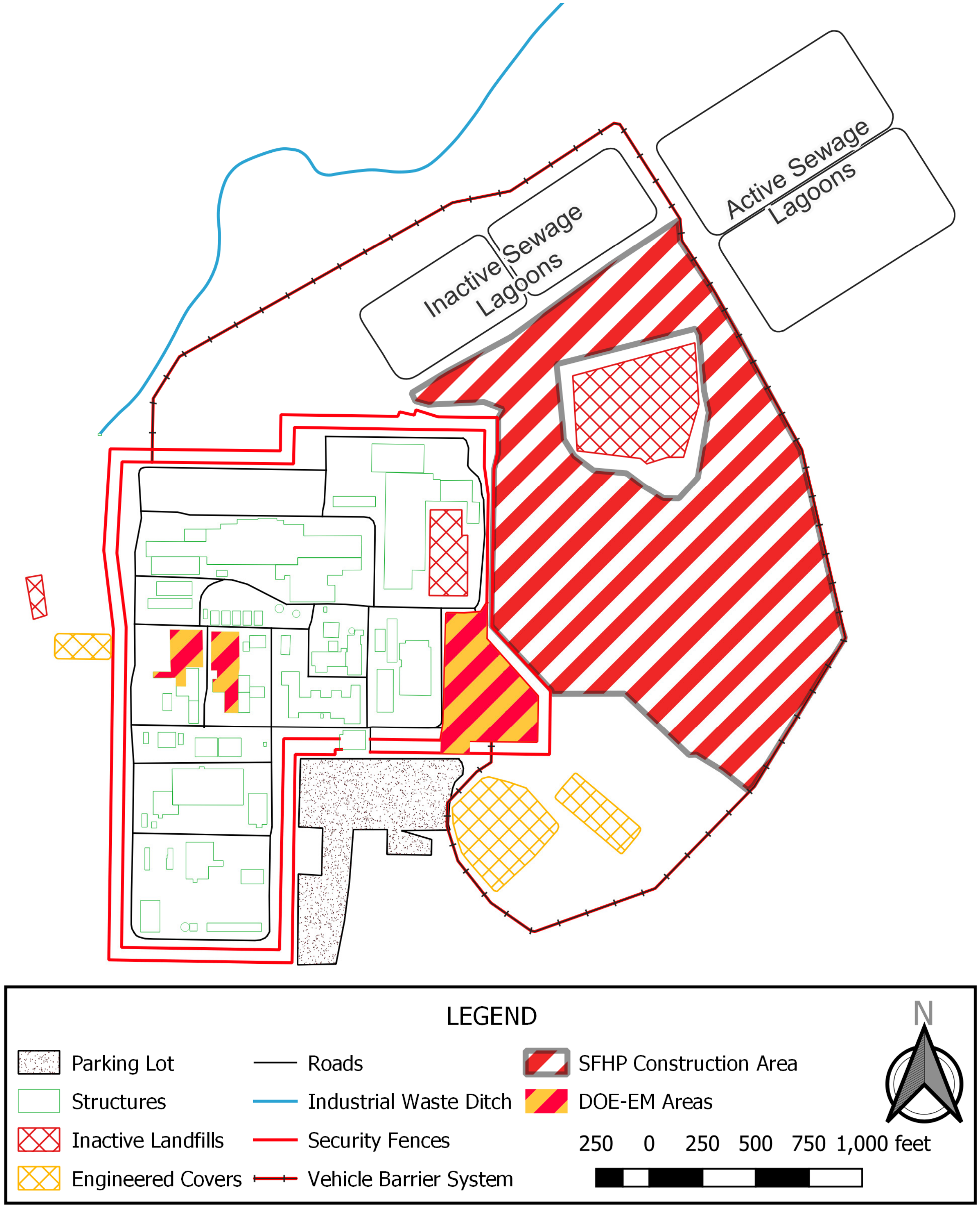

FIGURE 2 – THE NAVAL REACTORS FACILITY

and final phase of this project, that includes the remaining portion of the A1W building, is expected to be turned over later in 2024.

Upon turnover of the facilities from NRF, DOE-EM assumed responsibility for compliance with applicable regulatory requirements for both S1W and A1W projects, including any permitting, monitoring, and reporting activities associated with this project. Therefore, this report does not address environmental information related to the S1W and A1W projects and support areas after turnover.

Current facilities, processes, and operations that are being used to support the mission of NRF are discussed below with a brief description explaining their function.

Expended Core Facility. The ECF receives fuel removed from naval reactors for examination. Since naval nuclear fuel is robust in nature and designed to meet the stringent operational requirements for naval nuclear propulsion reactors in ships of war, the fuel maintains its integrity indefinitely under the less demanding conditions encountered during storage. Measurements of the corrosion rates for naval fuel designs have shown that naval spent nuclear fuel can be safely stored indefinitely wet or dry with no adverse effects to the environment. In addition to spent fuel, the ECF also receives irradiated materials testing specimens for examination.

Developmental nuclear fuel material samples, naval spent fuel, and irradiated reactor plant components/materials are examined at the ECF. The knowledge gained from these examinations is used to improve current designs and to monitor the performance of existing reactors. The examination of naval spent fuel performed at the ECF is critical to the design of longer-lived cores, which results in the creation of less spent fuel requiring disposition. NRF also prepares spent naval nuclear fuel for dry storage. Over many decades, the NNPP has safely shipped hundreds of containers of spent nuclear fuel without injury to a member of the public or a release of radioactivity to the environment.

The ECF is a single building about 1,000 feet long and 194 feet wide, with a 38-foot high bay running the length of the building. The high bay contains 4 water pool work areas 20 to 45 feet deep designed for safe underwater disassembly, examination, and analysis of radioactive components and irradiation tests. The high bay area enclosing the water pools and servicing areas has four large overhead cranes.

The water pools contain 3.2 million gallons of water, which is cooled to prevent algae growth and enhance clarity. All this water is recirculated and filtered so no radioactive liquid is discharged to the environment.

The ECF also contains several shielded cells for remote manipulation of radioactive materials. The shielded cells are adjacent to the high bay area and are fully enclosed. These cells are maintained at a negative air pressure with ventilation exhausted through charcoal and high efficiency particulate air filters. The effluent downstream of the filters is monitored to confirm that emissions are very low. The cells have been refurbished and updated to improve their working capacity.

All radioactive water generated at NRF is collected and processed through a filtration and ion exchange system to remove particulate materials and reduce the radioactivity levels. The processed water is then reused. The system filters and resin are disposed of as solid radioactive waste. All of the essential processing facilities for liquid and solid waste are serviced by filtered and monitored exhaust systems. All of the solid radioactive waste is disposed of in compliance with current regulations.

Spent Fuel Packaging Facility. The Spent Fuel Packaging Facility is presently capable of receiving spent fuel directly from the ECF water pools. Baskets of spent fuel are loaded and seal welded into Spent Fuel Canisters. These canisters are loaded into concrete shielded overpacks, and the loaded overpacks are moved to a temporary dry storage facility.

The Spent Fuel Packaging Facility consists of three distinct facilities, the Overpack Construction and Storage Facility, the Canal Dry Processing Facility, and the South End Extension. Pathways between the facilities provide for movement of the overpacks using a combination of air pallets and crawler transport vehicles.

> **Overpack Construction and Storage Facility.** This facility contains an area equipped with a crane and utilities necessary for constructing concrete shielded overpacks. Another portion of the facility provides for temporary storage of loaded and unloaded overpacks.
>
> **Canal Dry Processing Facility.** This facility is equipped with two cranes and receives spent fuel directly from the ECF water pools and contains a loading station for placing the fuel into the canisters and shielded overpacks. A canal connects this facility with the ECF water pools.
>
> **South End Extension Facility.** This facility receives baskets of spent fuel transported from the Canal Dry Processing Facility in a shielded container. The facility contains four stations located in a single pit; two stations are for an inactive process and two are used for loading and sealing spent fuel canisters and overpacks. The building contains a high bay with two overhead cranes.

Cask Shipping and Receiving Facility. In 2016, this facility began receiving shipping containers loaded with canisters of spent naval fuel. The canisters were removed from the shipping container and placed into concrete shielded overpacks that are temporarily stored in the Overpack Storage Facility until a permanent off-site repository becomes available. The facility is a high bay structure with two railcar bays, a pit with two ports for shipping container operations, and a single overhead crane.

Chemistry Laboratories. NRF maintains a chemistry laboratory that performs chemical analyses, radiochemistry, and isotopic identification. The chemistry lab is located at A1W for the support of NRF operations, remediation work, ECF support, and environmental monitoring.

Boiler House. The first boiler house at NRF was located in S1W. A second boiler house was later placed north of the machine shop. Both were replaced in 1958 by the existing boiler house located north of the Administration Building. The boiler system included three diesel oil fired saturated steam boilers (Boilers 1, 2 and 3) and all necessary auxiliaries. As of 2018, these boilers were removed from service. NRF installed two new portable boilers, designated as Boiler 4, in late 2016 and Boiler 5 in 2017. These two new portable boilers are located to the south and to the west of the existing boiler house. Steam is supplied to various NRF buildings for heat. Fuel oil is trucked to the facility and stored in two above ground 25,000-gallon storage tanks surrounded by concrete revetments.

Craft Support Buildings. To support planned facility maintenance, NRF has a site services craft shop. This shop has a fully equipped machine shop capable of handling most facility components. Also located within the shop are a pipe fitting area, welding booths, sheet metal shop, rigging loft, mechanics area, carpenter shop, paint shop, and a locksmith shop.

Warehouses. There are several different warehouses on site. Some of these are used for spare parts and general warehousing. Others are used for the storage of records, radioactively contaminated components, or by subcontractor personnel. Warehouses containing radioactive material are controlled as Radioactive Material Storage Areas.

Sewage Treatment Lagoons. In 2012, NRF began operation of a 21-acre, dual-cell, lined sanitary sewer lagoon complex. These lagoons were installed to replace the existing clay lined lagoons that had been in operation since the 1960s. This sanitary sewage lagoon complex is located northeast of the previous lagoons.

Industrial Waste Ditch (IWD). The IWD, an evaporative-percolation type wastewater disposal system, was used to channel non-hazardous, non-sewage wastewater from stormwater, snowmelt runoff, and NRF operations as discussed in the Liquid Effluent Monitoring section. The IWD follows the course of two old stream beds that have been connected, straightened, and deepened by dredging. The large uncovered portion of the IWD is 3 to 10 feet wide, running approximately 3.2 miles in length. Because discharges to the IWD have decreased dramatically with the shutdown of the three prototype plants and the associated support equipment, water, 1 to 2 feet in depth, generally occupies only the first 300 yards of the uncovered portion of the IWD.

Deep Wells and Drinking Water System. NRF has six deep wells that provide water for all operations at NRF. Two of these wells are not currently being used. Five of the six wells are between 500 and 600 feet deep and one well is approximately 1,300 feet deep. Two wells (NRF-3 and NRF-14) are used for drinking water. The other two working wells (NRF-1 and NRF-4) are used primarily for site production, lawn watering, and fire protection. One well (NRF-2) was used until 2006 for drinking water, but is currently out of service with the intention that it could be returned to service in the future if needed. Wells 2 and 5 are only used as observation wells.

Fire Water Tank. A new 150,000 gallon fire water tank was recently constructed. This large tank is needed to support NRF operations. Once commissioning of this tank is finalized, it will replace an older smaller tank currently in use.

Demineralizer Facility. Many NRF operations require the use of demineralized water that is processed from well water. Previously this process used large quantities of sulfuric acid and sodium hydroxide for regeneration of the ion exchange resin used in the demineralizers. Prior to 1985, the acid and basic reagent solutions were discharged directly to the IWD where the acid and basic reagents self-neutralized in the channel. In 1985, a facility to neutralize these solutions and monitor pH prior to discharge was put into operation, and direct discharge of demineralizer regeneration solutions to the IWD was terminated. In 1997, a reverse osmosis water purification system was installed, eliminating the need for ion exchange resin and the resulting regeneration solutions.

Hazardous Waste Management. Hazardous waste routinely generated at NRF is managed in satellite accumulation areas in accordance with Federal and State regulations. Once full, containers are transferred to a Central Accumulation Area for less than 90-day storage. Hazardous wastes stored in this less than 90-day area are manifested and shipped to an off-site EPA-permitted facility for treatment or disposal by the INL.

Radioactive Waste Storage. NRF has temporary storage areas for the collection of radioactive wastes. Until April 2021, NRF Remote-Handled Low-Level Waste was disposed at the INL Radioactive Waste Management Complex (RWMC). The RWMC is an INL facility under the cognizance of the DOE Idaho Operations Office. The RWMC has closed and no longer receives radioactive waste shipments. The Remote-Handled Low-Level Waste Disposal Facility located on the INL now accepts NRF Remote-Handled Low-Level Waste. All non-CERCLA contact handled wastes are shipped to commercial facilities for recycling, volume reduction, or disposal.

Mixed Waste Storage. Mixed wastes generated at NRF are managed in satellite accumulation areas in accordance with Federal and State regulations. Full containers of mixed waste are placed in a Central Accumulation Area for less than 90-day storage. Mixed wastes are manifested and shipped to an off-site EPA-permitted facility for treatment or disposal through the INL.

Radioactive Airborne Effluents. Ventilation air from radiological facilities is discharged to the atmosphere through exhaust vents and stacks. Prior to release, air with significant potential to carry radiological particulates is passed through high efficiency particulate air (HEPA) filters and monitored to ensure compliance with existing radiation protection guidelines. Additionally, exhaust from fuel examination is passed through a second bank of HEPA filters as well as charcoal absorbers. The filtered air exhausted from NRF radiological facilities typically contains less particulate radioactivity than that in the background air that was drawn into the facilities.

Monitoring of exhaust air is accomplished through the collection and analysis of samples of the effluent. Sampling techniques used include filter papers (for particulates), activated charcoal cartridges (for iodine gas), and molecular sieve canisters (for tritium).

CONCLUSIONS

After decades of operation, NRF has had no significant impact on the environment or adverse effect on the surrounding communities. NRF has a well-defined program in place to protect the environment, to comply with State and Federal environmental requirements and interagency agreements, and to address remediation of the isolated residues from previous activities.

The purpose of this report is to summarize NRF environmental monitoring program results for calendar year 2023. This report also evaluates current operations at NRF and documents compliance with applicable regulations governing the use, emission, and disposal of solid, liquid, and gaseous materials.

ENVIRONMENTAL PROGRAM AND COMPLIANCE

ENVIRONMENTAL PROGRAM

POLICY

NRF is committed to conducting operations and activities in a manner that provides and maintains safe and healthful working conditions, protects the environment and the public, and conserves natural resources. NRF is committed to environmental excellence through compliance with all applicable Federal, State, and local regulations; proactive planning to integrate sound environmental, safety, and health principles; and a solid commitment to waste minimization and pollution prevention.

OBJECTIVES

The objectives of the NRF environmental monitoring program are to:

- Demonstrate compliance with regulatory requirements;
- Demonstrate site operations do not significantly impact the environment;
- Confirm the effectiveness of control methods in preventing increases in environmental radioactivity levels;
- Confirm that the potential radiation exposure received by a member of the public is insignificant compared to the dose received from natural background radioactivity;
- Maintain an accurate record of NRF effluent releases to the environment;
- Notify appropriate regulatory agencies of potential compliance concerns; and
- Provide accurate monitoring results to applicable Federal, State, Tribal, and local officials and to the general public.

ORGANIZATION

NRF employs environmental professionals who are responsible for identifying, interpreting, and communicating environmental requirements to NRF personnel for implementation; assisting NRF organizations in meeting their environmental responsibilities; monitoring environmental activities for compliance; interfacing with regulatory agencies; and completing required regulatory reports.

ENVIRONMENTAL, SAFETY, AND HEALTH MANAGEMENT SYSTEM

The Environmental, Safety, and Health Management System documents the management processes and systems to perform work in a manner protective of employees, the public, and the environment, while ensuring regulatory compliance. Environmental performance objectives, performance measurements, and commitments are prepared and reviewed annually. The management processes and systems are used to identify, communicate, implement, assess, and update environmental programs at NRF.

ENVIRONMENTAL COMPLIANCE

Compliance with environmental regulations is an integral program objective and is essential for successful facility operations. Compliance with environmental regulations is demonstrated by several methods. For example, Federal, State, and local regulatory personnel periodically perform site visits and compliance inspections. During 2023, five site inspections/visits were performed at NRF by Federal, State, or local agencies. A list of the inspections/visits for the past five years is shown in Table 1. These inspections/visits did not identify any noncompliant issues. If questions or deficiencies are identified during these inspections, they are immediately addressed and promptly corrected.

TABLE 1– SUMMARY OF INSPECTIONS/VISITS BY REGULATORY AGENCIES

Date	Purpose	Regulatory Agency
4/10/2019	Annual Industrial Reuse Permit inspection. No deficiencies were noted.	Idaho Department of Environmental Quality (IDEQ)
5/9/2019	Hazardous waste compliance inspection of waste storage areas. No deficiencies were noted.	IDEQ
11/19/19	Site inspection for nuclear waste.	Department of Energy
11/20/19	Site familiarization tour for new staff members.	IDEQ
2/25/20	Site familiarization tour for new staff members.	IDEQ
9/15/21	Champion Batch Plant Air Permit Inspection.(1) No deficiencies were noted.	IDEQ
2/2/22	Drinking Water Sanitary Survey.	IDEQ
6/16/22	CERCLA Site Tour/Visit.	IDEQ/EPA
10/25/22	Participation in Emergency Response Drill.	IDEQ-INL Oversight
4/25/23	Tour with EPA and IDEQ on the site prototypes.	IDEQ/EPA
7/25/23	Familiarization tour with IDEQ of the water and wastewater utilities.	IDEQ
10/3/23	Tour with EPA and IDEQ on the site prototypes.	IDEQ/EPA
10/11/23	Air quality compliance inspection.	IDEQ
10/26/23	Familiarization tour with the Idaho Site Historic Preservation Office on the prototypes and other buildings on-site.	Site Historic Preservation Office

(1) This air permit was issued to an NRF subcontractor for the operation of a concrete batch plant on the NRF site.

There were no Federal, State, or local Notices of Violation or other types of enforcement actions issued to NRF in 2023.

Internally, compliance is evaluated during environmental audits and evaluations performed by elements of the NNPP, the NRF Site Assessment organization, and by self-assessments and surveillances performed by professionals in the NRF Environmental organizations, and other site personnel (e.g., technicians, engineers, and managers).

Compliance with regulatory requirements is also demonstrated by effluent and environmental monitoring results. These results are discussed in this report. Compliance is also reported in many other environmental reports prepared each year. A number of environmental related reports were submitted to Federal, State, and local agencies during the year.

NRF operated under four environmental permits in 2023 that were issued by regulatory agencies. These permits are shown in Table 2.

NRF must meet all applicable environmental laws and regulations. A description of environmental compliance with key environmental regulations at NRF is provided.

TABLE 2 – NRF ENVIRONMENTAL PERMITS

Permit Number	Permit Type	Issuing Agency	In Compliance	Expiration Date	Other Information
MB 04294B-2	Federal Fish and Wildlife Permit	US Fish and Wildlife(1)	Yes	3/31/2025	Migratory Bird Permit
P-2020.0045	INL Permit to Construct with Facility Emissions Cap	IDEQ(1)	Yes	1/29/2026	This Permit to Construct serves to limit total INL emissions below Tier I permitting thresholds.
25012	Scientific Collecting Permit	Idaho Department of Fish and Game(1)	Yes	12/31/2023(2)	Wildlife Salvage Permit
EPA ID No. ID48900008952	Resource Conservation and Recovery Act (RCRA) Storage and Treatment Permit	IDEQ(3)	Yes	11/20/2024	Hazardous and Mixed Waste Management Permit

(1) These permits were issued to the INL, which includes NRF.

(2) In January 2024, the INL completed the submittal to renew this annual permit.

(3) This permit is issued to the INL, which includes NRF. NRF does not have any permitted units.

CLEAN AIR ACT (CAA)

The CAA was originally passed in 1955 to protect and enhance the quality of the nation's air resources. The CAA was completely replaced by the Air Quality Act of 1967, although the common name "Clean Air Act" was retained. However, these laws did not have control or enforcement strategies.

Amendments adopted in 1970 set ambient air quality standards and controls for emissions from stationary, mobile, and new stationary sources. These amendments also control hazardous air pollutants (HAPs). Amendments adopted in 1977 established a standard basis for rulemaking regarding criteria for national ambient air quality standards, new source performance standards, HAP standards, motor vehicle standards, fuel and fuel-additive provisions, and aircraft emission standards.

The CAA Amendments of 1990 comprehensively revised existing US air laws to provide for the attainment and maintenance of national ambient air quality. The 1990 amendments revised ozone and carbon monoxide (CO) classifications and pollutant control strategies for urban areas, tightened vehicular emission standards, required the production of clean-fuel vehicles, reformulated gasoline, mandated the regulation of new and existing sources of 189 HAPs, developed maximum achievable control technologies, required reductions of power plant sulfur dioxide (SO_2) emissions, developed utility emission standards for nitrogen oxides (NO_x), called for the establishment of a new permit system for major sources that consolidates all applicable emission control requirements, and mandated a production phase-out of the five most destructive ozone-depleting chemicals by 2000. These amendments also strengthened the EPA civil and criminal enforcement powers to address violations of the CAA.

The majority of the CAA regulations that affect the NRF site have been delegated by the EPA to the IDEQ. Many non-radiological air emission sources at NRF are regulated under the IDEQ Air Permitting Program. Specific requirements to demonstrate CAA compliance are specified in the INL Permit to Construct with Facility Emissions Cap relative to operation of various pieces of equipment at the INL. NRF boilers and emergency diesel generators must comply with requirements in the INL Permit to Construct with Facility Emissions Cap. NRF must also comply with all general provisions of the permit, which includes recordkeeping, reporting, fugitive dust control, and visible emission limits.

The INL Permit to Construct with Facility Emissions Cap limits the total INL emissions to 25 tons per year of all HAPs, 10 tons per year of any single HAP, and provides various limits on Criteria Air Pollutants.

The EPA, under the Code of Federal Regulations (CFR), 40 CFR Part 61, Subpart H, regulates radionuclide air emission sources at the DOE Facilities. The results of NRF airborne radiological effluent monitoring for 2023 have shown that the amount of radioactivity released at NRF was too small to result in any measurable change in the background radioactivity levels in the environment. Annual emission reports are provided to the EPA, as required by the regulations.

The EPA enacted Mandatory Reporting of Greenhouse Gases regulations in 2009 (40 CFR Part 98). Each year since this rule was finalized, up to and including 2016, the INL submitted a Mandatory Greenhouse Gas Report to the EPA. Because the INL emissions had not exceeded the threshold of

25,000 tons carbon dioxide equivalent for five consecutive years, the INL was allowed to discontinue submitting this report to the EPA. The INL still quantifies carbon dioxide equivalent emissions each year to ensure that its emissions remain below the threshold.

CLEAN WATER ACT (CWA)

The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the US and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972 and was named the Clean Water Act. The CWA expresses two over-arching national goals: eliminating the discharge of pollutants into navigable waters by 1985; and achieving an interim water quality level that would protect fish and provide for recreation wherever attainable by 1983. Although these broad goals have not yet been achieved, they are intended to be achieved in the future through the elimination of both point and non-point source pollutant discharges to waters of the US.

Discharges of pollutants to any waters of the US are required to be permitted by this act. Significant programs relative to protecting water quality include; section 402 (National Pollutant Discharge Elimination System (NPDES)), section 404 (dredge and fill), section 311 (oil spill prevention and response), section 303 (water quality standards and total maximum daily load), and section 401 (State water quality certification process). The EPA, in partnership with the US Army Corps of Engineers (Corps) and other Federal (e.g., the Natural Resources Conservation Service) and State environmental agencies, oversee the implementation of various CWA programs. The EPA has the primary authority for administering the CWA. The Corps generally implements the section 404, dredge and fill permit program; however, the EPA has the final authority over all decisions made in this program.

Based on a comprehensive evaluation of the site-specific hydrology and the requirements associated with the CWA, in 2017 the EPA determined that a reasonable potential does not exist for storm water or wastewater from industrial or construction activities at NRF to discharge to waters of the US (Reference 6).

In 2018, the EPA approved the Idaho Pollutant Discharge Elimination System (IPDES) Program and authorized the transfer of permitting authority to the State of Idaho for wastewater discharges. The goal of IPDES, like NPDES, is to address water pollution by regulating point sources that discharge pollutants to waters of the US. Therefore, neither NPDES nor IPDES permits are required for construction- or industrial-related storm water discharges, and/or industrial wastewater discharges at the NRF site. However, as a best management practice, NRF implements internal programs that mirror many aspects of the NPDES program in order to help eliminate the discharge of pollutants to the environment.

In 2007, the IDEQ issued NRF an Industrial Reuse Permit for the discharge of industrial wastewater to the IWD. The discharges under this Industrial Reuse Permit were not discharged to waters of the US based on the 2017 EPA determination. This permit required the sampling and monitoring of groundwater, IWD wastewater effluent, IWD sediment, drinking water, and effluent flow measurements (hydraulic loading) on a routine basis. Results from this monitoring, along with any environmental impacts or non-compliant conditions occurring from NRF operations, were reported annually to the IDEQ and summarized in this report.

In the fall of 2020, NRF completed the rerouting of industrial wastewater from the IWD to the non-discharging, lined, evaporative sewage lagoons. On January 4, 2021, the IDEQ approved NRF's Industrial Reuse Permit closure plan and terminated the permit. Effluent sampling is not required at the IWD but will continue to be done as a best management practice. NRF will continue to monitor groundwater as required in the IDEQ approved Closure Plan.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

In 1980, Congress enacted CERCLA, commonly referred to as "Superfund". The CERCLA impetus was the emerging realization that inactive hazardous waste sites presented a great risk to public health and the environment and that existing law did not address these abandoned disposal sites. CERCLA was designed to respond to situations involving the past disposal of hazardous substances. As such, it complements the RCRA, which regulates on-going hazardous waste handling and disposal.

The National Priorities List (NPL) is an important facet of CERCLA response procedures. First established in 1981 under section 105(a)(8)(B) of CERCLA, the NPL is part of the National Contingency Plan and must be updated annually to list sites warranting evaluation and/or cleanup under CERCLA.

Hazard ranking calculations performed according to Federal guidelines for judging the significance of chemical and radioactive residues have been conducted in accordance with Federal law. These calculations indicate that NRF itself scored well below the cutoff for designation to the NPL of high priority sites requiring prompt action to protect public health and safety. While NRF did not qualify for listing on the NPL as an individual facility, it was included with other INL facilities on the NPL and in the corresponding Federal Facility Agreement and Consent Order (FFA/CO) and Action Plan that was signed in 1991.

Under the FFA/CO, 87 sites were identified at NRF for investigation to determine potential risks to human health and the environment. Thirteen of the 87 sites were already evaluated prior to the FFA/CO under the RCRA Consent Order and Compliance Agreement that preceded and was replaced by the CERCLA FFA/CO. The remaining 74 sites were assessed as CERCLA-type investigations. The CERCLA investigations included Track 1, Track 2, and Remedial Investigation/Feasibility Study (RI/FS) type investigations. A Track 1 investigation involved sites that were believed to have a low probability of risk and sufficient information available to evaluate the sites and recommend a course of action. A Track 2 investigation was conducted at sites that did not have sufficient data available to make a decision concerning the level of risk; for these sites, additional data collection was necessary. A RI/FS is the most extensive CERCLA investigation. It is intended to characterize the nature and extent of contamination, to assess risks to human health and the environment from potential exposure to contaminants, and to evaluate potential cleanup actions. In addition to the investigations performed for each site through a Track 1, Track 2, or RI/FS process, a comprehensive RI/FS was performed to assess the potential cumulative, or additive, effects to human health and the environment from all sites at NRF.

The investigation of the 87 sites resulted in 63 sites that required no action and were released for unrestricted use, 12 sites that only required institutional controls to prevent access to the sites because a source or potential source was present (referred to as "No Further Action" sites), and 12 sites that required remedial action. The remedial actions were completed at the 12 sites under two Records of Decision signed in 1994 and 1998 by Naval Reactors, the State of Idaho, and the EPA.

In 2008, one site was reclassified from a No Further Action site to a site released for unrestricted use. In 2012, a minor change to the 1998 Record of Decision (ROD) released four No Further Action sites for unrestricted use (i.e., removed institutional controls) since it was determined that the source or potential source present represented an acceptable risk. During 2017, an additional No Further Action site was remediated per a minor change to the 1998 ROD. The site was released for unrestricted use to support future development and construction activities. Six No Further Action sites remain under institutional controls.

During construction activities near a site that was previously assessed under the FFA/CO and did not require action and was released for unrestricted use, analytical data indicated higher than expected levels of polychlorinated biphenyls (PCBs) in the soil. A minor change to the ROD was issued to remediate the site to below remediation goals that would allow the site to be released again for unrestricted use. Remediation of the area was completed in 2021 and the site has been released for unrestricted use in 2022 after receiving regulator concurrence. Signs and excavation controls were established for the PCB contaminated building footings that are adjacent to the remediated soil that contained elevated PCBs.

The CERCLA monitoring data collected at NRF continues to support the conclusion that NRF operations have not had a significant impact on the environment or adverse effect on the surrounding communities. NRF has a well-defined program in place to protect the environment, to comply with the State and Federal environmental requirements and interagency agreements, and to address remediation of the isolated residues found in the environment from historical activities.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

All Federal agencies must comply with the planning and reporting provisions of EPCRA. Sections 302 to 304 of EPCRA (Subtitle A) require the creation of emergency response and emergency planning authorities. These authorities are known as the State Emergency Response Commission and the Local Emergency Planning Committee. This subtitle also requires facilities that have extremely hazardous substances (EHSs) above their respective Threshold Planning Quantity to give notice that these substances are present at that facility and to report releases of those substances and other listed hazardous substances in excess of their respective reportable quantity.

Sections 311 to 313 (Subtitle B) established the reporting requirements under EPCRA. The status for EPCRA reporting at NRF is shown below in Table 3. Section 311 requires the submission of Material Safety Data Sheets/Safety Data Sheets (MSDSs/SDSs) or a list of chemicals (grouped by hazard category) for which a MSDS/SDS is required. Reporting is required for hazardous chemicals stored on-site in quantities greater than 10,000 pounds and for EHSs present in quantities greater than 500 pounds or the Threshold Planning Quantity (whichever is less). Under Section 312, NRF coordinates with the INL to complete an annual Tier II Inventory Report for all hazardous chemicals present in excess of the specified quantities during the previous calendar year. The information is submitted to the State Emergency Response Commission, Local Emergency Planning Committee, and local fire departments for emergency planning purposes.

TABLE 3 – STATUS OF NRF SITE EPCRA REPORTING

EPCRA Section	Description of Reporting	Status
EPCRA Sec. 302-303	Planning Notification	Notification completed for the calendar year
EPCRA Sec. 304	EHS Release Notification	Notification completed for the calendar year
EPCRA Sec. 311-312	MSDS/SDS/Chemical Inventory	Notification completed for the calendar year
EPCRA Sec. 313	Toxic Release Inventory (TRI) Reporting	Notification completed for the calendar year(1)

(1) Notification is required due to INL inventory, which includes NRF. Individually NRF met the "otherwise use" TRI reporting threshold for naphthalene.

Section 313 of EPCRA established the Toxic Release Inventory (TRI), which requires certain facilities with North American Industry Classification System (NAICS) codes to report annually to the EPA on whether they manufacture, process, or otherwise use any of the listed toxic chemicals above the designated activity thresholds. The Federal Facility Compliance Act (FFCA) requires all Federal facilities regardless of NAICS code to complete TRI reports if the listed activity threshold quantities are exceeded. During 2001, the EPA lowered the Section 313 reporting thresholds for chemicals classified as persistent, bioaccumulative, and toxic. Individually, NRF met the Section 313 "otherwise use" reporting threshold for naphthalene. The INL also had additional toxic chemicals above reporting thresholds in 2023. This requires NRF to report its chemical inventory for these additional chemical constituents, as well as naphthalene, via the INL to comply with Section 313 of EPCRA.

FEDERAL FACILITY COMPLIANCE ACT

The FFCA was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act. The FFCA applied certain RCRA requirements and sanctions to Federal facilities. In short, the FFCA waives sovereign immunity for Federal facilities from all civil and administrative penalties and fines; this includes waivers for both coercive and punitive sanctions for violations of the Solid Waste Disposal Act. Relative to mixed waste, waste that contains both hazardous and radioactive material, the FFCA gave the DOE sites until October 1995 to develop Site Treatment Plans (STPs) with schedules for mixed waste treatment and to obtain approval from the appropriate Federal or State regulatory agencies. NRF is included in the INL STP, which is updated annually.

The STP identifies the planned treatment options, schedules for shipment to selected treatment facilities, and arrangements for pre-treatment storage and post-treatment residual management for each mixed waste stream. Projected schedules for the start of operation of selected treatment facilities are identified and a single schedule milestone for shipment to the treatment facility within 12 months of the start of facility operations is incorporated for each waste stream. Thus, on-site pre-treatment storage at the INL is planned until the selected treatment facilities are available. The STP also includes commitments to perform additional evaluations and to work with the IDEQ to determine the viability of alternative treatment options, in the event completion of a targeted treatment facility is delayed.

NRF generates some mixed waste as a result of site operations. This waste represents a very small percentage of the total amount of mixed waste generated from DOE facilities. The STP balances the concern of expeditious completion of treatment, cost/efficiency, minimizing shipments, and minimizing risk/liability, while representing the best overall plan for achieving compliance with Land Disposal Restriction (LDR) requirements for NRF mixed waste.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

The Insecticide Act of 1910 established the first Federal control over the use of pesticides. In 1947, Congress enacted FIFRA, which has since been amended several times. By 1972, this law was virtually rewritten. This statute gives the EPA the authority over the field-scale use of pesticides and requires the registration of all pesticides used in the US. The EPA restricts the application of certain pesticides through State-administered certification programs. Only State certified commercial applicators or personnel under their supervision are allowed to apply restricted-use pesticides at NRF. The applicator is responsible for providing the appropriate pesticides and application equipment, and for the proper use and disposal of all pesticide waste, including empty containers. Authorized site personnel are only allowed to apply general use (unrestricted-use) pesticides at NRF. The washing of restricted-use pesticide/herbicide application equipment and containers on-site is also prohibited.

All FIFRA required reports are completed by the certified applicator for all pesticides and rodenticides. All chemicals applied by a subcontractor, licensed commercial application, business, or under their guidance, are reported directly by the subcontractor.

LAND DISPOSAL RESTRICTIONS

Since the enactment of the RCRA in 1976, a nationwide movement has been underway to restrict the land disposal of hazardous wastes. The 1984 Hazardous and Solid Waste Amendments required the EPA to issue four major sets of regulations collectively referred to as the “Land Disposal Restrictions.”

The main purpose of the LDR program is to discourage activities that involve placing untreated wastes in or on the land when a better treatment or immobilization alternative exists. LDRs do not allow storage of restricted hazardous wastes, except for the purpose of accumulating such quantities as are necessary to facilitate proper recovery, treatment, or disposal. The amendments require that, prior to land disposal, all wastes meet treatment standards based on the “best demonstrated available technology.”

The same restrictions apply to mixed waste. However, because adequate mixed waste treatment capacity remains an issue, regulatory agreements have been executed to achieve compliance. (See the previous discussion related to the FFCA.)

MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act of 1918, as amended, is intended to protect birds that have common migration patterns between the US, Canada, Mexico, Japan, and Russia. Under this act, taking, killing, or possessing migratory birds is unlawful unless and except as permitted by regulation.

NRF is subject to a special purpose Federal fish and wildlife permit that allows the removal or relocation of a limited number of migratory bird nests under certain circumstances. The permit was issued to the DOE and is applicable to all facilities on the INL. The permit requires the DOE to submit an annual report to the US Fish and Wildlife Service of all migratory birds, nests, and eggs that were taken and/or salvaged. NRF provides the DOE with information about permit activity that occurs at NRF for inclusion in the report.

The Idaho Department of Fish and Game issued a Scientific Collecting Permit to the DOE for the INL, which provides State authorization for the activities allowed by the Federal Fish and Wildlife Service permit described above. It also provides authorization for capture, possession, and disposal of State protected animals. The State permit requires the DOE to submit an annual report of the activities carried out under the permit. NRF provides the DOE with information about permit activity that occurs at NRF for inclusion in the report.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Significant construction, renovation, and demolition activities are reviewed for their impact on the environment under NEPA requirements as provided by the DOE. Other physical construction projects or capital equipment that have the potential for creating new emissions to the environment also receive a NEPA evaluation. Categorical Exclusions and all NEPA documentation for NNPP DOE sites, including NRF, are posted online at www.energy.gov/NEPA/NEPA-documents. This website is linked to the DOE website located at www.nepa.energy.gov.

RESOURCE CONSERVATION AND RECOVERY ACT

RCRA, an amendment to the Solid Waste Disposal Act of 1965, was enacted in 1976 to address the safe disposal of solid wastes.

The goals set by RCRA are intended to:

- Protect human health and the environment from the hazards posed by waste disposal;
- Conserve energy and natural resources through waste recycling and recovery;
- Reduce or eliminate, as expeditiously as possible, the amount of waste generated, including hazardous waste; and
- Ensure management of wastes in a manner that is protective of human health and the environment.

To achieve these goals, RCRA established three distinct yet interrelated programs. The hazardous waste program, under RCRA Subtitle C, establishes a system for controlling hazardous waste from the time it is generated until it is ultimately disposed – in effect, from "cradle to grave." The solid waste program, under RCRA Subtitle D, addresses the disposal of nonhazardous industrial and municipal solid wastes. Finally, the underground storage tank program, under RCRA Subtitle I, regulates underground tanks storing hazardous substances and petroleum products. This discussion focuses mainly upon RCRA Subtitle C.

The regulations that the EPA promulgated to implement RCRA Subtitle C are structured to first identify the criteria to determine what solid wastes are hazardous, and then establish various requirements for the three categories of waste handlers: 1) generators, 2) transporters, and 3) Treatment, Storage, and Disposal (TSD) facilities. Additionally, the regulations set technical standards for the design and safe operations of TSD facilities and serve as a basis for developing and issuing the permits required by the Act for each facility.

RCRA, like most environmental legislation, encourages states to develop their own hazardous waste programs as an alternate to direct implementation of the Federal program. To this end, the EPA has delegated its authority to the IDEQ for all aspects of RCRA, with the exception of a few specific portions associated with the 1984 Hazardous and Solid Waste Amendments to RCRA.

The INL RCRA permit addresses hazardous wastes and mixed wastes management activities at the INL. Hazardous and mixed wastes typically come from Deactivation & Decommissioning, operations, and laboratory activities conducted at the INL. These wastes may be accumulated on-site in satellite accumulation areas, in central accumulation areas ("less than 90-day"), stored and treated on-site under a generator treatment plan or in a RCRA unit, or transported off-site to a TSD facility. Similar to the INL, NRF generates hazardous and mixed wastes from various activities. These wastes are stored either in satellite accumulation areas or in the NRF central accumulation areas. These wastes are subsequently shipped off-site to a TSD facility for treatment and/or disposal.

During 2023, NRF continued to operate as a hazardous waste generator. As such, NRF must follow specific requirements for the handling/accumulation of hazardous waste under applicable Idaho State regulations.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

The US Congress enacted TSCA in 1976. TSCA authorizes the EPA to secure information on all new and existing chemical substances and to control those substances determined to cause an unreasonable risk to public health or the environment. Unlike many other environmental laws, which generally govern discharge of substances, TSCA requires a review of the potential health and environmental effects prior to the manufacture of new chemical substances for commercial use.

PCBs are the primary TSCA-related substance of concern at NRF. They are regulated as a toxic substance under TSCA (40 CFR Part 761). PCBs can range in physical form from oily liquids to white crystalline solids. They were commonly used prior to 1979 mainly as a dielectric fluid in electrical equipment such as transformers and capacitors. In addition, they were added to certain paint coatings prior to 1980 to increase resistance to heat, chemicals, or fire.

NRF has removed all known PCB electrical transformers from the site. Remaining PCBs are primarily painted items and some lighting fixtures with PCB-containing ballasts. NRF employs strict controls for the proper handling and disposal of PCB items.

WASTE MINIMIZATION, POLLUTION PREVENTION AND RECYCLING PROGRAMS

The NRF waste minimization and pollution prevention program promotes pollution prevention and waste minimization by encouraging employees to reduce the use of hazardous materials, energy, water, and other resources while protecting existing resources through conservation and more efficient use. The program focuses mainly on process efficiency improvements, source reduction, inventory control, preventive maintenance, improved housekeeping, recycling, and increasing employee awareness of and participation in pollution prevention.

The goal of these programs is to minimize the quantity and toxicity of waste generated at its source and, if waste is generated, to ensure that the treatment and disposal method used minimizes the potential present and future threat to people and the environment. The program consists of the following elements:

- Control of chemical acquisitions, including type and quantity;
- Maximized use of on-hand chemicals;
- Minimized production of process wastes (source reduction); and
- Process evaluation/modification.

NRF ensures pollution prevention strategies are met by reviewing chemical purchases and major construction projects to incorporate source reduction strategies for environmentally hazardous substances and through recycling.

Consistent with the Environmental, Safety, and Health Management System, NRF has established and implemented a sustainable acquisition program. Progress in sustainable acquisition is reported annually to the DOE via the Naval Reactors Sustainability Report. Sustainable acquisition maximizes the amounts of material procured that contain recycled material. Environmentally preferable items reported in the NRF program include but are not limited to: paper and paper products; vehicular fluids (e.g., engine coolants and oils), construction materials (e.g., insulation, carpet, concrete, and paint); and transportation products (e.g., traffic barricades, traffic cones; park and recreation products); landscaping products; non-paper office products (e.g., binders, toner cartridges, and office furniture); and miscellaneous products (e.g., pallets, sorbents, and industrial drums).

NRF also maintains an extensive recycling program that includes cardboard, clothing/laundry, printer cartridges, scrap metal, batteries, scrap lead, cooking oil, aluminum cans, asphalt, concrete, oil, light bulbs, computer equipment/cell phones, soil/gravel, wood and other materials.

ENVIRONMENTAL MONITORING

PROGRAM OVERVIEW

The NRF environmental monitoring program, which includes both radiological and non-radiological monitoring, is conducted in accordance with accepted monitoring procedures and management practices to ensure compliance with applicable Federal, State, and local standards. A complete synopsis of sampling and analyses performed in support of the NRF environmental monitoring program can be found in Tables 4 and 5. Data from this monitoring program confirms that operations at NRF have not had adverse effects on the quality of the environment or the health and safety of the general public. These results are summarized below and discussed in detail in the following sub-sections.

The liquid effluent monitoring program includes sampling discharges to both the IWD and sewage lagoons. Samples of liquid effluent and sediment are collected at the IWD. IWD liquid effluent samples are analyzed for both chemical constituents and radioactivity while sediment samples are analyzed for radioactivity. At the sanitary sewage lagoons, samples of liquid effluent are collected and analyzed for radioactivity.

The drinking water monitoring program involves the collection of water samples at the wellheads (radiological) or at a point prior to entering the distribution system (non-radiological) to help ensure a high quality drinking water supply is maintained at NRF. Non-radiological samples are drawn from a sampling port prior to the distribution system. In addition, drinking water samples collected throughout the NRF distribution system are analyzed for lead, copper, and the presence of total coliform and *Escherichia coli* (E. coli) bacteria in accordance with Reference 7.

The groundwater monitoring program is designed to ascertain whether NRF operations have had an impact on groundwater quality. Samples are collected on an established schedule from eight groundwater monitoring wells surrounding NRF. Occasionally, samples are collected from other observation wells to provide additional groundwater characteristics about the aquifer. These samples are analyzed for chemical constituents and radioactivity.

Airborne emissions are monitored and/or calculated to ensure air emissions at NRF meet Federal and State standards. The emissions from boilers and engines are calculated based on fuel consumed, using standard emission factors published by the EPA. Trained and certified visual emissions observers monitor emissions from fuel-burning equipment at NRF. In addition, NRF monitors and/or calculates the airborne radioactivity emissions from radiological areas. These calculations are performed in accordance with established standards and guidelines.

Continuous direct measurement of radiation levels at the NRF site is accomplished by dosimeters located along the security fence and at non-developed locations five to ten miles away from the NRF perimeter. The INL conducts additional on-site monitoring independently at other locations along the NRF perimeter and measures radiation levels at off-site background locations.

TABLE 4 – RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
LIQUID EFFLUENT			
INDUSTRIAL WASTE DITCH			
Water (At Outfall)	Grab	Quarterly	Quantitative isotopic gamma
Water (At Outfall)	Grab (Composite)	Quarterly	Strontium-90 and tritium (H-3)
Sediment (At Outfall)	Grab	Quarterly	Quantitative isotopic gamma
Sediment (Along length)	Grab	Annually	Quantitative isotopic gamma
Vegetation (Along length)	Grab	Annually	Quantitative isotopic gamma
SEWAGE LAGOONS			
Water	Grab	Quarterly	Quantitative isotopic gamma
Water	Grab (Composite)	Quarterly	Strontium-90 and tritium (H-3)
DRINKING WATER			
On-site Wells	Grab	Quarterly	Gross alpha, gross beta, and tritium (H-3)
On-site Wells	Grab (Composite)	Annually	Strontium-90 and quantitative isotopic gamma
GROUNDWATER			
Regional Up-gradient Well and Effluent Monitoring Well	Grab	Semiannually	Tritium (H-3), strontium-90, and cesium-137
Site Down-gradient Wells	Grab	Annually	Tritium (H-3), strontium-90, and cesium-137
Regional Down-gradient Wells	Grab	As Needed Non-routine	Tritium (H-3), strontium-90, and cesium-137
AIRBORNE EMISSIONS			
Fixed Filter Air Samplers	Continuous	Monthly	Gross alpha and gross beta Quantitative isotopic gamma
Charcoal Cartridges	Continuous	Weekly	Iodine-131
Selected Emission Points	Calculated based upon production	Monthly	Carbon-14 Krypton-85 Iodine-129 Tritium (H-3)
Fugitive Air Emissions from Windblown Soil	Calculated based upon soil characterization	Annually	Cesium-137 and cobalt-60

TABLE 4 – RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM – CONT.

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
SOIL AND VEGETATION			
NRF Perimeter	Random Grab	Annually	Quantitative isotopic gamma
Engineered Cover Area S1W Leaching Beds and Old Sewage Basin	Random Grab and/or Radiation Survey(1)	Annually	Quantitative isotopic gamma and radiation level
Engineered Cover Area A1W Leaching Bed	Random Grab and/or Radiation Survey(1)	Annually	Quantitative isotopic gamma and radiation level
GENERAL SITE RADIATION			
NRF Perimeter Fence	Survey	Annually	Radiation level
Background Locations	Survey	Annually	Radiation level
Environmental Dosimeters (Perimeter, Background)	Continuous	Quarterly	Gamma exposure

(1) Collection method includes a combination of sample locations and survey locations.

TABLE 5 – NON-RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
LIQUID EFFLUENT			
INDUSTRIAL WASTE DITCH			
Water (At Outfall)	Composite	Monthly	Aluminum, antimony, barium, chloride, iron, manganese, nitrate as nitrogen, nitrite as nitrogen, nitrogen (total Kjeldahl), oil and grease, pH, potassium, sodium, specific conductance, sulfate, thallium, total dissolved solids (TDS), total suspended solids
DRINKING WATER[1]			
Drinking Water/ Distribution System at selected locations	Grab	Monthly	Coliform bacteria (total) and E. coli
Drinking Water/ Distribution System at selected locations	Grab	Three times from 2020 to 2028	Copper and lead
Drinking Water/ Manifold	Grab	Once during 2023 to 2028	Regulated Volatile Organic Compound (VOCs).
Drinking Water/ Manifold	Grab	Annually	Nitrate as nitrogen
Drinking Water/ Manifold	Grab	Once during 2020 to 2028	Nitrite as nitrogen
Drinking Water/ Manifold	Grab	Once during 2020 to 2028	Arsenic
Drinking Water/ Manifold	Grab	Once during 2020 to 2028	Antimony, barium, beryllium, cadmium, chromium, copper, fluoride, mercury, nickel, selenium, thallium
Drinking Water/ Manifold	Grab	Once during 2020 to 2028	Regulated semi-volatile organic compounds (SVOCs).

TABLE 5 – NON-RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM – CONT.

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
GROUNDWATER			
Regional Up-gradient Well and Effluent Monitoring Well	Grab	Semiannually	Aluminum, antimony, arsenic, barium beryllium, cadmium, calcium, chloride, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, nitrate-nitrite as nitrogen, nitrite as nitrogen, pH, potassium, selenium, silver, sodium, specific conductance, sulfate, TDS, thallium, zinc
Site Down-gradient Wells	Grab	Annually	
Regional Down-gradient Wells	Grab	As Needed Non-routine	
Regional Up-gradient Well, Effluent Monitoring Well, Site Down-gradient Wells, and Regional Down-gradient Wells	Grab	As Needed Non-routine(2)	Selected VOCs and SVOCs
SOIL GAS MONITORING			
Soil Gas Monitoring Probes for Site 8-05-01	Grab	Quarterly	Selected VOCs
Soil Gas Monitoring Probes for Sites 8-05-51 and 8-06-53	Grab	Annually	Selected VOCs
Selected Surface Soil Gas Emission Points for Sites 8-05-01, 8-05-51, and 8-06-53 (See Figure 4)	Survey	Annually	Total VOCs

TABLE 5 – NON-RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM – CONT.

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
AIRBORNE EMISSIONS			
Selected Emission Points	Calculated	Annually	The emission amount of various air pollutants are calculated using various methods, in support of the EPCRA Report and Air Permit Determination compliance
Boiler and Stationary Engine Emissions	Calculated	Monthly	HAPs, Particulate Matter (PM), SO_2, NO_X, CO, and VOC are calculated based on amount of fuel consumed, in accordance with the INL Permit to Construct with Facility Emissions Cap
Point Source Visible Emissions	Visual Observation	Quarterly	See/no see observations or Method 9 opacity in accordance with the INL Permit to Construct with Facility Emissions Cap
Fugitive Dust	Visual Observation	Quarterly	Surveillance of new and existing sources of fugitive dust in accordance with the INL Permit to Construct with Facility Emissions Cap

(1) Waivers granted by the IDEQ for 2020 through 2028.

(2) Sampling of these wells for organic compounds will be performed voluntarily as needed.

NRF performs soil and vegetation monitoring at the NRF site to ensure that NRF operations do not adversely impact the surrounding environment. Data collected from soil sampling is also used to estimate the amount of radioactivity that leaves the NRF property in windblown dust.

Because it is located on the INL, NRF is party to a FFA/CO for environmental remediation under CERCLA. Groundwater, surface soils, and subsurface soils were sampled and analyzed as part of the NRF Comprehensive RI/FS. The results of this investigation were documented in the NRF Comprehensive RI/FS Report dated October 21, 1997.

In 1996, NRF completed remedial actions on three inactive landfill areas. Initial groundwater and soil gas samples were collected and analyzed after the construction phase of the remedial action. The results of the groundwater sampling efforts, which supported the inactive landfill Remedial Action, appeared in the Final Remedial Action Report. This report was issued to the State of Idaho and the EPA on February 20, 1997.

These inactive landfill areas have now entered into the Operation and Maintenance (O&M) phase as described in the Final Remedial Action Report. In support of the O&M phase, groundwater and soil gas samples will continue to be collected and analyzed on a routine basis.

On September 30, 1998, the EPA, State of Idaho, the DOE, and the Naval Reactors Idaho Branch Office signed a ROD, which delineated performance of remedial actions at NRF. These actions included pipe and soil removal, consolidation, and containment.

In 2004, NRF completed remedial actions associated with this ROD including the construction of three engineered covers. These covers have entered into the O&M phase, which includes groundwater and soil/vegetation sampling.

Under the CERCLA program, the sampling frequency, constituents, and sample locations are reviewed and modified, if needed, with regulator concurrence during the CERCLA 5-Year Review process. The most recent 5-Year Review was completed in 2021 with the 5-Year Review Report issued in 2022.

A complete summary of the data collected during routine environmental groundwater and soil gas monitoring is presented in this Environmental Monitoring Report. The results of this monitoring support the conclusion that operation of NRF has had no adverse effect on the quality of the environment or the health and safety of the general public and that the cleanup activities at NRF have resulted in actions that are protective of human health and the environment.

LIQUID EFFLUENT MONITORING

The purpose of the liquid effluent monitoring program is to confirm that no chemically hazardous or radioactive wastes have been discharged to the environment.

SOURCES

Non-radiological

Non-radioactive water disposal at NRF is segregated into two separate systems. Water from NRF operations and storm water runoff is discharged to the IWD. In the fall of 2020, NRF rerouted industrial wastewater from the IWD to the sewage lagoons. Only storm water and approved exempt wastewater as outlined in the Closure Plan are discharged to the IWD. Sanitary wastewater from NRF is discharged to evaporative sewage lagoons.

Industrial Waste Ditch

The IWD system at NRF consists of two discrete parts. The interior portion of the IWD system is comprised of a network of buried pipes, culverts, manholes, lift station, and open channels within the NRF security fence. This network empties storm water and process water into a culvert, calming basin, and junction chamber, which flows through an environmental monitoring station vault, and ultimately outfalls to an open channel at the northwest corner of NRF.

The exterior portion of the IWD system begins at this outfall. Wastewater can flow up to 3.2 miles northeast from the outfall into the desert in a former creek bed. At this point, an earthen berm across the creek bed prevents water from traveling further down this drainage. Normally, no surface water is visible beyond 300 yards from the outfall. Water discharged through the IWD system is dissipated through a combination of percolation and evapotranspiration along the course of the exterior IWD.

Approximately 10.5 million gallons of water were released to the IWD during 2023. Sources of water to the IWD primarily include storm water, snowmelt runoff, and raw water from discharges of the fire protection system.

Sewage Lagoons

In February 2012, NRF began operation of a new 21-acre, dual cell, lined sanitary lagoon system. This lagoon system was installed to replace the existing clay lined lagoons that had been in operation since the 1960s. This lagoon system was constructed to meet the new design standards for State seepage testing requirements for wastewater lagoons. A valve box located in the southern berm of the lagoons allows wastewater to be directed to either one or both of the cells depending upon the volume of wastewater being generated. An equalization line is located at the opposite end of the cells to stabilize the water level between the cells if needed.

The sewage lagoons work primarily through aerobic digestion with anaerobic digestion occurring in the sludge layer. All liquids are dissipated by evaporation; no liquids are discharged to the ground surface or subsurface.

Radiological

A water reuse system is operated at NRF to collect, process, and reuse radioactive liquids rather than discharge them to the environment. However, radiological monitoring is still maintained for all effluent discharges to the IWD and the sewage lagoons as a best management practice, to ensure no detectable radiological contamination is released to the environment.

MONITORING, ANALYSES, AND RESULTS

Liquid effluents discharged to the IWD were analyzed for chemical constituents and radioactivity. Liquid effluents discharged to the sewage lagoons were only analyzed for radioactivity.

Non-radiological

In 2007, the IWD, which received industrial wastewater from site operations, was permitted as a "reuse treatment system" by the IDEQ. Until this Industrial Reuse Permit was issued, no monitoring was required for this facility by regulatory agencies. However, NRF has always monitored the IWD as a best management practice. This permit required certain analytes to be monitored and it also stipulated the frequency they were to be monitored.

In the fall of 2020, NRF completed the rerouting of industrial wastewater from the IWD to the non-discharging, lined, evaporative sewage lagoons. On January 4, 2021, the IDEQ approved NRF's Industrial Reuse Permit Closure Plan and terminated the permit. This closure plan still allows the operation of the IWD for storm water runoff, raw water, demineralized water, steam condensate, chlorinated potable water, and heating/air conditioning condensate to be discharged. Now that the IWD does not operate under a permit, effluent sampling is not required at the IWD but will continue to be performed as a best management practice. NRF will continue to monitor groundwater as required in the IDEQ approved Closure Plan.

Analytes in the wastewater are monitored based on previous requirements of the reuse permit. Composite samples of the liquid effluents discharged to the IWD were collected monthly at the outfall of the interior drainage system. A summary of the liquid effluent monitoring results from the IWD is presented in Table 6.

The monitoring results showed no appreciable concentrations of heavy metals and a near neutral pH in the IWD liquid effluent. Various concentrations of calcium, chloride, magnesium, sodium, and other ions were present in the liquid effluent due to NRF operations/activities. None of these constituents were harmful to the environment.

Radiological

Water samples collected from the IWD and sewage lagoons were analyzed for quantitative gamma, tritium, and strontium-90 radioactivity. The analytical results confirmed that no programmatic radioactivity above natural background levels was present in liquid effluent streams discharged from NRF.

Sediment samples collected at the outfall and the wetted portion of the IWD were analyzed using gamma spectrometry to identify gamma-emitting radionuclides. The analytical results further

TABLE 6 – SUMMARY OF IWD WASTEWATER QUALITY ANALYSES

PARAMETER	UNITS	INDUSTRIAL WASTE DITCH[1]		
		MIN	MAX	MEAN
Aluminum	Milligrams/ Liter (mg/L)	0.0257	1.88	0.41
Antimony	mg/L	<0.001	<0.001	<<0.001
Barium	mg/L	0.0320	0.146	0.107
Chloride	mg/L	31.5	486	157
Iron	mg/L	<0.033	2.39	<0.53
Manganese	mg/L	0.00196	0.228	0.052
Nitrate As Nitrogen	mg/L	0.0750	2.25	1.21
Nitrite As Nitrogen	mg/L	<0.033	<0.33	<0.14
Nitrogen (Total Kjeldahl)	mg/L	<0.033	1.52	<0.62
Oil And Grease	mg/L	<1.32	4.44	<2.14
pH	pH	7.65	8.82	8.09[2]
Potassium	mg/L	1.4	3.89	2.59
Sodium	mg/L	23.1	336.0	103.9
Specific Conductance	µmho/cm	267	2,200	873
Sulfate	mg/L	6.16	44.1	26.5
Thallium	mg/L	<0.0006	<0.0006	<<0.0006
TDS	mg/L	132	1,100	449
Total Suspended Solids	mg/L	<0.814	58.0	<13.2

(1) Values preceded by < contained at least one "less than minimum detection level" (MDL) value in the data set for that parameter. Values preceded by << contained all "less than MDL" values in the data set for that parameter and were the average of the MDLs.

(2) Means for pH were calculated using a geometric method.

confirmed that no programmatic radioactivity above natural background levels was discharged in liquid effluent streams from NRF. In addition, vegetation and sediment samples collected along the wetted portion of the IWD did not reveal any programmatic radioactivity above background levels.

LIQUID EFFLUENT MONITORING CONCLUSIONS

Non-radiological

Liquid effluent monitoring confirms that non-radiological liquid effluents from NRF were controlled in accordance with applicable Federal and State laws. The levels of nonhazardous constituents that NRF discharged via the IWD have had no adverse effect on the quality of the environment.

Radiological

No radioactive liquid effluents were discharged from NRF operations. Monitoring shows that the procedures and equipment used to process radioactive liquids have been effective in eliminating discharges to the environment.

DRINKING WATER MONITORING

NRF conducts a comprehensive drinking water monitoring program to ensure a high quality drinking water supply is available for NRF.

SOURCES

Designated as on-site wells, NRF 1, 2, 3, 4, 5, and 14 are within the security fence, and they provide all water utilized for production and domestic use at NRF. In January of 1994, NRF wells 1 and 4 were permanently removed from the NRF drinking water system. These two wells currently provide water for the NRF fire main system, construction activities, and lawn watering.

NRF wells 2 and 3 provided all domestic (drinking) water for NRF from 1994 to 2006. In 2006, well 2 was removed from service leaving well 3 as the only well providing drinking water to the facility. Construction of well 14, replacing well 2, was completed in March of 2009. Since 2009, wells 3 and 14 have provided all domestic water for NRF. Wells 2 and 5 are only used as observation wells.

MONITORING, ANALYSES, AND RESULTS

The NRF drinking water monitoring program is conducted in compliance with requirements established by the State of Idaho and the Safe Drinking Water Act.

Non-radiological

Drinking water samples were collected and analyzed for the presence of total coliform bacteria and E. coli. Results were reported monthly to the IDEQ per the requirements of applicable Federal and State regulations. Sampling locations were randomly selected at points throughout the distribution system. These samples were analyzed by a State-certified laboratory. Results confirmed the absence of total coliform and E. coli bacteria in the water supply.

Drinking water samples for nitrate were also collected from the drinking water system prior to the water entering the distribution system and after any treatment. Results from all samples were compliant with the standards identified in the Idaho Regulations for Public Drinking Water Systems.

Non-regulatory baseline samples were collected from the NRF drinking water wells in 2021 for perfluoroalkyl and polyfluoroalkyl substances (PFAS). These samples were collected in collaboration with the IDEQ to help determine PFAS levels in drinking water throughout the State of Idaho. In addition, three additional sets of PFAS samples were collected from the NRF drinking water wells in 2023. The PFAS contaminants associated with the EPA's 2016 Health Advisory Level, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), and the constituents used to calculate the proposed Hazard Index Maximum Contaminant Level (MCL) were not detected in the NRF drinking water wells. While EPA finalized drinking water limits for certain PFAS in 2014, the 2016 Health Advisory Level was in place through 2023 and therefore is referenced here. None of the PFAS constituents from the current EPA drinking water limits were detected in NRF drinking water samples.

Radiological

Samples were drawn from all four operating drinking/production water wells (NRF 1, 3, 4, and 14) and analyzed for radiological drinking water parameters. These samples were submitted for analyses to a subcontracted laboratory. Analytical results reported for these samples were below the maximum allowable concentrations for drinking water.

DRINKING WATER MONITORING CONCLUSIONS

Non-radiological

Monitoring of the NRF drinking water system for bacterial contaminants demonstrated compliance with public drinking water regulations. Drinking water monitoring for other required parameters verified that no contaminants were present in NRF drinking water above levels established by drinking water standards.

Radiological

The radioactivity levels in the drinking water were significantly below levels established by drinking water standards.

GROUNDWATER MONITORING

NRF maintains a comprehensive groundwater monitoring program to verify that NRF operations have not adversely affected the quality of the groundwater.

SOURCES

The top of the Snake River Plain Aquifer is approximately 385 feet below the ground surface at NRF. Previous studies at the INL have determined that the groundwater moves along a horizontal flow path from the northeast to the southwest with a velocity ranging from 2 to 26 feet per day (Reference 5).

This program includes the collection and analysis of samples from monitoring wells surrounding NRF. Figure 3 plots the location of all groundwater monitoring wells used to support the CERCLA and Industrial Reuse Permit Closure Plan monitoring activities at NRF. These wells are located within a 3-mile radius of the developed portion of the NRF site. In 2023, groundwater samples were collected by United States Geological Survey (USGS) personnel and analyzed by laboratories contracted by NRF.

For analysis purposes, NRF groundwater monitoring wells are placed into four groups consistent with the well groupings used for the hydrogeologic study that was performed in 1996 as part of the NRF Comprehensive Remedial Investigation associated with the CERCLA process. Groundwater monitoring was conducted through the collection and analysis of samples from Regional Up-gradient (NRF-16), Effluent Monitoring (NRF-6), and Site Down-gradient (NRF-8 through NRF-12 and USGS 102) wells. Samples may also be periodically collected from the Regional Down-gradient (USGS-97, USGS-98, and USGS-99) wells.

Based upon results from the 2016 5-Year CERCLA review, it was determined that routine sampling of the Regional Down-gradient wells was no longer required since other nearby wells provide similar groundwater information. Groundwater samples were collected regularly from these wells through November 2018. The Regional Down-gradient wells were removed from the CERCLA monitoring network. However, samples will continue to be collected periodically on a voluntary basis to provide additional water quality information. Most of the target analytes monitored by NRF were derived from the list of drinking water contaminants published by the EPA or were identified as potential contaminants of concern through the CERCLA investigation process.

NRF-16 is located approximately 1.4 miles north of NRF. It is used to monitor water that is hydrologically up-gradient to NRF and is representative of site background quality. It is the only up-gradient well within the CERCLA program used by NRF. Several nearby non-CERCLA wells are sampled to provide additional up-gradient water quality information. NRF-6 is called the “Effluent Monitoring” well due to its location 0.1 mile north of NRF, next to the IWD outfall. This well is used to monitor the effects on groundwater quality due to current and past discharges of effluent to the IWD.

One well (USGS-102) constructed in 1989, and five wells (NRF-8 through NRF-12) constructed in 1996, are called “Site Down-gradient” wells. These wells are located just south of NRF along an arc extending from USGS 102 on the west side of NRF to NRF-12 on the east side of NRF. These wells are used to assess potential migration of constituents from the IWD, sewage lagoons, and the NRF site. Most wells in this group have detected consistently low levels of metal and ion constituents.

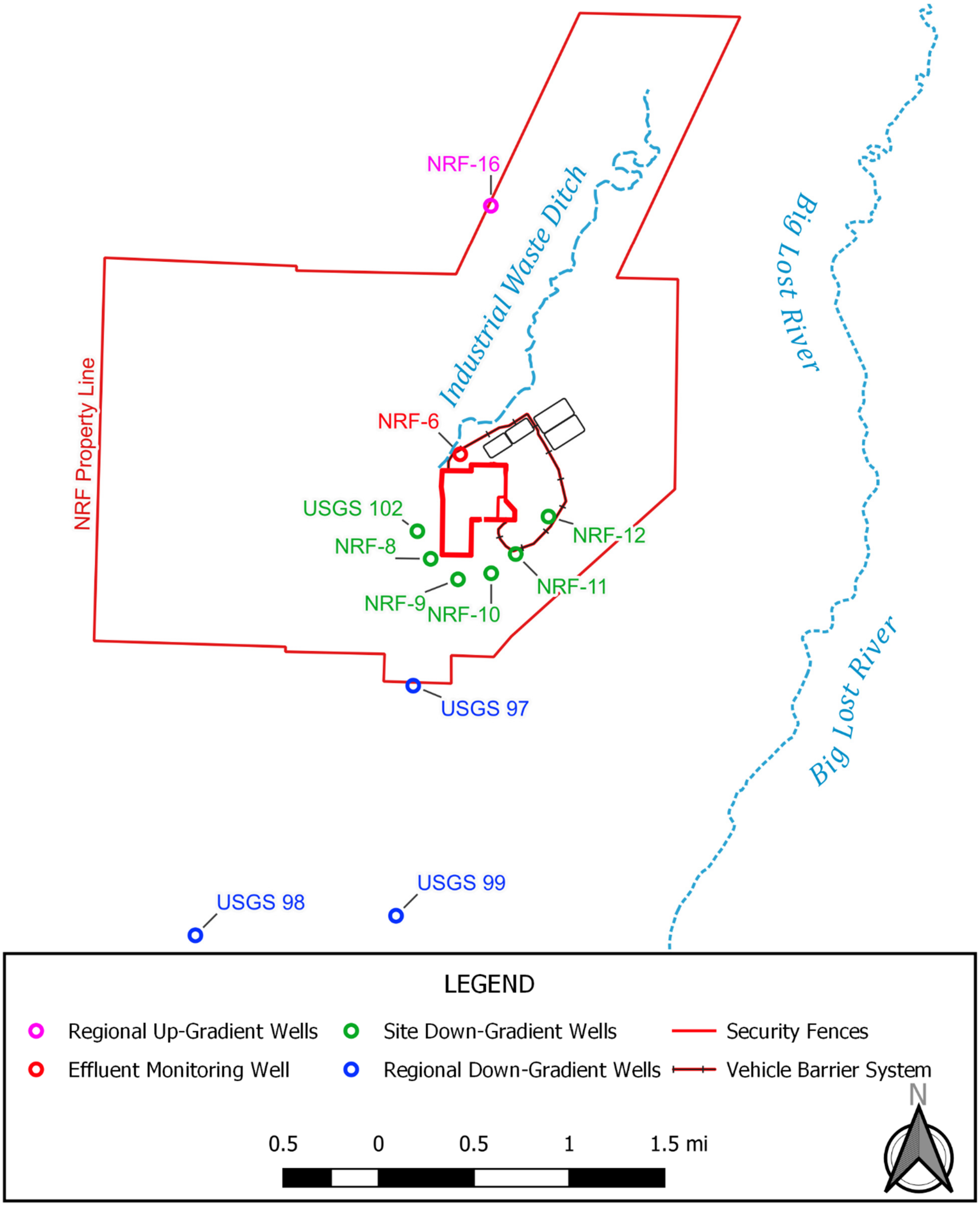

FIGURE 3 – GROUNDWATER MONITORING NETWORK

However, the results from NRF-10 have typically contained slightly elevated metal concentrations believed to be associated with suspended sediments in the water samples.

MONITORING, ANALYSES, AND RESULTS

During this reporting period, NRF completed all required sampling from CERCLA wells NRF-6, NRF-8 through NRF-12, NRF-16, and USGS 102. Samples were also collected from USGS 97, USGS 98, and USGS 99. All sample results are reviewed by an independent data validator. Results are evaluated against standardized criteria for laboratory quality control. Typically, the NRF monitoring wells NRF-6 and NRF-16 are sampled twice a year (i.e., in May and November). The remaining wells are typically sampled once a year. The analytical results are described below.

Non-radiological

The results of analyses for inorganic chemical constituents and other selected parameters are summarized in Table 7 and discussed below. The mean ionic concentrations of calcium, chloride, magnesium, potassium, sodium, and sulfate measured at the Effluent Monitoring well, NRF-6, were higher than results from any other well grouping. The results for two parameters, specific conductance and TDS were also higher. These elevated constituents and parameters can be traced to the past discharge of salts from the site water softener, demineralization systems, and salt used as a site-deicing agent. The mean annual concentration of chloride and TDS exceeded their Secondary Maximum Contaminant Level (SMCL) of 250 mg/L and 500 mg/L, respectively in NRF-6. SMCL refers to guidelines that are not federally enforced and relate to cosmetic and/or aesthetic effects and do not detrimentally affect public health and safety. The long-term downward trending concentrations for chloride that began around 2009 appear to have reversed and are now slowly rising (i.e., from 339 mg/L in 2022 to 368 mg/L in 2023. Conversely, the concentration of sulfate fell from 87 mg/L in 2022 to 76 mg/L in 2023. The concentration of sulfate was about one-third of its SMCL of 250 mg/L. The cause or causes for the changes in the trends for chloride and sulfate are still being evaluated. Since NRF no longer discharges high concentrations of these constituents to the IWD, falling concentrations are expected in the future. None of the other constituents (i.e., calcium, magnesium, potassium, or sodium) have an associated SMCL. The results discussed above are typical for well NRF-6. Salt constituents at concentrations found in well NRF-6 do not detrimentally affect public health and safety nor degrade the beneficial use of the aquifer.

The mean total (unfiltered) concentration of chromium in well NRF-6 (0.0867 mg/L) is elevated compared to the other well groups. This elevated concentration is partially related to historical releases to the IWD, but other factors are likely influencing chromium concentrations as well. The concentration of total chromium in NRF-6 ranged from 0.0959 mg/L in May 2023 to 0.0737 mg/L in December 2023. For perspective, the MCL for chromium in drinking water is 0.100 mg/L. The cause or causes for the elevated chromium concentrations in NRF-6 are currently being evaluated by NRF.

The mean concentrations for several constituents in the Site Down-gradient and Effluent (NRF-6) well groups are elevated compared to the Regional Up-gradient Monitoring well. All mean metal concentrations were below their respective MCLs during 2023.

TABLE 7 – SUMMARY OF GROUNDWATER ANALYSES – INORGANIC AND OTHER SELECTED PARAMETERS

PARAMETER	UNITS	GUIDELINE [1]	REGIONAL UP-GRADIENT (Well NRF-16) [2]		EFFLUENT MONITORING (Well NRF-6) [2]		SITE DOWN-GRADIENT (Wells NRF-8, 9, 10, 11, 12, & USGS 102) [2] [6]		REGIONAL DOWN-GRADIENT (Wells USGS 97, 98, & 99) [2]	
			RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
Aluminum	mg/L	0.2	<< 0.0193	<< 0.0193	< 0.0193 to 0.0337	< 0.0229	< 0.0193 to 0.0327[7]	< 0.0238	< 0.0193 to 0.0331	< 0.0239
Antimony	mg/L	0.006	<< 0.001	<< 0.001	<< 0.001	<< 0.001	<< 0.001	<< 0.001	<< 0.001	<< 0.001
Arsenic	mg/L	0.010	0.0025 to 0.0029	0.0027	0.0046 to 0.0051	0.0048	0.0024 to 0.0029[7]	0.0027	0.0026 to 0.0036	0.0029
Barium	mg/L	2	0.072 to 0.074	0.073	0.114 to 0.124	0.119	0.126 to 0.149[7]	0.136	0.055 to 0.125	0.093
Beryllium	mg/L	0.004	<< 0.0002	<< 0.0002	<< 0.0002	<< 0.0002	<< 0.0002[7]	<< 0.0002	<< 0.0002	<< 0.0002
Cadmium	mg/L	0.005	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003
Calcium	mg/L	(3)	43.8 to 44.4	44.1	118.0 to 141.0	128.0	60.6 to 68.0[7]	64.2	46.8 to 59.9	53.5
Chloride	mg/L	250	13.1 to 13.3	13.2	344.0 to 384.0	367.8	27.2 to 51.0	37.9	14.1 to 28.1	20.3
Chromium	mg/L	0.1	0.0080 to 0.0080	0.0080	0.0737 to 0.0959	0.0867	0.0069 to 0.0175[7]	0.0119	0.0053 to 0.0067	0.0061
Copper	mg/L	1.0	<< 0.0003	<< 0.0003	0.0007 to 0.0009	0.0008	< 0.0003 to 0.0004[7]	< 0.0003	<< 0.0003	<< 0.0003
Iron	mg/L	0.3	<< 0.033	<< 0.033	0.081 to 0.122	0.110	0.054 to 0.187[7]	0.122	0.038 to 0.069	0.054

TABLE 7 – SUMMARY OF GROUNDWATER ANALYSES – INORGANIC AND OTHER SELECTED PARAMETERS, CONT.

PARAMETER	UNITS	GUIDELINE (1)	REGIONAL UP-GRADIENT (Well NRF-16) (2)		EFFLUENT MONITORING (Well NRF-6) (2)		SITE DOWN-GRADIENT (Wells NRF-8, 9, 10, 11, 12, & USGS-102) (2) (6)		REGIONAL DOWN-GRADIENT (Wells USGS 97, 98, & 99) (2)	
			RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
Lead	mg/L	0.015 [4]	<< 0.0005	<< 0.0005	<< 0.0005	<< 0.0005	<< 0.0005[7]	<< 0.0005	<< 0.0005	<< 0.0005
Magnesium	mg/L	(3)	16.3 to 16.9	16.6	30.8 to 35.5	32.7	20.0 to 21.2[7]	20.6	17.6 to 21.5	19.2
Manganese	mg/L	0.05	<< 0.00100	<< 0.00100	<< 0.00100	<< 0.00100	< 0.00100 to 0.00209[7]	< 0.00157	<< 0.00100	<< 0.00100
Mercury	mg/L	0.002	<< 0.000067	<< 0.000067	<< 0.000067	<< 0.000067	< 0.000067 to 0.000079	< 0.000069	<< 0.000067	<< 0.000067
Nickel	mg/L	(3)	<< 0.00060	<< 0.00060	0.00112 to 0.00437	0.00216	< 0.00060 to 0.00435[7]	< 0.00202	<< 0.00060	<< 0.00060
Nitrate-Nitrite Measured As Nitrogen	mg/L	10	0.81 to 0.87	0.84	2.16 to 2.31	2.25	2.27 to 3.08	2.48	1.26 to 2.51	1.88
Nitrite Measured As Nitrogen	mg/L	1	<< 0.033	<< 0.033	< 0.033 to <0.330	<< 0.107	<< 0.033	<< 0.033	<< 0.033	<< 0.033
pH	pH	6.5 to 8.5	7.93 to 7.97	7.95[5]	7.67 to 7.71	7.69[5]	7.69 to 8.21	7.88[5]	7.88 to 7.93	7.90[5]
Potassium	mg/L	(3)	2.32 to 2.47	2.40	5.45 to 6.30	5.98	2.17 to 2.59[7]	2.39	1.75 to 2.20	2.02

TABLE 7 – SUMMARY OF GROUNDWATER ANALYSES – INORGANIC AND OTHER SELECTED PARAMETERS, CONT.

PARAMETER	UNITS	GUIDELINE (1)	REGIONAL UP-GRADIENT (Well NRF-16) (2)		EFFLUENT MONITORING (Well NRF-6) (2)		SITE DOWN-GRADIENT (Wells NRF-8, 9, 10, 11, 12, & USGS 102) (2) (6)		REGIONAL DOWN-GRADIENT (Wells USGS 97, 98, & 99) (2)	
			RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
Selenium	mg/L	0.05	<< 0.002	<< 0.002	0.002 to 0.002	0.002	< 0.002 to 0.005	< 0.003	< 0.002 to 0.002	< 0.002
Silver	mg/L	0.1	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003	<< 0.0003
Sodium	mg/L	(3)	7.6 to 7.7	7.7	154 to 170	161.3	16.0 to 20.5(7)	17.5	10.5 to 17.1	14.2
Specific Conductance	µmho/cm	(3)	376 to 381	379	1,720 to 1,810(8)	1,768	543 to 678	587	416 to 547	484
Sulfate	mg/L	250	22.0 to 22.5	22.3	72.5 to 81.4	76.2	32.5 to 40.5	36.2	26.6 to 33.2	29.0
Thallium	mg/L	0.002	<< 0.0006	<< 0.0006	<< 0.0006	<< 0.0006	<< 0.0006	<< 0.0006	<< 0.0006	<< 0.0006
TDS	mg/L	500	204 to 207	205	872 to 982(8)	943	295 to 368	319	226 to 297	263
Zinc	mg/L	5	<< 0.0033	<< 0.0033	<< 0.0033	<< 0.0033	<< 0.0033(7)	<< 0.0033	<< 0.0033	<< 0.0033

(1) Concentration guidelines from Code of Federal Regulations, Title 40, Part 141, National Primary Drinking Water Regulations, and Title 40, Part 143, National Secondary Drinking Water Regulations unless otherwise stated. Drinking water standards are used as a guide at NRF for monitoring groundwater, and are shown for comparison only.

(2) Values preceded by < contained at least one "less than MDL" value in the data set for that parameter. Values preceded by << contained all "less than MDL" values in the data set for that parameter and were the average of the MDLs. The same applies to range values preceded by < and <<.

(3) No guideline available per Federal or State regulations.

(4) Action level for lead that requires treatment.

(5) Means for pH were calculated using a geometric method.

(6) Samples from the Site Down-gradient wells NRF-8, 9, 11, 12, and USGS 102 were collected once during 2023; however, well NRF-10 was sampled twice due to anomalous results in May.

(7) Results do not include NRF-10 data due to high suspended solids in samples.

(8) Results represents an average of field and laboratory derived values instead of field-derived values only.

Unfiltered (total) chromium concentrations in samples collected from NRF-10 during May and November were 527 and 206 micrograms per liter (µg/L), respectively, and exceeded their MCL of 100 µg/L. Corresponding filtered samples had chromium concentrations of 30.1 and 13.4 µg/L. Several other metal results in NRF-10 exceeded their SMCLs including aluminum, iron, and manganese. Past experience supported by evidence indicates that the elevated levels of metals in NRF-10 are due to the presence of sediment in the samples.

All inorganic results collected in 2023 from the Regional Down-gradient wells were at or above corresponding concentrations in NRF-16, with most concentrations occurring below corresponding values found in the Site Down-gradient wells. Most inorganic concentrations for 2023 were at or below corresponding values from 2021 (the last time Regional Down-gradient wells were sampled).

Radiological

All groundwater samples were analyzed for tritium, quantitative isotopic gamma, and strontium-90. All results were below the Minimum Detectable Concentration (MDC) for strontium-90 and program specific gamma emitters. A review of the tritium results indicate that the mean activity level in the Effluent Monitoring well (NRF-6) slightly exceeded the Regional Up-gradient tritium level due to legacy operations. Tritium concentration in this well continues to follow a long-term downward trend. The results for radioactivity in groundwater are shown in Table 8.

GROUNDWATER MONITORING CONCLUSIONS

Non-radiological

NRF groundwater monitoring wells do not supply drinking water to NRF; therefore, references to the Federal MCLs and SMCLs here are provided for perspective only. The Effluent Monitoring well (NRF-6), used to monitor the migration of constituents from the IWD, showed elevated mean concentrations of calcium, chloride, chromium, magnesium, potassium, sodium, sulfate ions, specific conductance, and TDS compared to the other well groups. The mean annual concentration of chloride and TDS were above their respective SMCLs. TDS concentrations in well NRF-6 exceeded its SMCL due primarily to the elevated levels of dissolved chloride. The mean concentration for chromium in well NRF-6 was elevated compared to the other well groups. Concentrations of chromium in all NRF drinking water wells and downgradient monitoring wells were significantly below the MCL. Elevated chromium concentrations are localized near well NRF-6 and do not have an effect on the beneficial uses of the groundwater, human health, or the environment.

Radiological

Analysis of NRF groundwater samples showed that strontium-90 and programmatic gamma emitters were at or below their respective MDCs. Measurements for tritium were orders of magnitude below drinking water standards. These levels do not pose a threat to human health or the environment.

TABLE 8 – SUMMARY OF GROUNDWATER RADIOACTIVITY RESULTS

PARAMETER	UNITS	GUIDELINE	REGIONAL UP-GRADIENT (Well NRF-16) (1)(2)		
			MINIMUM	MAXIMUM	MEAN
Strontium – 90	pCi/L	8	< - 0.15	< 0.26	<< 0.05 ± 0.33
Tritium	pCi/L	20,000	9.55	10.33	9.79 ± 1.13
Cesium – 137	pCi/L	200	< - 0.20	< - 0.75	<< - 0.48 ± 1.13

PARAMETER	UNITS	GUIDELINE	EFFLUENT MONITORING (Well NRF-6) (1)(2)		
			MINIMUM	MAXIMUM	MEAN
Strontium – 90	pCi/L	8	< 0.31	< 0.58	<< 0.44 ± 0.31
Tritium	pCi/L	20,000	11.10	13.34	11.39 ± 2.86
Cesium – 137	pCi/L	200	< -0.04	< -1.07	<< -0.56 ± 1.82

PARAMETER	UNITS	GUIDELINE	SITE DOWN-GRADIENT (Wells NRF-8, 9, 10, 11, 12, & USGS-102) (1)(2)(3)		
			MINIMUM	MAXIMUM	MEAN
Strontium – 90	pCi/L	8	< - 0.13	< 0.49	<< 0.27 ± 0.21
Tritium	pCi/L	20,000	8.21	25.54	9.04 ± 2.77
Cesium – 137	pCi/L	200	< - 0.96	< 2.50	<< 0.33 ± 1.04

(1) The instruments used in the laboratory to measure radioactivity in environmental media are sensitive enough to measure the natural (or background) radioactivity along with any contaminant radioactivity in a sample. To obtain a true measure of the contaminant level in a sample, the background radioactivity level is subtracted from the total amount of radioactivity measured by an instrument. When a larger background is subtracted from a smaller total radioactivity measurement, a negative result is generated.

(2) The (±) value represents the statistical error at two standard deviations for the mean.

< Less than the MDC. Values preceded by < contained at least one "less than MDC" value in the data set for that parameter.

<< All results are less than the MDC.

(3) Samples from the Site Down-gradient wells NRF-8, 9, 11, 12, and USGS 102 were collected once during 2023; however, well NRF-10 was sampled twice due to anomalous results in May.

SOIL GAS MONITORING

Soil gas data are collected as required by the CERCLA Remedial Action pertaining to the NRF Inactive Landfills (Sites 8-05-01, 8-05-51, and 8-06-53) (Figure 4).

The Remedial Action included a construction phase and an O&M phase. The construction phase consisted of the placement of landfill covers and the installation of soil gas monitoring probes around the perimeter of the landfill areas.

The O&M Plan requires that soil gas monitoring be performed to verify that the migration of subsurface gaseous volatile organic constituents away from the landfill areas is minimized. The O&M Plan also requires that soil gas monitoring include a soil gas emissions survey to assess the effectiveness of the landfill cover in limiting surface soil gas emissions to the atmosphere.

SOURCES

The principal source of the landfill soil gases is from residual VOCs located in the buried waste at the three landfill areas. The chemicals required to be monitored in the soil are listed in Table 9. In accordance with standard industry practices in the past, various types of non-radiological wastes were disposed of in the three landfill areas. Based on employee interviews and historical records, these wastes primarily included construction debris, paper, cafeteria wastes, office debris, limited amounts of waste chemicals, petroleum based products, paints, paint thinner, and spent solvents.

Standard industrial waste disposal practices of the time were deposition of the waste at the landfill site, incineration of the waste contents, and burial. Site 8-05-01 was in operation from the early 1950s until approximately 1960. Site 8-05-51 was in operation during the late 1950s and early 1960s. Site 8-06-53 was in operation from approximately 1960 until the late 1960s. The locations of these landfill areas are depicted in Figure 4.

These sites are not accessible to the general public. During the early 1990s, a risk assessment was performed under CERCLA to determine the most hazardous constituents present in the landfills. The levels of these constituents detected during current sampling were comparable to the levels reported in the risk assessment. The risk assessment concluded that the levels for the target constituents did not present any significant risk to NRF personnel, the general public, or the environment. In addition, none of these constituents have been detected at the surface in past sampling evolutions.

MONITORING, ANALYSES, AND RESULTS

The soil gas samples were collected from permanent soil gas monitoring probes that are installed around the perimeter of each landfill area (Figure 4). An initial set of soil gas data was collected soon after the completion of the Remedial Action construction phase in October 1996. This data was used to determine whether the soil gas monitoring probes were functional and to serve as a baseline for all subsequent sample data obtained in support of the O&M phase of the Remedial Action.

The O&M sampling schedule dictates that soil gas samples from Sites 8-05-01, 8-05-51, and 8-06-53 be collected annually. The 2021 CERCLA 5-Year Review recommended to increase the sample collection frequency at Site 8-05-01 from semi-annually to quarterly to assess tetrachloroethylene (PCE) trends at this location. This change was due to PCE levels in one well at this location

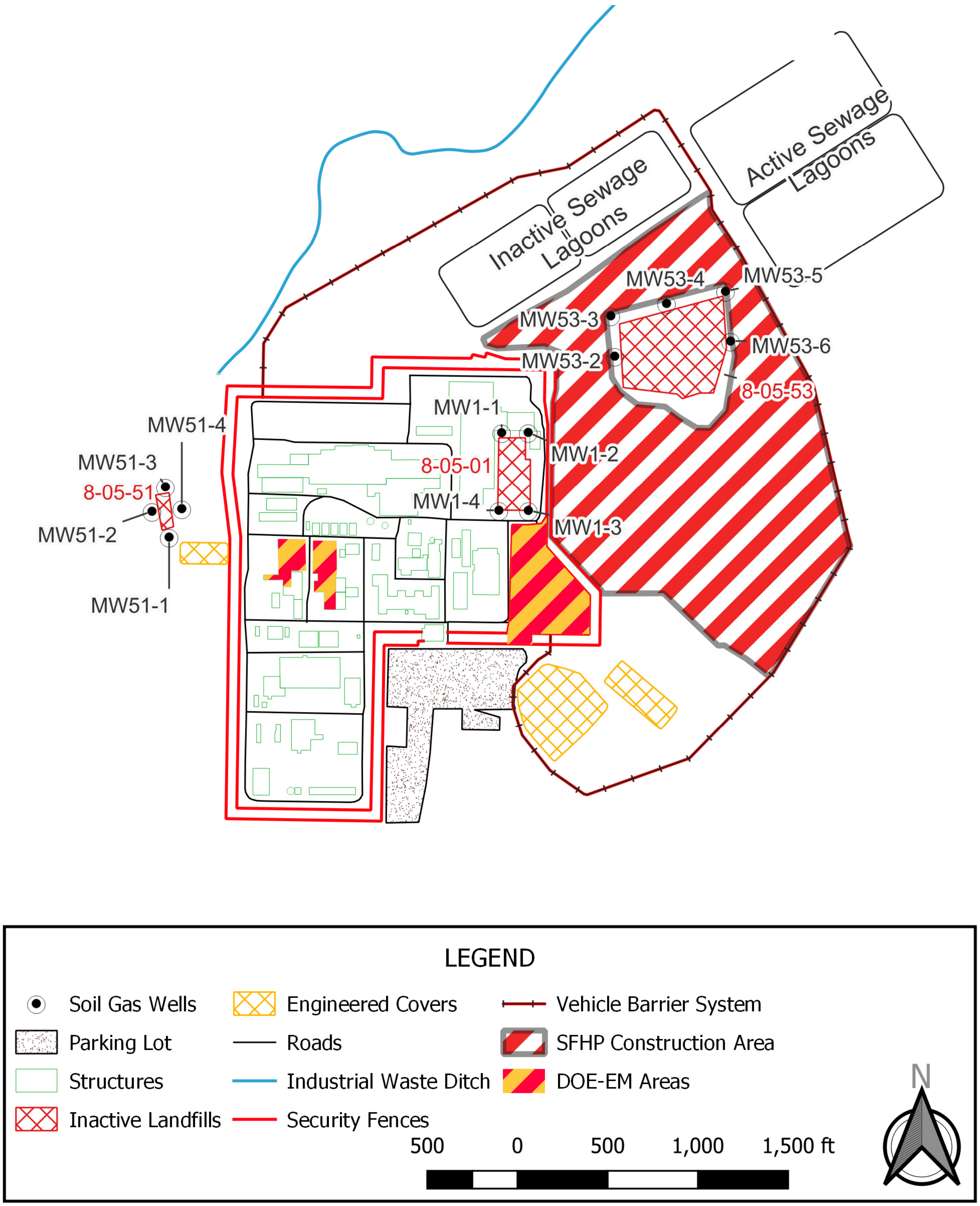

FIGURE 4 – SOIL GAS MONITORING LOCATIONS

TABLE 9 – NRF SOIL GAS MONITORING REQUIRED CHEMICALS

REQUIRED CHEMICALS[1]
Benzene
Carbon Tetrachloride
Chloroform
Dichlorodifluoromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,2-Dichloroethylene
cis-1,2-Dichloroethylene
trans-1,2-Dichloroethylene
Ethylbenzene
Methylene Chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
1,1,1-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
1,1,2-Trichloro-1,2,2-trifluoroethane
Vinyl Chloride
Xylenes

(1) The chemical constituents for soil gas monitoring are as required in the CERCLA O&M Plan.

periodically exceeding the Remedial Action baseline level. Well MW53-1 from Site 8-06-53 was permanently removed in the spring of 2019. Analysis of all the samples collected in 2023 was performed using the laboratory's analytical procedure, based on the EPA TO-15 analytical method. The soil gas data for detected chemicals, obtained in 2023, are presented in Table 10.

The specific VOCs that have been consistently detected at or above the sample quantitation limit during sampling are as follows: dichlorodifluoromethane (Freon-12), trichlorofluoromethane (Freon-11), chloroform, acetone, PCE, and trichloroethylene (TCE).

Only PCE was consistently detected at all three landfills, with PCE being detected at the highest concentration of all the VOCs. The maximum PCE result was detected at sample location MW1-4 within Site 8-05-01.

In addition to the soil gas monitoring probe sampling, an annual soil gas emissions survey was conducted on the surface of the landfill soil covers at each landfill area using a portable photo-ionization detector. This survey was conducted for the detection of total VOCs. The survey indicated no detectable levels of total VOCs at the surface of any of the landfills. This is consistent with past survey results.

SOIL GAS MONITORING CONCLUSIONS

The analytical results for this sampling period for the three NRF inactive landfills indicate there were no significant increases in VOC levels in the surrounding environment. The landfills that contain low levels of VOCs from past operations continue to be adequately controlled and contained to minimize migration of those contaminants. The levels of VOCs present in the subsurface at the three landfills do not present any significant risk to NRF personnel, the general public, or the environment. The results of the soil gas emissions survey verify that the landfill soil covers for all three landfills are effective in limiting surface soil gas emissions to the environment.

TABLE 10 – SUMMARY OF SOIL GAS MONITORING RESULTS[1][2]

Site/ Monitoring Probe ID	Trichlorofluoro-methane or Freon-11		Dichlorodifluoromethane or Freon-12		Chloroform		Acetone		Tetrachloroethylene or PCE		Trichloroethylene or TCE	
	RANGE ppbv	**MEAN** ppbv	**RANGE** ppbv	**MEAN** ppbv	**RANGE** ppbv	**MEAN** ppbv	**RANGE** ppbv	**MEAN** ppbv	**RANGE** ppbv	**MEAN** ppbv	**RANGE** ppbv	**MEAN** ppbv
OU 8-05-01												
MW1-1	0.70 – 1.0	0.89	<0.64 – 0.95	<0.73	3.2 – 3.5	3.4	<6.4 – 40.0	<15.3	2.9 - 3.2	3.1	250 - 350	285
MW1-2	<0.67 – 0.96	<0.79	<<0.65 - <<0.67	<<0.66	<<0.65 – <<0.67	<<0.66	<<6.5 - <<6.7	<<6.6	0.68 - 12	7.2	<<0.65 - <<0.67	<<0.66
MW1-3	<0.65 – 0.92	<0.77	<<0.65 - <<0.69	<<0.67	<<0.65 - <<0.69	<<0.67	<<6.5 - <<6.9	<<6.7	12 - 210	143	0.76 - 13	8.29
MW1-4	0.64 – <1.3	<0.84	1.0 – 4.3	2.3	<0.68 – <1.3	<0.92	<<6.4 - <<13.0	<<8.3	400 – 1,100	900	5.5 - 16	12.4
OU 8-05-51[3]												
MW51-1	0.87	NA	<<0.71	NA	<<0.71	NA	<<7.1	NA	8.2	NA	<<0.71	NA
MW51-2	0.78	NA	<<0.70	NA	<<0.70	NA	<<7.0	NA	7.0	NA	<<0.70	NA
MW51-3	<<0.70	NA	<<0.70	NA	<<0.70	NA	<<7.0	NA	6.5	NA	<<0.70	NA
MW51-4	0.78	NA	<<0.72	NA	<<0.72	NA	<<7.2	NA	7.8	NA	<<0.72	NA
OU 8-06-53[3]												
MW53-2	<<0.70	NA	<<0.70	NA	<<0.70	NA	<<7.0	NA	11	NA	<<0.70	NA
MW53-3	<<0.70	NA	<<0.70	NA	<<0.70	NA	<<7.0	NA	<0.7	NA	<<0.70	NA
MW53-4	<<0.70	NA	<<0.70	NA	<<0.70	NA	<<7.0	NA	1.9	NA	<<0.70	NA
MW53-5	<<0.71	NA	<<0.71	NA	1.2	NA	<<7.1	NA	2.8	NA	<<0.71	NA
MW53-6	<<0.71	NA	<<0.71	NA	<<0.71	NA	<<7.1	NA	5.0	NA	<<0.71	NA

(1) Range and mean values preceded by < contained one or more "less than the sample quantitation limit" value in the data set for those parameters. Range and mean values preceded by << contained all "less than the sample quantitation limit" values in the data set for those parameters.

(2) The concentration of ppbv (parts per billion based on the volume of contaminant in a sample per the total sample volume) may also be expressed as micrograms per cubic meter (μg/m^3).

(3) Sample locations sampled annually. Therefore, mean values show "NA" since only one sample result is available.

AIRBORNE EMISSION MONITORING

The purposes of the NRF airborne emission monitoring program are to determine the effectiveness of air pollution control methods and to measure concentrations of air pollutants released from NRF for comparison with applicable standards and natural background levels.

SOURCES

The principal source of non-radioactive industrial pollutants at NRF is fuel combustion products from the steam generating boilers. Diesel fuel oil is utilized in boiler operations, and the resulting combustion products are released through elevated exhaust stacks. The boilers provide steam for heating buildings in the winter and are not used during summer months. Although not part of the INL Permit to Construct with Facility Emissions Cap, Champion Concrete operates two boilers supporting construction of the Naval Spent Fuel Handling Facility at NRF. The boilers provide steam and heated water at a concrete batch plant.

Other sources at NRF release small quantities of air pollutants, both particulates and gases. These include emergency diesel generators that are tested monthly and miscellaneous portable engines. In addition, production operations and maintenance shops release air pollutants from welding and the use of various chemical products.

Friable asbestos that can become airborne is also controlled at NRF. This includes asbestos containing material (ACM) primarily in the form of friable pipe insulation. Small amounts of ACM have also been identified in floor tiles and mastic, ceiling tiles, drywall joint compound, fire resistive safes, and gasket materials. These materials are managed to prevent asbestos from becoming friable and airborne in accordance with all applicable regulations.

Small quantities of airborne radioactivity are produced by radiological work at NRF. However, HEPA filters and charcoal filters are used on appropriate exhaust stacks to reduce radioactive air emissions.

Naturally occurring radon present in the environment is also entrained in the exhaust air. In addition, fugitive radiological air emissions may arise from soils containing residual radioactivity from historic discharges in some areas. These areas were evaluated under the CERCLA Comprehensive RI/FS. Fugitive soil emissions are conservatively calculated using soil sampling data generated by the Soil and Vegetation Monitoring Program. These areas are sampled on an annual basis to confirm the low levels of radioactivity. These areas are not accessible to the general public.

MONITORING, ANALYSES, AND RESULTS

Non-radiological

Emissions from stationary fuel-burning equipment were calculated using the EPA-approved emission factors contained in Reference 8.

The type of diesel fuel oil consumed at NRF met the CFR requirements specified in the INL Permit to Construct with Facility Emissions Cap. The fuel supplier certified the type of fuel oil purchased to meet the requirements.

Estimated non-radiological air emissions for boilers, emergency generators, and a small gasoline generator in 2023 are listed in Table 11. Criteria air pollutants regulated by the INL Permit to Construct with Facility Emissions Cap include: CO, NO_x, lead (Pb), PM, PM less than or equal to 10 micrometers (PM_{10}), PM less than or equal to 2.5 micrometers ($PM_{2.5}$), SO_2, and VOCs. In 2023, NRF only purchased and burned ultra-low sulfur number 2 diesel fuel oil in its boilers, which reduces emissions of PM and SO_2. Champion Concrete also burned only ultra-low sulfur number 2 diesel fuel oil in their boilers.

TABLE 11 – NON-RADIOLOGICAL AIR EMISSIONS

Pollutant	Boilers(1) (ton/year)	Emergency Diesel Generators(2) (ton/year)	Small Generator(3) (ton/year)
CO	9.0E-01	3.4E-01	3.1E-04
NO_x	3.6E+00	1.3E+00	5.1E-04
Pb	2.3E-04	3.6E-06	Not Applicable
PM	5.9E-01	2.8E-02	3.1E-05
PM_{10}	4.1E-01	2.3E-02	3.1E-05
$PM_{2.5}$	2.8E-01	2.2E-02	3.1E-05
SO_2	3.8E-02	6.0E-04	2.5E-05
VOC(4)	3.6E-02	3.3E-02	9.4E-04

(1) The values are totals for NRF and Champion Concrete boilers, calculated based on fuel consumption.
(2) The values are totals for the four emergency diesel generators, calculated based on fuel consumption.
(3) Values calculated based on gasoline fuel consumption.
(4) “VOC” emissions are non-methane total organic compounds.

NRF has four emergency diesel generators used for emergency power. Stationary engines are regulated under 40 CFR Part 63 (Reference 9) Subpart ZZZZ, National Emissions Standards for HAPs for Stationary Reciprocating Internal Combustion Engines. However, because the engines at NRF were installed prior to the applicability date of the regulation, and because they are only operated for emergency purposes, requirements of Subpart ZZZZ do not apply to the generators. In 2023, each NRF emergency diesel generator was operated less than 20 hours each for maintenance and testing.

In December 2023, a small gasoline generator associated with a training simulator was installed for use. The generator will continue to be used until permanent power is established and may be used intermittently thereafter. Once the training simulator is connected to permanent power, this generator will be removed from the INL Permit to Construct with Facility Emissions Cap.

Quarterly inspections for visible emissions and fugitive dust were required by the INL Permit to Construct with Facility Emissions Cap. These inspections were performed as required. No deviations from the permit conditions were observed.

When work was performed at NRF that could result in airborne asbestos, sampling was performed in or near the worksite, and the samples were analyzed in accordance with National Institute for Occupational Safety and Health (NIOSH) analytical method 7400, “Asbestos and Other Fibers by

PCM" (Phase-Contrast Microscopy). In cases where there was a high potential for both asbestos and non-asbestos fibers, samples were taken and analyzed per NIOSH method 7402, "Asbestos by TEM" (Transmission Electron Microscopy). Samples were either analyzed on-site by qualified personnel or by an outside laboratory accredited by the American Industrial Hygiene Association.

Both area and personal monitoring samples have also shown that the engineering controls in place were effective for controlling asbestos exposures. This sampling verified there were no measurable discharges of asbestos fibers to the environment. Therefore, all asbestos work performed at NRF was conducted in accordance with the applicable federal regulatory requirements.

Radiological

Airborne emissions from radiological areas at NRF were monitored for particulate radioactivity using fixed filter air samplers. These samplers drew air from each radiological area or stack and deposited the particulate matter on filter papers. All filter papers were analyzed for gross alpha, gross beta, and gamma radioactivity. The concentration of radiological activity in the exhaust air was determined based on the sample results. If airborne concentrations are found to be above defined action levels, an investigation is performed to determine the cause. All concentrations of particulate radionuclides from programmatic activities were below action levels during 2023.

A fixed filter air sampler is located at the NRF gatehouse to measure background levels of airborne radiological particulate. In addition, fixed filter air samplers are located at the north perimeter fence and south of the NRF parking lot to serve as upwind and downwind monitoring stations. These samplers measured ambient radioactivity levels at NRF for comparison with emissions from radiological areas.

In addition, four fixed filter air samplers have been setup and positioned around each of the perimeters of the S1W and A1W DOE-EM D&D projects. These fixed filter air samplers are used to detect any increase in background radioactivity levels as a result of the D&D activities and to ensure there are no adverse effects to human health and the environment.

There are two potential sources of tritium air emissions at NRF. One source is gaseous tritium resulting from nuclear fuel examinations in the ECF hot cells. Since there is no practical method to sample gaseous tritium, the amount of gaseous tritium is determined by calculations based on specific hot cell work evolutions. The second source is tritium in the form of water vapor that is released from the NRF water pools. Many years of tritium air sampling established that tritium emissions from the water pools were gradually declining because the source for the majority of the tritium was eliminated. Because of this, sampling was discontinued in May of 2016. Since then, water pool tritium emissions have been calculated using a set emission rate established from previous sampling results.

The quantities of gaseous carbon-14, iodine-129, and krypton-85 radioactivity in the air effluent were measured based on fuel handling operations and hot cell examination work. In addition, charcoal cartridges were used to sample for gaseous radioiodine (iodine-131) in airborne emissions at the ECF. These charcoal cartridges were replaced weekly and promptly counted using gamma spectrometry for quantitative identification. During 2023, no radioiodine above the Decision Level Concentration (DLC) was found on the sample media, although emissions of radioiodine were conservatively calculated by using the DLC value as the actual measured radioactivity.

Windblown dust radionuclide emissions from soil surrounding NRF were calculated using average wind velocities and data collected from soil sampling (see Soil and Vegetation Monitoring section). Cobalt-60 and cesium-137 from historical NRF operations have been found in the soil surrounding NRF in the past, so they may be components of windblown dust. The total radioactivity in NRF air emissions during 2023 is listed in Table 12.

TABLE 12 – RADIOLOGICAL AIR EMISSIONS

Radionuclide(1)	Curies	Half-Life
Carbon-14	2.1E-01	5715 years
Cobalt-60 (fugitive soil)	0.0E+00	5.271 years
Cesium-137 (fugitive soil)	8.0E-05	30.07 years
Gross Alpha	2.7E-06	24,100 years (2)
Gross Beta	5.6E-05	28.8 years (3)
Tritium	1.1E-02	12.32 years
Iodine-129	9.6E-06	15 million years
Iodine-131	4.6E-06	8.023 days
Krypton-85	4.2E-03	10.76 years

(1) Limits for radiological air emissions are based on the committed effective dose equivalent. Refer to the Radiation Dose Assessment section for a comparison of radiological emissions with the dose limits.

(2) Based on plutonium-239.

(3) Based on strontium-90.

Note: In 2023, there was no measurable or calculated release of cobalt-60.

The only potential radiation exposure to the public from NRF operations in 2023 was from airborne releases. As such, effective dose equivalent to any member of the public is estimated using the CAP-88 computer code, which is an EPA-approved modeling software.

In 2023, the resultant evaluation of airborne releases conservatively estimated an effective dose equivalent of 0.000093 mrem per year to an individual off-site. This is well below the EPA airborne radiation exposure limit of 10 mrem per year (Reference 2). It is also well below the radiation exposure limit of 100 mrem per year established by the DOE and the Nuclear Regulatory Commission (References 3 and 4). The 100 mrem per year standard includes all potential exposure pathways. Further, the dose is negligible when compared to the naturally occurring background radiation dose of approximately 366 mrem per year for residents of southeast Idaho. The dose is also much less than the approximate three mrem that an individual would receive from a single cross-country airplane flight.

AIRBORNE EMISSION MONITORING CONCLUSIONS

Non-radiological

The results of airborne non-radiological emission monitoring for 2023 have shown that air emissions from NRF did not exceed the applicable air quality standards set by the EPA and the State of Idaho. All asbestos removal work was completed in compliance with the applicable requirements and there was no measurable discharge of asbestos fibers to the environment.

Radiological

The results of airborne radiological emission monitoring at NRF for 2023 have shown that the amount of radioactivity released to the atmosphere was too small to result in any measurable change in the background radioactivity levels in the environment. Therefore, the amounts of the particulate and gaseous airborne radioactivity released from the NRF site during 2023 were well within the applicable standards for radioactivity in the environment. Furthermore, the estimated radiation dose to any member of the general public from the airborne radioactivity released was too low to measure and it was conservatively calculated to be significantly below the standard established by the EPA.

SOIL AND VEGETATION MONITORING

The soil and vegetation monitoring program at NRF has three purposes. The first is to verify that current NRF operations are not adding any measurable radioactivity to the environment surrounding the NRF site. The second purpose is to verify continued containment of the few areas around NRF known to contain residual low-level radioactivity from past operations. The third purpose is to provide data used to calculate windblown radiological air emissions.

SOURCES

In accordance with standard practices at the time and in full compliance with existing regulations, water containing low levels of radioactivity was discharged to specific, defined areas on NRF property during past operations. This practice was discontinued in 1979 when on-site systems for recycling water containing trace amounts of radioactivity became operational.

Due to these historical practices there are a few localized areas of soil on NRF property that contain small amounts of residual radioactivity, principally cobalt-60 and cesium-137. The primary areas that were affected include the A1W leaching bed, the S1W leaching beds/pit, the Old Sewage Basin, and the inactive sewage lagoons (Figure 5). These areas are not accessible to members of the general public. With the exception of the inactive sewage lagoons, which have been filled in, these areas are sampled on a routine basis to verify that the radioactivity is not migrating.

As part of the remedial action under the NRF ROD for Operating Unit 8-08, engineered covers were constructed over the A1W leaching bed, the S1W leaching beds/pit area, and the Old Sewage Basin area. In addition, a chain link fence and signs were installed around the perimeter of these areas. The S1W leaching beds/pit area is in close proximity to the Old Sewage Basin area. Therefore, both areas are encompassed by a common fence and were combined to form one sampling area. In addition, this sampling area includes the Old Seepage Basin Pumpout Area that surrounds the Old Sewage Basin on three sides. This is an area where the radioactively contaminated contents of the Old Sewage Basin were pumped out to the surrounding desert around 1958.

MONITORING, ANALYSES, AND RESULTS

Soil and vegetation sampling is currently conducted in three sampling areas surrounding NRF: the NRF Perimeter Sampling Area; the Combined S1W Leaching Beds and Old Sewage Basin Engineered Covered Sampling Area; and the A1W Leaching Bed Engineered Cover Sampling Area.

Along the Perimeter Sampling Area, 40 soil samples and 40 vegetation samples were collected. Less than 40 soil samples and less than 40 vegetation samples were collected in the Combined S1W Leaching Beds and Old Sewage Basin Engineered Cover Sampling Area and the A1W Leaching Bed Engineered Cover Sampling Area. Fewer samples were collected in these areas compared to past years (prior to 2011) using the following approach. If the randomly selected sample locations fell within the area where the engineered cover was constructed, the locations were not sampled because: 1) only clean soil was used in the construction of these engineered covers; and 2) the sample results from the engineered cover soil were all below the DLCs (non-detectable) over several years of sample collection. Instead, a radiation survey was performed over these sample locations within the cover areas to verify that radiation levels were at background levels. Therefore, soil and vegetation samples were only collected if the sample locations were outside of the engineered cover areas and if the

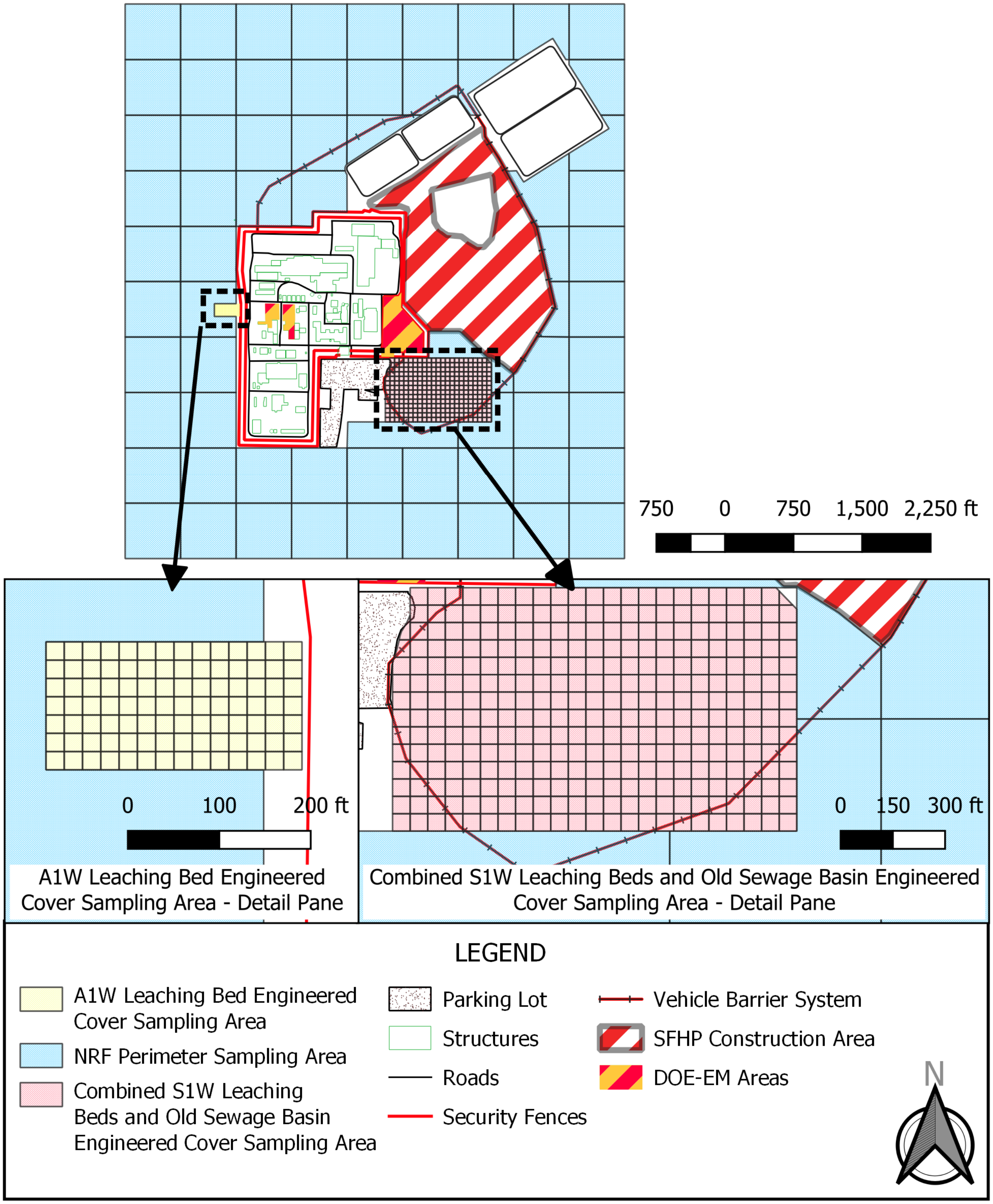

FIGURE 5 – NRF SOIL AND VEGETATION SAMPLE COLLECTION AREAS

radiation survey within the covers indicated readings above background levels. This approach was implemented per the O&M Plan for the engineered cover areas.

All sample and survey locations were determined randomly from a grid coordinate system superimposed over each area. In the Combined S1W Leaching Beds and Old Sewage Basin Engineered Cover Sampling Area, samples were collected from the areas immediately surrounding the covers. These inactive areas are the locations where residual radioactivity from past operations are known to have been discharged or had the potential to have been inadvertently discharged. In addition, soil and vegetation samples were collected from the surrounding NRF perimeter area to confirm that radioactivity was not migrating from known areas of residual activity or deposited downwind of emission points. Samples were not taken from construction areas. The NRF sample collection areas are illustrated in Figure 5.

In the A1W Leaching Bed Engineered Cover Sampling Area, radiation monitoring meters were used to obtain survey results. All survey results were below background levels; therefore, soil and vegetation samples were not collected.

Analyses of all samples collected were performed using a gamma spectrometry system. Data collected from soil and vegetation sampling were evaluated to detect any changes in surface radioactivity levels. The results of the routine soil and vegetation sample analyses are summarized in Table 13.

TABLE 13 – SUMMARY OF SOIL AND VEGETATION GAMMA RADIOACTIVITY RESULTS (pCi/gram Dry Weight)(1)

	Cobalt-60				Cesium-137			
	Soil		Vegetation		Soil		Vegetation	
Area	Range	Mean	Range	Mean	Range	Mean	Range	Mean
A1W Leaching Bed Engineered Cover (Inactive)	<DLC	NA	<DLC	NA	<DLC	NA	<DLC	NA
Combined S1W Leaching Beds and Old Sewage Basin Engineered Cover Area (Inactive)	<DLC	NA	<DLC	NA	<0.6 – 4.0	2.03	<DLC	NA
NRF Perimeter	<DLC	NA	<DLC	NA	<0.6 – 2.8	1.43	<DLC	NA

(1) The < preceding the range values signifies the data were below the DLC. The DLC varies due to the sample size, count time, and the background (natural) radioactivity at the time of analysis. Results that are less than DLC indicate that no radioactivity was detected by photopeak analysis. Because of the variance in the DLC, detectable radioactivity reported for one sample can be lower than the DLC reported for another sample. Mean values preceded by < contained at least one "less than DLC" value in the data set for that parameter. No range is given and no mean values were calculated if all of the values in the data set were below the DLC.

For 2023, the maximum radioactivity detected from the soil samples was cesium-137 at 4.0 picocuries per gram. This sample was collected from a location within the S1W Leaching Beds and Old Sewage Basin Engineered Cover area. Based on previous sampling, this level of radioactivity has been detected sporadically within this area in the past since the level of radioactivity will vary based on sample locations. There was no detectable radioactivity in any of the vegetation samples. The results of the radiation survey performed within the Combined S1W Leaching Beds and Old Sewage Basin Engineered Cover Sampling Area and the A1W Leaching Bed Engineered Cover Sampling Area indicated no readings above background.

For comparison, the mean concentration of residual radioactivity associated with NRF operations in the soil and vegetation samples is less than the average concentration of naturally occurring potassium-40 in the same samples.

SOIL AND VEGETATION MONITORING CONCLUSIONS

NRF operations in 2023 did not contribute to any measurable increase in radiation levels to the soil and vegetation in the surrounding environment. The localized areas at NRF that contain low levels of residual radioactivity from past operations continue to be controlled and contained to prevent contaminant migration. This radioactivity does not present any significant risk to NRF personnel, the general public, or the environment.

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CONTROL OF WASTES

During 2023, operations at NRF generated regulated wastes that fall into the following categories: ACM, PCBs, RCRA hazardous, RCRA hazardous and PCB, radioactive, radioactive PCB, mixed (radioactive and hazardous) wastes, and mixed PCB wastes. The generation of these wastes is minimized and controlled through the following practices.

ORIGIN

Operational, construction, and maintenance activities at NRF result in the generation of some RCRA hazardous wastes. These wastes primarily include heavy metal debris and laboratory wastes. Activities at NRF during 2023 also resulted in the generation of various types of low-level radioactive waste material, ranging from irradiated metal to paper and plastic products. Activities at the NRF site resulted in the generation of some mixed wastes. These wastes included radioactively-contaminated paint chips and heavy metal-contaminated debris. Some activities at the site also generated PCB-contaminated and ACM wastes.

CONTROL PROGRAM

The waste management program in place at NRF facilitates the minimization of the quantity of routine waste material generated, assures safe storage of the materials on-site, and provides proper off-site disposal.

A principal component of the overall control program is the review of purchase orders prior to the acquisition of chemicals at NRF. Purchase orders are reviewed to determine that the procurement of a hazardous material is necessary, to assure excessive quantities are not ordered, and to determine if a suitable nonhazardous substitute is available.

In 1992, a Chemical Management Program was developed, and a major revision to the NRF Waste Minimization and Pollution Prevention Program was completed. The Chemical Management Program was designed to track and control the volume and use of hazardous materials. This program additionally strengthens the control over procurement of hazardous materials. NRF minimizes waste generation through source reduction, segregation, reuse, and recycling. NRF reports waste minimization efforts in reports such as the Naval Reactors Sustainability Plan.

Appropriate training is provided to site personnel who handle hazardous materials to ensure that they are knowledgeable of safe handling techniques, emergency response procedures, and the use of MSDSs/SDSs. Personnel were also provided training on workers' Hazard Communication and Right-to-Know Standards as defined in 29 CFR § 1910.1200. Workers who handle hazardous, PCB, or ACM waste receive the appropriate level of training to manage these types of waste.

Waste generated from the use of hazardous materials is accumulated and stored in approved areas. These approved areas are managed in accordance with RCRA and State of Idaho hazardous waste regulations. Hazardous waste accumulation and storage areas are inspected routinely to verify that hazardous wastes are properly stored and controlled in accordance with approved work procedures and regulatory requirements.

The volume of radioactive waste generated at NRF is minimized by work-specific training programs, detailed work instructions, limitations of the amounts of material introduced to a radiological environment, and volume reduction programs.

All mixed wastes are managed in accordance with the State of Idaho hazardous waste regulations and the INL STP that was implemented by a Consent Order signed by the DOE and the IDEQ. This plan specifies the mixed waste treatment and disposal methods for all of the INL, which includes NRF.

Since mixed wastes are both hazardous and radioactive, hazardous waste controls are applied to account for the hazardous constituents and radioactive controls are applied to account for the radioactive components at the point of generation.

The volume of mixed waste generated at NRF is minimized by work-specific training programs, development of detailed work instructions to avoid the use of hazardous chemicals where appropriate, engineering work to avoid generation of mixed waste, segregation of waste types, and volume reduction programs.

All PCB waste is managed in accordance with TSCA (40 CFR Part 761). PCB waste that contains RCRA hazardous constituents is managed utilizing both TSCA and RCRA controls. Radioactive PCB waste is managed by employing both radiological and TSCA controls. Mixed PCB waste is managed in accordance with all three sets of requirements (RCRA, radiological, and TSCA).

DISPOSAL PROGRAMS

Table 14 summarizes NRF waste disposal totals in calendar year 2023. The amounts of waste shipped for disposal include legacy wastes.

TABLE 14 – WASTE DISPOSAL AMOUNTS(1)

Type of Waste	Weight (lbs)
Hazardous Waste(2)	4,626
Low-Level Radioactive Waste(3)	221,110
Low-Level Mixed Waste(4)	7,912
Municipal Waste(5)	8,719,730
PCB Waste(6)	77
Universal Waste(7)	497

(1) This table does not include material recycled or diverted for recycling.

(2) Hazardous waste category includes hazardous PCB waste and hazardous asbestos waste.

(3) Low-level radioactive waste category includes radioactive PCB bulk product and radioactive PCB remediation waste.

(4) Low-level mixed waste category includes hazardous radioactive and hazardous radioactive PCB waste.

(5) Municipal Waste (e.g., industrial, construction, and demolition) disposed of at the INL and off-site landfills.

(6) PCB waste other than that which would be characterized as hazardous, radioactive, or mixed waste.

(7) Universal waste category includes non-radioactive hazardous waste batteries, lamps, and mercury-containing equipment.

Hazardous wastes generated by NRF were transported by contractors to EPA-approved TSD facilities. The transportation vendors and the TSD facilities operate under the appropriate approvals or permits granted by Federal and State regulatory agencies. NRF determines the appropriate treatment and disposal methods in accordance with RCRA LDRs.

All non-hazardous and non-radioactive PCB wastes were disposed at an approved facility. PCB wastes (including hazardous and radioactive) were disposed at TSD facilities approved to receive both hazardous and TSCA wastes. Radioactive PCB bulk product and remediation wastes are disposed at an approved TSCA facility.

Depending upon treatment and disposal services availability, hazardous and mixed wastes are either stored at NRF for less than 90 days or shipped to the INL TSD facility for temporary storage before they are shipped to off-site TSD facilities. Mixed PCB wastes can also be shipped to the INL TSD facility for temporary storage, pending treatment and disposal facility availability. NRF did not utilize the INL TSD facility in 2023.

RECYCLING

During 2023, NRF continued to recycle as much waste material as practical. The recycling efforts at NRF are summarized in Table 15.

In 2023, NRF shipped radioactive recyclable metal to a vendor for recycling and reuse within the DOE program. However, recycling of non-radioactive scrap metal originating in radiological facilities is presently on hold, pending the lifting of a DOE Moratorium on recycling scrap metal released from radiological facilities. NRF continues to ship recyclable scrap metal from non-radiological areas to vendors for recycle and reuse.

NRF is also reducing the amount of mixed waste sent for disposal by recycling radioactively contaminated elemental lead through a Navy contract with an approved out-of-state radioactive material recycling facility. This material is stored as recyclable until sufficient quantities are accumulated to justify a shipment.

Shipping casks and other obsolete components containing lead shielding have been sent to the recycling facility for dismantling, meltdown, and recycling into shipping containers for radioactive material and into shield blocks.

TABLE 15 – RECYCLING AMOUNTS

Type of Material		Amount Recycled (lbs.)
Asphalt		628,795
Batteries[1]		3,979
Cardboard		64,680
Clothing/Laundry		11,101
Computers/Cell Phones		14,000
Cooking Oil/Grease		0
Concrete		2,479,605
Lead	(Non-Radioactive)	0
	(Radioactive)	309,279
Light Bulbs		164
Mercury Containing Devices		0
Oil (Used & Unused)		2,300
Plastic		0
Scrap Metal	(Non-Radioactive)	665,440
	(Radioactive)	192,229
Soil and Gravel		776,058
Toner Cartridges (Copier/Toner)		3,676
Wood		459,608

(1) Lead-acid batteries and lithium ion batteries.

RADIATION DOSE ASSESSMENT

The purpose of the radiation monitoring program is to verify that NRF operations do not increase radiation exposure to the general public.

MONITORING, ANALYSES, AND RESULTS

Measurement of radiation along the NRF perimeter was performed independently by NRF and the INL. Additionally, the INL performed radiation monitoring at locations along the INL boundary and distant communities.

The NRF radiation monitoring program involves measuring ionizing radiation levels at 18 locations along the NRF security fence and 6 other locations along the NRF perimeter. Lithium-fluoride thermoluminescent dosimeters (TLDs) were placed at each location approximately three feet above the ground. These TLDs are calibrated using National Institute of Standards and Technology traceable equipment at the Naval Dosimetry Center. Figure 6 shows the locations of the 24 NRF TLDs posted at the NRF site.

NRF also posted 15 TLDs (three groups of five) throughout the INL varying from five to ten miles from the NRF to determine INL radiation background levels. All NRF environmental TLDs were collected and processed quarterly.

The INL measured radiation levels at locations surrounding NRF (Figure 6). This monitoring was performed by placing optically stimulated luminescence dosimeters (OSLDs) at each of the pre-designated locations. The INL OSLDs were collected and processed every six months. For the first six-month monitoring period, nine locations were monitored. For the second six-month monitoring period, the INL expanded its monitored boundary to locations outside the vehicle barrier system on the north and east perimeter, and added four locations. Thirteen total locations were monitored during the second six-month period.

The INL measured natural background ionizing radiation levels at off-site locations under the DOE Off-site Environmental Surveillance program using OSLD measurements obtained from 16 locations along the INL boundary and distant communities (Figure 7). The DOE environmental OSLDs were collected and processed every six months.

In addition to the TLD and OSLD network, any radiation surveys that were conducted around the NRF site perimeter were performed using a highly sensitive radiation detection instrument.

The results of the radiation monitoring programs conducted by NRF and the INL in 2023 are summarized in Table 16. A comparison of the average TLD reading around the NRF perimeter and the average background TLD reading measured by NRF at locations on the INL five to ten miles away indicates that NRF does not contribute to an increase in off-site radiation levels. This is further verified by comparing the average NRF perimeter reading to the average reading of the DOE environmental OSLDs posted along the INL boundary and distant communities.

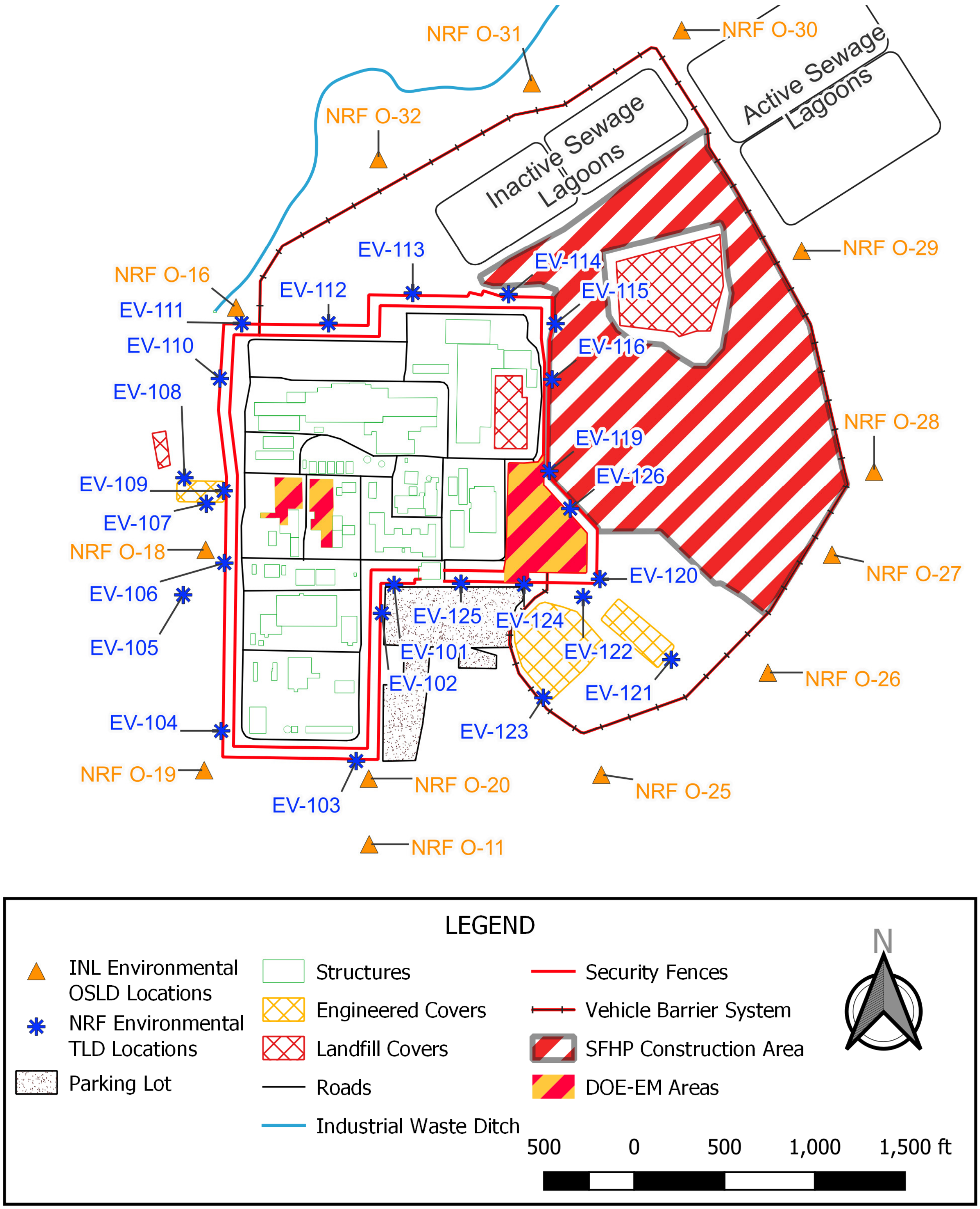

FIGURE 6 – NRF AND INL ENVIRONMENTAL DOSIMETER LOCATIONS AT NRF

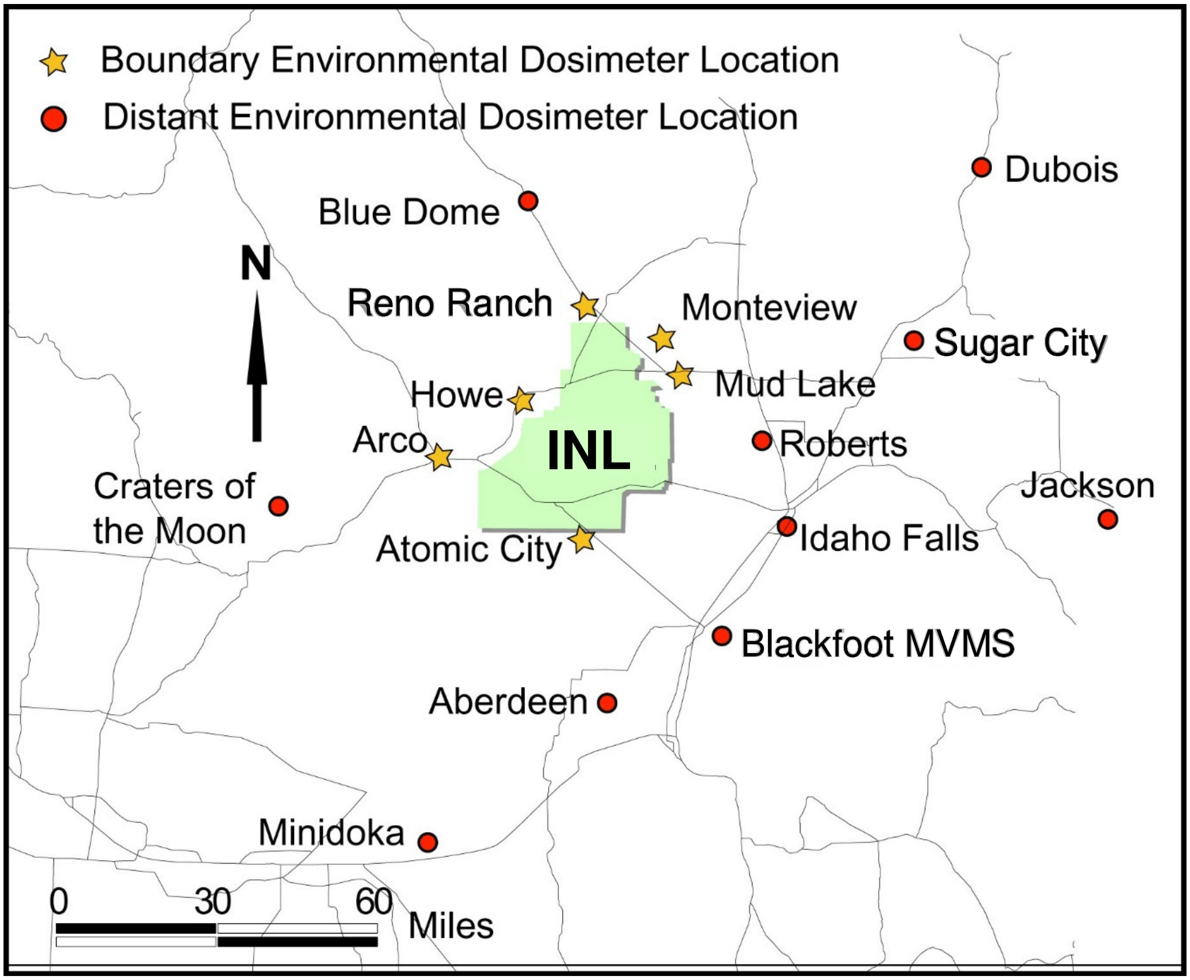

FIGURE 7 – DOE OFF-SITE ENVIRONMENTAL SURVEILLANCE PROGRAM ENVIRONMENTAL DOSIMETER LOCATIONS FOR THE INL BOUNDARY AND DISTANT COMMUNITIES

Environmental monitoring results from 2023 did not reveal any measurable increase above naturally occurring radioactivity levels in the environment from NRF operations. Radiation exposure to the general public from NRF emissions was too low to measure and could only be determined with conservative computer models based on the various effluent radiological data. Therefore, an assessment of the radiation dose-to-man was performed by analyzing the exposure pathways whereby radioactivity might theoretically be transported from NRF to the general public. The following potential exposure pathways were considered in this assessment:

- Liquid Pathways: Ingestion of radioactivity in the drinking water supply.
- Airborne Pathways: Exposure as a result of radionuclide emissions to the air.
- Direct Exposure Pathways: Direct external radiation from NRF operations.

TABLE 16 – ENVIRONMENTAL IONIZING RADIATION MEASUREMENTS FOR NRF (mrem)

	NRF On-site Readings (91 day quarterly period)(1)				**INL Readings of NRF Site** (6 month period)(2)				**NRF Readings of INL Background (Remote from NRF)** (91 day quarterly period)(1)				**Readings from INL Boundary and Distant Communities(3)** (6 month period)(2)			
Quarter	**Number of Measurements**	**Mean(4)**	**Max**	**Min**	**Number of Measurements**	**Mean(4)**	**Max**	**Min**	**Number of Measurements**	**Mean(4)**	**Max**	**Min**	**Number of Measurements**	**Mean(4)**	**Max**	**Min**
1st	24	19 ± 4	24	17	9	59 ± 10	66	50	15	18 ± 2	21	17	16	55 ± 12	67	45
2nd	24	23 ± 3	27	20					15	24 ± 3	25	21				
3rd	24	23 ± 4	29	20	13	70 ± 12	78	60	15	24 ± 4	27	22	16	61 ± 16	87	55
4th	24	25 ± 4	28	21					15	24 ± 3	26	22				

(1) All readings are normalized in mrem for a 91 day quarter, the first quarter begins 01/05/2023 and the fourth quarter ends 01/03/2024.

(2) The first, six-month period from 11/01/2022 to 04/30/2023 and the second, six-month period from 05/01/2023 to 10/31/2023. Readings reflect total time between anneal and processing.

(3) The INL boundary and distant communities monitored in Idaho included Aberdeen, Arco, Atomic City, Blackfoot - Mountain View Middle School, Blue Dome, Craters of the Moon, Dubois, Howe, Idaho Falls, Jackson, Minidoka, Monteview, Mud Lake, Reno Ranch, Roberts and Sugar City. Off-site dosimeter readings were collected by the INL as part of the Off-site Environmental Surveillance program for the DOE at the INL.

(4) The uncertainties given in the "mean" column represent a 95% confidence level.

Note: The slight variations in the values were not significant and were due to the variables inherent in dosimetry processing, monitoring location, and dosimeter types used by NRF and the INL radiation monitoring programs.

There is no potential for exposure to the public from liquid pathways because NRF did not discharge any radioactive liquid from operations in 2023. NRF drinking water radiological monitoring showed levels comparable to background concentrations measured in groundwater at the INL and significantly below Federal and State drinking water limits.

The dose for each airborne exposure pathway was explicitly calculated for each radionuclide and its applicable daughter products. The total effective dose equivalent for airborne pathways was calculated using the EPA approved CAP-88 computer program described in Reference 1. The airborne pathway calculations used 2023 meteorological data collected by the National Oceanic and Atmospheric Administration.

Because the radiation levels at the NRF site boundary are low, and the site is removed from public access, there is no exposure to the public from direct exposure pathways.

RADIOLOGICAL DOSE ASSESSMENT CONCLUSIONS

The only potential radiation exposure to the public from NRF operations in 2023 was from airborne releases. The potential maximum effective dose equivalent that a member of the general public could have received due to NRF operations in 2023 was 0.000093 mrem per year, see Table 17. This is well below the EPA airborne radiation exposure limit of 10 mrem per year (Reference 2). It is also below the radiation exposure limit of 100 mrem per year established by the DOE and the Nuclear Regulatory Commission (References 3 and 4). The 100 mrem per year includes all potential exposure pathways. Further, the dose is negligible when compared to the naturally occurring background radiation dose of approximately 366 mrem per year for residents of southeast Idaho. The dose is also much less than the approximate three mrem that an individual would receive from a single cross-country airplane flight. Therefore, operations at NRF did not result in any measurable radiation exposure to the general public.

TABLE 17 – ANNUAL RADIATION DOSE-TO-MAN FROM SITE OPERATIONS

Pathway	Dose to Maximally Exposed Individual		% of DOE 100 mrem/yr Limit	Estimated Population Dose		Population within 80 Kilometers	Estimated Background Radiation Population Dose
	(mrem)	(mSv)		(person-rem)	(person-Sv)		(person-rem)
Air	9.3E-05	9.3E-07	9.3E-05	4.7E-03	4.7E-05	1.76E5	6.44E4
Water	None		None	None			
Other Pathways	None		None	None			
All Pathways	9.3E-05	9.3E-07	9.3E-05	4.7E-03	4.7E-05		

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QUALITY ASSURANCE

The NRF Quality Assurance Program (QAP) is conducted to ensure the accuracy and precision of effluent and environmental sampling, analysis, and reporting.

The program consists of the following elements:

INTERNAL QUALITY ASSURANCE PROCEDURES

- Personnel training and qualification
- Written procedures for sampling, sample analysis, and computational methods
- Calibration of sampling and sample analysis equipment
- Internal quality assurance sample analyses
- Data review/validation and computation check

The internal quality assurance procedures start with the training of all personnel involved in the collection and analysis of samples, in accordance with established internal policies. Personnel are not permitted to perform sampling and sample analysis until they are trained and have demonstrated the ability to properly perform their duties. Written procedures cover collection and analysis of samples, the computation of results, and the calibration of sampling and analytical equipment. Internal quality assurance procedures also provide for a system of duplicate (or replicate) analyses of the same sample, blank samples, and the analyses of spiked samples to demonstrate precision and accuracy. All measurement data are assessed to detect anomalies, unusual results, and trends.

PARTICIPATION IN A QUALITY ASSESSMENT PROGRAM ADMINISTERED BY COMMERCIAL LABORATORY

NRF participates in a QAP administered by a commercial laboratory, Environmental Resource Associates (ERA). The QAP provides an independent verification of the accuracy and precision of analyses of effluent and environmental monitoring samples. The results in the ERA QAP are summarized in Table 18. The data demonstrate satisfactory performance.

SUBCONTRACTOR QUALITY ASSURANCE PROCEDURES

Vendor subcontractor laboratories perform effluent and environmental sample analyses. NRF maintains a quality assurance program to ensure the accuracy and precision of the subcontractor analytical results. This includes submitting blanks and replicate samples along with routine samples for analysis. If unsatisfactory results are obtained, follow-up investigations are performed to correct the problems.

PROGRAM AUDITS

Periodic audits are conducted that examine the effluent and environmental monitoring programs to ensure compliance with all procedures and applicable Federal and State regulations.

TABLE 18– NRF PERFORMANCE IN THE ENVIRONMENTAL RESOURCE ASSOCIATES QUALITY ASSESSMENT PROGRAM

DATE	SAMPLE TYPE	ANALYSIS	NRF RESULT(1)	ERA ASSIGNED VALUE(1)	ACCEPTANCE LIMIT(1, 2)	
MAR23	Air Filter	Cobalt-60	476	467	397	593
		Cesium-137	890	892	733	1,170
	Soil	Cobalt-60	4,194	3,490	2,750	4,310
		Cesium-137	4,236	3,570	2,700	4,520
	Vegetation	Cobalt-60	676	696	546	910
		Cesium-137	1,708	1,840	1,410	2,480
	Water	Cobalt-60	421	412	355	473
		Cesium-137	768	762	652	866
SEP23	Air Filter	Cobalt-60	102	95.5	81.2	121
		Cesium-137	953	932	765	1,220
	Soil	Cobalt-60	8,936	7,960	6,270	9,830
		Cesium-137	1,962	1,780	1,350	2,250
	Vegetation	Cobalt-60	2,146	2,250	1,770	2,940
		Cesium-137	869	949	730	1,280
	Water	Cobalt-60	2,056	2,020	1,740	2,320
		Cesium-137	1,012	1,010	865	1,150

(1) Units reported: Air = pCi/filter, Soil & Vegetation = pCi/kg, Water = pCi/l.

(2) The acceptance limits are provided by the ERA.

HISTORICAL OPERATIONS

PAST OPERATIONS

In addition to the three prototypes (S1W, A1W, S5G) and ECF previously mentioned, other significant facilities used during past operations to support the NRF mission are briefly described below.

Spray Ponds and Cooling Towers. Two large spray ponds were built for cooling the S1W Prototype, each with a capacity of 2,250,000 gallons. Both spray ponds have been removed.

The A1W and S5G Prototypes both had cooling towers used to dissipate the heat from the secondary cooling system. During operations of these cooling systems, continuous blowdown of water at a rate of a few gallons per minute was used to control concentrations of dissolved minerals naturally present in the supply water. The blowdown water, which was not radioactive, was discharged into the NRF IWD. The A1W cooling tower has been completely removed with its concrete basin buried in its original location. The S5G cooling tower was dismantled except for the concrete basin, which is used for the storage of emergency firefighting water.

Industrial Waste Ditch. To accommodate the high volumes of cooling water needed to support the operation of the prototypes, construction of a wastewater ditch began in 1951 that extended along the east and north border of the facility. This portion of the ditch was designed to flow into an old riverbed channel that flowed northwest of NRF. Some portions of the old riverbed were excavated to ensure proper flow of liquid discharges. Liquid discharges were non-sewage and non-radioactive effluent. Occasionally, dredging of the waste ditch was required to help with water percolation. Debris dredged from the channel was placed along the banks of the ditch. As the footprint of NRF grew, some portions of the waste ditch were encased in pipe and covered with dirt. Early discharges to the ditch included oily residues and dilute solutions of hazardous waste, which was a common disposal practice for the time. In 1985, NRF installed a neutralization facility that eliminated all hazardous wastes being discharge to the waste ditch.

Investigations have been performed on the interior and exterior portions of the IWD. These investigations were performed in accordance with the INL CERCLA FFA/CO. No remedial action was determined to be necessary for these areas as documented in the IWD and Landfill Areas ROD.

Currently, all industrial wastewater at NRF is discharged to the existing sewage lagoons, and the NRF Industrial Waste Discharge permit has been closed.

Sewage Treatment Facilities. In 1951, a small sewage treatment plant was constructed consisting of an Imhoff Tank, sludge drying beds and an effluent drain field. The drain field was used until 1955 for combined radioactive liquid effluent and sewage effluent. In 1956, a sewage disposal basin was constructed southeast of NRF for sewage effluent. Radioactivity was inadvertently introduced into the disposal basin in 1956. This sewage disposal basin was used until 1960 when the NRF sewage lagoons were constructed on the northeast corner of NRF.

The original sewage disposal basin and associated systems have been remediated as specified in the NRF Final ROD signed by the EPA and State of Idaho in September of 1998 and as modified by an Explanation of Significant Difference signed by the EPA and State of Idaho in 2002.

In 1972, the lagoons, constructed in 1960, were expanded to their maximum size. The sewage lagoons were in operation until 2012 when a new lined lagoon complex was constructed to meet the state design standards for wastewater lagoons. In 2019, these old lagoons were filled in with clean soil from the excavation associated with the project to construct a new spent fuel handling facility. See Present Operations section above for additional information on the new spent fuel handling facility.

Leaching Beds. Prior to 1979, controlled releases of water containing low levels of radioactivity were made to soil beds near the A1W and S1W Prototypes. The releases to these leaching beds were made in accordance with standards applicable at the time, and no member of the general public has ever received any measurable radiation exposure from the beds. The releases were discontinued in 1979 when on-site facilities for recycling water containing trace amounts of radioactivity became operational. The residual radioactivity remaining in the soil beds today cannot be reached by members of the general public, as the areas have been capped and access is controlled. Remedial actions were performed in these areas per the ROD. See Residual Radioactivity in Soil section below for further details.

Landfills. NRF maintained its own non-radioactive landfill operations until the early 1960s, when all solid wastes began to be shipped to the landfill at the INL Central Facilities Area. These landfills were typical for that era, containing garbage, construction debris, waste oil, solvents, scrap iron, and asbestos. Most of the waste in the landfills was burned. The first NRF landfill was north of the S1W Prototype. After this landfill was closed, a location on the west side of the facility and a large area at the northeast corner of the facility were utilized for solid waste disposal.

During the time they were used, there were no local, State, or Federal requirements governing such operations. Remedial corrective actions for these have been completed in accordance with the INL CERCLA FFA/CO. The remedial actions required that landfill covers be placed over the landfills and monitored. The EPA and the State of Idaho oversaw these actions. The remedial actions implemented at NRF under the FFA/CO were used as an example of successful application of CERCLA presumptive remedies by a December 1996 EPA directive (Reference 10).

The initial CERCLA Five-Year Review for the remedial actions that were implemented for the inactive landfill areas was completed in 2001. More recent Five-Year Reviews that provided updates for the remedial actions implemented for the inactive landfill areas and remedial actions at other CERCLA sites have been completed. All of these reviews, through the use of annual inspections of the landfill covers placed over the inactive landfill areas and the ongoing review of groundwater and soil gas monitoring data, concluded that the landfill covers continue to be effective at containing contaminants by inhibiting infiltration of precipitation and by preventing direct contact with contaminated soils and landfill wastes.

PAST RADIOACTIVE WASTE MANAGEMENT

Radioactive waste management practices have evolved over the years consistent with advances in technology and changes in regulatory requirements. NRF has always maintained an environmental program in accordance with the national standards in effect at the time. In 1979, NRF took action to eliminate discharges of liquids containing even trace amounts of radioactivity. This action was not required by rule or law. It was done because it had become feasible and was consistent with the conservative engineering approach followed by the NNPP of minimizing releases of radioactivity.

NRF has always been involved in handling radioactive materials and in maintaining a radioactive waste management program. For example, requirements for treatment and disposal of solid and liquid wastes were provided for in the design of the operating facilities. Features such as retention tanks and evaporators for liquid waste, surface and subsurface facilities for temporary storage of waste, and air cleaning systems using high efficiency filters were incorporated into the initial design of the facilities.

RADIOACTIVE LIQUID WASTE

Liquid wastes were managed by a variety of methods. NRF has complied with the then-existing limits for discharges of water containing low concentrations of radioactivity since the beginning of Site operations in the 1950s. Water containing low levels of radioactivity was discharged to specific, defined areas on NRF property that were monitored and controlled. Water exceeding radioactivity concentration limits was not discharged directly to the environment, but instead was processed through ion exchangers to remove as much radioactivity as practicable, or diluted to permissible levels prior to discharge.

Today, concentrations of radioactivity in the surface soils near the leaching beds are near background levels. Approximately 32 curies are estimated to remain in the beds, out of the 345 curies released since NRF operations began. There is no evidence that the radioactivity, except tritium, has left the immediate area of the beds as confirmed by sampling performed as part of the NRF Comprehensive RI/FS. The decrease in curie content is due to steady decay of cobalt-60 and cesium-137, the major radionuclides of concern in the leaching beds, with half-lives of 5.3 and 30 years, respectively. These areas were identified for remedial actions as part of the NRF Comprehensive RI/FS and agreed to by the State of Idaho and EPA in the ROD signed in September 1998. The remedial actions for these areas consisted of placement of an engineered cover, institutional controls, and monitoring. The placements of the three engineered covers over these areas were completed in 2004 and are now under institutional controls with periodic monitoring.

RADIOACTIVE SOLID WASTE

Most of the radioactive solid waste volume generated by the NRF has been low-level waste. Solid waste generated at NRF and sent to the INL waste disposal facilities were characterized as follows:

Incinerable Low-Level Radioactive Waste (Radiation levels less than 20 millirem per hour (mrem/hr) at the surface of each container):

- This type of waste consisted of paper and cloth wipes, protective clothing, wood and floor sweepings. These wastes were collected in waste cans, packaged in boxes and sent to the Waste Experimental Reduction Facility (WERF) for incineration. The ash and residue were shipped to the RWMC for disposal. Incineration of radioactive waste ceased in the fall of 2000.

Compactable Low-Level Radioactive Waste (Radiation levels less than 200 mrem/hr at the surface of each container):

- This included such wastes as contaminated equipment, air filters, and materials that exceeded the radiation limits for incineration. These wastes were packaged in polyurethane bags and transported by cargo container to the WERF for compaction. The processed wastes were then shipped to the RWMC for disposal. In August 2001, compaction at the WERF ceased.

Size-reducible Low-Level Radioactive Waste (Radiation levels less than 100 mrem/hr at contact with the item):

- This included such wastes as contaminated equipment that could be segmented to reduce the volume by at least a factor of three. Until August 2001, these wastes were packaged and transported to the WERF for segmentation. The processed wastes were shipped to the RWMC for disposal.

Contact-Handled Non-processible Low-Level Radioactive Waste (Radiation levels less than 500 mrem/hr at 1 meter from the surface of the container):

- This included such waste as contaminated equipment that was not acceptable as incinerable, compactable, or size-reducible waste. These wastes were packaged in boxes or drums and sent to the RWMC for disposal. In October 2008, disposal of contact-handled wastes at the RWMC ceased.

Remote-Handled Low-Level Radioactive Waste (Radiation levels greater than 500 mrem/hr at the surface of each container):

- This included such waste as irradiated metallic scrap. This waste was generated in the ECF water pools and shielded cells. The irradiated metallic scrap was packaged in containers underwater using remote handling equipment. Waste generated in the shielded cells was placed in containers while in the cells, removed to the water pools, and placed in shipping containers underwater. Specially designed shielded shipping casks were used to transport this waste by truck for burial at the RWMC. The radiation levels on all shipments in areas accessible to the general public were less than the limits imposed by the Department of Transportation for radioactive material shipments over public highways.

- NRF has also examined and tested fuel from nuclear-powered warships, the Shippingport Atomic Power Station, and specimens that were irradiated in test reactors. These examinations resulted in waste containing small amounts of irradiated fuel. The individual waste items containing irradiated fuel from NRF did not consist of entire cores or whole fuel cells, which were considered a valuable resource at the time and retained for reprocessing. Prior to 1971, about 220 kilograms of mostly irradiated natural uranium was disposed of at the RWMC, in accordance with the radioactive waste requirements at that time. In 1971, the Atomic Energy Commission modified the requirements for low-level waste that precluded the burial at the RWMC of wastes containing irradiated fuel. Accordingly, since 1971, NRF has not disposed of waste at the RWMC that contains irradiated fuel.

RADIOACTIVE AIRBORNE EFFLUENTS

For details of current practices related to ventilation air from radiological facilities, see the Present Operations section above.

Overall, less than an estimated 1,100 curies of radioactivity have been released to the atmosphere during the period of 1953 through 1989, with the majority occurring in the 1950s. Most of the radioactivity (over 80 percent) consisted of the inert gaseous isotopes argon, krypton, and xenon. These inert gases do not deposit on surfaces and are readily dispersed in the atmosphere. The remainder consisted of smaller amounts of other beta-gamma emitting activated corrosion and wear products, carbon-14, tritium, and trace quantities of fission products. Since 1990, airborne emissions of radionuclides have typically been less than 2 curies per year, and annual exposure to the public from these emissions has been less than 0.001 mrem per year. For perspective, Federal regulations allow up to 10 mrem per year exposure to the general public from airborne emissions from DOE facilities.

In addition to the regular annual releases, a single release occurred in 1955 during the performance of an engineering test to obtain information on the effects of boiling conditions in naval reactors. During the testing, a specially designed and instrumented test assembly was subjected to carefully controlled conditions designed to explore fuel element integrity beyond operational limits in effect at the time. Small amounts of fission products were released from the test assembly, most of which were retained in the primary coolant. A conservative estimate of the amount of radioactivity released from NRF was 870 curies. The radioactivity remaining in this coolant went to the leaching beds or purification media. The purification media was subsequently disposed of at the RWMC. Conservative calculations indicate the maximum exposure to a member of the general public was 0.5 mrem, which is only 5 percent of today's general public annual exposure limits from DOE facilities.

RESIDUAL RADIOACTIVITY IN SOIL

There are several localized areas of soil on NRF property that contain small amounts of residual radioactivity from historical liquid radioactivity releases. These areas were included in remedial actions as determined by the Comprehensive RI/FS and agreed to by the State of Idaho and the EPA in the ROD signed in September 1998. The specific affected areas that have undergone remedial action are discussed below.

S1W Tile Drain Field and L-shaped Sump. This area consisted of a below-surface sump and various underground, tile drain field pipes downstream of the sump. The drain field was likely used between 1953 and 1955 for sewage and radioactive liquid discharges. The sump was isolated from the drain field in 1955 and was used until 1960 as part of the sewage system. Sampling indicated that any significant contamination at the drain field was likely confined within the pipes. Remedial actions were completed in 2002.

Underground Piping to Leaching Pit. In 1955, a drain field was constructed south of S1W, adjacent to the S1W Tile Drain field. The drain field was an underground, perforated pipe. This drain field was used for radiological discharges after the S1W Tile Drain field was no longer used. The drain field was used for discharges until 1960. Sampling indicated most of the contamination at this drain field was within three to five feet of the underground pipe. Contaminated soil was removed from this area. Remedial actions were completed in this area in 2003.

S1W Leaching Pit. In 1957, a pit was dug at the end of the underground, perforated pipe drain field. This pit was known as the S1W Leaching Pit. The pit was used from 1957 until 1961 when it was filled in with soil. An asphalt cover was placed over the leaching pit location in 1978 and was removed in 2003 as part of the remedial actions. An engineered cover was constructed over this area and completed in 2004.

S1W Leaching Beds. The first S1W Leaching Bed was constructed in 1960. The bed was an open pond that allowed the water to evaporate or infiltrate into the ground. A second bed was constructed in 1963 adjacent to the first bed. The beds originally received effluent from the S1W Prototype plant and later received effluent from the S5G and A1W Prototypes and the ECF. The beds were used from 1960 to 1979. Sampling indicated the extent of contamination in this area was primarily within the soil directly below the leaching beds. As part of remedial actions, contaminated soil from other CERCLA remedial action sites was consolidated into these beds. An engineered cover was constructed over this area and completed in 2004.

S1W Retention Basins. The S1W Retention Basins were constructed in 1951. The basins were two concrete structures, which received radioactive effluent from the S1W Prototype plant and later received effluent from the S5G and A1W Prototype plants and the ECF. The basins were used as a radioactive liquid storage facility prior to discharging the liquid to the discharge areas. One of the basins is known to have leaked in 1971. The leak was directly below the basins. Remedial actions were completed at this area in 2001. These actions included the removal of the basins and associated contaminated soil.

A1W Leaching Bed. The A1W Leaching Bed was constructed west of NRF in 1957. The bed was not an open pond like the S1W Leaching Beds. The A1W Leaching Bed was similar to a drain field with underground, perforated pipes distributing the liquid to an area constructed of gravel and sand. The bed was used continually from 1958 to 1964 for effluent discharges from the A1W Prototype and the ECF. The bed was used sporadically from 1964 until 1972, when use of the bed was discontinued. Sampling indicated that the extent of contamination at the A1W Leaching Bed was limited to the soil within and directly below the leaching bed. An engineered cover was constructed over the area and completed in 2004.

A1W/S1W Radioactive Line Near Butler Building 19. During the construction of the A1W Prototype, a pipe was installed from the A1W Prototype to the S1W Retention Basins that allowed radioactive effluents from A1W to be sent to the S1W radioactive discharge system. The pipe was buried approximately six feet below the surface. The pipe is known to have leaked on one occasion. During decontamination and decommissioning work at NRF in 1995, portions of the pipe were removed and contamination was detected in the soil. Remedial actions were completed at this site in 1999. Residual contamination was left in place in the soil. During the demolition of the adjacent S1W Spray Pond #1, the residual contamination was remediated with concurrence by the State of Idaho and EPA. This removal action was completed in early 2010.

Old Sewage Basin. In 1956, a sewage basin was constructed to the southeast of NRF. The sewage basin was an open pond. The basin was cross-contaminated with the radiological discharge system in 1956. The basin was enlarged in 1957 and was used until 1960. The basin was then filled in with soil. Remedial actions began at this site in 2000. An Explanation of Significant Difference to the ROD was issued for this site in 2002 that modified remedial actions to include the construction of an engineered cover over the area. The cover was constructed over this area and completed in 2004.

Sludge Drying Bed. The sludge drying bed was constructed in 1951 as part of the sewage system at NRF. The bed was a concrete slab approximately five feet below the surrounding ground elevation.

The bed received sludge from the sewage system. The bed was suspected to have been contaminated with radionuclides when the sewage system was cross-contaminated with the radiological discharge system in 1956. Remedial actions were completed at this area in 2002 with the removal of the bed and associated soil.

Seepage Basin Pump-out Area. This site is an area that physically surrounds the sewage disposal basin and was formed when the radioactively contaminated contents of the basin were pumped out in 1958. Additional contaminated areas associated with the Seepage Basin Pump-out Area were found in 2009 and 2010. These areas were remediated in 2012 by the removal and disposal of soil with contamination above the CERCLA remediation goal. A minor change to the ROD was issued with concurrence by the State of Idaho and EPA that documented the remedial action.

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RADIATION AND RADIOACTIVITY

GENERAL INFORMATION

This section provides general information on radiation and radioactivity for those who may not be familiar with the terms and concepts.

Humans have always lived in a sea of natural background radiation. This background radiation was and is as much a part of the earth's environment as the light and heat from the sun's rays. There are three principal sources of natural background radiation: cosmic radiation from the sun and outer space, radiation from the natural radioactivity in soil and rocks (called 'terrestrial radiation'), and internal radiation from the naturally radioactive elements that are part of our bodies. A basic knowledge of the concepts of radiation and radioactivity is important in understanding how effective control programs are in reducing radiation exposures and radioactivity releases to levels that are as low as reasonably achievable.

RADIATION

In simple terms, radiation is a form of energy. Microwaves, radio waves, x-rays, light, and heat are all common forms of radiation. The radiation from radioactive materials (radionuclides) is in the form of particles or rays. During the decay of radionuclides, alpha, beta, and gamma radiation are emitted.

Alpha radiation consists of small, positively charged particles of low penetrating power that can be stopped by a sheet of paper. Radionuclides that emit alpha particles include radium, uranium, and thorium.

Beta radiation consists of charged particles that are smaller than alpha particles but are generally more penetrating and may require up to an inch of wood or other light material to be stopped. Examples of beta emitters are strontium-90, cesium-137, and cobalt-60.

Gamma radiation is an energy emission like an x-ray. Gamma rays have great penetrating power but are stopped by up to several feet of concrete or several inches of lead. The actual thickness of a particular shielding material required depends on the quantity and energy of the gamma rays to be stopped. Most radionuclides emit gamma rays along with beta or alpha particles.

Each radionuclide emits a unique combination of radiations that is like a "fingerprint" of that radionuclide. Alpha or beta particles and/or gamma rays are emitted in various combinations and energies. Radionuclides may be identified by measuring the type, relative amounts, and energy of the radiations emitted. Measurement of half-life and chemical properties may also be used to help identify radionuclides.

RADIATION AND DOSE

Body tissue can be damaged if enough energy from radiation is absorbed. The amount of energy absorbed by body tissue during radiation exposure is called "absorbed dose". The potential biological effect resulting from a particular dose is based on a technically defined quantity called "dose equivalent." The unit of dose equivalent is called the Roentgen equivalent man or rem. Another quantity called "effective dose equivalent" is a dose summation that is used to estimate the risk of health effects when the dose is received from sources that are external to the body and from radioactive materials that are within the various body tissues. The traditional unit of effective dose equivalent, which is used in the United States, is also the rem, while the standard international (SI) unit is the Sievert (One Sievert is equal to 100 rem). The rem is a unit that is relatively large compared with the level of radiation doses received from natural background radiation or projected as a result of releases of radioactivity to the environment. The millirem (mrem, or one thousandth of a rem)), is frequently used instead of the rem. The rem and mrem are better understood by relating to concepts that are more familiar.

Radiation comes from both natural and man-made sources. Natural background radiation includes cosmic radiation from the sun and outer space, terrestrial radiation from radioactivity in soil, radioactivity in the body, and inhaled radioactivity.

The National Council on Radiation Protection and Measurements estimates that the average member of the population of the United States receives an annual effective dose equivalent of approximately 311 mrem from natural background radiation. This is composed of approximately 33 mrem from cosmic radiation, 21 mrem from terrestrial radiation, 29 mrem from radioactivity within the body and 228 mrem from inhaled radon and its decay products. The cosmic radiation component in the United States varies from 22 mrem at Honolulu, Hawaii to 65 mrem in Colorado Springs, Colorado. The terrestrial component varies from approximately 10 mrem on the Atlantic and Gulf Coastal Plain to about 40 mrem in the mountainous regions of the west. The dose from inhaled radon and its decay products is the most variable because of fluctuations in radon concentrations within houses due to changes in weather patterns and other factors such as changes in living habits.

The average natural background radiation level measured in southeast Idaho is approximately 366 mrem per year. Individual locations will vary based on soil composition, soil moisture content, and snow cover.

In addition to natural background radiation, people are also exposed to man-made sources of radiation, such as medical and dental x-rays and conventional fluoroscopy, computed tomography, nuclear medicine and interventional fluoroscopy. The average radiation dose from these sources is about 300 mrem per year. Other man-made sources include consumer products such as building products (brick and concrete) and lawn and garden fertilizer. Additionally, an airplane trip typically results in increased radiation exposure. A single cross-country flight between the east and the west coast results in a dose of about three mrem.

RADIOACTIVITY

All materials are made up of atoms. In the case of a radioactive material, these atoms are unstable and give off energy in the form of rays or tiny particles in order to reach a stable state. Each type of radioactive atom is called a radionuclide. Each radionuclide emits a characteristic form of radiation as it gives off energy. Radionuclides change as radiation occurs, and this transition is called radioactive decay. The rate at which a particular radionuclide decays is measured by its half-life. Half-life is the time required for one-half the radioactive atoms in a given amount of material to decay. For example, the half-life of the man-made radionuclide cobalt-60 is 5.3 years. This means that during a 5.3-year period, half of the cobalt-60 atoms initially present will have decayed. In the next 5.3 year period, half the remaining cobalt-60 atoms will have decayed, and so on.

The half-lives of radionuclides differ greatly. The half-life of naturally occurring radon-220, for instance, is only 55 seconds. In contrast, uranium-238, another naturally occurring radionuclide, has a half-life of 4.5 billion years.

Through the decay process, each radionuclide changes into a different nuclide or atom, often becoming a different chemical element. For example, naturally occurring radioactive thorium-232, after emitting its radiation, transforms to a second radionuclide, which transforms to a third, and so on. Thus, a chain of 11 radionuclides is formed including radon-220, before non-radioactive lead-208 is formed. Each of the radionuclides in the series has its own characteristic half-life and type of radiation. The chain finally ends when the newest nuclide is stable. The uranium chain starts with uranium-238 and proceeds through 13 radionuclides, ending with stable lead-206. All of these naturally occurring radionuclides are present in trace amounts in the soil in your backyard as well as in many other environmental media.

MEASURING RADIOACTIVITY

The curie (Ci) is the common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. The analogous SI unit to the Ci is the Becquerel (Bq). Specifically, the curie is that amount of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second and a Bq is equal to one disintegration per second. For environmental monitoring purposes, the curie is usually too large a unit to work with conveniently and is broken down into smaller values such as the microcurie (μCi, one millionth of a curie or 10^{-6} Ci) and the picocurie (pCi, one trillionth of a curie or 10^{-12} Ci). Older wristwatches that were painted with radium to allow the numbers or segments to "glow in the dark" contained about one microcurie (1 μCi) of radium on the dial. The average person has about one tenth (0.1) microcurie of naturally occurring potassium-40 in his body. Typical soil and sediment samples contain about one picocurie (1 pCi) of natural uranium per gram.

SOURCES OF RADIOACTIVITY

Of the radioactive atoms that exist in nature, some have always existed and natural processes continually form others. For example, uranium has always existed, it is radioactive, and it occurs in small but variable concentrations throughout the earth. Radioactive carbon and tritium, on the other hand, are formed by cosmic radiation striking atoms in the atmosphere. Radionuclides can also be created by man. For example, radionuclides are created in nuclear reactors and consist of fission products and activation products. The fission products are the residues of the uranium fission process that produces the energy within the reactor. The fission process also produces neutrons that interact with structural and other materials in the reactor to form activation products. Because of the nature of the fission process, many fission products are unstable and, hence, radioactive. Most fission products have short half-lives and are retained within the nuclear fuel itself; however, trace natural uranium impurities in reactor structural materials release small quantities of fission products to the reactor coolant.

It should be noted that a certain level of "background" fission-product radioactivity also exists in the environment, primarily due to past atmospheric nuclear weapons testing. Although the level is very low, these fission products are routinely detected in air, food, and water when analyzed with extremely sensitive instruments and techniques.

CONTROL OF RADIATION AND RADIOACTIVITY

To reduce the exposure of persons to ionizing radiation to "as low as reasonably achievable," controlling the use and disposal of radioactive materials and comprehensive monitoring programs to measure the effectiveness of these controls are required. Effluent streams that may contain radioactive materials must be treated by appropriate methods to remove the radioactive materials and the effluent monitored to ensure that these materials have been reduced to concentrations that are as low as is reasonably achievable and are well within all applicable guidelines and requirements prior to discharge.

GLOSSARY

Activation Products – As cooling water circulates through the reactor, certain impurities present in the water and even components of the water itself can be converted to radioactive nuclides (they become "activated"). Important activation products present in reactor coolant water include radionuclides of corrosion and wear products (cobalt-60, iron-59, cobalt-58, chromium-51), of impurities dissolved in the water (argon-41, sodium-24, carbon-14) and of atoms present in the water molecules (tritium). Of these, the predominant radionuclide and also the one with the most restrictive limits is cobalt-60.

Algae – Simple rootless plants that grow in bodies of water in relative proportion to the amount of nutrients available. Algae blooms, or sudden growth spurts can affect water quality adversely.

Alkalinity – The measurable ability of solutions or aqueous suspensions to neutralize an acid.

Alpha Radioactivity – A form of radioactivity exhibited by certain radionuclides characterized by emission of an alpha particle. Many naturally occurring radionuclides including radium, uranium, and thorium decay in this manner.

Aquifer – A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

Background Radiation – Radiation present in the environment as a result of naturally occurring radioactive materials and cosmic radiation. Generally treated as including widespread low-level human-made radiation sources, including fallout.

Benthic Macroinvertebrates – Small organisms inhabiting the bottom of lakes and streams or attached to stones or other submersed objects. The study of macroinvertebrate communities gives an indication of the overall quality of the body of water from which they are taken.

Beta-Gamma Radioactivity – A form of radioactivity characterized by emission of a beta particle and/or gamma rays. Many naturally occurring radionuclides such as lead-212, bismuth-212, and bismuth-214 decay in this manner.

Biochemical Oxygen Demand (BOD) – The BOD test is used to measure the content of organic material in both wastewater and natural waters. BOD is an important parameter for stream and industrial waste studies and control of waste treatment plants because it measures the amount of oxygen consumed in the biological process of breaking down organic materials in the water.

Birge-Ekman Dredge – A device used for sampling the bottom sediment in rivers, streams, lakes, etc. The Birge-Ekman dredge is lowered to the bottom on a line and its spring-loaded "jaws" are remotely tripped from the surface. It samples an area of approximately 230 cm^2 to an average depth of 2.5 cm.

British Thermal Unit (BTU) – A unit commonly used to quantify the heat output of boilers, furnaces, etc. Specifically, the amount of heat necessary to raise 1 lb. of water one degree Fahrenheit.

Calibration – The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

Chain Electro-Fishing Techniques – A technique of collecting samples of fish from a body of water whereby the fish are stunned with an electric current, categorized, and returned to the water unharmed.

Chemical Oxygen Demand (COD) – A measure of the oxygen required to oxidize all compounds in water, organic and inorganic.

Collective Dose Equivalent and Collective Effective Dose Equivalent – The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within an 80-km (50 miles) radius and they are expressed in units of person-rem.

Committed Dose Equivalent (CDE) – The predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem.

Committed Effective Dose Equivalent (CEDE) – The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem.

Composite Sample – A sample that is comprised of a number of grab samples over the compositing period. In some cases, the composite sample obtained may be proportional to effluent flow and is called a proportional sample or flow-composited sample.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – Also known as "Superfund," CERCLA was enacted by Congress in 1980 to clean up inactive hazardous waste sites that presented great risk to public health and the environment.

Conductivity – A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

Confidence Interval – Statistical terminology for the error interval (±) assigned to numerical data. A two sigma (2σ) confidence interval means there is 95% confidence that the true value (as opposed to the measured one) lies within the (±) interval. The 95% is the confidence level (See (±) value, Standard Deviation of the Average).

Contaminant – Any physical, chemical, biological, or radiological substance in a location or concentration that is not naturally occurring.

Corrosion and Wear Products – Piping and components used in construction of a nuclear reactor are fabricated from extremely durable, corrosion and wear resistant materials. Even under the best circumstances, however, small amounts of these materials enter the reactor coolant due to wear of moving parts and corrosion of the water contact surfaces of reactor plant components. While in no way affecting operational characteristics or reactor plant integrity, some of these corrosion and wear products may become activated as they pass through the reactor core. This necessitates that the reactor coolant be processed by filtration or other methods of purification before it is discharged or reused (See Activation Products).

Curie (Ci) – The curie is the common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. Specifically, the curie is that amount of radioactivity equal to 3.7 x 10^{10} (37 billion) disintegrations per second. For environmental monitoring purposes, the curie is usually too large a unit to conveniently work with and is broken down to smaller values. (See Microcurie and Picocurie.)

Data Validation – A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

Decision Level Concentration (DLC) – The quantity of radioactivity above which a decision is made that a net amount of radioactivity is present with a five percent probability of erroneously reporting net radioactivity when none is present (false positive).

Derived Concentration Guide (DCG) – The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem (0.1 rem).

Dose Equivalent – The quantity that expresses the biological effects of radiation doses from all types (alpha, beta-gamma) of radiation on a common scale. The unit of dose equivalent is the rem.

Down-gradient – Referring to the flow of groundwater, down-gradient is analogous to downstream and is a point that is “after” an area of study that is used for comparison with up-gradient or upstream data.

Dosimeter – See Thermoluminescent Dosimeters

Duplicate Sample – A sample that is created by splitting existing samples before analysis and treating each split sample as a separate sample. The samples are then analyzed as a quality assurance method to assess the precision in the analytical process.

Ecosystem – The integrated, interdependent system of plant and animal life existing in an environmental framework. Understanding of an entire ecosystem is important because changes or damage to one component of the system may have effects on others.

Effective Dose Equivalent – The effective dose equivalent is the sum of the dose equivalent to the whole body from external sources plus the dose equivalents to specific organs times a weighting factor appropriate for each organ. The weighting factor relates the effect of individual organ exposure relative to the effect of exposure to the whole body. The unit of effective dose equivalent is the rem.

Effluent – Any treated or untreated air emission or liquid discharge to the environment, including storm water runoff.

Eh – A measure of the oxidation-reduction potential of water expressed in units of millivolts. The oxidation-reduction potential affects the behavior of many chemical constituents present in water in the environment.

Field Blank – A sample of laboratory distilled water that is put into a sample container at the field collection site and is processed from that point as a routine sample. Field blanks are used as a quality assurance method to detect contamination introduced by the sampling procedure.

Fission Products – During operation of a nuclear reactor, heat is produced by the fission (splitting) of "heavy" atoms, such as uranium, plutonium or thorium. The residue left after the splitting of these "heavy" atoms is a series of intermediate weight atoms generally termed "fission products." Because of the nature of the fission process, many fission products are unstable and, hence, radioactive. Most fission products have short lives and are retained within the nuclear fuel itself; however, trace natural uranium impurities in reactor structural materials release small quantities of fission products to the reactor coolant.

It should be noted that a certain level of "background" fission product radioactivity exists in the environment, primarily due to atmospheric nuclear weapons testing. The level is very low, but may be detectable when environmental samples are analyzed with extremely sensitive instruments and techniques.

Fugitive Air Emission – Any air emission that goes directly to the air, rather than out a stack or vent or other engineered emission point.

Grab Sample – A single sample that is collected and is representative of the stream or effluent.

Greenhouse Gas (GHG) – Air compounds, which include carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

Groundwater – Subsurface water in the pore spaces and fractures of soil and bedrock units.

Half-Life – A time period associated with a radionuclide that specifies how long it takes for one half of a given quantity of radioactivity to decay away. Half-lives may range from fractions of a second to millions of years.

High Efficiency Particulate Air (HEPA) Filter – A throwaway, extended-media, dry type filter with a rigid casing enclosing the full depth of the pleats. The filter shall exhibit a minimum efficiency of 99.97% when tested at an aerosol diameter of 0.3 micrometers aerodynamic diameter.

High Purity Germanium Gamma Spectrometer System – A High Purity Germanium gamma spectrometer system is a sophisticated set of components designed for characterizing and quantifying the radionuclides present in a sample. This system makes use of the fact that during the decay of most radionuclides, one or more gamma rays are emitted at energy levels characteristic of the individual radionuclide. For example, during the decay of cobalt-60, two gamma rays of 1.17 and 1.33 million electron volts (MeV) are emitted while the decay of argon-41 produces one gamma ray of 1.29 MeV. The high purity germanium detector used in this system is capable of detecting and very precisely resolving differences in gamma ray energy levels and sending this information along to electronic components where it is processed and evaluated.

Influent – The water entering the pump, the filter or other equipment. Water going into the pump is called the influent, while water leaving the pump is called the effluent.

Long-Lived Gamma Radioactivity – Two very important characteristics of radionuclides are the length of time it takes for a given amount to decay away and the type of radiation emitted during decay. From an environmental standpoint, some of the most significant radionuclides are those whose "life" is relatively long and that also emit penetrating gamma radiation during decay. Two radionuclides of concern in these respects are cobalt-60 (a corrosion and wear activation product) and cesium-137 (a fission product). (See Half-Life, Beta-Gamma Radioactivity.)

Macrophyton – Macroscopic plants in an aquatic environment.

Method Detection Limit – The lowest value at which a non-radiological sample result shows a statistically positive difference from a sample in which no constituent is present.

Microcurie (µCi) – One millionth of a curie (10^{-6} Ci). The typical radium dial watch might contain 1 µCi of radioactive material. (See Curie and Picocurie.)

Micrograms per liter (µg/l) – A unit of concentration commonly used to express the levels of impurities present in a water sample. A microgram is one millionth of a gram. One microgram per liter is equal to one part per billion.

Milligrams per liter (mg/l) – A unit of concentration commonly used to express the levels of impurities present in a water sample. A milligram is a thousandth of a gram. A milligram per liter is equal to a part per million.

Millirem (mrem) – One thousandth of a rem (10^{-3} rem).

Minimum Detectable Concentration (MDC) – Depending on the sample medium, the smallest amount or concentration of a radioactive or non-radioactive analyte that can be reliably detected using a specific analytical method.

Optically Stimulated Luminescence Dosimeter (OSLD) – A sensitive monitoring device that records accumulated dose due to radiation. These dosimeters derive their name from a property that the material exhibits when exposed to radiation and subsequently stimulated with light from a laser or light-emitting diode. The material, when stimulated with light, emits a secondary amount of light within a specific frequency range that is proportional to the amount of radiation exposure received.

Osmotic Pressure – The pressure produced by a solution in a space that is enclosed by a differentially permeable membrane.

Outfall – A point of discharge (e.g., drain or pipe) of liquid effluent into a stream, river, ditch, or other water body.

Plankton – Tiny plants and animals that live in water.

Parshall Flume – A specially constructed channel designed such that discharge water flow rate can be accurately measured. The Parshall Flume may also be instrumented to record the total volume of flow over long periods of time.

Pasquill Stability Class – A classification that defines the relative stability and dispersive capability of the atmosphere. Classification is highly dependent upon the change in temperature with height.

Periphyton – Communities of microorganisms growing on stones, sticks, and other submerged surfaces. The quantities and types of periphyton present are very useful in assessing the effects of pollutants on lakes and streams.

Person-Rem – The sum of the individual dose equivalents or effective dose equivalents received by each member of a certain group or population. It is calculated by multiplying the average dose per person by the number of persons within a specific geographic area. For example, a thousand people each exposed to 0.001 rem would have a collective dose of one person-rem.

pH – A measure of the acidity or alkalinity of a solution on a scale of 0 to 14 (low is acidic, high is alkaline or caustic, 7 is neutral).

Picocurie (pCi) – One trillionth of a curie (10^{-12} Ci). Typical soil and sediment samples contain approximately one pCi of natural uranium per gram. (See Curie and Microcurie)

± Value (plus or minus value) – An expression of the uncertainty in sample results. The magnitude of the (±) value depends on the number of samples, the size of the sample, intrinsic analytical uncertainties and the degree of confidence required. The (±) value assigned to data in this report is for the 95% confidence level (See Confidence Interval).

Polychlorinated Biphenyls (PCBs) – Halogenated aromatic hydrocarbons formed by the chlorination of biphenyl molecules. PCBs were commonly used in transformers as a dielectric fluid because of their stability.

Polynuclear Aromatic Hydrocarbon (PAH) – Multi-ring compounds found in fuels, oils, and creosote. These are also common combustion products.

Practical (Minimum) Quantitation Limit – The lowest concentration that can be reliably achieved in non-radiological samples within specified limits of precision and accuracy during routine laboratory operating conditions.

Primary Maximum Contaminant Level (PMCL) – Federal and State primary drinking water standards that are enforceable limits regulating toxic contaminants in drinking water.

Quantitation limit – The lowest level at which a chemical may be accurately and reproducibly quantified. The sample quantitation limit is typically three to five times higher than the analytical method detection limit.

Radionuclides - Atoms that exhibit radioactive properties. Standard practice for naming radionuclides is to use the name or atomic symbol of an element followed by its atomic weight (e.g., cobalt-60 or Co-60, a radionuclide of cobalt). There are several hundred known radionuclides, some of which are man-made and some of which are naturally occurring. Radionuclides can be differentiated by the types of radiation they emit, the energy of the radiation and the rate at which a known amount of the radionuclide decays away. (See Half Life.)

RCRA (Resource Conservation and Recovery Act) – A Federal law that established a structure to track and regulate hazardous wastes from the time of generation to disposal. The law requires safe and secure procedures to be used in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent new, uncontrolled hazardous waste sites. RCRA particularly addresses chemical issues; Atomic Energy Act regulated radioactivity is exempted from RCRA.

Rem – The unit of dose equivalent and effective dose equivalent.

Reverse Osmosis – Also known as hyper-filtration, it is a process that allows the separation of solutes (i.e., dissolved substances) from a solution by forcing the solvent through a semi-permeable membrane by applying a pressure greater than the osmotic pressure associated with the solutes. A semi-permeable membrane is a membrane that allows diffusion of solvent molecules through it, while retarding the diffusion of solute molecules.

Secondary Maximum Contaminant Level (SMCL) – Federal and State secondary drinking water standards that are non-enforceable guidelines regulating contaminants that may cause cosmetic or aesthetic effects in drinking water.

Settleable Solids – A measurement of the amount of solids that will settle out of a sample of water in a certain interval of time. This parameter commonly applies to water being processed in sewage treatment plants and is used to control the operation and evaluate the performance of these plants.

Short-Lived Gamma Radioactivity – Radioactive material of relatively short life that decays with the emission of gamma rays. It is generally not important with respect to environmental discharges because of the short life span. Some examples of short-lived gamma emitting radionuclides are argon-41 (an activation product gas), krypton-88 (a fission product gas), and xenon-138 (a fission product gas).

Spiked Sample – A sample to which a known quantity of the material that is being analyzed for has been added for quality assurance testing.

Standard Deviation of the Average – A term used to characterize the uncertainty assigned to the mean of a set of analyzed data (See Confidence Interval, (±) Value).

Suspended Solids – Particulate matter, both organic and inorganic suspended in water. High levels of suspended solids not only affect the aesthetic quality of water by reducing clarity, but may also indirectly indicate other undesirable conditions present. The analysis for suspended solids is performed by passing a sample of water through a filter and weighing the residue.

Surber Bottom Sampler – A device for collecting samples of benthic macroinvertebrates from the bottom of relatively shallow, fast moving streams.

Thermoluminescent Dosimeters (TLDs) – TLDs are sensitive monitoring devices that record accumulated dose due to radiation. The TLDs used by NRF for environmental monitoring consist of small chips of lithium fluoride (LiF) encased in appropriate materials and strategically located at site perimeter and off-site locations. Thermoluminescent Dosimeters derive their name from a property that LiF crystals exhibit when exposed to radiation and subsequently heated-that of emitting light proportional to the amount of radiation exposure received (thermoluminescence). The emitted light can then be read out on special instrumentation and correlated to the amount of radiation dose accumulated. The TLDs used by NRF for environmental monitoring are specially selected for their accuracy and consistency of results.

Total Dissolved Solids (TDS) – Total Dissolved Solids is used as a general indicator of water quality. As the name describes, TDS tests measure the amount of all dissolved solids in the water. These solids are primarily minerals/salts, but can also include organic matter.

Turbidity – A cloudy condition in water due to suspended silt or organic matter. Turbidity is measured in nephelometric turbidity units (ntu).

Upgradient – Referring to the flow of groundwater, upgradient is analogous to upstream and is a point that is “before” an area of study that is used as a baseline for comparison with downgradient or downstream data.

Volatile Organic Compound (VOC) – An organic (carbon-containing) compound that evaporates (volatilizes) readily at room temperature.

Weight Percent – A term commonly used to describe the amount of a substance in a material. For example, oil containing 0.5 lb. sulfur per 100 lb. oil would contain 0.5 percent by weight sulfur.

Weighting Factor – Tissue-specific representation of the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue.

Whole Effluent Toxicity (WET) – The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility’s wastewater. WET tests measure wastewater’s effects on specific test organisms’ (plants, vertebrates and invertebrates) ability to survive, grow, and reproduce.

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