NRFEA-464

Naval Reactors Facility

ENVIRONMENTAL MONITORING REPORT

Calendar Year 1997

Prepared for the
U.S. Department of Energy
By Westinghouse Electric Company,
a division of CBS Corporation
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DISCLAIMER

1997 ENVIRONMENTAL MONITORING REPORT

FOR THE

NAVAL REACTORS FACILITY

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY BY
WESTINGHOUSE ELECTRIC COMPANY
A DIVISION OF CBS CORPORATION
BETTIS ATOMIC POWER LABORATORY
NAVAL REACTORS FACILITY

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ABSTRACT

The results of the radiological and nonradiological environmental monitoring programs for 1997 at the Naval Reactors Facility (NRF) are presented in this report. The results obtained from the environmental monitoring programs verify that releases to the environment from operations at NRF were in accordance with state and federal regulations. Evaluation of the environmental data confirms that the operation of NRF continues to have no adverse effect on the quality of the environment or the health and safety of the general public. Furthermore, a conservative assessment of radiation exposure to the general public as a result of NRF operations demonstrated that the dose received by any member of the public was well below the most restrictive dose limits prescribed by the Environmental Protection Agency (EPA) and the Department of Energy (DOE).

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SUMMARY

The results of the radiological and nonradiological environmental monitoring programs for the Naval Reactors Facility (NRF) are summarized below. Current operations at NRF are in compliance with applicable regulations governing use, emission, and disposal of solid, liquid, and gaseous materials. Current operations at NRF did not result in any significant release of radioactivity or hazardous materials to the environment.

• Liquid Releases (Other than to Sanitary Sewer): Approximately 55 million gallons of water were released to the environment via the Industrial Waste Ditch (IWD). No radioactivity attributable to operations at the NRF Site was detected in any of the environmental samples from these releases. Radioactivity concentrations were either below minimum detectable levels or were typical of natural background levels in water from the Snake River Plain Aquifer.

Monitoring data for chemical constituents of liquid wastewater effluents continued to demonstrate compliance with U.S. Department of Energy (DOE) and applicable state and federal regulations.

• Sanitary Sewer Discharges: All sanitary effluents were discharged to the NRF sewage treatment lagoon. 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 applicable regulations.

• Drinking Water Monitoring: Analysis of water from drinking water wells collected onsite did not detect any radioactivity in excess of natural background levels.

Monthly drinking water monitoring confirmed the absence of coliform bacteria within the distribution system. Volatile organic compounds were not detected above minimum detection levels. Inorganic constituents and other water quality parameters were all below regulatory limits. Concentrations of lead and copper at NRF were below regulatory action levels for this monitoring.

• Groundwater Monitoring: The average gross alpha and gross beta radioactivity measured in samples collected from groundwater well groups located onsite and offsite did not exceed natural background levels. Measurements for tritium radioactivity were at least two orders of magnitude below drinking water standards.

The results from many of the groundwater analyses for a variety of chemicals were less than minimum detectable levels; however calcium, chloride, magnesium, potassium, sodium, and sulfate, nonhazardous ionic constituents likely resulting from water softening and deionization processes, were detected in the groundwater. None of these constituent concentrations averaged above primary drinking water standards.

• Airborne Effluent: Airborne radioactivity in NRF effluents was controlled using high efficiency particulate air filters and, in some cases, charcoal filters to maintain particulate and gaseous radioactivity releases to as low as reasonably achievable. The results of NRF's airborne radiological effluent monitoring for 1997 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. The concentrations of the particulate and gaseous radioactivity released from the NRF Site during 1997 were well within the applicable standards for radioactivity in the environment.

The quantity of long-lived (greater than one day half-life) particulate radioactivity released in airborne effluents from NRF was 0.000073 curie. The quantity of long-lived gaseous radioactivity released was 0.89 curie of which carbon-14 (as carbon dioxide) and hydrogen-3 (tritium) were the principal contributors.

Emissions of nonradiological air effluents were conservatively estimated and were well below applicable Environmental Protection Agency (EPA) and State of Idaho standards.

• **Soil and Vegetation Monitoring**: NRF operations in 1997 did not contribute to any measurable increase in radiation levels of man-made radioactivity in the surrounding environment. 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 onsite personnel, the general public or the environment. These areas are monitored on a routine basis to verify that radioactivity is not migrating and to ensure that the risk remains insignificant.

• **Radiation Monitoring**: Measurement of radiation along the NRF security fence was performed independently by NRF and the Environmental Monitoring Unit of Lockheed Martin Idaho Technologies Company (LMITCO). A comparison of the average reading along the NRF security fence and the average background reading measured by NRF at locations on the Idaho National Engineering and Environmental Laboratory (INEEL) 5 to 10 miles away from NRF indicates that NRF does not contribute to an increase in radiation levels.

• **Radiation Dose-to-Man**: Radiation exposure to the general public from NRF airborne releases was too low to measure and could only be estimated using conservative EPA approved calculational models. Direct exposure to the public as a result of NRF operations was also too low to measure. The resultant evaluation of all exposure pathways conservatively estimated a maximum annual hypothetical dose of 0.00056 millirem to an individual offsite. This dose is substantially below the radiation exposure limits of 100 millirem per year established by the Nuclear Regulatory Commission and DOE. This dose is negligible when compared to the approximately 360 millirem received by an average individual from natural background radiation each year in southeastern Idaho, and much less than the 1-2 millirem which an individual would receive from a single cross-country airplane flight.

• **Control of Chemical and Hazardous Wastes**: Chemically hazardous materials were neither manufactured nor disposed of at the NRF Site. However, chemically hazardous wastes were generated during site operations. These wastes were handled, controlled and stored by trained personnel in accordance with applicable federal and state regulations. Offsite disposal was arranged with waste vendors operating under state and federal permits.

• **Control of Radioactive Waste Materials**: The volume of solid, low-level radioactive waste was minimized by limiting the materials that could become contaminated and by compacting wastes. Solid, low-level radioactive wastes were packaged in strong, tight containers meeting U.S. Department of Transportation (DOT) requirements. Shipment of this waste to the DOE Radioactive Waste Management Complex (RWMC), located at the INEEL, was controlled by written procedure to ensure compliance with all applicable DOE and DOT requirements.

INTRODUCTION

The Naval Reactors Facility (NRF) is operated for the U.S. Naval Nuclear Propulsion Program by Westinghouse Electric Company, Bettis Atomic Power Laboratory-Idaho. It is located on the Idaho National Engineering and Environmental Laboratory (INEEL) 6.7 miles from the nearest INEEL boundary (Figure 1). The developed portion of the site within the security fence covers approximately 84 of the 4400 acres under the cognizance of NRF. The INEEL Site, including NRF, is not accessible by the general public. Three naval reactor prototypes and the Expended Core Facility (ECF) are located within the NRF security fence (Figure 2). The S1W, A1W and S5G prototypes were shut down in October 1989, January 1994, and May 1995, respectively.

Developmental nuclear fuel material samples, spent naval fuel, and irradiated reactor plant components/materials are examined at 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 ECF is critical to the design of longer-lived cores, which results in the creation of less spent fuel requiring disposition. Six hundred eighty-six container shipments of naval spent fuel have been made to ECF through 1997 with no release of radioactivity or impact on public health and safety. ECF also prepares naval fuel for transport to the Idaho Chemical Processing Plant.

The purpose of this report is to summarize the NRF environmental monitoring program results for calendar year 1997. This report also evaluates current operations at NRF and documents compliance with applicable regulations governing use, emission, and disposal of solid, liquid, and gaseous materials.

GEOLOGICAL AND DEMOGRAPHIC SITE DESCRIPTION

The NRF Site is located on a parcel of land within the boundaries of the INEEL. The INEEL is comprised of 569,000 acres 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 an L-shaped plateau approximately 200 miles long and 50 to 70 miles wide. Within its land area of 12,000 square miles, the plain descends from an elevation of 6,000 feet in the east, near Ashton, to 2,300 feet in the west, near Boise. The plain is naturally bordered on all sides by mountains, some exceeding 12,000 feet in elevation.

The NRF Site is underlain by a succession of interlocking flows of basaltic lava. These lava flows form layers of hard rock varying in thickness from 10 to 100 feet. The Snake River Plain Aquifer lies approximately 370 feet below the land surface. Groundwater within the aquifer generally flows to the south and west (Reference 1). Located in a semi-arid desert environment, NRF has an average annual temperature of 42 degrees Fahrenheit with extremes of -47 degrees Fahrenheit to 101 degrees Fahrenheit. Precipitation at NRF averages approximately 9 inches annually, and prevailing winds are out of the southwest (Reference 1).

The largest surrounding urban areas of the INEEL include Pocatello to the southeast and Idaho Falls to the east. Both cities are approximately 45 to 50 air miles from NRF. Small farming communities are located on the western, northwestern, and southeastern boundaries of the INEEL. The surrounding area, within 50 miles from the INEEL borders, contains a population of approximately 150,000.

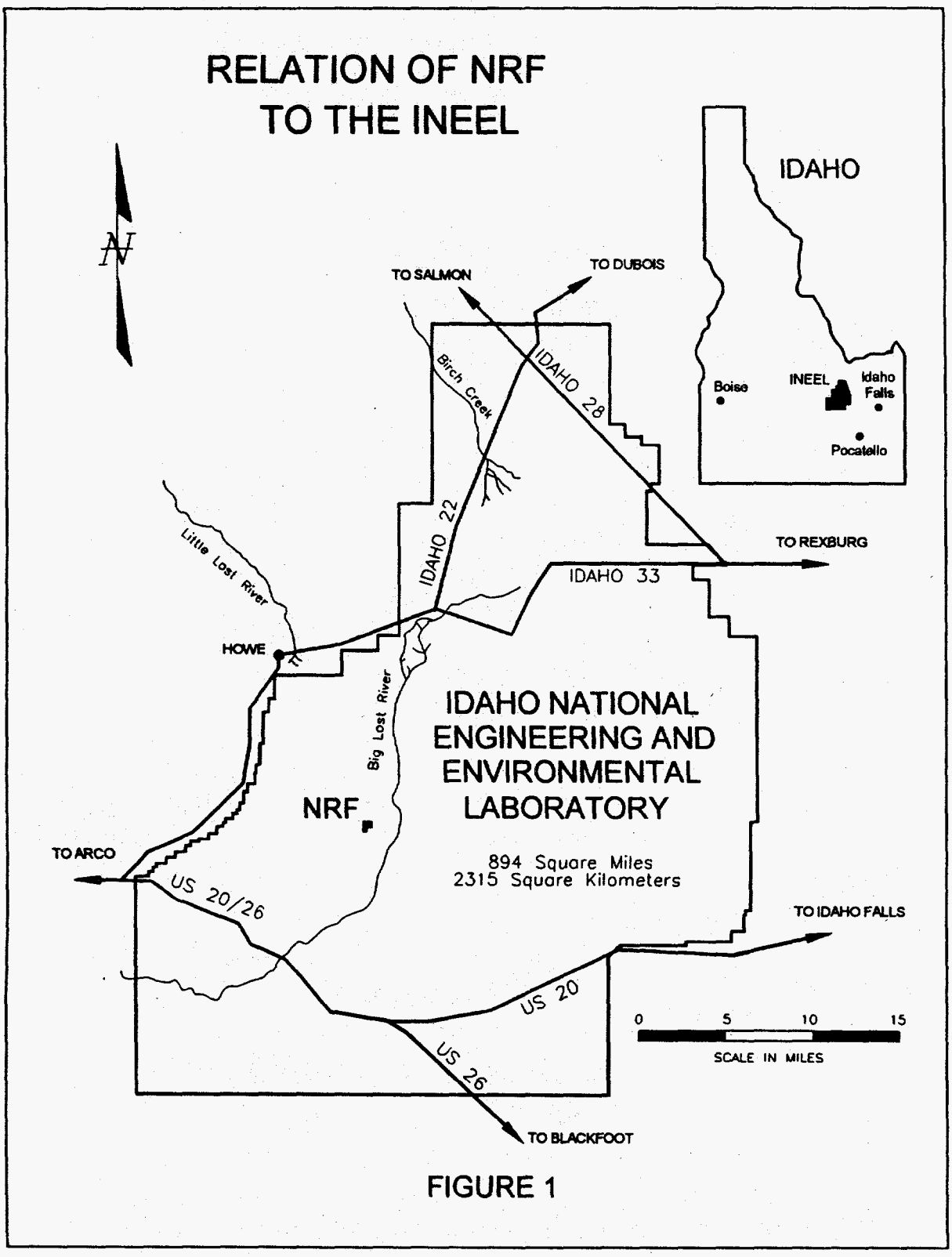
RELATION OF NRF
TO THE INEEL
N
IDAHO
Boise
INEEL
Idaho Falls
Pocatello
TO SALMON
TO DUBOIS
Birch Creek
IDAHO 28
IDAHO 22
TO REXBURG
IDAHO 33
Little Lost River
HOWE
Big Lost River
IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY
NRF
894 Square Miles
2315 Square Kilometers
TO ARCO
US 20/26
TO IDAHO FALLS
US 20
US 26
0 5 10 15
SCALE IN MILES
TO BLACKFOOT

FIGURE 1

NRF AREA WITHIN THE SECURITY FENCE

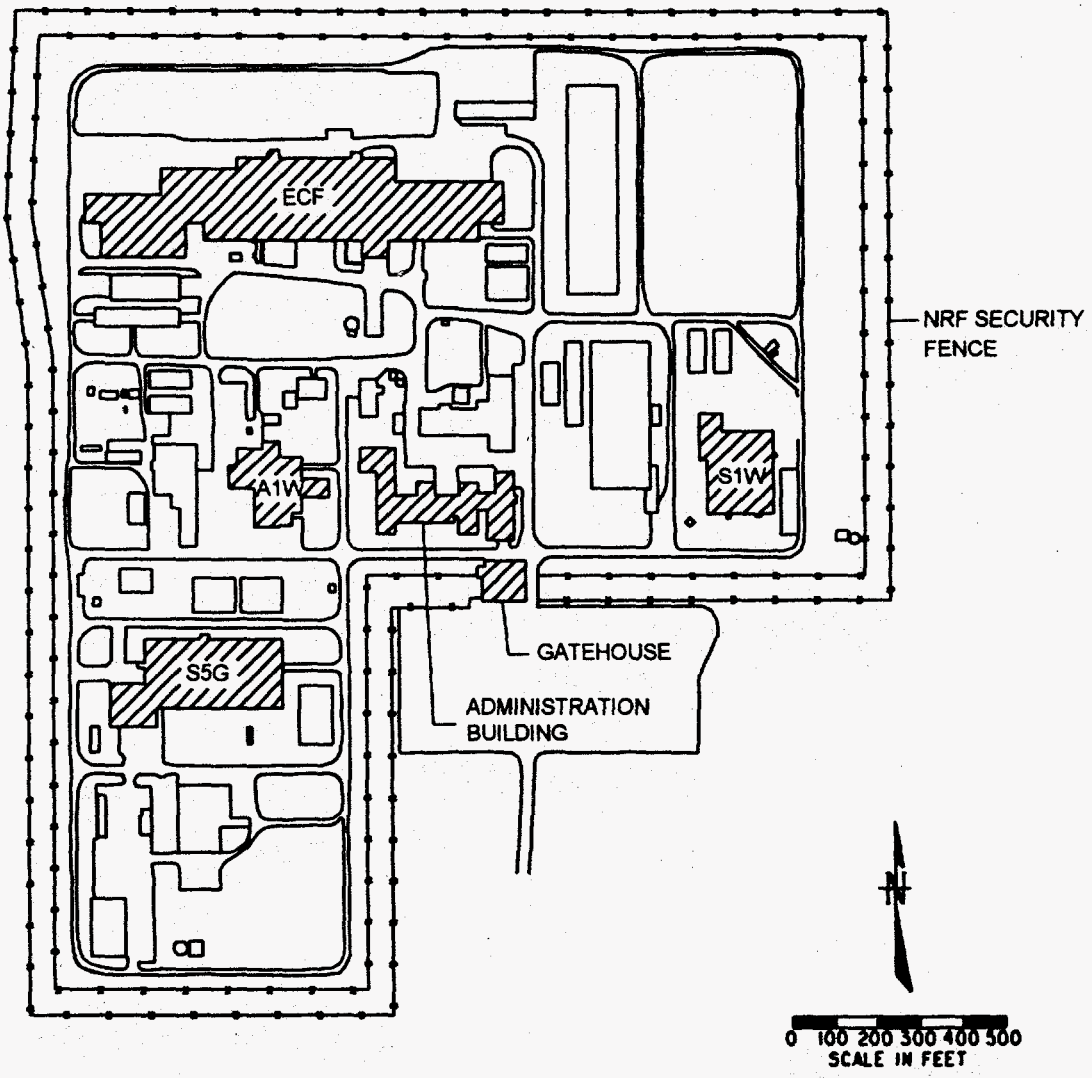

FIGURE 2

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ENVIRONMENTAL MONITORING

PROGRAM OVERVIEW

The NRF environmental monitoring program, which includes radiological and nonradiological monitoring, is conducted in accordance with accepted monitoring procedures and management practices to ensure compliance with applicable state and federal standards. A complete synopsis of sampling and analyses performed in support of the NRF environmental monitoring program can be found in Tables 1 and 2. Data from this monitoring program confirm that operations at NRF have had no significant impact on human health or the environment.

Samples of liquid effluents and sediments are collected at the Industrial Waste Ditch outfall and the Sanitary Sewage Lagoon. These samples are analyzed for chemical constituents and radioactivity. The analyses of liquid effluent and associated sediments are used to confirm that no hazardous wastes or radioactivity have been discharged to the environment.

The drinking water monitoring program involves the collection of water samples at the well heads (radiological) or a point prior to entering the distribution system (nonradiological) to ensure a high quality drinking water supply. Nonradiological samples are drawn from a sampling port immediately downstream of the water softening treatment system at the NRF boilerhouse. In addition, drinking water samples collected throughout the NRF distribution system are monitored for the presence of coliform bacteria, lead, and copper in accordance with Reference 2.

The groundwater monitoring program is designed to ascertain whether operations have had any measurable impact on groundwater. Samples are collected from thirteen groundwater monitoring wells surrounding NRF. These samples are analyzed for chemical constituents and radioactivity.

Airborne effluents are either monitored or calculated to ensure emissions meet state and federal standards. Emissions of industrial gases from fuel-burning equipment are calculated and particulate matter in the air is monitored at NRF by the Lockheed Martin Idaho Technologies Company (LMITCO), prime contractor of the INEEL. NRF monitors and/or calculates the airborne radioactivity emissions from radiological areas. Calculations are performed in accordance with established standards and guidelines.

Continuous direct measurement of radiation levels at the NRF Site is accomplished by locating dosimeters along the security fence. This monitoring is conducted by NRF and independently by the Environmental Monitoring Unit of LMITCO. In addition, the Environmental Science and Research Foundation (ESRF) measures radiation levels at offsite background locations.

Soil and vegetation monitoring is also performed at NRF to ensure that NRF operations do not adversely impact the surrounding environment. Data collected from soil sampling is used to calculate fugitive air emissions.

Because it is located on the INEEL, NRF is party to a Federal Facility Agreement and Consent Order (FFA/CO) for environmental remediation under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Groundwater, surface soils, and subsurface soils were sampled and analyzed in 1996 as part of the NRF Comprehensive Remedial Investigation and Feasibility Study (RI/FS). The results of this investigation were documented in the NRF Comprehensive RI/FS Report dated October 21, 1997.

In 1996, NRF completed the Remedial Action (RA) 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 were presented in the Final Remedial Action Report which 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 of the Remedial Action as described in the RA Report. In support of the O&M phase, groundwater and soil gas samples will continue to be collected and analyzed on a quarterly basis.

A complete summary of the groundwater monitoring data for 1997 is also presented in this Environmental Monitoring Report.

Thus far, soil gas sampling results were consistent with those presented in the Track 2 Summary Reports for the inactive landfill areas. These soil gas sampling data will be evaluated in the first quarter of 1998 after the completion of the first four quarters of sampling associated with the O&M phase.

TABLE 1
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Page 1 of 2)

Sample Type/Location	Data/Sample Collection Method[1]	Analysis Frequency	Routine Analysis
LIQUID EFFLUENT			
INDUSTRIAL WASTE DITCH			
Water (At Outfall)	Composite	Weekly	Gross gamma
Water (At Outfall)	Composite	Monthly Composite	Strontium-90, tritium, and quantitative isotopic gamma
Sediment (At Outfall)	Grab	Monthly	Quantitative isotopic gamma
Sediment (Along length)	Grab (6)	Annually	Quantitative isotopic gamma
Vegetation (Along length)	Grab (10)	Annually	Quantitative isotopic gamma
SEWAGE LAGOON (Northeast active cell)			
Water	Grab	Weekly	Gross gamma
Water	Grab	Monthly Composite	Strontium-90, tritium, and quantitative isotopic gamma
Sediment	Grab	Monthly	Quantitative isotopic gamma
DRINKING WATER			
Onsite Wells	Grab	Monthly	Gross alpha, gross beta, and tritium
Onsite Wells	Grab	Annual Composite	Strontium-90 and quantitative isotopic gamma
GROUNDWATER			
Regional Upgradient Wells, Effluent System Wells, Site Downgradient Wells, and Regional Downgradient Wells	Grab	Quarterly	Gross alpha, gross beta, tritium, strontium-90, and quantitative isotopic gamma

TABLE 1
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Page 2 of 2)

Sample Type/Location	Data/Sample Collection Method[1]	Analysis Frequency	Routine Analysis
AIR EFFLUENT			
Fixed Filter Air Samplers	Continuous Continuous	Biweekly & Monthly Annual Composite	Gross alpha and gross beta Quantitative isotopic gamma
Tritium Samplers	Continuous	Monthly	Tritium
Charcoal Cartridges	Continuous	Weekly	Iodine-131
Selected Emission Points	Calculated	Monthly Annually	Carbon-14 Krypton-85 and tritium
Fugitive Air Emissions	Calculated based upon soil characterization	Annually	Cesium-137 and cobalt-60
SOIL AND VEGETATION			
NRF Perimeter	Random Grab (40)	Annually	Quantitative isotopic gamma
S1W Seepage Basins	Random Grab (40)	Annually	Quantitative isotopic gamma
A1W Leaching Bed	Random Grab (40)	Annually	Quantitative isotopic gamma
Sewage Lagoon (Southwest inactive cell)	Random Grab (40)	Annually	Quantitative isotopic gamma
GENERAL SITE RADIATION			
NRF Perimeter Fence	Survey	Annually	Gamma exposure
Background Dosimeters	Survey	Annually	Gamma exposure
Environmental Dosimeters (Perimeter, Background)	Continuous	Quarterly	Gamma exposure

[1] Single samples collected at each location unless specified in parentheses (total excludes the collection of quality assurance samples).

TABLE 2
NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Page 1 of 3)

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
LIQUID EFFLUENT			
INDUSTRIAL WASTE DITCH			
Water (At Outfall)	Composite	Biweekly	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chloride, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, nitrogen measured as nitrate, nitrogen measured as nitrite, nitrogen (total Kjeldahl), oil and grease, pH, phosphorus, selenium, silver, sodium, specific conductance, sulfate, thallium, total dissolved solids, total suspended solids, zinc
Water (At Outfall)	Composite	Annually	Selected volatile organic compounds (VOCs) and semivolatile organic compounds (SOCs)
Sediment (At Outfall)	Grab	Annually	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chloride, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, nitrogen measured as nitrate, nitrogen measured as nitrite, nitrogen (total Kjeldahl), oil and grease, phosphorus, selenium, silver, sodium, sulfate, thallium, zinc, selected VOCs and SOCs
SEWAGE LAGOON (Northeast active cell)			
Water	Grab	Biweekly	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chloride, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, nitrogen measured as nitrate, nitrogen measured as nitrite, nitrogen (total Kjeldahl), oil and grease, pH, phosphorus, selenium, silver, sodium, specific conductance, sulfate, thallium, total dissolved solids, total suspended solids, zinc

TABLE 2
NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Page 2 of 3)

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
LIQUID EFFLUENT	*(continued)*		
SEWAGE LAGOON (Northeast active cell)			
Water	Grab	Annually	Selected VOCs and SOCs
Sediment	Grab	Annually	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chloride, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, nitrogen measured as nitrate, nitrogen measured as nitrite, nitrogen (total Kjeldahl), oil and grease, phosphorus, selenium, silver, sodium, sulfate, thallium, zinc, selected VOCs and SOCs
DRINKING WATER			
Drinking Water Distribution System at selected locations	Grab	Monthly	Coliform bacteria (total)
Drinking Water Distribution System at selected locations	Grab	Annually	Copper and lead
Boilerhouse	Grab	Annually	Chloride, nitrogen measured as nitrate, nitrogen measured as nitrite, nitrogen (total Kjeldahl), pH, phosphorus, specific conductance, sulfate, total dissolved solids, total suspended solids, regulated and unregulated VOCs
Boilerhouse	Grab	Three year period beginning in 1994	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, cyanide, fluoride, iron, lead, manganese, mercury, nickel, selenium, silver, sodium, thallium, zinc
Boilerhouse	Grab	Three year period beginning in 1995	Regulated and unregulated SOCs
Boilerhouse	Grab	Three year period beginning in 1996	Dioxin

TABLE 2
NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Page 3 of 3)

Sample Type/Location	Data/Sample Collection Method	Analysis Frequency	Routine Analysis
DRINKING WATER	*(continued)*		
Boilerhouse	Grab	Every nine years beginning in 1994	Asbestos
GROUNDWATER			
Regional Upgradient Wells, Effluent System Wells, Site Downgradient Wells, and Regional Downgradient Wells	Grab	Quarterly	Aluminum, antimony, arsenic, barium beryllium, cadmium, calcium, chloride, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, nitrogen measured as nitrate-nitrite, nitrogen measured as nitrite, nitrogen (total Kjeldahl), organic carbon (total), organic halogen (total), pH, phosphorus, potassium, selenium, silver, sodium, specific conductance, sulfate, thallium, zinc
AIR MONITORING			
Selected emission points	Calculated	Annually	Carbon monoxide (CO), hazardous air pollutants (HAPs), lead, nitrogen oxides (NOx), opacity, particulate matter, sulfur oxides (SOx), toxic air pollutants (TAPs), and VOCs

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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 and Treatment

• Nonradiological: Nonradioactive water disposal at NRF is segregated into two separate systems. Water from NRF operations and stormwater runoff is discharged to the Industrial Waste Ditch (IWD). Sanitary wastewater from NRF is discharged to a sewage treatment lagoon.

Industrial Waste Ditch: The Industrial Waste Ditch at NRF consists of two discrete drainage systems. The interior IWD is comprised of a network of buried pipes, culverts and open channels within the NRF security fence. This network empties into a covered exterior culvert, through an environmental monitoring station vault, and finally, outfalls to an uncovered exterior channel at the northwest corner of NRF. The exterior IWD begins at this outfall and progresses 3.2 miles northeast into the desert from NRF along a former creek bed. An earthen berm across the creek bed prevents water from traveling further down this concourse. Water discharged through the IWD system is dissipated through a combination of percolation and evapotranspiration from plant life along the course of the exterior IWD. Normally, no surface water is visible beyond 1.0 miles from the outfall.

In 1997, approximately 55 million gallons of water were released to the IWD. Sources of water to the IWD include: stormwater and snow-melt runoff; spray pond, equipment cooling system, site boiler system, reverse osmosis demineralizer, and site water softening system discharges; and discharges resulting from the neutralization of ion exchange resin regenerating solutions produced by a system that demineralizes water for various site operations. During The summer of 1997, a new reverse osmosis water purification system was installed, eliminating the need for ion exchange resin and the associated discharges.

Sewage Lagoon: Sanitary wastewater at NRF is conveyed to the northeast cell of a dual cell evaporative sewage lagoon. Approximately 16 million gallons of sanitary sewage were discharged to the sewage lagoon in 1997. The sewage lagoon is a facultative lagoon which combines aerobic and anaerobic digestion to break down solids. The remaining liquid is dissipated by a combination of percolation through soils and evaporation.

• Radiological: During 1997, as in previous years, a water reuse system was used whereby liquids containing radioactivity were collected, processed and reused rather than intentionally discharged to the environment.

Monitoring, Analyses and Results

Liquid effluents discharged to the IWD and sewage lagoon were analyzed for chemical constituents and radioactivity. Results of these analyses for the IWD are reported monthly in the INEEL Nonradiological Waste Management Information System.

• Nonradiological: Monitoring of the IWD and sewage lagoon used the same target analytes for each effluent source. These analytes were derived from those used for drinking water monitoring. Composite samples of the liquid effluents discharged to the IWD were collected biweekly at the outfall of the interior drainage system. Grab samples of water in the northeast cell of the sewage lagoon were also collected biweekly near the inlet piping of the lagoon. A summary of the liquid effluent monitoring results from the IWD as well as from the sewage lagoon is presented in Table 3. Results of monitoring showed no appreciable concentrations of heavy metals and a near neutral pH in the IWD liquid effluent. The analytical results of sewage effluent samples were typical of ranges expected in a nonaerated evaporative sewage treatment lagoon.

Varying levels of nonhazardous salts

Varying levels of nonhazardous salts (containing ions of chloride, sodium, and sulfate) used to soften site water or resulting from the regeneration of nonradiological ion exchange systems were detectable in the liquid effluents from NRF. Although the amount of salts discharged to the IWD have remained constant, the detected levels of several of these salts have increased relative to 1996 concentrations due to improved sampling technique. The sampling technique for liquid effluents to the IWD changed in late 1996 from grab sampling to composite sampling. This has resulted in better characterization of periodic effluent streams such as water softener recharge and demineralizer effluents that contribute heavily to these parameters. In addition, aluminum, iron, and phosphorus were present at low levels in the liquid effluent originating from NRF operations. None of these constituents were harmful to the environment at the levels discharged from NRF.

NRF effluent water was also monitored for the presence of hazardous organic constituents. No hazardous organic constituents were found in the liquid effluent. Specific chemical components of the hazardous organic analyses are summarized in Appendix A.

Sediment samples were collected at the outfall of the IWD and from the active cell of the sewage lagoon to confirm that NRF did not inadvertently discharge hazardous substances. These samples were analyzed for the same constituents as the liquid effluent samples. Results of the analysis of the sediment samples were consistent with or lower than the values reported by the Remedial Investigation and Feasibility Study (RI/FS) on the Industrial Waste Ditch under the INEEL FFA/CO. The results of this investigation were documented in the 1994 Final RI/FS Report and the recommendation of no remedial action was documented and agreed to by the EPA and the State of Idaho in a Record of Decision in 1994.

• **Radiological**: At NRF, water containing radioactivity was collected, processed to remove the radioactivity, and reused rather than discharged to the environment. This process system includes collection tanks, particulate filters, activated carbon columns and/or mixed bed ion exchange columns to remove radioactivity and inorganic material. The water processing practices ensured that over 99.9 percent of the gamma radioactivity contained in liquids associated with NRF operations was removed. The remaining 0.1 percent is retained in the water that is reused.

Water samples collected from the IWD and sewage lagoon were analyzed for gross gamma, tritium, and strontium-90 radioactivity. In addition, gamma spectrometry was performed on these samples to identify gamma emitting radionuclides. Liquid scintillation was used to analyze for tritium. The analytical results confirmed that no radioactivity above natural background levels was present in liquid effluent streams discharged from NRF.

Sediment samples collected at the outfall of the IWD and sediment samples collected from the active cell of the sewage lagoon were analyzed using gamma spectrometry to identify gamma emitting radionuclides. The analytical results further confirmed that no radioactivity above natural background levels was discharged in liquid effluent streams from NRF. Vegetation and sediment samples collected along the wetted portion of the IWD did not reveal any radioactivity above background levels.

Liquid Effluent Monitoring Conclusions

• **Nonradiological**: The liquid effluent monitoring confirms that all liquid effluents from NRF were controlled in accordance with applicable federal and state laws. The levels of nonhazardous salts of chloride, sodium, and sulfate, and concentrations of aluminum, iron, and phosphorus, that NRF discharged via the IWD and the sewage lagoon were below all applicable limits and not harmful to the environment.

• **Radiological**: No radioactive liquid effluents were discharged from NRF. The procedures and equipment used to process

radioactive liquids have been effective in eliminating intentional discharges to the environment.

TABLE 3
SUMMARY OF EFFLUENT WATER QUALITY ANALYSES, CALENDAR YEAR (CY) 1997

PARAMETER	UNITS	STANDARD or GUIDELINE[1]	INDUSTRIAL WASTE DITCH			SEWAGE LAGOON		
			MIN	MAX	MEAN ± s [2]	MIN	MAX	MEAN ± s [2]
ALUMINUM	mg/L	(3)	<0.05	0.40	<0.15	<0.05	0.47	<0.13
ANTIMONY	mg/L	(3)	<0.10	<0.20	<<0.11	<0.10	<0.10	<<0.10
ARSENIC	mg/L	5.0	0.0015	<0.005	<0.0034	0.002	<0.005	<0.0039
BARIUM	mg/L	100	0.15	1.20	0.53 ± 0.35	0.003	0.068	0.026 ± 0.017
BERYLLIUM	mg/L	(3)	<0.0005	<0.001	<0.006	<0.0005	<0.0005	<<0.0005
CADMIUM	mg/L	1.0	<0.005	<0.010	<<0.0054	<0.005	<0.005	<<0.005
CHLORIDE	mg/L	(3)	270	8000	2755 ± 2187	5	480	119 ± 81
CHROMIUM	mg/L	5.0	<0.005	0.011	<0.0086	<0.005	0.008	<0.0052
COPPER	mg/L	(3)	<0.01	0.04	<0.016	<0.01	0.04	<0.015
CYANIDE	mg/L	(3)	<0.01	<0.02	<<0.011	<0.01	<0.02	<<0.012
IRON	mg/L	(3)	<0.05	0.28	<0.096	0.06	1.10	0.27 ± 0.25
LEAD	mg/L	5.0	<0.05	<0.1	<<0.054	<0.05	<0.05	<<0.05
MANGANESE	mg/L	(3)	<0.005	0.075	<0.021	<0.005	0.059	<0.018
MERCURY	mg/L	0.2	<0.0002	0.0003	<0.0002	<0.0002	0.0008	<0.0002
NICKEL	mg/L	(3)	<0.01	<0.02	<<0.011	<0.01	<0.01	<<0.01
NITROGEN measured as NITRATE	mg/L	(3)	1.0	3.3	2.1 ± 0.5	<0.01	0.50	<0.08
NITROGEN measured as NITRITE	mg/L	(3)	<0.5	<10	<<4.1	<0.1	<1.0	<0.2
NITROGEN, (Total Kjeldahl)	mg/L	(3)	<0.2	1.2	<0.3	8.8	44	17.7 ± 9.7
OIL and GREASE	mg/L	(3)	<3	5	<3	<3	12	<3.9
pH	pH	2.0 to 12.5	7.68	9.66	7.98 ± 0.28	8.13	10.79	9.02 ± 0.25
PHOSPHORUS	mg/L	(3)	0.05	2.7	0.61 ± 0.65	1.4	10	3.87 ± 2.45
SELENIUM	mg/L	1.0	0.002	<0.005	<0.0038	<0.001	<0.005	<0.0033
SILVER	mg/L	5.0	<0.005	<0.02	<0.0097	<0.0005	<0.02	<0.0088
SODIUM	mg/L	(3)	180	3800	1395 ± 1051	130	250	215 ± 29
SPECIFIC CONDUCTANCE	µmho/cm	(3)	1400	21000	8363 ± 5619	620	1500	1163 ± 202
SULFATE	mg/L	(3)	46	940	216 ± 224	4	110	86 ± 21
THALLIUM	mg/L	(3)	<0.05	<0.10	<<0.06	<0.05	<0.05	<<0.05
TOTAL DISSOLVED SOLIDS	mg/L	(3)	880	14000	5573 ± 3933	460	1000	756 ± 130
TOTAL SUSPENDED SOLIDS	mg/L	(3)	<1	200	<18	11	380	103 ± 99
ZINC	mg/L	(3)	0.02	0.39	0.009 ± 0.009	0.03	0.22	0.08 ± 0.05

(1) Code of Federal Regulations, Title 40, Part 261, Subpart C unless otherwise noted.

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

(3) This analyte is monitored to help characterize any possible influence of NRF liquid effluents on a perched water zone located north of NRF. No standard or guideline exists for this parameter under Code of Federal Regulations, Title 40, Part 261, Subpart C.

DRINKING WATER MONITORING

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

Sources and Treatment

Designated as onsite wells, NRF 1, 2, 3, and 4 are within the security fence and provide all water required for production and domestic use (Figure 3). In January of 1994, NRF wells 1 and 4 were permanently removed from the NRF drinking water system. Well 2 was made the prime drinking water source for NRF and well 3 was designated as an emergency alternative source.

Water withdrawn from the Snake River Plain Aquifer beneath NRF is naturally high in calcium and magnesium (hard water). Therefore, water for domestic use and some water for use in the prototype plants is processed through a water softening system. This system utilizes common salt (sodium chloride) as the water softening agent. The use of softened water significantly reduces hard water deposits or scale build-up which extends equipment life, reduces maintenance costs, and minimizes the need to use other chemical treatments to contend with the consequences of using hard water.

Operations at NRF require the use of demineralized water. To achieve this, water was withdrawn from the onsite wells and processed through a demineralizer. Periodically, the ion exchange resins in the demineralizers were restored to full ion exchange capacity through regeneration with sulfuric acid and sodium hydroxide solutions. These solutions were then neutralized in the NRF elementary neutralization system with the pH being monitoried prior to discharge as nonharzardous liquids. In 1997, a new reverse osmosis water purification system was installed, eliminating the need for ion exchange resin and the resulting regeneration process.

Monitoring, Analyses and Results

NRF has a drinking water monitoring program which includes the collection and analysis of drinking water samples in compliance with requirements established by the State of Idaho and the Safe Drinking Water Act.

• **Nonradiological**: Drinking water samples were collected monthly and analyzed for the presence of coliform bacteria. The frequency of this monitoring met the requirements of applicable state and federal regulations. Sampling locations were varied and randomly selected at points throughout the distribution system. These samples were analyzed by the LMITCO Industrial Hygiene Laboratory (State of Idaho certified) which confirmed the absence of coliform bacteria in the water supply.

Drinking water samples were also collected from source water prior to entering the distribution system and monitored for Volatile Organic Compounds (VOCs), dioxin, inorganic constituents, and water quality parameters. These samples were drawn from a sampling port immediately downstream of the water softening treatment system at the NRF boilerhouse (Figure 3). No dioxin or VOCs listed in Appendix B were detected above the minimum detection levels established for the analyses of these compounds. Concentrations of inorganic analytes and water quality parameters as listed in Appendix C were all below regulatory limits.

Lead and copper monitoring of drinking water sampled throughout the NRF drinking water system was continued in 1997 in accordance with applicable state and federal regulations. Monitoring results verified that no regulatory action levels were exceeded per Reference 2.

• **Radiological**: Samples were drawn from all four well heads and analyzed for radiological drinking water parameters. These samples were submitted for analyses to a subcontract laboratory certified by the State of Idaho. Analytical results reported for these samples

were consistent with the standards identified in the Idaho Regulations for Public Drinking Water Systems. A summary of analytical results is provided in Table 4. All average values for gross alpha, gross beta and tritium were below the yearly average drinking water limits established by Reference 2. Gross alpha radioactivity levels are consistent with naturally occurring radionuclide levels. Gross beta radioactivity levels are consistent with naturally occurring radionuclide levels and, even when making the very conservative assumption that all of the detected beta activity (including naturally occurring beta activity) was due to strontium-90, meet the Reference 2 yearly average drinking water limit for strontium-90. Tritium values are generally comparable to background concentrations measured in groundwater on the INEEL, and showed no increases over the tritium levels reported in 1996. Annual composites drawn from monthly samples were also analyzed for strontium-90 (none was detected) and quantitative isotopic gamma radioactivity. These composite samples had radioactivity levels consistent with those naturally occurring in the groundwater beneath the INEEL.

Drinking Water Monitoring Conclusions

- **Nonradiological**: Monitoring of the NRF drinking water system for bacterial contaminants demonstrated compliance with public drinking water regulations and verified the system to be free of potentially harmful coliform bacteria. Drinking water monitoring for VOCs, dioxin, inorganic analytes, and other water quality parameters verified that no contaminants were present in NRF drinking water above levels established by drinking water standards. Lead and copper monitoring results verified that no regulatory action levels were exceeded per Reference 2.

- **Radiological**: The radioactivity levels in the drinking water were significantly below the concentration limits presented in Reference 2.

NRF DRINKING WATER SOURCE MONITORING LOCATIONS

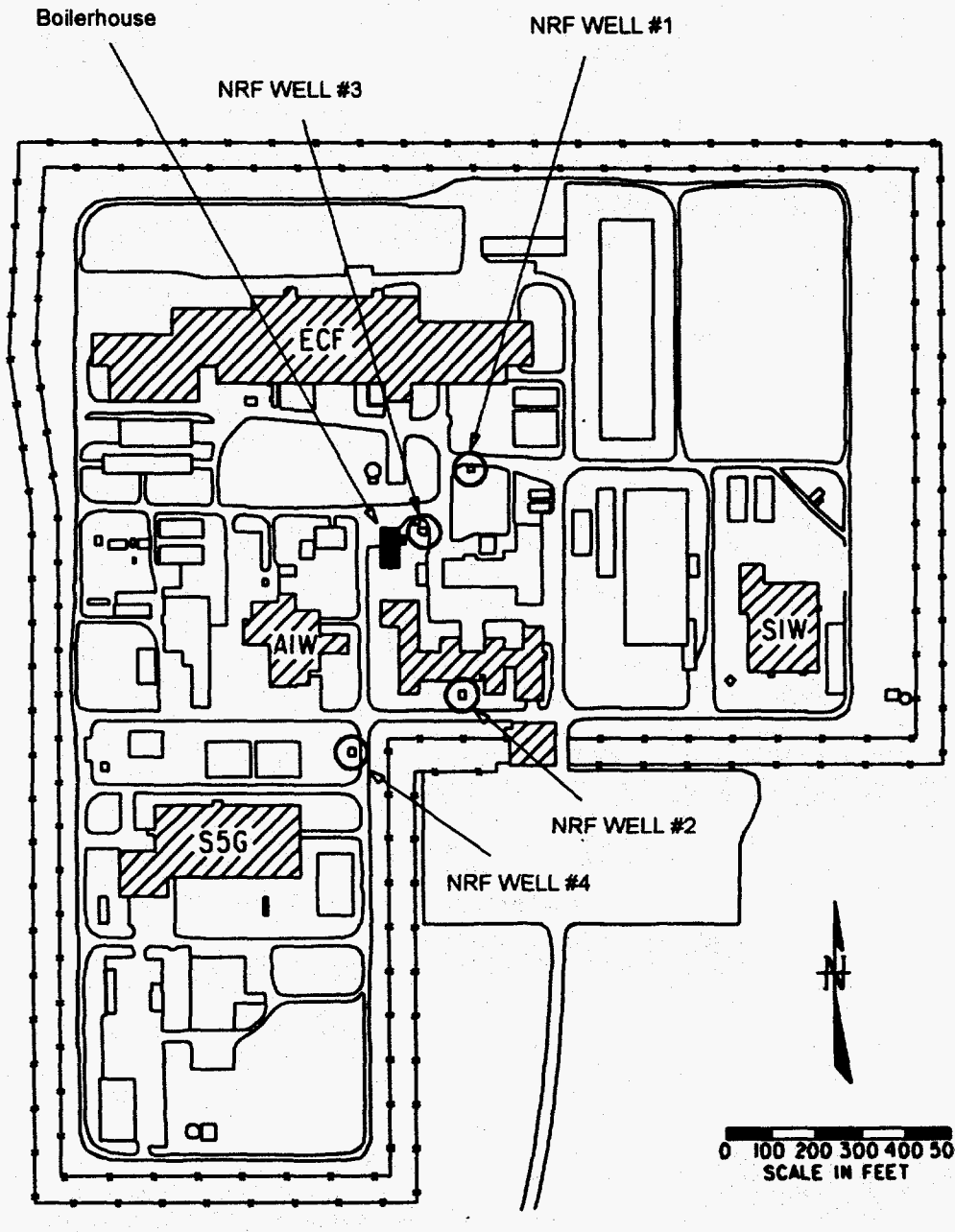

FIGURE 3

TABLE 4
SUMMARY OF DRINKING WATER RADIOACTIVITY RESULTS, CY 1997 [1,2]

NRF WELL #1	GROSS ALPHA x 10^{-9} µCi/ml [3]	GROSS BETA x 10^{-9} µCi/ml [4]	TRITIUM x 10^{-7} µCi/ml
Minimum	1.0 ± 0.5	1.3 ± 0.7	-1.6 ± 1.0
Maximum	3.9 ± 1.1	5.5 ± 1.1	1.3 ± 1.1
Mean	2.5 ± 0.8	3.4 ± 0.8	0.01 ± 1.1
NRF WELL #2			
Minimum	1.6 ± 0.7	2.3 ± 0.9	-1.4 ± 1.0
Maximum	3.3 ± 0.8	5.4 ± 0.9	1.4 ± 1.0
Mean	2.4 ± 0.8	3.5 ± 0.8	-0.01 ± 1.1
NRF WELL #3			
Minimum	1.2 ± 0.6	2.3 ± 0.8	-0.9 ± 1.1
Maximum	2.7 ± 0.8	4.3 ± 0.1	1.5 ± 1.2
Mean	1.9 ± 0.7	3.3 ± 0.8	0.2 ± 1.1
NRF WELL #4			
Minimum	1.3 ± 0.6	2.6 ± 0.9	-0.9 ± 1.2
Maximum	3.7 ± 1.0	7.4 ± 1.3	1.8 ± 1.1
Mean	2.3 ± 0.8	4.2 ± 0.9	0.7 ± 1.1

(1) Uncertainties for random counting error were stated ± 1 sigma level, 1s. Results less than or equal to 2s were interpreted as including "zero" or as not detected. For results greater than 2s but less than or equal to 3s, detection was questionable. Results greater than 3s indicated detection. Negative results indicate sample counts were less than background.

(2) Gross alpha and tritium results were below the drinking water limits, per Reference 2. These limits are yearly average limits and are 1.5×10^{-8} uCi/ml and 2.0×10^{-5} uCi/ml for gross alpha and tritium, respectively. Also, even when conservatively assuming gross beta activity (including naturally occurring beta activity) was entirely due to strontium-90, the results meet the Reference 2 yearly average limit of 8×10^{-9} uCi/ml for strontium-90 in drinking water.

(3) Analyses performed for samples used americium-241 as a reference source.

(4) Analyses performed for samples collected used strontium-90 as a reference source.

GROUNDWATER MONITORING

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

Sources and Treatment

The Snake River Plain Aquifer (SRPA) is approximately 370 feet below the ground surface at NRF. Previous studies at the INEEL have determined that the groundwater moves in a horizontal direction with a flow velocity ranging from 5 to 20 feet per day from the northeast to the southwest (Reference 1).

Figure 4 plots the location of all deep wells used for groundwater monitoring at NRF. The 13 wells are located within a 3.5 mile radius of the NRF Site and were sampled by the U. S. Geological Survey (USGS). These wells are placed into four groups consistent with the well groupings of the Hydrogeologic Study which was performed as part of the NRF Comprehensive RI. Two of these wells (USGS-12 located 3.5 miles north of NRF and NRF-7 located one-quarter mile northwest of NRF), are termed "Regional Upgradient" wells, and are used to monitor water which is hydrologically upgradient to NRF or which is representative of regional background quality. NRF-6 and NRF-13 are called "Effluent System Monitoring" wells, and are used to monitor the potential migration of liquid effluent from the IWD and the sewage lagoon. One older well (USGS-102) constructed in 1988, and five new wells (NRF-8, NRF-9, NRF-10, NRF-11, and NRF-12) constructed in 1995, are termed "Site Downgradient" wells. Located just south of NRF along a semi-circular shaped arc which extends from USGS-102 on the west to NRF-12 on the east, these wells are used to assess potential migration of constituents from the IWD, sewage lagoon, and the NRF site. Three wells (USGS-97, USGS-98, and USGS-99) are located between one-half and one mile south of NRF, and are termed "Regional Downgradient" wells. These wells are used to monitor water which is hydrologically downgradient to the NRF facility or which is representative of regional background quality.

Monitoring, Analyses and Results

NRF has a groundwater monitoring program which includes the collection and analysis of samples from monitoring wells surrounding NRF. In 1997, first quarter samples were collected by NRF personnel and analyzed by contract laboratories. The second, third, and fourth quarter samples were collected by USGS personnel, and analyzed by their contract laboratories. Samples were collected approximately every three months in 1997 and were analyzed for chemical constituents and radioactivity.

• Nonradiological: Groundwater monitoring was conducted through the collection and analysis of samples from Regional Upgradient, Effluent System Monitoring, Site Downgradient, and Regional Downgradient wells. In 1997, the practice of deriving most of the target analytes from those for drinking water monitoring was continued. Two new constituents were added to the list of analytes of concern in 1997 to better parallel the list of drinking water parameters. The results of these analyses for inorganic chemical constituents and other selected parameters are summarized in Table 5.

The average ionic concentrations of calcium, chloride, magnesium, potassium, sodium, and sulfate measured at NRF wells 6 and 13 were higher than all other well groupings. This may be attributed to the discharge of salts from the site water softener and demineralization system (see Liquid Effluent Monitoring section). These wells were designed to monitor the influence of NRF liquid effluent on the SRPA immediately north of NRF. All concentrations of these nonhazardous salt constituents were below recommended drinking water limits, and had no detrimental effect on the quality of the groundwater.

The average groundwater concentrations of aluminum, iron, and manganese were at or near the federal drinking water concentration guidelines in the Effluent System monitoring well group. However, these elemental concentrations were due exclusively to the influence of higher than expected concentrations in well NRF-13. Unfiltered samples from this well were extremely turbid. Previous analysis of filtered samples showed that filtering significantly removes the high levels of metals; therefore, the sediment layers in the aquifer which create the turbidity found in the samples from this well are responsible for the elevated concentration of metals. The concentrations found at NRF for aluminum and iron were consistent with unfiltered samples throughout the INEEL.

• **Radiological**: Samples were analyzed for dissolved gross alpha and gross beta, and tritium radioactivity. The results of these analyses are shown in Table 6. Gross alpha and gross beta values were below the yearly average drinking water limits established by Reference 2 and are consistent with naturally occurring radionuclide levels. In 1997, quantitative isotopic gamma and strontium-90 analyses were performed. All results were below detection limits and were not reported in Table 6.

A review of analytical results from the NRF-11 well (Site Downgradient well group) indicates that the average activity level for tritium in this well exceeds background levels, but is two orders of magnitude below drinking water standards. This activity is believed to be a remnant of the radioactive effluent discharged to the S1W seepage basins between 1955 and 1979.

Groundwater Monitoring Conclusions

• **Nonradiological**: Most groundwater monitoring parameter variations that existed between well groups were not statistically significant. NRF wells 6 and 13, used to monitor the migration from the IWD and sewage lagoon, showed elevated average calcium, chloride, magnesium, potassium, sodium, and sulfate concentrations when compared to the three other well test groups. The concentration of these non-hazardous water softening and demineralization process ions were below applicable drinking water limits and had no detrimental effect on the quality of the groundwater.

• **Radiological**: Analysis of water from groundwater wells collected onsite and offsite did not detect any annual average gross alpha or gross beta radioactivity in excess of natural background levels. Measurements for tritium were at least two orders of magnitude below drinking water standards.

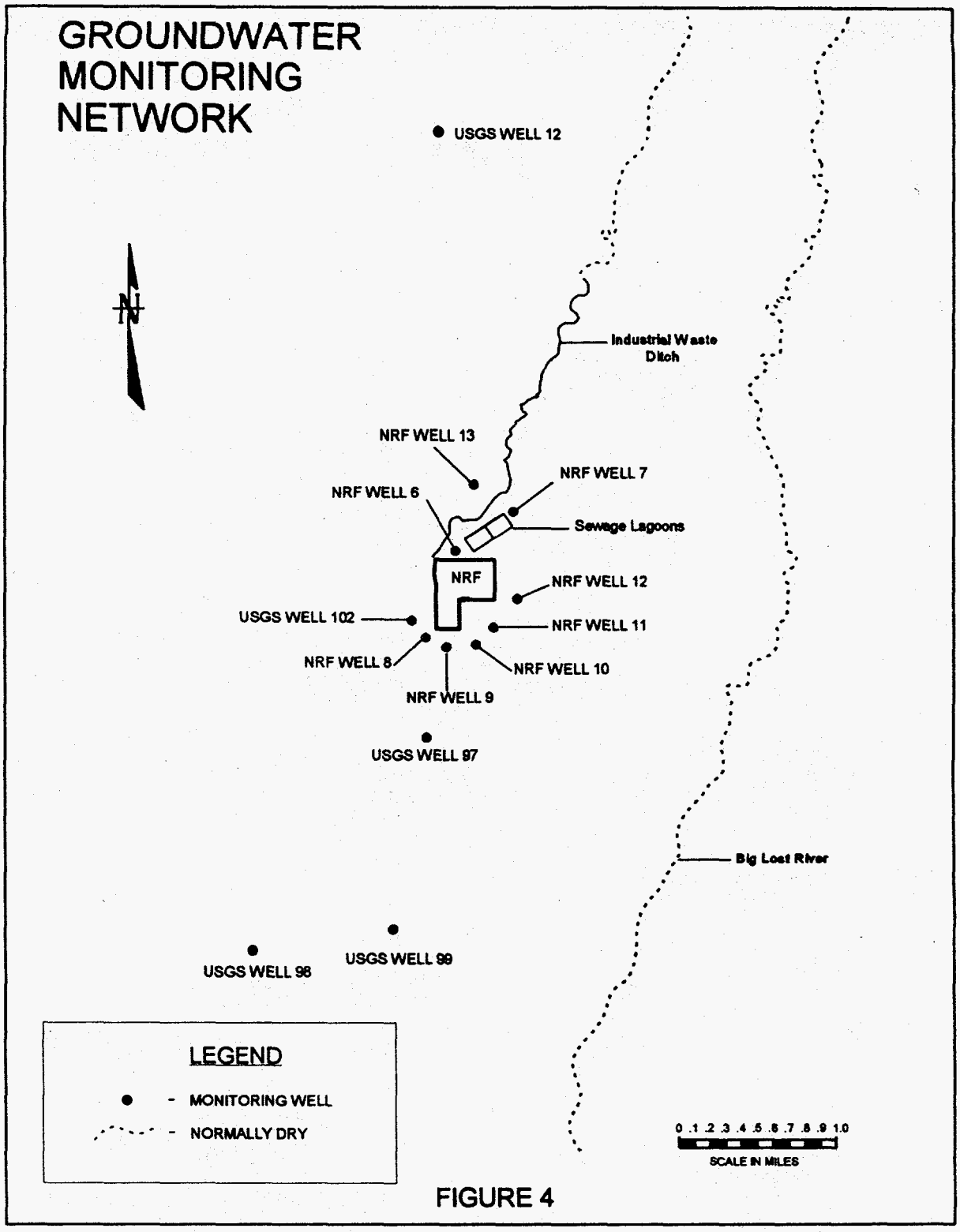
GROUNDWATER
MONITORING
NETWORK
USGS WELL 12
N
Industrial Waste
Ditch
NRF WELL 13
NRF WELL 7
NRF WELL 6
Sewage Lagoons
NRF
NRF WELL 12
USGS WELL 102
NRF WELL 11
NRF WELL 8
NRF WELL 10
NRF WELL 9
USGS WELL 97
Big Lost River
USGS WELL 98
USGS WELL 99
LEGEND
- MONITORING WELL
- NORMALLY DRY
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0
SCALE IN MILES

FIGURE 4

TABLE 5
SUMMARY OF GROUNDWATER ANALYSES - INORGANIC AND OTHER SELECTED PARAMETERS, CY 1997
(Page 1 of 3)

PARAMETER	UNITS	CONCENTRATION GUIDELINE [1]	REGIONAL UPGRADIENT (USGS WELL 12, & NRF WELL 7)		EFFLUENT SYSTEM MONITORING (NRF WELLS 6 & 13)		SITE DOWNGRADIENT (NRF WELLS 8, 9, 10, 11, 12, & USGS WELL 102)		REGIONAL DOWNGRADIENT (USGS WELLS 97, 98, & 99)	
			RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]
ALUMINUM	mg/L	0.2	0.044 to 0.130	< 0.097	<0.100 to 19.20	<5.15	0.043 to 0.2000	< 0.101	< 0.100 to 0.500	< 0.113
ANTIMONY	mg/L	0.006	<.0002 to 0.0005	< 0.0004	<0.0003 to 0.0005	<0.0004	< 0.0002 to 0.0005	< 0.0005	< 0.0039 to 0.0005	< 0.0005
ARSENIC	mg/L	0.05	<0.0010 to 0.0050	<0.0019	0.0014 to 0.0050	<0.0036	<0.0010 to 0.0090	<0.0030	0.0012 to 0.0050	<0.0020
BARIUM	mg/L	2	0.051 to 0.140	0.0940± 0.0440	0.075 to 0.1500	0.0971± 0.0301	0.1100 to 0.1600	0.1292± 0.0132	0..0450 to 0.1300	0.0889± 0.0327
BERYLLIUM	mg/L	0.004	< 0.005	<< 0.005	<0.0000 to 0.0005	<0.0004	< 0.0005	<< 0.0005	<0.0005	<< 0.0005
CADMIUM	mg/L	0.005	< 0.00002 to 0.0003	< 0.0002	<0.00003 .0003	<0.0002	< 0.00001 to 0.0003	<< 0.0002	< 0.00004 to 0.0003	<< 0.0002
CALCIUM	mg/L	(3)	21 to 71	46.5± 22.6	74 to 141	110.7± 26.4	67 to 81	74.8± 3.75	48 to 92	64.3± 13.1
CHLORIDE	mg/L	250	4 to 39	19.4± 16.0	57 to 270	162.2± 106.1	35 to 62	45.6± 8.5	14 to 38	24.6± 9.7
CHROMIUM	mg/L	0.1	0.0049 to 0.012	0.0085 ± 0.0027	0.0270 to 0.4000	0.0899± 0.1272	0.0047 to 0.3600	0.0294± 0.0721	0.0036 to 0.0150	0.0058± 0.0003
COPPER	mg/L	1.3	0.0019 to 0.0670	0.0139± 0.0221	0.0039 to 0.0300	0.0106± 0.0840	< 0.0017 to 0.0100	< 0.0046	0.0020 to 0.5500	< 0.0524
IRON	mg/L	0.3	0.003 to 1.800	0.467± 0.6100	0.6100 to 20.500	6.390± 7.531	0.0100 to 1.900	<0.235	0.0320 to 5.100	<0.5000
LEAD	mg/L	0.015	< 0.001 to 0.0013	< 0.0099	<0.0006 to 0.0030	<0.0014	< 0.0002 to 0.001	< 0.0007	0.0012 to 0.0600	0.0088± 0.01810

TABLE 5
SUMMARY OF GROUNDWATER ANALYSES - INORGANIC AND OTHER SELECTED PARAMETERS, CY 1997
(Page 2 of 3)

PARAMETER	UNITS	CONCENTRATION GUIDELINE [1]	REGIONAL UPGRADIENT (USGS WELL 12, & NRF WELL 7)		EFFLUENT SYSTEM MONITORING (NRF WELLS 6 & 13)		SITE DOWNGRADIENT (NRF WELLS 8, 9, 10, 11, 12, & USGS WELL 102)		REGIONAL DOWNGRADIENT (USGS WELLS 97, 98, & 99)	
			RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]
MAGNESIUM	mg/L	(3)	8.3 to 22.7	15.4± 6.9	20.2 to 35.9	29.3 ± 6.2	21.0 to 26.3	23.8± 1.2	18.0 to 24.3	21.7± 2.0
MANGANESE	mg/L	0.05	0.013 to 0.0240	0.0079± 0.0079	0.0043 to 0.300	0.0810± 0.1145	< 0.0002 to 0.0130	< 0.0038	< 0.0004 to 0.0280	< 0.0043
MERCURY	mg/L	0.002	< 0.0001± to 0.0002	< 0.0002	<0.0004 to 0.0002	<0.0002	< 0.0001 to 0.0002	< 0.0002	<0.0001 to 0.0002	< 0.0002
NICKEL	mg/L	0.1	< 0.0024 to 0.0100	< 0.0060	0.0140 to 0.0400	0.0265± 0.0105	0.0026 to 0.0500	<0.0112± 0.0120	<0.002 to 0.0100	< 0.0047
NITROGEN measured as NITRATE-NITRITE	mg/L	10	0.440 to 2.200	1.261± 0.753	0.750 to 2.000	1.366± 0.552	1.800 to 2.500	2.154 ± 0.1740	1.200 to 2.400	1.783 ± 0.4240
NITROGEN measured as NITRITE	mg/L	1	<0.0036 to 0.0100	< 0.0091	<0.0064 to 0.0600	0.0165	< 0.0047 to 0.0100	< 0.0086	< 0.0100 to 0.1000	< 0.0347
NITROGEN (Total Kjeldahl)	mg/L	(3)	<0.500	<<0.500	<0.500	<<0.500	<0.500	<<0.500	<0.500	<<0.500
ORGANIC CARBON (Total)	mg/L	(3)	<0.200 to 3.600	<0.916	0.260 to 1.000	0.609± 0.286	0.220 to 0.690	0.450± 0.121	0.200 to 3.700	0.675± 0.963
ORGANIC HALOGEN (Total)	mg/L	(3)	0.0006 to 0.0300	0.0220± 0.0120	0.0130 to 0.0300	0.0210± 0.0080	0.0030 to 0.0300	0.0140± 0.0110	0.0050 to 0.0300	0.0250± 0.0100
pH	pH	6.5 to 8.5	7.79 to 8.55	8.11± 0.32	7.87 to 8.37	8.07± 0.23	7.62 to 8.05	7.90± 0.09	7.83 to 8.01	7.92± 0.05
PHOSPHOROUS	mg/L	(3)	0.024 to 0.170	< 0.071	0.088 to 0.900	<0.270	0.026 to 0.240	< 0.085	0.019 to 0..210	< 0.077

TABLE 5
SUMMARY OF GROUNDWATER ANALYSES - INORGANIC AND OTHER SELECTED PARAMETERS, CY 1997
(Page 3 of 3)

PARAMETER	UNITS	CONCENTRATION GUIDELINE [1]	REGIONAL UPGRADIENT (USGS WELL 12, & NRF WELL 7)		EFFLUENT SYSTEM MONITORING (NRF WELLS 6 & 13)		SITE DOWNGRADIENT (NRF WELLS 8, 9, 10, 11, 12, & USGS WELL 102)		REGIONAL DOWNGRADIENT (USGS WELLS 97, 98, & 99)	
			RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]	RANGE	MEAN ± s [2]
POTASSIUM	mg/L	(3)	2.000 to 3.300	2.563± 0.515	4.700 to 6.000	5.138± 0.460	2.000 to 5.000	2.663± 0.583	1.800 to 2.400	2.100± 0.195
SELENIUM	mg/L	0.05	< 0.0001 to 0.005	< 0.0019	<0.0001 to 0.005	<0.0023	0.0016 to 0.005	0.0030± 0.0013	0.001 to 0.005	0.0022± 0.0014
SILVER	mg/L	0.1	< 0.0003 to 0.0005	< 0.0005	0.0002 to 0.0007	<0.0005	< 0.0001 to 0.0005	< 0.0004	< 0.0001 to 0.0005	< 0.0003
SODIUM	mg/L	(3)	8.3 to 17.7	13.0± 4.3	11.4 to 124	65.2± 56.3	14.0 to 23.2	17.7± 2.8	9.6 to 16.4	13.6± 2.7
SPECIFIC CONDUCTANCE	µmho/cm	(3)	210 to 560	368± 153	406 to 1500	958± 530	456 to 730	599± 58	400 to 608	474± 74
SULFATE	mg/L	250	13.5 to 36.0	23.9± 10.7	68 to 200	133.1± 63.0	34.8 to 62.0	45.6± 8.3	21.6 to 38.0	28.6± 6.3
THALLIUM	mg/L	0.002	< 0.00001 to 0.0001	< 0.0001	<0.00004 to 0.0001	<0.0001	< 0.00001 to 0.0001	< 0.00007	<0.00002 to 0.0001	< 0.00007
ZINC	mg/L	5	< 0.0051 to 0.1200	< 0.0268	<0.0053 to 0.0700	<0.0294	< 0.0069 to 0.0380	< 0.0163	0.093 to 0.310	0.1560± 0.0601

(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. *Used for comparison only.*

(2) Mean values recorded ± 1 standard deviation (s). Mean values preceded by < contained at least one "less than minimum detection level" (MDL) value in the data set for that parameter and no standard deviation reported. Mean values preceded by << contained all "less than minimum detection level" values in the data set for that parameter and were the average of the MDLs.

(3) No guideline available per federal or state regulations.

TABLE 6
SUMMARY OF GROUNDWATER RADIOACTIVITY RESULTS, CY 1997 [1, 2]
(USGS LABORATORY)

REGIONAL UPGRADIENT	GROSS ALPHA x 10^{-9} µCi/ml [3]	GROSS BETA x 10^{-9} µCi/ml [4]	TRITIUM x 10^{-7} µCi/ml
Minimum	0.0 ± 0.08	1.20 ± 0.50	-0.77 ± 0.07
Maximum	3.0 ± 0.25	4.51 ± 0.60	0.63 ± 0.06
Mean	1.35 ± 0.25	2.94 ± 0.34	0.10 ± 0.19
EFFLUENT SYSTEM MONITORING			
Minimum	1.12 ± 1.02	-2.62 ± 2.05	0.24 ± 0.10
Maximum	5.64 ± 1.25	17.0 ± 1.65[5]	0.87 ± 0.06
Mean	2.76 ± 0.55	7.48 ± 0.78	0.57 ± 0.20
SITE DOWNGRADIENT			
Minimum	1.26 ± 0.60	2.43 ± 0.70	-0.55 ± 1.0
Maximum	4.48 ± 1.05	64.0 ± 3.50[5]	2.96 ± 0.15
Mean	2.41 ± 0.34	6.38 ± 0.79	1.03 ± 0.27
REGIONAL DOWNGRADIENT			
Minimum	1.14 ± 0.43	1.19 ± 0.75	0.16 ± 0.04
Maximum	2.25 ± 0.65	3.63 ± 0.85	0.53 ± 0.05
Mean	1.84 ± 0.28	2.64 ± 0.39	0.33 ± 0.16

(1) Uncertainties for random counting error were stated ± 1 sigma level, 1s. Results less than or equal to 2s were interpreted as including "zero" or as not detected. For results greater than 2s but less than or equal to 3s, detection was questionable. Results greater than 3s indicated detection.

(2) All radioactivity levels for gross alpha and tritium were below the average yearly limits of 1.5 x 10^{-6} µCi/ml and 2.0 x 10^{-5} µCi/ml respectively, per Reference 2.

(3) Based on dissolved thorium-230.

(4) The gross beta activity results listing in this table are based on a cesium-137 reference source. The gross beta activity results, if based on strontium-90 as a reference source, would be about two-thirds the values listed above. Thus, even when conservatively assuming gross beta activity in the groundwater (including naturally occurring beta activity) was entirely due to strontium-90, the results meet the yearly average limit of 8 x 10^{-9} uCi/ml for strontium-90 in drinking water, per Reference 2.

(5) These values were anomalously high when compared to prior or subsequent analytical results from samples collected from the same well locations. Ten of thirteen samples collected during the first quarter of 1997 from both upgradient and downgradient well groups yielded gross beta results which were maximum for the year. These samples were also analyzed for the presence Sr-90 and individual gamma emitting isotopes. All supporting analyses resulted in typical background levels. The high gross beta activity occurred in both upgradient and down gradient wells and the fact that additional analysis did not reveal a source for this activity indicate that a laboratory quality control problem existed for the gross beta analysis of these groundwater samples. The USGS and their contracting laboratory have beeen informed of these anomalous results.

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AIRBORNE EFFLUENT MONITORING

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

Sources and Treatment

The principal sources of nonradioactive industrial pollutants are exhausts from facility maintenance operations and fuel combustion products from the three steam generating boilers. Fuel oil is utilized in boiler operation and the resulting combustion products are released through elevated exhaust stacks. The boilers provide steam primarily for heating and, therefore, are in maximum use during the colder months. Other operations at NRF release small quantities of air pollutants. These sources include chemistry laboratories, emergency power diesel generators, janitorial activities, and shops which encompass activities such as painting, welding and carpentry.

All of these sources contribute to particulate matter present in the ambient air. However, the primary source of airborne particulate matter at NRF is considered to be windblown dust from high winds and agricultural operations (Reference 1).

A long-term asbestos abatement plan was completed in 1997 to reduce the amount of asbestos on the NRF Site. This project, started in 1988, removed approximately 30,484 linear feet of asbestos containing material (ACM) primarily in the form of friable pipe insulation. The final phase of this project removed approximately 966 linear feet of ACM from ECF in 1997. The amounts of ACM pipe insulation which remain at NRF are inspected semi-annually. NRF has identified and labeled all remaining known asbestos-containing thermal insulation onsite. Small amounts of ACM have also been identified in floor tiles and mastic, in fire resistive safes and in gasket materials and are managed in accordance with all applicable regulations.

Small quantities of radioactivity are contained in the airborne effluent from prototype plant and defueling operations and from work performed at ECF. High efficiency particulate air (HEPA) filters and charcoal filters are used on select exhaust stacks to reduce radioactive air emissions. Naturally occurring radon present in the environment is also present in the exhaust air.

Fugitive air emissions may arise from soil containing residual radioactivity from historic discharge areas evaluated under the comprehensive RI/FS. Air emissions are conservatively calculated using soil sampling data generated by the soil and vegetation monitoring program. These areas are not accessible to the general public and are sampled on an annual basis to confirm the low emissions.

Monitoring, Analyses and Results

• Nonradiological: Emissions from fuel-burning equipment were calculated using the sulfur content of the fuel oil and Environmental Protection Agency (EPA) approved emission factors. These calculations provided values for the amount of sulfur oxides, nitrogen oxides and particulate matter emitted as a result of NRF operations.

The fuel oil consumed at NRF conformed to the State of Idaho standard for sulfur content as confirmed by vendor data. Calculated per Reference 3, total annual emissions for 1997 were 5.1 tons of nitrogen oxides (expressed as nitrogen dioxide), 2.1 tons of sulfur oxides and 0.51 tons of particulate matter.

Air emissions from the three steam generating boilers were substantially reduced by burning ASTM grade number 1,2, and 4 fuels oils and discontinuing the use of ASTM grade number 5 fuel oil in 1995.

The ESRF inputs the calculated emissions of sulfur oxides and nitrogen oxides into an air dispersion model. The air dispersion model accounts for meteorological conditions such as wind speed, wind direction, and rainfall when calculating average annual concentrations for air pollutants. ESRF calculates the maximum average annual sulfur dioxide and nitrogen dioxide concentrations at the INEEL Site boundary from all INEEL primary sources including NRF. These values are reported in the annual Idaho National Engineering and Environmental Laboratory Site Environmental Report.

In addition, the INEEL Environmental Monitoring Program (INEEL-EMP) operates air monitors at the INEEL and the surrounding communities to determine the concentration of particulates in the air as required by References 4 and 5. Concentrations are measured as particulate matter and total suspended particulates. Particulate matter includes only particulates with an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}). The total suspended particulate and PM_{10} concentrations measured on the NRF Site are reported in the annual Idaho National Engineering and Environmental Laboratory Site Environmental Report.

Opacity of fuel-burning equipment was checked in April of 1997. The State of Idaho regulations assert that emissions may not exceed twenty percent opacity for more than three minutes in any sixty minute period (Reference 4). The steady-state opacities of all observed exhaust plumes were less than or equal to 20 percent and were determined to be in compliance with Reference 4.

Four diesel generators are operated at the NRF Site under a permit to construct exemption issued by the State of Idaho. The permit specifically allows each of the diesels to be operated 228 hours per year. In 1997, the diesel generators were operated less than 20 hours each in compliance with the State of Idaho requirements.

Whenever work was being performed that could result in airborne asbestos, sampling in or near the worksite was performed by drawing a measured volume of air through filter paper. Samples were analyzed locally using phase contrast microscopy or were analyzed by outside laboratories using transmission electron microscopy. NRF's ongoing area monitoring program has confirmed that workers in spaces containing asbestos materials were not exposed to asbestos fibers above regulatory limits. Area samples and personal monitoring devices have also shown that engineering controls in place were effective. This sampling verified there were no measurable discharges of asbestos fibers to the environment. All asbestos work performed at NRF was conducted in accordance with federal regulatory requirements.

Additional NRF information concerning calculations of federal hazardous air pollutants (HAPs), state toxic air pollutants (TAPs), carbon monoxide (CO), lead, and VOCs, air emission estimating methods, and monitoring locations is contained in the Air Emission Inventory for the INEEL.

• **Radiological**: Airborne effluents from radiological areas at NRF were monitored for particulate radioactivity through the use of fixed filter air samplers. These samplers drew air from each area and deposited particulate matter on filter papers. These filters were then analyzed monthly for radioactivity with a low-background alpha-beta counter. Samples which exceeded the control level of 2×10^{-14} microcuries per milliliter of air were investigated as to the source. Filters which were greater than 6×10^{-14} microcuries per milliliter of air were also analyzed using a gamma spectrometer to identify specific radionuclides. All filters were composited annually and analyzed using a gamma spectrometer to identify contributing radionuclides.

Tritium sampling was conducted at three NRF locations. The tritium samplers used silica gel to absorb water vapor from the air. The absorbed water was subsequently recovered and analyzed. The quantity of tritium

radioactivity in the effluent air at ECF resulting from fuel handling operations was calculated.

Fixed filter air and tritium samplers were located at the NRF gatehouse. These samplers measured ambient radioactivity levels at NRF for comparison with emissions from radiological areas. In addition, two fixed filter air samplers were located both north and south of NRF and served as upwind and downwind monitoring stations.

The quantity of gaseous carbon-14 radioactivity in the effluent air was calculated based on fuel handling operations. In addition, charcoal cartridges were used to sample for radioiodine in airborne effluent at ECF. These charcoal cartridges were periodically replaced and promptly counted using gamma spectrometry for quantitative identification.

The radioactivity contained in the exhaust air during 1997 consisted of: (1) 0.000073 curie of particulate fission and activation products having half-lives greater than one day, (2) 0.078 curie of tritium, (3) 0.81 curie of carbon-14 (4) 0.000017 curie of iodine-131, (5) 0.0000003 curie of mercury-203, (6) 0.000000087 curie of cobalt-58, and (7) 0.000015 curie of osmium-191. Results that indicate the average concentration and total amount of airborne radioactivity are reported via the INEEL Radioactive Waste Management Information System.

Fugitive air emissions from soil surrounding NRF were calculated using average wind velocities as reported per Reference 6 and data collected from soil sampling (see Soil and Vegetation Monitoring section). Cobalt-60 and cesium-137 were the principle components of these fugitive emissions having an estimated emission activity of 0.0000018 and 0.000036 curie, respectively.

An effective dose equivalent of 0.00056 millirem per year from NRF air emissions was calculated for the maximally exposed members of the general public. This calculation was performed using CAP-88, the EPA approved computer model (Reference 6). This is 0.0056 percent of the EPA's standard of 10 millirem per year for exposure of a member of the general public to airborne radioactivity (Reference 7) and much less than the 1-2 millirem an individual would receive from a single cross-country airplane flight.

Airborne radioactivity and effective dose calculation information is also contained in the INEEL National Emission Standard for Hazardous Air Pollutants Annual Report.

Airborne Effluent Monitoring Conclusions

• **Nonradiological**: 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 with no measurable discharge of asbestos fibers to the environment.

• **Radiological**: The results of NRF's airborne radiological effluent monitoring for 1997 have shown the amount of radioactivity released was too small to result in any measurable change in the background radioactivity levels in the environment. The concentrations of the particulate and gaseous radioactivity released from the NRF Site during 1997 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 was conservatively calculated to be significantly below the standard established by the EPA.

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SOIL AND VEGETATION MONITORING

The soil and vegetation monitoring program has two purposes. The first is to determine whether current NRF operations are adding any radioactivity to the environment surrounding the NRF Site. The second purpose is to verify continued containment of the few areas around the site known to contain residual low-level radioactivity from past operations.

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 onsite systems for recycling water containing trace amounts of radioactivity became operational. There are several localized areas of soil within NRF's area of responsibility, such as the A1W Leaching Bed and the S1W Seepage Basins, that contain small amounts of residual radioactivity, principally cobalt-60 and cesium-137 from past operations. These areas are not accessible to members of the general public and are sampled on a routine basis to verify that the radioactivity is not migrating.

Monitoring, Analyses and Results

Forty soil and vegetation samples were collected in each of four areas surrounding NRF. Sample locations were determined randomly from a grid coordinate system superimposed over each area. Soil and vegetation samples were collected from the A1W Leaching Bed area, the area surrounding the S1W Seepage Basins, and the southwest cell of the sewage lagoon complex (Figure 5). These inactive areas were the locations where residual radioactivity from past operations was 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 discharged downwind of exhaust points. The NRF perimeter sample collection points are illustrated in Figure 6. Analyses of all samples collected from these four areas were performed using a gamma spectrometry system. Data collected from soil and vegetation sampling were evaluated statistically to detect any average annual changes in surface radioactivity levels.

The results of the soil and vegetation sample analyses are summarized in Table 7. The maximum radioactivity detected from the soil samples was 24 picocuries per gram of cesium-137. This sample was collected from a location within the controlled area of the A1W Leaching Bed. However, all areas containing residual radioactivity are not accessible to the general public and are sampled on an annual basis to verify that the radioactivity is not migrating. These areas are included in the scope of remediation activities under the INEEL FFA/CO.

The maximum radioactivity detected from the vegetation samples was 3.97 picocuries per gram of cesium-137, which was also collected from a location within the controlled area of the A1W Leaching Bed. Once again, these areas are not accessible to the general public and are sampled on an annual basis. A person would have to consume almost 1,100 pounds of vegetative material containing the highest measured levels each year before exceeding the dose permitted a member of the general public by the Nuclear Regulatory Commission (NRC).

Soil and Vegetation Monitoring Conclusions

NRF operations in 1997 did not contribute to any measurable increase in radiation levels in the surrounding environment. The localized areas at NRF that contain low levels of residual radioactivity from past operations continue to be adequately controlled and

contained to prevent migration. This radioactivity does not present any significant risk to NRF personnel, the general public or the environment.

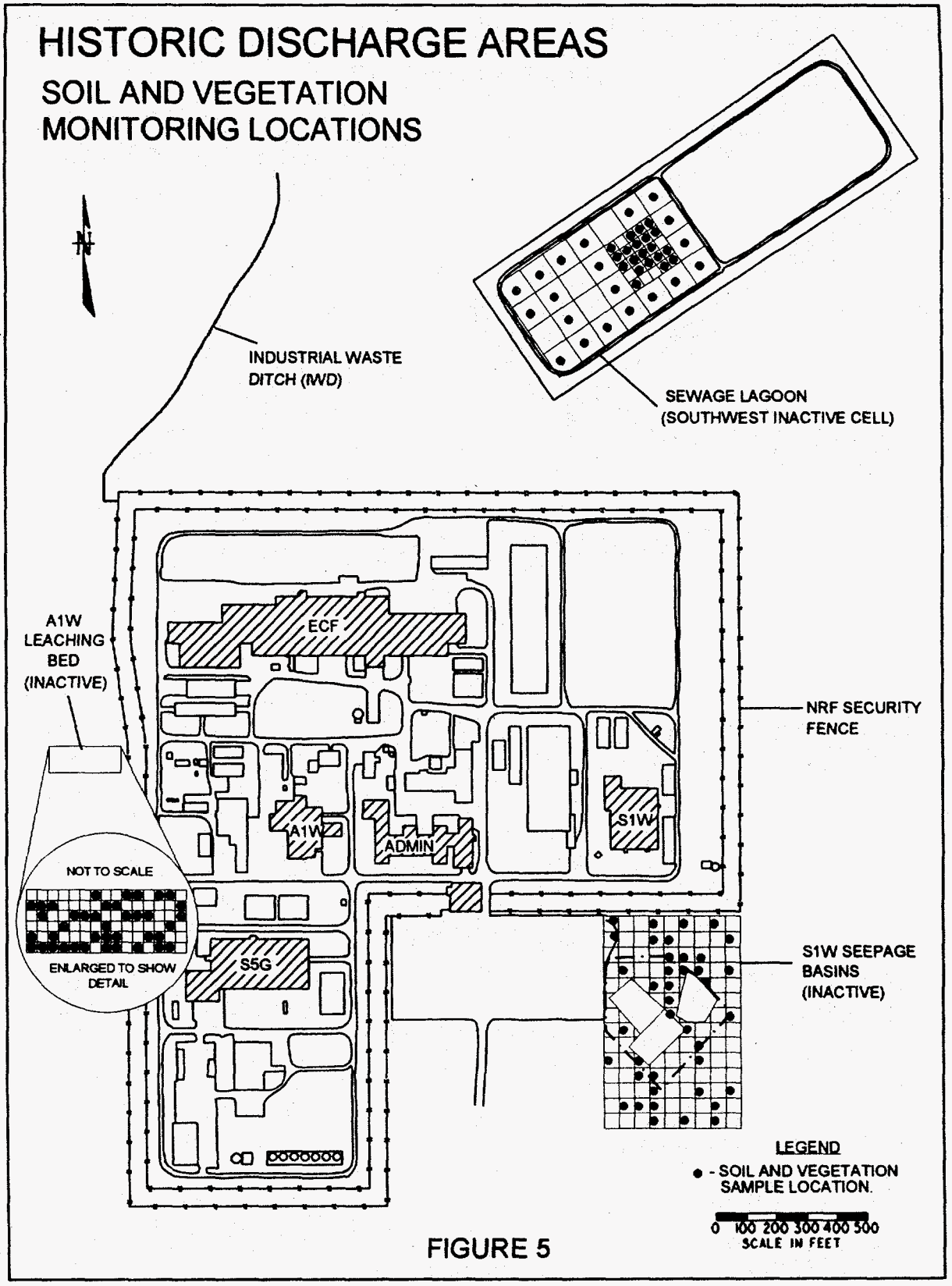
HISTORIC DISCHARGE AREAS
SOIL AND VEGETATION
MONITORING LOCATIONS
N
INDUSTRIAL WASTE
DITCH (IWD)
SEWAGE LAGOON
(SOUTHWEST INACTIVE CELL)
A1W
LEACHING
BED
(INACTIVE)
ECF
NRF SECURITY
FENCE
A1W
ADMIN
S1W
NOT TO SCALE
ENLARGED TO SHOW
DETAIL
S5G
S1W SEEPAGE
BASINS
(INACTIVE)
LEGEND
● - SOIL AND VEGETATION
SAMPLE LOCATION.
0 100 200 300 400 500
SCALE IN FEET

FIGURE 5

NRF PERIMETER AREA
SOIL AND VEGETATION MONITORING LOCATIONS

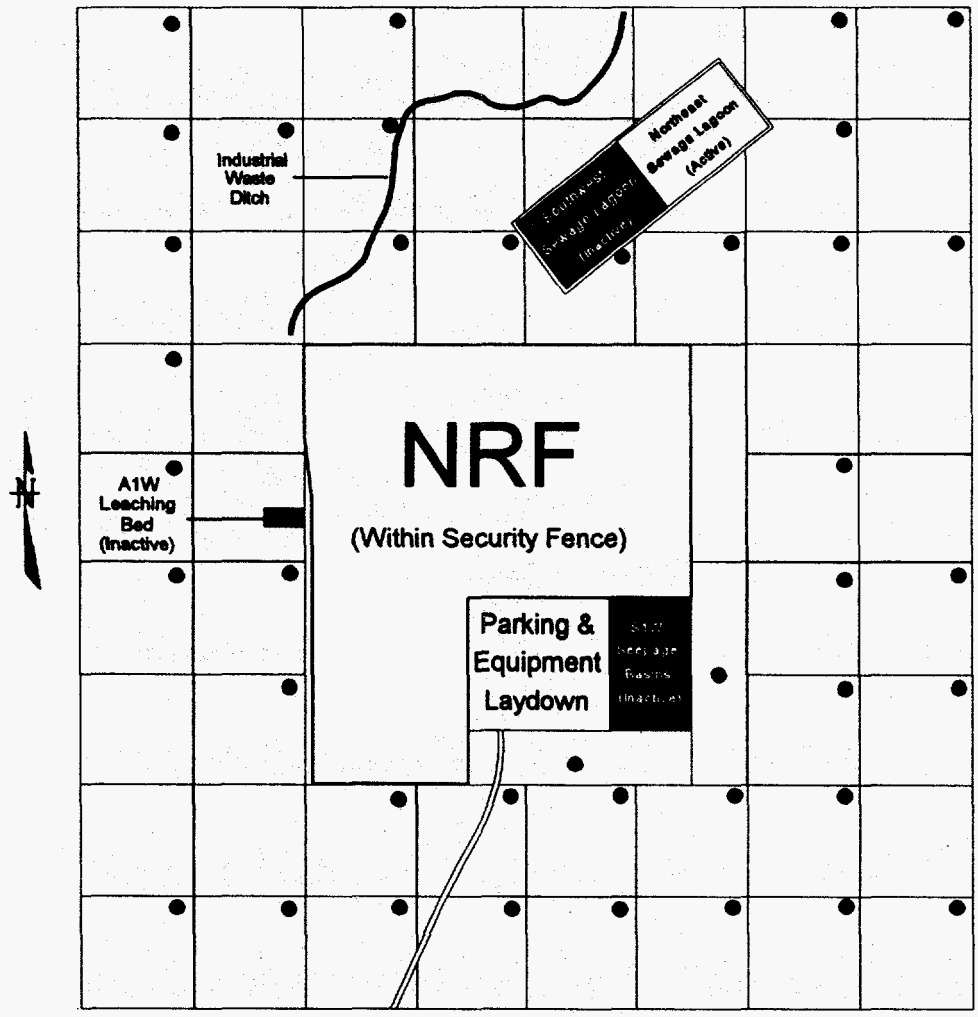

FIGURE 6

TABLE 7
SUMMARY OF SOIL AND VEGETATION GAMMA RADIOACTIVITY RESULTS, CY 1997 (1)
pCi/gram Dry Weight

	Cobalt-60				Cesium-137			
	Soil		Vegetation		Soil		Vegetation	
Area	Mean	Range	Mean	Range	Mean	Range	Mean	Range
A1W Leaching Bed (Inactive)	0.55 ± 0.14	0.06 ± 0.04 to 2.0 ± 0.23	0.43 ± 0.28	0.23 ± 0.14 to 0.76 ± 0.46	3.91 ± 0.58	0.14 ± 0.09 to 24.0 ± 2.04	0.58 ± 0.24	0.0 ± 0.0 to 3.97 ± 0.5
S1W Seepage Basins (Inactive)	0.34 ± 0.13	0.05 ± 0.03 to 2.64 ± 0.29	0.25 ± 0.17	0.09 ± 0.06 to 0.53 ± 0.32	3.73 ± 0.58	0.09 ± 0.06 to 20.6 ± 1.75	0.27 ± 0.14	0.01 ± 0.01 to 3.42 ± 0.44
Southwest Sewage Lagoon (Inactive)	0.27 ± 0.17	0.10 ± 0.07 to 0.53 ± 0.32	0.29 ± 0.2	0.06 ± 0.05 to 0.58 ± 0.35	2.07 ± 0.35	0.13 ± 0.09 to 10.9 ± 0.99	0.16 ± 0.11	0.01 ± 0.01 to 0.44 ± 0.27
NRF Perimeter	0.09 ± 0.06	0.0 ± 0.0 to 0.22 ± 0.13	0.29 ± 0.19	0.10 ± 0.09 to 0.62 ± 0.38	0.71 ± 0.16	0.10 ± 0.06 to 2.4 ± 0.29	0.22 ± 0.14	0.01 ± 0.01 to 0.45 ± 0.20

(1) Uncertainties for random counting error were stated ± 1 sigma level, 1s. Results less than or equal to 2s were interpreted as including "zero" or as not detected. For results greater than 2s but less than or equal to 3s, detection was questionable. Results greater than 3s indicated detection. All ranges were for 40 samples of soil and 40 of vegetation.

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RADIATION MONITORING

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

Direct measurement of radiation along the security fence was performed independently by NRF and the Environmental Monitoring Unit of LMITCO. The NRF radiation monitoring program involves measuring ionizing radiation levels at 17 locations along the site security fence and eight other locations within the NRF property boundaries. Standard Navy calcium-fluoride thermoluminescent dosimeters (TLDs) were placed at each location approximately one meter above the ground. These environmental TLDs are calibrated to a known source value. Figure 7 shows the locations of 23 of the posted NRF TLDs. The two remaining TLDs, 17 and 18, were located near the NRF Sewage Lagoon. NRF also posted 15 TLDs (three groups of five) throughout the INEEL varying from five to ten miles from the NRF Site to determine INEEL radiation background levels. All NRF environmental TLDs were collected and processed quarterly.

LMITCO measured ionizing neutron radiation levels at 11 points surrounding the NRF Site. This monitoring was performed by placing five individual lithium-fluoride TLD chips one meter above the ground at predesignated locations. Figure 7 depicts the locations of the LMITCO dosimeters. ESRF measures natural background ionizing radiation levels at offsite locations using TLD measurements obtained from four distant communities. The locations of these offsite monitoring points are shown in Figure 8.

The LMITCO and ESRF environmental TLDs were collected and processed every six months. In addition to the TLD network, radiation surveys were conducted around the site perimeter using a highly sensitive radiation detection instrument.

The results of the radiation monitoring programs conducted by NRF, LMITCO, and ESRF are summarized in Table 8. A comparison of the average reading along the NRF security fence and the average background reading measured by NRF at locations on the INEEL 5 to 10 miles away from NRF indicated that NRF does not contribute to an increase in radiation levels. This is further verified by comparing the average NRF security fence reading to the average distant community reading. The slight variations in the values were not significant and were due to the variables inherent in dosimeter processing, location and dosimeter types used by NRF, LMITCO, and ESRF radiation monitoring programs.

Some TLD monitoring locations on the NRF Site were located near known individual sources of radiation around the site, and as expected, recorded exposure higher than the natural background levels measured offsite. None of these TLDs showed any notable increase in exposure compared to previous monitoring periods. Even though these readings were higher than the NRF average environmental radiation level, the radiation levels were localized and do not contribute to increased radiation exposure to the general public.

Radiation Monitoring Conclusions

No measurable radiation exposure to the general public occurred as a result of NRF operations in 1997.

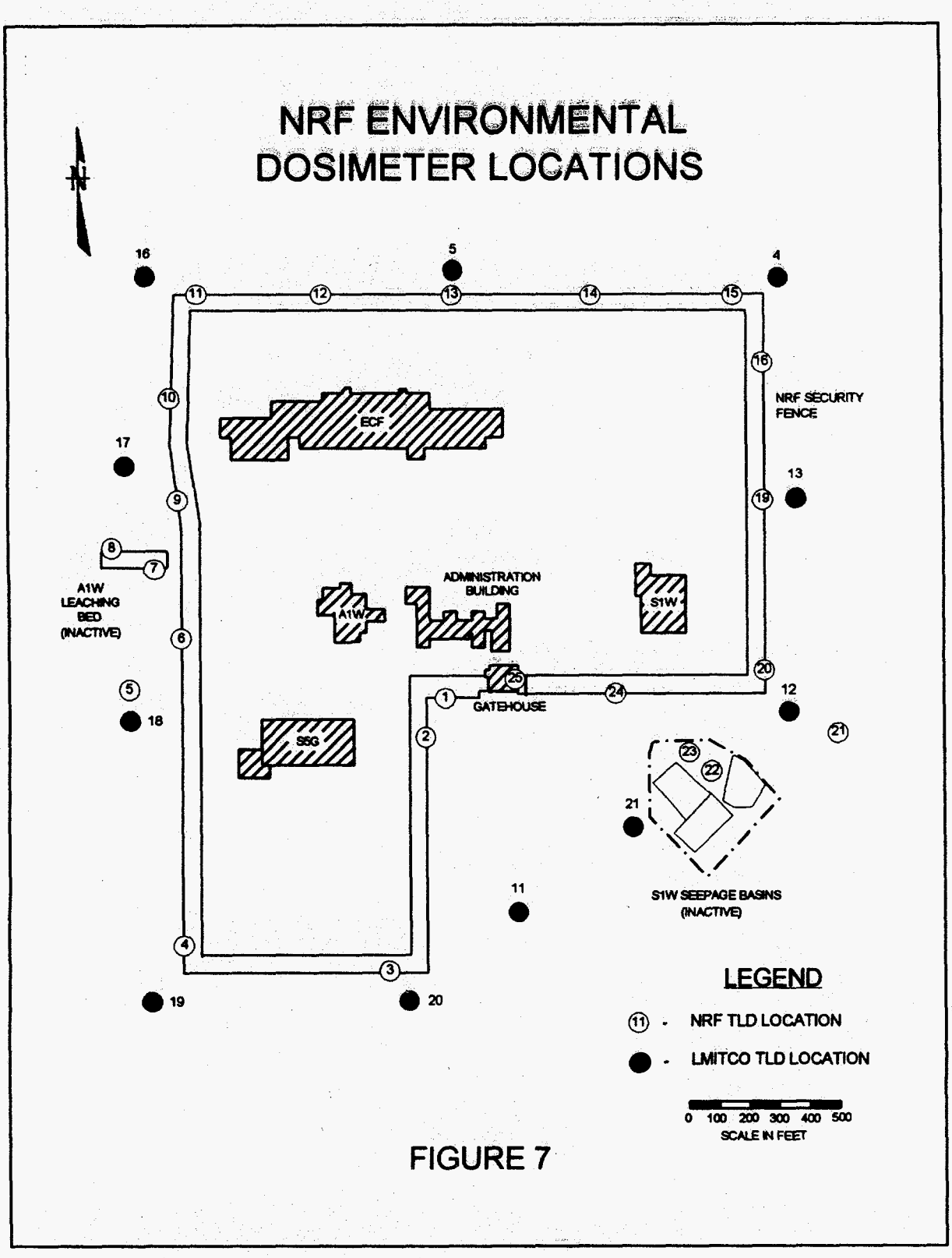
NRF ENVIRONMENTAL
DOSIMETER LOCATIONS
N
16
5
4
11
12
13
14
15
16
NRF SECURITY
FENCE
10
ECF
17
13
9
19
8
7
A1W
LEACHING
BED
(INACTIVE)
A1W
ADMINISTRATION
BUILDING
S1W
6
20
5
25
1
24
12
18
GATEHOUSE
21
S5G
2
23
22
21
11
S1W SEEPAGE BASINS
(INACTIVE)
4
3
19
20
LEGEND
11 - NRF TLD LOCATION
- LMITCO TLD LOCATION
0 100 200 300 400 500
SCALE IN FEET

FIGURE 7

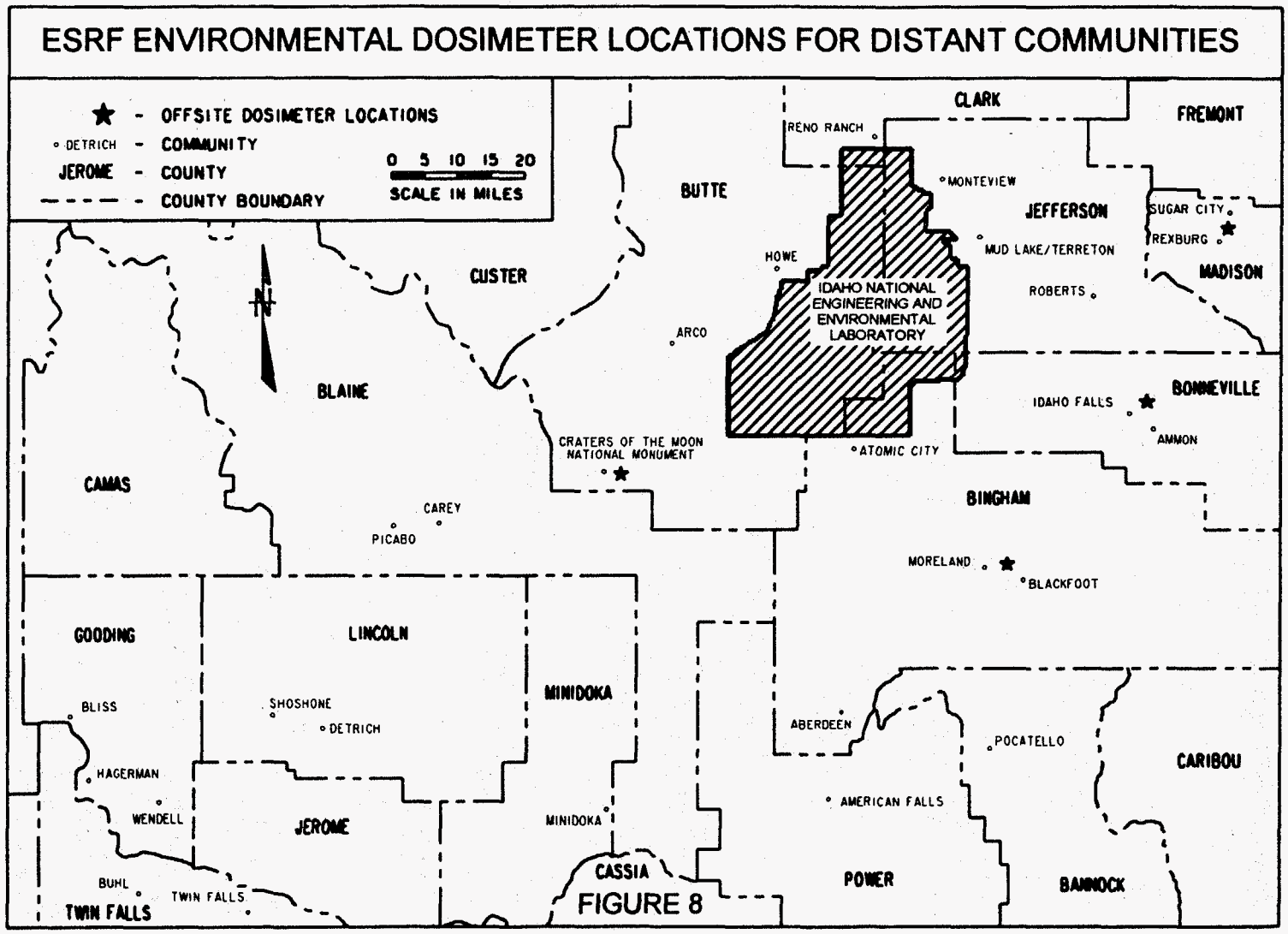
ESRF ENVIRONMENTAL DOSIMETER LOCATIONS FOR DISTANT COMMUNITIES
★ - OFFSITE DOSIMETER LOCATIONS
° DETRICH - COMMUNITY
JEROME - COUNTY
- - - - - - COUNTY BOUNDARY
0 5 10 15 20
SCALE IN MILES
N
CLARK
FREMONT
RENO RANCH
BUTTE
°MONTEVIEW
JEFFERSON
SUGAR CITY
REXBURG
MUD LAKE/TERRETON
HOWE
MADISON
CUSTER
ROBERTS
IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY
ARCO
BONNEVILLE
IDAHO FALLS
AMMON
BLAINE
CRATERS OF THE MOON NATIONAL MONUMENT
°ATOMIC CITY
CAMAS
BINGHAM
CAREY
PICABO
MORELAND
°BLACKFOOT
GOODING
LINCOLN
MINIDOKA
BLISS
SHOSHONE
°DETRICH
ABERDEEN
°POCATELLO
CARIBOU
HAGERMAN
WENDELL
JEROME
MINIDOKA
° AMERICAN FALLS
CASSIA
POWER
BANNOCK
BUHL
TWIN FALLS
TWIN FALLS
FIGURE 8

TABLE 8
ENVIRONMENTAL IONIZING RADIATION MEASUREMENTS
FOR THE NAVAL REACTORS FACILITY, CY 1997
(Millirem)

	NRF Onsite Readings (91 day quarterly period)				LMITCO Readings of NRF Site (6 month period)				NRF Readings of INEEL Background Remote from NRF (91 day quarterly period)				ESRF Readings from Distant Communities[3] (6 month period)			
Quarter	Number of Measurements	Mean[1]	Max	Min	Number of Measurements	Mean[2]	Max	Min	Number of Measurements	Mean[1]	Max	Min	Number of Measurements	Mean[2]	Max	Min
1st	25	35 ± 4	42	30	11	73 ± 5	79	69	15	33 ± 3	35	31	4	60 ± 4	62	57
2nd	25	39 ± 4	56	34					15	38 ± 4	40	35				
3rd	25	37 ± 4	53	31	11	72 ± 7	80	68	15	36 ± 4	38	34	4	59 ± 5	63	57
4th	25	36 ± 4	49	33					15	36 ± 4	38	33				

(1) The uncertainties given in the "mean" column represent a 90% accuracy.

(2) The uncertainties given in the "mean" column represent a 95% accuracy.

(3) The distant communities monitored by ESRF in Idaho included Blackfoot, Craters of the Moon, Idaho Falls, and Rexburg.

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

ASSESSMENT OF RADIATION DOSE-TO-MAN

Environmental monitoring results from 1997 did not reveal any measurable increase in the naturally occurring radioactivity levels in the environment from NRF operations. Radiation exposure to the general public from NRF airborne emissions was too low to measure and could only be determined with conservative calculational models based on the effluent radioactivity 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.

The dose for each exposure pathway was explicitly calculated for each radionuclide and applicable daughter products. The effective dose equivalent for airborne pathways was calculated using the EPA approved CAP-88 computer program described in Reference 6. The airborne pathway calculations used 1997 wind speed and direction data collected by the National Oceanic and Atmospheric Administration (NOAA) at NRF and average meteorological data measured by the INEEL meteorological observation network. 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.

The maximum effective dose equivalent which a member of the public could have hypothetically received due to NRF operations in 1997 as shown in Table 9 was 0.00056 millirem. The maximum potential dose of 0.00056 millirem per year is substantially below the radiation exposure limits of 100 millirem per year established by the Nuclear Regulatory Commission and the Department of Energy. Further, it is negligible when compared to the naturally occurring background radiation dose of approximately 360 millirem per year calculated in the surrounding communities and on the INEEL (Reference 1) and much less than the 1-2 millirem which an individual would receive from a single cross-country airplane flight. Operations at NRF did not result in any measurable radiation exposure to the general public.

TABLE 9
SUMMARY OF CALCULATED RADIATION DOSE-TO-MAN FROM NRF OPERATIONS, CY 1997

Estimated Dose to an Individual at the Residence Receiving the Highest Dose, millirem/year[1]	
Potential Exposure Pathways	**Effective Dose Equivalent[2]**
1. Liquid	None[3]
2. Airborne	
a. Immersion in air	1.14×10^{-10}
b. Ingestion	5.48×10^{-4}
c. Inhalation	8.97×10^{-6}
d. Ground surface	7.55×10^{-4}
Total airborne pathways (EPA limit is 10 millirem/year)[4]	5.58×10^{-4}
3. Direct exposure	None[5]
4. Total of all pathways (DOE limit is 100 millirem/year)[6] (NRC limit is 100 millirem/year)[7]	5.58×10^{-4}

(1) The dose for the airborne pathways was calculated using the EPA approved CAP-88 computer model (Reference 6). Gross beta radioactivity was conservatively modeled as strontium-90 with yttrium-90 progeny. Gross alpha radioactivity was conservatively modeled as plutonium-239.

(2) Effective dose equivalent means the sum of the products of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its distribution in the body of reference man. The unit for the effective dose equivalent is the millirem. For purposes of this report, doses caused by naturally occurring radon-222 and its respective decay products are not included.

(3) NRF did not discharge any radioactivity from current operations to liquid effluent streams.

(4) As per Reference 7.

(5) 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.

(6) As per Reference 8.

(7) As per Reference 9.

CONTROL OF CHEMICAL AND HAZARDOUS WASTES

ORIGIN

During 1997, the necessary use of hazardous materials at NRF resulted in the generation of some chemical and hazardous wastes. These wastes included photographic solutions, solutions containing heavy metals, organic solvents, paint related wastes, laboratory wastes, waste oils and wastes generated from prototype training activities.

CONTROL PROGRAMS

All hazardous wastes generated at NRF were managed in accordance with the Federal Resource Conservation and Recovery Act (RCRA) and the environmental regulations set forth by the State of Idaho. Non-hazardous chemical wastes were managed in accordance with applicable federal and state regulations.

The control programs assisted in the minimization of the quantity of routine waste material generated, assured safe usage and storage of the materials onsite and provided for proper offsite disposal of wastes by vendors permitted by state and/or federal agencies.

A principal component of the overall control program was the review of purchase orders prior to the acquisition of chemicals at NRF. Purchase orders were reviewed to determine that the procurement of a hazardous material was necessary, to assure excessive quantities were not ordered and to determine if a suitable nonhazardous substitute was available. NRF also utilized a chemical exchange program which allowed groups onsite to exchange rather than purchase additional hazardous materials.

In 1992, a Chemical Management Program was developed, and a major revision to NRF's Waste Minimization/Pollution Prevention Program was completed. These programs provide additional controls for the use of hazardous materials and further reduce the generation of hazardous waste. The Chemical Management Program was designed to track and control the volume and use of hazardous material. This program additionally strengthens the control over procurement of hazardous materials. NRF's Waste Minimization/Pollution Prevention Program provides a formal system to report amounts of waste generated, identifies waste streams to be reduced or eliminated, establishes waste minimization goals for generators, and provides for the issuance of progress reports on waste minimization efforts.

Appropriate training was provided to site personnel who handle hazardous materials to ensure they were knowledgeable of safe handling techniques, emergency response procedures and the use of Material Safety Data Sheets. Personnel were also provided training on workers' Hazard Communication or Right-to-Know Standard as required under the Occupational Safety and Health Act.

Waste generated from the use of hazardous materials was accumulated and stored in approved areas. Hazardous waste was managed in accordance with federal and state hazardous waste regulations. Hazardous waste accumulation and storage areas were inspected routinely to verify that hazardous wastes were properly stored and controlled in accordance with approved work procedures and regulatory requirements.

MANAGEMENT AND DISPOSAL PROGRAMS

No hazardous wastes were disposed of at the NRF Site during 1997. Approximately 16,202 pounds of solid hazardous waste and 3,272 gallons of liquid hazardous waste, mostly associated with remediation activities, were transported by contractors to EPA approved Treatment/Storage/Disposal (TSD) facilities. The transportation vendors and the TSD facilities operate under approvals or permits granted by state and federal regulatory agencies.

NRF determines treatment and disposal methods in accordance with federal land disposal restrictions that reduce long term liabilities and endangerment to the public and the environment. When appropriate, wastes are recycled, burned for energy recovery purposes (e.g., waste oil), or neutralized prior to disposal.

All hazardous waste generated at NRF in 1997 was directly shipped to offsite TSD facilities thus by-passing interim storage at the INEEL. This approach to waste management resulted in reduced costs associated with handling and transport of waste.

In 1997, personnel at NRF collected approximately 2,755 pounds of aluminum beverage containers for recycling. Approximately 10,487 pounds of cardboard material were also recycled at NRF.

Waste oil collected at NRF and shipped offsite to be burned for energy recovery amounted to 1,700 gallons.

Scrap metal, totaling an estimated 144 tons from NRF, was sold to a recycle subcontractor for $8,350. Approximately 1,075 cubic yards of scrap wood were also sent from NRF to the INEEL Central Facilities Area (CFA) landfill to be chipped and reused for mulch.

The use of elementary neutralization in the processing of corrosive wastewater has further reduced the volume of hazardous waste for disposal. Approximately 605,000 gallons of ion exchange resin regeneration solution were processed to a nonhazardous form in 1997. During 1997, a new reverse osmosis water purification system was installed, eliminating the need for ion exchange resin and the resulting hazardous regeneration solution.

In 1997, all nonhazardous solid wastes were transported to the INEEL landfills at the CFA.

CONTROL OF RADIOACTIVE WASTE MATERIALS

ORIGIN

Operations at NRF during 1997 resulted in the generation of various types of low-level radioactive waste material. This material ranged from irradiated metal to paper and plastic products.

CONTROL PROGRAM

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.

To facilitate the most effective means for disposal, radioactive waste was segregated into several categories: compactible, non-compactible, incinerable, and size-reducible. Where practicable, radioactive liquids were processed for reuse. Radioactive waste shipments were made in accordance with all applicable DOE and Department of Transportation (DOT) requirements.

DISPOSAL

All solid radioactive waste from NRF was shipped to either the Radioactive Waste Management Complex (RWMC) as non-compactible waste, or to the Waste Experimental Reduction Facility (WERF) for compaction, incineration, or size-reduction. After processing, WERF sends the final waste form to the RWMC for disposal. During 1997, approximately 27,660 cubic feet of solid radioactive waste containing 11,728 curies of radioactivity were shipped from NRF to these two radioactive material disposal facilities.

CONTROL OF MIXED WASTES

ORIGIN

A mixed waste is a waste that is both chemically hazardous and radioactive. Operations at the NRF Site resulted in the generation of a small quantity of mixed wastes. These wastes included water and oil with heavy metals, paint chips, radioactive lead, and solid heavy metal bearing debris.

CONTROL PROGRAM

All mixed wastes were managed in accordance with the State of Idaho hazardous waste regulations and the NRF Mixed Waste Management Plan which was concurred with by the Idaho Division of Environmental Quality (DEQ).

Since mixed wastes are chemically hazardous and radioactive, the controls for hazardous wastes were applied to the hazardous constituents and the controls for radioactive wastes were applied to the radioactive constituents of the mixed wastes at the point of generation.

The volume of mixed waste generated at NRF is minimized by work specific training programs, review of detailed work instructions to remove hazardous chemicals where appropriate, re-engineering work to avoid generation of mixed waste, and volume reduction programs.

DISPOSAL

Mixed wastes were not disposed of on the NRF Site. Mixed wastes were stored at NRF for less than 90 days and shipped to the INEEL Mixed Waste Storage Facility for temporary storage pending treatment and disposal facility availability. Approximately 710 cubic feet of mixed waste was generated by NRF and subsequently transferred to the INEEL Mixed Waste Storage Facility in 1997. The INEEL Site Treatment Plan, which is implemented by a Consent Order signed by DOE and the Idaho DEQ, specifies the treatment and disposal methods for all NRF mixed wastes.

NRF is also reducing the amount of mixed waste for disposal by recycling heavy metal bearing equipment (HMBE) through a Navy contract with GTS-Duratech. Shipping casks and other obsolete components containing lead shielding have been sent to GTS-Duratech in Tennessee for dismantling, meltdown and recycling into shipping containers for radioactive material and shield blocks. In 1997 NRF shipped a total of 126,170 pounds of HMBE for recycling.

ENVIRONMENTAL MONITORING QUALITY ASSURANCE

The NRF environmental monitoring program has an extensive quality assurance program plan which provides a detailed outline for data quality objectives, program organization, data and sample management, analytical procedures, program training and safety, audits, and data validation.

NRF also participates in the quality assurance programs of other government agencies which NRF uses to analyze samples. These programs were designed to test and demonstrate the consistency, continued precision and accuracy of laboratory techniques and analytical results in relation to samples submitted by NRF. The data generated by these agencies are forwarded to NRF in support of the drinking water and groundwater monitoring programs.

As prescribed by specific analytical methodology, subcontracted analytical laboratories demonstrated the precision and accuracy of the nonradiological and radiological analyses by properly analyzing quality control samples. NRF submitted a total of 428 quality assurance samples consisting of matrix spikes, duplicate samples, trip blanks, and field blanks. The vendor laboratories were not aware which samples were being used for quality control purposes. During 1997, all offsite subcontractor laboratories demonstrated satisfactory performance in sample quality control.

• Nonradiological: To demonstrate adequate control of the field sampling techniques during liquid effluent, drinking water, and groundwater sampling, trip blanks, field blanks, and field duplicates were collected and submitted for analysis. The results demonstrated satisfactory performance of field sampling techniques.

In addition, individual quality assurance programs practiced by subcontractor laboratories were reviewed and evaluated by chemists at NRF to ensure minimum standards were met per Reference 10.

• Radiological: To ensure and verify the quality of radiological data, drinking water and groundwater samples submitted for analysis were subjected to quality assurance programs established by Quanterra Environmental Services, Inc. and the United States Geological Survey Laboratory, respectively. The programs consisted of the following key elements:

- personnel training and qualification
- detailed analytical procedures
- calibration of instrumentation
- participation in an intercomparison program
- use of blind controls
- participation in analysis of calibration standards

The NRF Chemistry Laboratory performs radiological measurements of soil, vegetation, water, sediment, and air samples at NRF. This Laboratory participates in the EPA Performance Evaluation Studies Program and the DOE Environmental Measurements Laboratory Quality Assessment Program. Results of these interlaboratory cross check programs are presented in Appendices D and E, respectively.

Each quality assurance program for offsite subcontracted laboratories was thoroughly reviewed and approved by NRF. These quality assurance programs, in conjunction with existing NRF analytical quality assurance practices, provided for the validation of data to ensure accuracy in the radiological environmental monitoring program.

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REFERENCES

(1) The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1996, DOE/ID-12082(95), August 1997.

(2) Title 1, Chapter 8, Idaho Regulations for Public Drinking Water Systems.

(3) AP-42, Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, Section 1.3.

(4) IDAPA 16.01.01, Rules of Department of Health and Welfare, Title 1, Chapter 1, "Rules for the Control of Air Pollution in Idaho."

(5) Code of Federal Regulations, Title 40 Part 50.

(6) Clean Air Act Assessment Package - 1988 (CAP-88) - A Dose and Risk Assessment Methodology for Radionuclide Emissions to Air, September 1989.

(7) Code of Federal Regulations, Title 40 Part 61, Subpart H.

(8) DOE Order 5400.5, Radiation Protection of the Public and Environment.

(9) Code of Federal Regulations, Title 10 Part 20, Section 1301.

(10) U.S. Environmental Protection Agency, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW 846, current edition.

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APPENDIX A
LIQUID EFFLUENT ORGANIC ANALYTES

VOLATILE ORGANIC COMPOUNDS	SEMIVOLATILE ORGANIC COMPOUNDS
Benzene	Alachlor
Bromobenzene	Aldrin
Bromodichloromethane	Atrazine
Bromoform	Benzo[a]pyrene
Bromomethane	Butachlor
Carbontetrachloride	Chlordane
Chlorobenzene	2,4-D
Chlorodibromomethane	Dalapon
Chloroethane	Dicamba
Chloroform	Dieldrin
Chloromethane	Di[2-Ethylhexyl]adipate
o-Chlorotoluene	Di[2-Ethylhexyl]phthalate
p-Chlorotoluene	Dinoseb
m-Dichlorobenzene	Endrin
o-Dichlorobenzene	Heptachlor
p-Dichlorobenzene	Heptachlor epoxide
1,1-Dichloroethane	Hexachlorobenzene
1,2-Dichloroethane	Hexachlorocyclopentadiene
1,1-Dichloroethene	Lindane
cis-1,2-Dichloroethene	Methoxychlor
trans-1,2 Dichloroethene	Metolachlor
Dichloromethane	Metribuzin
1,2-Dichloropropane	PCB's
1,3-Dichloropropane	Pentachlorophenol
2,2-Dichloropropane	Picloram
1,1-Dichloropropene	Propachlor
cis-1,3-Dichloropropene	Simazine
trans-1,3-Dichloropropene	Toxaphene
Ethylbenzene	2,4,5-TP (Silvex)
Styrene	
1,1,1,2-Tetrachloroethane	
1,1,2,2-Tetrachloroethane	
Tetrachloroethene	
Toluene	
1,2,4-Trichlorobenzene	
1,1,1-Trichloroethane	
1,1,2-Trichloroethane	
Trichloroethene	
1,2,3-Trichloropropane	
Vinyl chloride	
Xylenes (total)	

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APPENDIX B
NRF DRINKING WATER SYSTEM VOLATILE ORGANIC COMPOUND (VOC) ANALYTES

REGULATED VOCs[1]	Maximum Allowable Contaminant Level (mg/L)[2]	UNREGULATED VOCs[3]
Benzene	0.005	Bromobenzene
Carbon tetrachloride	0.005	Bromodichloromethane
Chlorobenzene	0.1	Bromoform
o-Dichlorobenzene	0.6	Bromomethane
p-Dichlorobenzene	0.075	Chlorodibromomethane
1,2-Dichloroethane	0.005	Chloroethane
1,1-Dichloroethene	0.007	Chloroform
cis-1,2-Dichloroethene	0.07	Chloromethane
trans-1,2 Dichloroethene	0.1	o-Chlorotoluene
Dichloromethane	0.005	p-Chlorotoluene
1,2-Dichloropropane	0.005	m-Dichlorobenzene
Ethylbenzene	0.7	1,1-Dichloroethane
Styrene	0.1	1,3-Dichloropropane
Tetrachloroethene	0.005	2,2-Dichloropropane
Toluene	1	1,1-Dichloropropene
1,2,4-Trichlorobenzene	0.07	cis-1,3-Dichloropropene
1,1,1-Trichloroethane	0.2	trans-1,3-Dichloropropene
1,1,2-Trichloroethane	0.005	1,1,1,2-Tetrachloroethane
Trichloroethene	0.005	1,1,2,2-Tetrachloroethane
Vinyl chloride	0.002	1,2,3-Trichloropropane
Xylenes (total)	10	

(1) Regulated VOCs are organic compounds for which a maximum allowable contaminant level has been established under the State of Idaho and Federal Drinking Water Regulations.

(2) Per 40 CFR 141.61, Subpart G.

(3) Unregulated VOCs are organic compounds which must be analyzed, but have no associated maximum allowable contaminant level under the State of Idaho and Federal Drinking Water Regulations.

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APPENDIX C
NRF DRINKING WATER SYSTEM INORGANIC ANALYTES AND WATER QUALITY PARAMETERS

ANALYTE/PARAMETER ANNUAL SAMPLES	Maximum Allowable Contaminant Level (mg/L)[1]
Chloride	250
Nitrogen measured as Nitrate	10
Nitrogen measured as Nitrite	1
Nitrogen (total Kjeldahl)	(2)
pH	6.5 to 8.5 pH units
Phosphorus (total)	(2)
Specific Conductance	(2)
Sulfate	250
Total Dissolved Solids	500
Total Suspended Solids	(2)
TRIENNIAL SAMPLES TAKEN IN 1997	**Maximum Allowable Contaminant Level (mg/L)[1]**
Aluminum	0.2
Antimony	0.006
Arsenic	0.05
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium (total)	0.1
Copper	1.3
Cyanide (free)	0.2
Fluoride	4.0
Iron (total)	0.3
Lead	0.015
Manganese	0.05
Mercury	0.002
Nickel	0.1
Selenium	0.05
Silver	0.1
Sodium	(2)
Thallium	0.002
Zinc	5

(1) Maximum allowable contaminant level per primary and secondary drinking water standards (40 CFR 141 or 40 CFR 143).

(2) No maximum allowable contaminant level under the State of Idaho and Federal Drinking Water Regulations.

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APPENDIX D
1997 USEPA Performance Evaluation Studies Program Results for NRF Chemistry Laboratory

DATE	MEDIUM	ATTRIBUTE[1]	UNITS	REPORTED VALUE[2]	KNOWN VALUE	ND (Xσ)[3]	NOTE
Jun97	water	Co-60	pCi/liter	21.33	18.0 ± 5.0	1.15	
		Zn-65		95.67	100.0 ± 10.0	-0.75	
		Cs-134		18.67	22.0 ± 5.0	-1.15	
		Cs-137		47.33	49.0 ± 5.0	-0.58	
		Ba-133		23.00	25.0 ± 5.0	-0.69	
Nov97	water	Co-60	pCi/liter	27.40	27.0 ± 5.0	0.14	
		Zn-65		75.00	75.0 ± 8.0	0.00	
		Cs-134		6.67	10.0 ± 5.0	-1.15	
		Cs-137		69.10	74.0 ± 5.0	-1.70	
		Ba-133		90.40	99.0 ± 10.0	-1.49	

(1) Quantitative gamma analysis unless otherwise stated.

(2) Reported value is the average of a triplicate set.

(3) Normalized deviation (ND) from the known as described in EPA-600/7-77-068 dated August, 1977. Values -3 > ND > +3 require corrective action.

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APPENDIX E

1997 USDOE Environmental Measurements Laboratory Quality Assessment Program Results for NRF Chemistry Laboratory

DATE	MEDIUM	ATTRIBUTE[1]	UNITS	REPORTED VALUE	KNOWN VALUE	RATIO (Reported/Known)	ACCEPTABLE RANGE[2]
97 03	soil	K-40	Bq/kg	364 ± 73	334.25	1.09	0.73 - 1.67
		Cs-137		900 ± 180	825.5	1.09	0.80 - 1.34
97 09	soil	K-40	Bq/kg	346 ± 69	315	1.09	0.73 - 1.67
		Cs-137		862 ± 172	810	1.06	0.80 - 1.34
97 03	vegetation	K-40	Bq/kg	891 ± 178	811.5	1.10	0.79 - 1.50
		Co-60		15.2 ± 3.0	12.5	1.22	0.62 - 1.42
		Cs-137		224 ± 45	189.25	1.18	0.80 - 1.45
97 09	vegetation	K-40	Bq/kg	1177 ± 235	1130	1.04	0.79 - 1.50
		Co-60		33.4 ± 6.7	32.4	1.03	0.62 - 1.42
		Cs-137		673 ± 135	624	1.07	0.80 - 1.45

(1) Quantitative gamma analysis.

(2) Values outside of acceptable range require corrective action.

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