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**Annual Report—1993
Environmental Surveillance for
EG&G Idaho Waste Management Facilities at the
Idaho National Engineering Laboratory**

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ABSTRACT

This report describes calendar year 1993 environmental surveillance activities of Environmental Monitoring of EG&G Idaho, Inc., performed at EG&G Idaho-operated Waste Management facilities at the Idaho National Engineering Laboratory (INEL). The major facilities monitored include the Radioactive Waste Management Complex, the Waste Experimental Reduction Facility, the Mixed Waste Storage Facility, and two surplus facilities. Included are results of the sampling performed by the Radiological and Environmental Sciences Laboratory and the United States Geological Survey. The primary purposes of monitoring are to evaluate environmental conditions, to provide and interpret data, to ensure compliance with applicable regulations or standards, and to ensure protection of human health and the environment. This report compares 1993 environmental surveillance data with U. S. Department of Energy derived concentration guides and with data from previous years.

SUMMARY

This report describes the calendar year 1993 Radiological Environmental Surveillance Program (RESP) activities of the Environmental Monitoring Program of EG&G Idaho, Inc., performed at EG&G Idaho-operated Waste Management facilities at the Department of Energy (DOE), Idaho National Engineering Laboratory (INEL). Results are presented for the 1993 air, water, soil, biotic, and ambient radiation monitoring activities performed at the Radioactive Waste Management Complex (RWMC), the Waste Experimental Reduction Facility (WERF), the Mixed Waste Storage Facility (MWSF), and the two contaminated surplus facilities which are the Stationary Low-Power Reactor No. 1 (SL-1) and the Organic-Moderated Reactor Experiment (OMRE). In addition, this report discusses current methods and monitoring programs of RESP along with subsurface water monitoring at RWMC by the United States Geological Survey (USGS).

In 1993, the concentrations of gross beta activity of airborne particulate material at the RWMC, WERF, and MWSF were below DOE derived concentration guides (DCGs) for airborne release to a public area. Gamma spectrometric analyses did not identify any gamma-emitting radionuclides above background in airborne particulates at the RWMC, WERF, or MWSF.

There were no statistically significant differences between concentrations of gross beta activity in airborne particulates at the RWMC and those measured at the control location (EBR-I), and the concentrations were consistent with historical values. All air samples collected during 1993 were submitted for alpha- and beta-emitting radionuclide analysis. Low-level concentrations of Am-241 were detected in the third quarter of the year; and low-level concentrations of Sr-90 were detected in the second and third quarters. The concentrations for these radionuclides were 0.01% and 0.006% of their DCGs, respectively, for airborne releases to the public. No airborne releases of alpha- and beta-emitting

radionuclides were detected during the fourth quarter.

Surface water run-off samples were collected during all four quarters of 1993. During the fourth quarter, a sample collected at TSA-1 of the Transuranic Storage Area contained Cs-137, which was the only gamma-emitting radionuclide detected in any of the RWMC surface water run-off samples. The concentration for this radionuclide was 0.06% of the appropriate DCG. Am-241 was detected at the TSA-2 location. This concentration represented 0.23% of the DCG in water.

Baseline soil samples were collected at the Stored Waste Examination Pilot Plant area during 1992, and the results have been included in this report. Due to circumstances beyond the control of the analytical laboratory, this data was not available in time for inclusion into the 1992 annual report. The results of the calendar year 1992 specific alpha- and beta-emitting radionuclide analysis indicated that Sr-90, Pu-239,-240, and Am-241 were detected in the soils. The detected concentrations were at or near the lower limit of detection. The Sr-90 concentration was less than 11% of the Environmental Concentration Guidelines (ECG) (see Appendix D for discussion on ECG and their use). The Pu-239,-240, and Am-241 concentrations were less than 1% of their respective ECGs.

During 1993, soil samples were collected from 11 locations near WERF. Only one gamma-emitting radionuclide, Cs-137, was detected in the WERF soil samples. This concentration is comparable to historical samples collected at WERF and is equal to the Cs-137 concentrations attributed to fallout, which is normally distributed in surface soils across the INEL.

In the routine vegetation samples (Russian thistle) collected at the RWMC, no gamma-emitting radionuclides were detected in any of the samples. Selected vegetation samples were also submitted for specific alpha- and beta-emitting

ting radionuclide analysis. These samples contained detectable concentrations of Sr-90 and Am-241 that exceeded the levels found in the control sample. However, these concentrations were below concentrations of previous years and were also within the range of results reported by DOE-Radiological and Environmental Surveillance Laboratory (RESL).

Crested wheatgrass was collected from five major areas of the RWMC, and sagebrush samples were collected at 11 sample locations at WERF in 1993. Results for gamma analysis of the RWMC crested wheatgrass samples showed concentrations less than or equal to background levels and at or near the lower limit of detection. Selected samples submitted for specific alpha- and beta-emitting radionuclides, contained detectable concentrations of Sr-90 that exceeded the levels found in the control sample. These detections were below concentrations reported in previous years from samples of crested wheatgrass collected at the RWMC. These concentrations were also within the range of results reported by RESL. For gamma analysis of the sagebrush collected at WERF, no man-made, gamma-emitting radionuclides that can be attributed to waste operations were detected above the lower limit of detection.

During 1993, deer mice and excavated soil samples were scheduled for collection. However, the recontouring efforts at the RWMC has brought about a diminishing population of deer mice. As a result, no samples were collected for either media because it was unlikely that a representative sample could be obtained. There have also been concerns raised about the Hantavirus and its possible connection to deer mice. As a result of these problems, a programmatic decision was made to temporarily discontinue small mammal sampling. The program will evaluate this situation annually.

Around the current waste disposal pit and at localized areas within the SDA, thermoluminescent

dosimeter (TLD) data showed exposures above background exposures; however, in the vicinity of the disposal pit, exposures have decreased in recent years due to additional soil cover. Surface radiation surveys showed radiation levels above background levels. The maximum six-month ionizing radiation exposure measured by TLDs at the RWMC have, in general, decreased over time since 1974. Analysis of the WERF TLD data from November 1982 to November 1993 shows that the six-month exposures measured immediately around the WERF waste storage area were higher than all other exposures measured at WERF. This difference is due to the proximity of the TLD monitoring location to the radioactive waste storage area at WERF.

Surface radiation was routinely monitored at RWMC and at both surplus facilities, SL-1, and OMRE. No areas at the RWMC showed a reading of greater than 1 mR/h at 0.9 m (3 ft). No areas with levels exceeding the SL-1 administrative control limit (20 mR/h gamma at contact with the soil surface) were identified at SL-1. No areas at the OMRE exceeded the administrative control limit (1 mR/h at contact).

The USGS wells at the RWMC are monitored regularly for selected volatile organic compounds, specific conductance, chloride, and sodium. No maximum contaminant levels were exceeded for volatile organic compounds and radiological analyses. No positive detections of gamma-emitting radionuclides were detected in any of the wells.

Tritium was detected in three of nine RWMC wells monitored by the USGS with a maximum concentration of 0.1% of the DCG. The source of this tritium is attributed to past disposals from waste water operations at the Idaho Chemical Processing Plant and the Test Reactor Area. The concentrations detected in 1993 were similar to results reported in previous years.

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ACRONYMS

ANL-W	Argonne National Laboratory-West	NRF	Naval Reactor Facility
ARA	Auxiliary Reactor Area	NRTS	National Reactor Testing Station
C&S	Certified and Segregated Waste Storage	OMRE	Organic-Moderated Reactor Experiment
CFA	Central Facilities Area		
CFR	Code of Federal Regulations	PBF	Power Burst Facility
CPP	Chemical Processing Plant	PM ₁₀	particulate matter $\leq 10\mu\text{m}$
CV	coefficient of variation		
DCG	derived concentration guide	QA	quality assurance
DOE	U.S. Department of Energy		
DOE-ID	U.S. Department of Energy Idaho Operations Office	RESL	Radiological and Environmental Sciences Laboratory
DQO	data quality objectives	RESP	Radiological Environmental Surveillance Program
DVS	Drum Vent System	RML	Radiation Measurements Laboratory
EBR-I	Experimental Breeder Reactor No. 1	RWMC	Radioactive Waste Management Complex
ECG	Environmental Concentration Guidelines		
EDE	effective dose equivalent	SDA	Subsurface Disposal Area
EFS	Experimental Field Station	SL-1	Stationary Low-Power Reactor No. 1
EOCR	Experimental Organic-Cooled Reactor	SPERT	Special Power Excursion Reactor Test
ESPDMS	Environmental Surveillance Program Data Management System	SRPA	Snake River Plain Aquifer
ESRP	Eastern Snake River Plain	SWEPP	Stored Waste Examination Pilot Plant
FAAT	Federal Aviation Administration Tower		
HV	high-volume	TAN	Test Area North
IDAPA	Idaho Administrative Procedures Act	TLD	thermoluminescent dosimeter
ILTSF	Intermediate-Level Transuranic Storage Facility	TRA	Test Reactor Area
INEL	Idaho National Engineering Laboratory	TRU	transuranic
		TSA	Transuranic Storage Area
		TSP	total suspended particulate
		USGS	United States Geological Survey
		VOC	volatile organic compound
LLW	low-level radioactive waste	VRM-1	vehicle-mounted roadway monitor-1
LV	low-volume		
MAR	Monitoring Activities Review	WERF	Waste Experimental Reduction Facility
MCL	maximum contaminant level		
MWSF	Mixed Waste Storage Facility	WIPP	Waste Isolation Pilot Plant

Annual Report—1993

Environmental Surveillance for EG&G Idaho Waste Management Facilities at the Idaho National Engineering Laboratory

INTRODUCTION

In 1949, the National Reactor Testing Station (NRTS) was established in southeastern Idaho by the U.S. Atomic Energy Commission as an area to build, test, and operate nuclear reactors; a fuel-processing plant; and support facilities with maximum safety and isolation. In 1974, the NRTS was redesignated as the Idaho National Engineering Laboratory (INEL) to reflect a broader scope of engineering and scientific activities. The INEL is owned by the Department of Energy (DOE), and EG&G Idaho, Inc., is the prime contractor.

The INEL, located on the Eastern Snake River Plain (ESRP) in southeastern Idaho, is 2300-km². All air masses entering the ESRP must first cross a mountain barrier, which precipitates a large percentage of the moisture contained in the air masses. The average precipitation is 22 cm with maximum levels occurring in winter and late spring and the region has semiarid characteristics. The local northeast-southwest orientation of the ESRP and the bordering mountain ranges tend to channel the prevailing west winds so that a southwest wind predominates over the INEL; the second-most frequent winds come from the northeast. The relatively dry air and infrequent low clouds permit intense solar heating of the surface during the day and rapid cooling at night. These factors combine to give a large diurnal range of temperatures near the ground. Because of the moderating influence of the Pacific Ocean, most of the air masses flowing over this area are usually warmer during winter and cooler in the summer than air masses flowing at a similar latitude in the more continental climate east of the Continental Divide. The

Centennial and Bitterroot Mountain ranges keep most of the shallow, but intensely cold winter air masses from entering the ESRP when they move southward from Canada. Occasionally, however, the cold air can spill over the mountains. When this happens, the cold air is then held in the ESRP by the surrounding mountains, and the INEL experiences low temperatures for periods lasting a week or longer. The annual average temperature is 5.6°C, with recorded extremes of -43.9 and 39.4°C.¹

Subsurface geology at the INEL consists of successive layers of basalt and sedimentary strata, overlaid at the surface by wind- and water-deposited sediments. The primary groundwater source of the region is the Eastern Snake River Plain Aquifer (SRPA). Most of the INEL is located in the Mud Lake-Lost River Basin (Pioneer Basin), which is a closed drainage basin. Surface water within the Pioneer Basin includes that from the Big Lost River, the Little Lost River, and Birch Creek, all of which drain mountain watersheds located to the north and northwest of the INEL. Local rainfall and snowmelt contribute to surface water, mainly during the spring months. In very high-flow years, Birch Creek flows into the Birch Creek Playa on the north end of the INEL. The portion that is not lost to evapotranspiration infiltrates into the subsurface. The Little Lost River flows onsite during high-flow years and a portion infiltrates into the subsurface. Both aquifer and surface waters are used for irrigation outside the INEL. The SRPA is used as a drinking water source both on and off the INEL.

INEL soils are derived from silicic volcanic and Paleozoic rocks from nearby mountains and buttes and are underlain by basalt. Soils in the southern part of the INEL are gravelly to rocky and generally shallow. In general, most of the INEL soils have formed as a result of alluvial or aeolian deposition over basaltic lava flows. Basalt outcrops are common.

The INEL lies within an area designated as a "sagebrush ecosystem." This broad ecosystem occupies vast plains and plateaus derived from lava flows, ancient lake beds, and broad basins of alluvium. It is characterized by shrubs with an understory of perennial grasses and herbs. The flora in areas surrounding the Waste Management areas of EG&G Idaho are typical of those found elsewhere on the INEL.² The dominant and most conspicuous plant on the INEL is sagebrush, which covers approximately 80% of the area (113,664 ha). Crested wheatgrass seedings also exist throughout the INEL and have existed for 25 or more years, with little evidence of re-invasion by native species. Limited dispersal from the native community and abundant seed production by crested wheatgrass perpetuate this community. Crested wheatgrass plantings support a lower density of birds, mammals, and reptiles than do areas dominated by sagebrush.^{3,4}

Thirty-nine species of mammals are found on the INEL, 18 of which are rodents. The Townsend's ground squirrel, least chipmunk, Great Basin pocket mouse, Ord's kangaroo rat, and montane vole are the most common small mammals on the Site. These rodents are relatively common throughout sagebrush regions of the intermountain west. Game species such as sage grouse and antelope are frequently seen in these areas.

The Radiological Environmental Surveillance Program (RESP) provides monitoring data for all EG&G Idaho Waste Management facilities. The DOE Radiological and Environmental Sciences Laboratory (RESL) performed routine monitoring outside the Radioactive Waste Management

Complex (RWMC) and around other operational facilities on the INEL site during 1993. The RESP activities are structured to support the DOE Idaho Operations Office (DOE-ID) in maintaining an integrated INEL environmental monitoring program. The National Oceanic and Atmospheric Administration cooperates with DOE-RESL on a meteorology monitoring network.

RESP, conducted by the Environmental Monitoring Program, has the following general objectives: (a) provide indications of confinement integrity at EG&G Idaho radioactive waste storage and disposal facilities, (b) ensure compliance with applicable requirements regarding environmental surveillance of radioactivity at DOE Waste Management facilities, (c) identify trends in concentrations of radioactivity in environmental media near EG&G Idaho Waste Management facilities, (d) make monitoring data available to other programs conducting activities such as performance assessment, pathways analysis, and dose estimation, and (e) collect data in support of special studies designed to enhance RESP technical capabilities.

These stated program objectives are to be interpreted as including the program objectives identified in DOE Order 5400.1, Chapter IV; and DOE Order 5820.2A, Chapter II; for environmental surveillance of DOE Waste Management facilities.^{5, 6}

Overview of Monitoring Activities

Radiological Environmental Surveillance of Waste Management Facilities

A comprehensive radiological monitoring program is conducted at EG&G Idaho Waste Management facilities. This program includes routine and special studies of radioactive materials in air, water, soil, and biota (vegetation and small mammals), and monitoring of ambient radiation (see Table 1).

Table 1. Radiological Environmental Surveillance Program activities performed at Waste Management facilities.

Facility	Sample type/measurement	Description	Frequency of analysis	Type of analysis
RWMC				
SDA	Air			
	• PM ₁₀ ^a	8 air monitors operated at 0.11 m ³ /min (includes 1 control and 1 replicate)	Semimonthly Semimonthly Monthly Quarterly	Gross alpha Gross beta Gamma spectrometry Radiochemistry ^a
	• Total suspended particulate	1 air monitor operated at 0.14 m ³ /min	Semimonthly Semimonthly Monthly Quarterly	Gross alpha Gross beta Gamma spectrometry Radiochemistry ^a
	Surface Water	One 4-L sample from SDA and control location	Quarterly, but depends on precipitation	Gross alpha Gross beta Gamma spectrometry Radiochemistry ^{b,c,d}
	Subsurface Water (sampled by the USGS)	2-L samples from each of 6 wells	65-m well annually, 183-m wells quarterly, Production well monthly	Gamma spectrometry H-3, Sr-90, Pu-238 Pu-239, -240, Am-241 Specific conductance Chloride, sodium, nitrate
	Direct Radiation			
	• Surface gamma activity	Truck-mounted VRM-1 detector system	Semiannually	External radiation levels
	• Ionizing Radiation (conducted by RESL and EG&G Idaho)	15 TLD packets (RESL), 4 TLD packets (EG&G Idaho) and 7 background communities (RESL)	Semiannually	External radiation levels
	Small Mammal	3 composites in each of 5 major areas (plus 1 control area) ^d	Annually, but species sampled varies each year depending on availability	Gamma spectrometry Radiochemistry ^b

Table 1. (continued).

Facility	Sample type/measurement	Description	Frequency of analysis	Type of analysis
SWEPP	Soil	5 surface locations in each of 5 major areas (plus 1 control area)	Triennially	Gamma spectrometry Radiochemistry ^b
	Vegetation	3 composites in each of 5 major areas (plus 1 control area) ^d	Annually, but species sampled varies each year as determined by availability	Gamma spectrometry Radiochemistry ^b
	Visual Inspection	Tour SDA and TSA	Monthly	Results reported for any required corrective action
	Air			
	• PM ₁₀ ^a	5 air monitors operated at 0.11 m ³ /min	Semimonthly Semimonthly Monthly Quarterly	Gross alpha Gross beta Gamma spectrometry Radiochemistry ^b
	• Total suspended particulate	2 air monitors operated at 0.14 m ³ /min	Semimonthly Semimonthly Monthly Quarterly	Gross alpha Gross beta Gamma spectrometry Radiochemistry ^b
	Surface Water	One 4-L sample from TSA-1, TSA-2, TSA-3, TSA-4, and control locations	Quarterly, but depends on precipitation	Gross alpha Gross beta Gamma spectrometry Radiochemistry ^a
	Soil	9 locations sampled (plus 2 control areas)	Triennially	Gamma spectrometry Radiochemistry ^b
	Direct Radiation			
	• Surface gamma activity	Truck-mounted VRM-1 detector system	Semiannually	External radiation levels
	• Ionizing radiation (conducted by RESL and EG&G Idaho)	9 TLD packets (RESL), 3 TLD packets (EG&G Idaho) and 7 background communities (RESL)	Semiannually	External radiation levels

Table 1. (continued).

Facility	Sample type/measurement	Description	Frequency of analysis	Type of analysis
WERF	Air			
	• PM ₁₀ ^a	3 air monitors operated at 0.11 m ³ /min (includes 1 control)	Semimonthly Semimonthly Monthly	Gross alpha Gross beta Gamma spectrometry
	• Total Suspended Particulate	1 air monitor operated at 0.14 m ³ /min	Semimonthly Semimonthly Monthly	Gross alpha Gross beta Gamma spectrometry
	Direct Radiation			
	• Ionizing radiation conducted by RESL and EG&G Idaho	11 TLD packets (EG&G Idaho) and 7 background communities (RESL)	Semiannually	External radiation levels
	Soil	15 surface locations	Triennially ^e	Gamma spectrometry ^e
MWSF	Vegetation	15 locations (includes 3 controls)	Triennially	Gamma spectrometry
	Air			
	• PM ₁₀ ^a	1 air monitor operated at 0.11 m ³ /min	Semimonthly Semimonthly Monthly	Gross alpha Gross beta Gamma spectrometry
SL-1	Direct Radiation			
	• Surface gamma activity	Hand-held HHD-440	Semiannually	External radiation levels
	Visual Inspection	Tour SL-1	Semiannually	Results reported for any required corrective action

Table 1. (continued).

Facility	Sample type/measurement	Description	Frequency of analysis	Type of analysis
OMRE	Direct Radiation			
	• Surface gamma activity	Truck-mounted VRM-1 detector system	Annually	External radiation levels
	Visual Inspection	Tour OMRE	Annually	Results reported for any required corrective action

-
- a. PM₁₀ air monitoring started in July 1992.
- b. Analysis for Am-241, Pu-238, Pu-239,-240, U-235, U-238, and Sr-90.
- c. Samples for radiochemical analyses usually taken during second quarter only.
- d. Exact number of samples may vary, due to availability.
- e. Sampling frequency may vary if air radioactivity levels increase.
-

The Waste Management facilities monitored by RESP at the INEL (see Figure 1) include: the RWMC, the Waste Experimental Reduction Facility (WERF), the Stored Waste Examination Pilot Plant (SWEPP), the Stationary Low-Power Reactor No. 1 (SL-1) surplus area, the Organic-Moderated Reactor Experiment (OMRE) area, and the Mixed Waste Storage Facility (MWSF).

The RWMC is used to dispose of low-level radioactive waste (LLW) and to store transuranic (TRU) waste received from other DOE sites. Other Waste Management activities conducted at the WERF, MWSF, and SWEPP include waste reduction; incineration; and storage of mixed waste, TRU waste certification and processing, research, and technology development.

Airborne transport is the most likely near-term pathway for radionuclide migration from the active RWMC and WERF facilities. Consequently, more extensive air monitoring is conducted at these facilities to detect airborne transport of radionuclides.

Surface water run-off sampling is conducted quarterly at the RWMC if sufficient water is available. These samples are analyzed to determine radionuclide concentrations in run-off water and to determine if radionuclide transport from the area is possible during run-off conditions. Generally, run-off water does not flow from the RWMC except during or after heavy rainfalls or snowmelt.

RESP is responsible for routine soil surveillance at the WERF and RWMC. A preliminary assessment of surface soils was conducted at all EG&G Idaho facilities during 1989. RESL is responsible for conducting periodic soil monitoring outside the WERF and RWMC. The purposes of soil sampling and analyses are to determine if RWMC and WERF operations contribute to soil contamination and to determine long-term

trends. Surface soils at the RWMC demonstrate radionuclide levels slightly above background due to past transportation and handling of radioactive wastes, from past flooding,⁷ or by migration from buried waste. Surface soils at WERF could possibly become contaminated by deposition of radionuclides in airborne effluents or as a result of radioactive waste handling.

Biota can affect the integrity of buried contaminated waste by penetrating the soil and allowing water to reach the waste or by transporting radionuclides to the surface. Therefore, routine sampling of small mammals and vegetation is also conducted by RESP to detect potential biological radionuclide transport. Vegetation sampling is conducted at WERF and RWMC. Small mammal sampling and sampling of soil excavated by burrowing animals are conducted only at the RWMC.

Thermoluminescent dosimeters (TLDs) are used to measure cumulative exposures to ambient ionizing radiation at the RWMC and WERF. The TLDs are used to detect increases in ambient exposures attributable to handling, processing, or disposing of radioactive waste. In addition, a surface radiation survey is conducted at the RWMC every six months to monitor all areas within the facility boundary.

The SL-1 surplus area, located near the SL-1 reactor site, contains buried contaminated building remnants in one pit and two trenches. The OMRE area includes a leach pond and an area formerly occupied by a reactor facility, which has been decontaminated and decommissioned. Both SL-1 and OMRE are nonoperational surplus facilities and require less surveillance than the RWMC, WERF, and MWSF. Table 1 summarizes the monitoring activities conducted at the RWMC, WERF, MWSF, SL-1, and OMRE during 1993.

Selected Facilities at the Idaho National Engineering Laboratory

MWSF	Mixed Waste Storage Facility	RWMC	Radioactive Waste Management Complex
OMRE	Organic Moderated Reactor Experiment (inactive)	SL-1	Stationary Low Power Reactor No.1 Burial Ground
PBF	Power Burst Facility	SWEPP	Stored Waste Examination Pilot Plant
		WERF	Waste Experimental Reduction Facility

▲ Towns
 ■ Facilities
 — INEL Boundary

0 2 4 6 8 MILES
 0 4 8 12 KILOMETERS

B93 0158

Figure 1. Idaho National Engineering Laboratory location map.

The INEL Project Office of the United States Geological Survey (USGS) monitors groundwater in the SRPA, which is approximately 177 m beneath the RWMC. This monitoring helps determine whether radionuclides and hazardous constituents have migrated from the waste to the groundwater. Water samples are collected quarterly from eight aquifer wells and one perched-water well located in and adjacent to the RWMC Subsurface Disposal Area (SDA). These samples are analyzed for radiological and nonradiological parameters.

Data Management

The Environmental Surveillance Program Data Management System (ESPDMS) has been developed for radiological monitoring activities at EG&G Idaho Waste Management facilities. The purposes of the ESPDMS are to maintain databases (air, water, soil, biota, and TLD), store and sort data, provide a method of tracking trends in monitoring data, and help generate various monitoring reports.

Quality Assurance

The Quality Assurance (QA) Program is integrated into all of the measurement programs described above. The QA Program has been developed to ensure that the sampling methods provide representative samples, to confirm that laboratory analyses are reliable, and to verify that the quality of reported results are adequate. Sampling and analysis protocols have been documented in detailed procedures for the collection, analysis, and reporting of results. A description of the QA Program is found in the *Quality Program Plan for Environmental Monitoring*.⁸ Detailed QA information on the RESP such as data quality objectives and QA objectives can be found in the RESP Program Plan. (See Appendix A for QA objectives.)

Monitoring Activities Review

Changes in the existing program are made as a result of a Monitoring Activities Review (MAR).

The MAR process involves a technical review by a group of technical experts from the INEL and outside the INEL. The program is reviewed against current regulatory requirements and guidance, recent innovations in methods and equipment, data trends, and data deficiencies. One consideration in the MAR process is the desire to maintain some continuity with past designs for trending purposes. Other considerations include logistics, cost of implementation, compatibility with ongoing operations, and jurisdictional constraints. Based on the comments of the reviewers, the monitoring program or activity design is either revised, or recommended special studies are conducted to further investigate the need for revision. The most recent MAR was completed in March 1992,⁹ and the next MAR is scheduled for the spring of 1995.

Description of Waste Management Facilities

Radioactive Waste Management Complex

The RWMC occupies 38 ha of the southwestern part of the INEL (see Figures 2 and 3) in the north-central portion of the ESRP. The facility is situated in a small valley surrounded by basaltic ridges rising to 18 m above the landscape. Surface sediments vary in thickness from 0 to 7 m and consist of unconsolidated clay, silt, and gravel. The elevation is 1527 m above sea level.

Three major areas are within the RWMC: the SDA, 39 ha; the Transuranic Storage Area (TSA), 23 ha; and the Administrative and Operational Facility area, 4 ha. Low-level waste is segregated at the SDA according to radioactivity and container size, and then placed in a large pit (Pit 17) or in soil vaults (boreholes). Each filled pit or soil vault is covered with a minimum of 1 m of soil. Wastes contaminated with TRU elements in concentrations greater than 100 nCi/g are stored at the TSA in 208-L steel drums, fiberglass-covered wooden boxes, or steel bins.

B93 0038

Figure 2. Map of the Radioactive Waste Management Complex.

Figure 3. Aerial photograph of the Radioactive Waste Management Complex (facing west).

Pad A, formerly called the Transuranic Disposal Area, is a prominent waste management area within the SDA. Pad A was originally an asphalt-surfaced area at the RWMC established to store uranium waste, primarily in the form of nitrate salts. The uranium waste contains enriched and depleted uranium. Some waste containing TRU elements was also placed on Pad A from 1972 to 1978. Most of the TRU waste measures less than 10 nCi/g. However, a number of TRU waste drums are known to measure between 10 and 100 nCi/g, and a very small percentage of drums measure greater than 100 nCi/g. Waste containing beryllium is also stored on Pad A. When the pad was filled with stacked waste drums and boxes, the containers were covered with a 1-m soil berm. Pad A was closed in November 1978.

Two facilities located in the TSA, the SWEPP building (see Figure 4) and the Certified and Segregated Waste Storage (C&S) building, are used to examine stored TRU waste to ensure it meets the waste acceptance criteria of the Waste Isolation Pilot Plant (WIPP) located in New Mexico. Waste is retrieved, examined, and segregated into certifiable and uncertifiable waste packages. The certifiable waste packages will be prepared for shipment to WIPP. The C&S building (TSA-3) is an air-supported storage building located on a 43 x 254-m asphalt pad. The pad slopes from the center to the outer edges and from south to north. Drainage ditches on either side of the pad drain into sump pits.

The C&S building and Pad R (south of TSA-1) are currently active for surface storage of waste contaminated with TRU elements in concentrations greater than 100 nCi/g. In the past, waste containers were stacked on asphalt pads similar to Pad A and covered with plywood, plastic, and soil when pad areas were filled. Now, drums of TRU waste are stored in TSA-3 on an

asphalt pad and enclosed in an air-supported weather shield. Boxes of TRU waste, covered with vinyl-coated nylon, are also stored outside on Pad R because retrieval of the waste is planned.

Transuranic waste with high radiation levels (greater than 200 mR/h at contact) requiring remote handling is stored at the Intermediate-Level Transuranic Storage Facility (ILTSF) within the TSA. Such waste is stored in subsurface, cylindrical metal vaults capped with removable shield plugs.

Waste Experimental Reduction Facility

WERF is located in the south-central portion of the INEL (see Figure 5), about 8 km southeast of the Central Facilities Area (CFA). It is located in the decommissioned and modified Special Power Excursion Reactor Test No. 3 (SPERT-III) facility, and consists of a concrete block building (PER-609) with high bay and basement operating areas. Incineration, compaction, metal melting, and solidification processes are conducted in this facility. Waste sorting and bulk scrap metal sizing activities are performed in a metal building (PER-635) located to the northeast of PER-609. Transient storage pads for pre- and post-process waste are located adjacent to the facility.

WERF was established in 1982 for the research and development of production scale, volume-reduction methods for low-level beta/gamma-contaminated metals and combustible materials. This facility was designed to size-reduce and melt radiologically contaminated metal, compact nonincinerable waste, incinerate radiologically contaminated combustible waste, and stabilize the resultant fly-ash by solidification. Exhaust gases from WERF activities are filtered in a baghouse filter and a high-efficiency particulate air filter prior to discharge.

Figure 4. Aerial photograph of the Stored Waste Examination Pilot Plant (facing south).

Figure 5. Aerial photograph of the Waste Experimental Reduction Facility (facing east).

Mixed Waste Storage Facility

The MWSF is the temporary storage facility for mixed waste at the INEL. It is housed in the decontaminated and decommissioned SPERT-IV reactor building (PBF-613). The building, which was constructed in 1960, consists of a high bay and two low-bay wings. The high bay is a 22 x 15 x 14-m steel-girded, reinforced concrete, cinder block structure with a deep basement, and a metal roof. The total capacity of stored mixed waste is 365, 208-L drums, or equivalent. Cargo containers in the parking area adjacent to the MWSF are used for storage of mixed waste solids, including lead. No flammable liquids or solids or reactive wastes are stored in the cargo containers.

Stationary Low-Power No. 1 Surplus Area

The SL-1 surplus area is located in the south-central portion of the INEL, about 7.2 km north of the southern INEL boundary. The total area within the SL-1 Burial Ground fence is about

1 ha. No surface facilities have been constructed within the exclusion fence. The area contains most of the SL-1 dismantled reactor building, radiologically contaminated equipment, about 750 m³ of radiologically contaminated dirt and gravel, and decontamination waste in one trench and two pits.

Organic-Moderated Reactor Experiment

The OMRE area is located in the south-central portion of the INEL, about 7.6 km north of the southern INEL boundary, and occupies about 0.7 ha. The OMRE project was completed in 1963, and the facility was decontaminated and decommissioned in 1979. The building and underground reactor were disassembled; the radiologically contaminated material was disposed at the RWMC, and uncontaminated parts were sold as scrap. The leach pond was backfilled with soil, and the entire area was revegetated with a mixture of native grasses in 1981. No waste was buried within the OMRE boundaries, and no surface facilities exist today.

MONITORING METHODS AND RESULTS

The remainder of this report discusses the monitoring methods and results for calendar year 1993 with the major portion being radiological monitoring of EG&G Idaho-operated Waste Management facilities. Radiological surveillance includes the following topics: (a) airborne particulates, (b) RWMC surface water run-off, (c) soils, (d) biota (vegetation and small mammals), (e) penetrating radiation, and (f) surface radiation. Table 1 shows the RESP activities performed at these Waste Management facilities.

In addition, this report briefly discusses subsurface water monitoring at the RWMC by the USGS.

Appendices that discuss QA, Appendix A; detection limits, Appendix B; statistical methods, Appendix C; and environmental standards, Appendix D, are also included. Detailed information on radiological analyses of all sample media is in Appendix B.

Ambient Air Monitoring

Air is considered to be a critical pathway of

contaminants through the environment.¹⁰ Airborne materials from the RWMC are predominantly fugitive dusts with small amounts of sorbed radionuclides. The general approach to monitoring an area source, such as the fugitive dusts at the RWMC, is to monitor the perimeter of the facility.

The 1983 MAR (EGG 1983a) provides much of the rationale for the current ambient air monitoring design.¹¹ Following the MAR recommendations, the number of high-volume (HV) air monitor locations around the SDA was reduced to seven. The MAR recommendations were based on the identification of redundant sampling locations, using statistical comparisons of data with time and location. In response to MAR comments, a replicate sampler and a control location were also added to the air monitoring system. In addition, based on the MAR comments, HV air monitors were replaced in 1986 with low-volume (LV) air monitors (see Figure 6) that operate at 0.14 m³/min. Particulate material is collected on a membrane filter (Gelman Model Versapor-1200, 1.2 μ m, 102 mm diameter).

Figure 6. Collection of particulate air filter from LV air sampler.

During July 1992, most of the existing total suspended particulate (TSP) air monitors were replaced with intermediate flow ($0.11 \text{ m}^3/\text{min}$) particulate matter $\leq 10\mu\text{m}$ (PM_{10}) air monitors (see Figure 7). These new PM_{10} air monitors use the same membrane filter as the TSP air monitors and sample particulates less than $10 \mu\text{m}$ in size, which is considered to be the respirable fraction. The PM_{10} fraction is also the range of particle sizes that can be transported to offsite locations

by wind. Measuring the respirable fraction provides data which meets the general RESP objective for providing data which may be used for dose calculations.

TSP air monitors remain at strategic locations at RWMC and WERF including Location 300 of WERF (see Figures 8 and 9). One air monitor remains at Location 2 of the SDA while two others remain at Locations 20 and 26 of SWEPP.

Figure 7. PM_{10} air monitor.

KL94 0083

Figure 8. RWMC TSP and PM₁₀ air monitor locations.

- Low-volume air monitor operated by RESL
- ▲ EG&G PM₁₀ air monitor
- EG&G TSP air monitor

Figure 9. WERF air monitoring locations.

Replicate PM₁₀ samples are taken as part of the RESP Quality Assurance/Quality Control Program at Location 4.3 at the RWMC (see Figure 8). Control sample Locations 15 and 15.3 for the RWMC is at the Experimental Breeder Reactor No. 1 (EBR-I) area, approximately 3 km east-northeast of the RWMC. The WERF control sample location, which serves both WERF and MWSF, is next to the INEL Main Gate, Building 603 (see Figure 10). The prime factors influencing the selection of sampler locations were prevailing wind patterns, accessibility, and availability of electrical power.

RESL maintains several LV air monitors near EG&G Idaho-managed facilities and at offsite locations (see Figure 11). One air monitor is located at each of the following locations: RWMC, PBF, and EBR-I. The RESL's samplers operate at about 0.06 m³/min through a set of filters consist-

ing of a membrane filter (Gelman Model V-1200) followed by an activated charcoal cartridge filter (SAIC Model BG-300). These filters are 99% efficient for removal of radioactive airborne particulates and elemental iodine vapor from ambient air.

Ambient air was sampled for radioactive particulates during 1993 at the RWMC, WERF, and MWSF. In addition to the general RESP objectives, the specific objectives of the ambient air sampling are as follows: (a) determine concentrations of airborne radionuclides in the vicinity of EG&G Idaho Waste Management facilities, (b) report comparisons of measured concentrations to reference levels based on derived concentration guides (DCGs) for the public given in DOE Order 5400.5,¹² and (c) detect and report significant trends in measured concentrations of airborne radionuclides.

Figure 10. WERF air monitoring control location at the Main Guard Gate.

B93 0033

Figure 11. RESL's air sampling network at the INEL and vicinity.

EG&G Idaho air filters were collected and analyzed semimonthly for gross alpha and gross beta activity, and monthly composites at each location are analyzed quantitatively for gamma-emitting radionuclides. All filters from the RWMC are also composited on a quarterly basis and analyzed for specific alpha- and beta-emitting radionuclides. The statistical approach applied to analyze the data is presented in Appendix C. RESP samples are compared to data supplied by RESL from air monitors located both onsite and offsite.

The primary purpose for gross alpha analysis is to detect significant changes in concentration of airborne alpha activity at the RWMC. The gross alpha results are also used as a criterion to screen samples for immediate radiochemical analyses for specific alpha-emitters.

Results of gross beta analysis of the air filters are evaluated to determine if there are any significant increases in the sample radioactivity that may require more immediate or more in-depth analysis by gamma spectrometry or radiochemistry. Gross beta analysis is thus used as a quick and inexpensive screening tool. The results are also used to indicate any trends in environmental radioactivity.

EG&G Idaho evaluates gross beta results semimonthly by comparing them with historical and background data for an indication of trends, using a log concentration-versus-time plot. Control concentrations, detection limits, and alert levels are compared for each plot. Alert levels are 25% of the most restrictive DCGs for the public. Comparisons are made between stations and with the control monitors, using analysis of variance (see Appendix C). The RESP also compares gross

beta activity to DCGs. Measured concentrations are compared to the DCGs as a point of reference for interpreting the results (see Appendix D). Sr-90 and Cs-137 are the most likely waste-related beta-emitting radionuclides to be found at the RWMC. Of these two, Sr-90 has the more restrictive DCG. For this reason, the Sr-90 DCG was adopted as the equivalent gross beta DCG for airborne particulates (see Appendix D). (Pu-241 is also a low-energy beta-emitter and has a more restrictive DCG than Sr-90; however, it is generally detected through its alpha- and gamma-emitting daughter, Am-241.)

Trend Analysis

Graphs of gross alpha and gross beta concentrations over time from all locations (except the two control locations) are given in Figures 12 through 15. For both alpha and beta concentrations, there is one graph for the PM₁₀ monitor results and one for the TSP results.

Changes in the differences over time between the PM₁₀ air monitors and the TSP air monitors are shown in Figures 16 and 17. Average con-

centrations of PM₁₀ and TSP air monitor data from the paired locations (locations with both PM₁₀ and TSP monitors) are charted over time for gross alpha and gross beta. Additionally, data in the graphs were smoothed using polynomial smoothing to indicate the general trend in differences over time.

One reason for the difference in the measured values from the two monitor types is that the PM₁₀ air monitors are designed to only admit particles less than 10 microns in diameter while the TSPs admit larger particles. The particle size restriction of the PM₁₀ air monitors has been determined to be appropriate for some pathway modeling since larger particles suspended in air do not present a significant risk due to inhalation. The differences seen in Figures 16 and 17 in the average air concentrations might be attributed to fluctuations in the size of the particles from natural or man-made origins in the atmosphere at a particular time. In any case, the significant differences between the PM₁₀ and TSP air monitors must be taken into account in any comparative analyses of the data.

Figure 12. 1993 gross alpha concentrations for PM₁₀ air monitors using fifth order polynomial smoothing.

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Figure 13. 1993 gross alpha concentrations for TSP air monitors using third order polynomial smoothing.

VG94 0219

Figure 14. 1993 gross beta concentrations for PM_{10} air monitors using fifth order polynomial smoothing.

VG94 0218

Figure 15. 1993 gross beta concentrations for TSP air monitors using third order polynomial smoothing.

VG94 0217

Figure 16. Gross alpha concentrations by monitor type for Locations 2, 15, 20, 26, and 300 using third order polynomial smoothing.

VG94 0216

Figure 17. Gross beta concentrations by monitor type for Locations 2, 15, 20, 26, and 300 using third order polynomial smoothing.

Radioactive Waste Management Complex

Figure 8 shows the sampling locations of both EG&G Idaho's and RESL's air monitors at the RWMC. EG&G Idaho has measured gross beta activity since 1979. Quarterly averages of RWMC gross beta activity (Cs-137 equivalent) are given in Figure 18.

The rise in beta activity in 1986 is attributed to the fallout from the April 1986 Chernobyl accident in the Soviet Union. The control values prior to 1983 are not shown in Figure 18 since the RWMC control location was not established until 1983.

Figures 19 and 20 show the maximum gross beta concentrations (Cs-137 equivalent) at the SDA and SWEPP, respectively, during each semimonthly sampling period during 1993. The

gross beta data have historically followed a seasonal trend that usually increases during the latter part of the year. This same pattern was noted while trending the 1993 data.

Monthly averages of RESL's LV air samples at the RWMC for particulate beta activity are given in Figure 21. RESL's data (monthly averages) and EG&G Idaho's data (quarterly averages shown in Figure 18) show similar trends.

Analysis for Gamma-Emitting Radionuclides Gamma-emitting radionuclides that could be present due to RWMC operations were not detected in either the RESP or RESL air samples collected at the RWMC in 1993. (Radionuclides most likely to be found at the RWMC and detection limits are listed in Table B-2 of Appendix B.)

Figure 18. Quarterly averages of RWMC gross beta air concentrations since 1983.

Figure 19. Maximum gross beta concentrations (Cs-137 equivalent) for SDA air filters during each semimonthly period of 1993.

Analysis for Specific Alpha- and Beta-Emitting Radionuclides

Only four data points for specific alpha and beta emitters are collected per location in any year, with results frequently less than the detection limit. In general, trend information cannot be developed over a one-year period, nor is it possible to obtain information regarding the time of a release within a one-quarter period. Analysis of quarterly composited air samples provides an indication of waste confinement. Figure 22 shows a plot of Pu-239,-240 and Am-241 concentrations measured at all RWMC locations since the first quarter of 1986 and their association to the appropriate DCG. In accordance with DOE Order 5400.5 for Am-241 and Pu-239,-240, the DCG is 2.0×10^{-14} $\mu\text{Ci/mL}$. Sampling and analysis for these radionuclides were instrumental in identifying and evaluating the breached container containing alpha-emitting radionuclides at the TSA-R Pad that occurred during 1986 through 1988.

No specific alpha- and beta-emitting radionuclides were detected during the first or fourth

quarters. However, during the third quarter of 1993, Am-241 was detected in composite air samples from SWEPP Location 20. This concentration was $2.4 \pm 0.7 \text{ E-18 } \mu\text{Ci/cc}$ and represents 0.01% of the DCG for airborne releases of Am-241 to the public. This low-level airborne activity is due to resuspended soil from the previously flooded areas. It is near the lower limit of detection and is below concentrations detected in previous years.

During the second and third quarters of 1993, Sr-90 was detected in composite air samples from the SDA Location 4 and SWEPP Location 26. These detections also indicate relatively low levels of airborne activity. The maximum concentration was $5.5 \pm 0.9 \text{ E-16 } \mu\text{Ci/cc}$ and represents 0.006% of the DCG for airborne releases of Sr-90 to the public. These concentrations were comparable to concentrations detected in previous years. Sr-90 is a radionuclide that was deposited on soil worldwide as a result of fallout from nuclear weapons tests and has been detected at or near these levels at control and offsite locations due to dust resuspension.

R94 0452

Figure 22. Am-241 and Pu-239,-240 quarterly composite concentrations for air filters at RWMC locations.

The air-monitoring locations around the WERF are shown in Figure 9, and the control location is shown in Figure 10. The quarterly average of gross beta activity for the WERF is shown graphically in Figure 23. The unusually high gross beta results observed in 1986 were attributed to the Chernobyl accident.

activity at the WERF for each semimonthly period. Monthly mean concentrations were not statistically different from those reported for the control location.

During 1993, there were no detections above background of gamma-emitting radionuclides in WERF monthly air sample composites. Since no known source of TRU radionuclides exists in this area, no specific alpha and beta analyses were performed.

VG94 0212

Figure 24. Maximum gross beta concentrations (Cs-137 equivalent) for WERF air filters during each semimonthly period of 1993.

Mixed Waste Storage Facility

Figure 9 shows the location of the air monitor at the MWSF. This monitor was installed in October 1986. No airborne gross alpha or beta concentrations above ambient levels were detected (see Figure 25). No man-made, gamma-emitting radionuclides were detected at the MWSF during 1993. No specific alpha and beta analyses were performed on any air filters because no known source of TRU radionuclides exist in this area.

Surface Water Run-off

Radionuclides could be transported outside the boundaries of the RWMC via surface water run-off. Surface water run-off occurs at the SDA only during periods of snowmelt or heavy precipita-

tion. At these times, water is pumped out of the SDA into a drainage canal. Water also runs off the asphalt pads around TSA, into drainage culverts and the drainage canal, which directs the flow outside the RWMC. The canal also carries outside run-off that has been diverted around the RWMC. Ponding of the run-off in a few low areas may increase subsurface saturation, enhancing subsurface migration.

Water samples are collected during each quarter during which sufficient rain falls or snow melts to produce run-off water from the TSA asphalt pads and in the SDA gate ditch. One sample is collected from each of the four culverts that drain off of the TSA asphalt pads. These four sampling points are upstream from a drainage ditch. In addition, a sample is taken at the point of discharge from the SDA near the sump pump.

VG94 0209

Figure 25. Maximum gross beta concentrations (Cs-137 equivalent) for MWSF air filters during each semimonthly period of 1993.

Each sample was collected in a 4-L polyethylene container, preserved with acid, added filter paper pulp tablets, sealed, dated, and identified by location. The Radiation Measurements Laboratory (RML) analyzed the samples by means of gamma spectrometry. Gamma spectrometry was performed on both liquid and particulate fractions. Detection limits for specific radionuclides, including those most likely to be found at the RWMC, are listed in Tables B-1, B-2, and B-3 of Appendix B. The statistical approach used to analyze and interpret the data is discussed in Appendix C.

Figure 26 shows the collection of a surface water run-off sample at the RWMC. Figure 27 shows sample collection locations, including the four TSA culverts (TSA-1, TSA-2, TSA-3, and TSA-4) and the SDA pump.

Surface water run-off draining from the SDA is pumped into the SDA/TSA drainage ditch. Sampling at this point allows a direct assessment of radionuclide migration from the SDA via surface water run-off. Sampling at the TSA-1, TSA-2, TSA-3, and TSA-4 culverts (see Figure 27) allows similar assessments of these areas. Control samples are collected to determine background concentrations of the radionuclides of interest in locations unaffected by facility operations. In 1984, the control sample location was changed from the Big Lost River because it was not representative of background surface water run-off at the RWMC, to a ponding area 1.2 miles north of the RWMC (T-12 Road). This control location is currently being used with samples collected at the SDA, and a new control location was established at the rest area on Highway 20 for samples collected at the TSA Pad.

Figure 26. RWMC surface water run-off collection.

Figure 27. Sampling locations for surface water run-off.

The specific objectives of the surface water sampling activity are to: (a) determine concentrations of radionuclides in any surface waters leaving EG&G Idaho Waste Management facilities, (b) report comparisons of measured concentrations against reference levels based on DCGs for the public given in DOE Order 5400.5, and (c) detect and report significant trends in measured concentrations of radionuclides in surface waters leaving EG&G Idaho Waste Management facilities.

Surface water run-off samples were collected during all four quarters of 1993. A sample collected at TSA-1 during the fourth quarter of 1993 contained Cs-137 in the particulate fraction at a concentration of $1.85 \pm 0.14 \text{ E-9 } \mu\text{Ci/mL}$. This was the only man-made, gamma-emitting radionuclide detected during 1993. Cs-137 is commonly detected in the environmental samples collected at the RWMC, and is usually at or near background levels. This concentration represents 0.06% of the DCG for water releases of Cs-137 to the public.

Surface water run-off samples were also submitted and analyzed for specific alpha- and beta-emitting radionuclides. Am-241 was detected at Location TSA-2 at a concentration of $6.8 \pm 1.5 \text{ E-11 } \mu\text{Ci/mL}$. This concentration represents 0.23% of the DCG in water. Comparable concentrations of Am-241 have been measured in run-off water at the RWMC in the past. These concentrations are near the detection limits and are comparable to concentrations noted at distant community locations.

Soils

Soil samples are collected to detect potential changes in soil concentrations caused by surface deposits of airborne contamination and to detect the loss of waste confinement. Measurement of surface deposition over a large area, relative to the area represented by a soil sample, provides a better indication of waste confinement and potential soil contamination.

The specific objectives of the surface soil sampling activity are to determine concentrations of radionuclides in soils in the vicinity of EG&G Idaho Waste Management facilities and detect and report significant trends in measured concentrations of radionuclides in soils.

At each sampling station, a soil sample is collected at each of the four corners and at the center of a 10 x 10-m square. The samples are then combined to form one composite sample. A stainless-steel sampling ring is used to collect a 12-cm diameter x 5-cm deep sample from these soils (see Figure 28).

The samples are dried, weighed, homogenized (ball-milled), screened through a number 35 sieve, and then analyzed for gamma spectrometry and radiochemistry. Specific radionuclides that are most likely to be detected, and their detection limits, are listed in Tables B-1 and B-2 of Appendix B.

Radioactive Waste Management Complex

Surface and near-surface soils at the RWMC have become contaminated from past flooding of open pits, waste handling, and biotic intrusion. Of particular concern is the presence of Pu-239,-240 and Am-241 deposited during flooding events, in surface soils, in and outside the northeast corner of the SDA.⁷ Wind, water, and biota can transport contaminated soil particulates onsite and offsite.

The 1983 MAR provides much of the basis for the current surface soil sampling design.¹³ The MAR recommendations were implemented in 1984. The major design modification was implemented from the 1983 MAR which called for randomly selected sampling locations in five permanent plots. These plots reflect the five major areas of the RWMC, as indicated by the types of waste buried, current operational activities, and past flooding events. Those major areas are the TSA, Pad A, previously flooded areas, inactive areas, and active areas (see Figure 29).

Figure 28. Soil sample collection.

Figure 29. Five major areas of the RWMC used for vegetation, mammal, and soil collection.

Although the original sampling areas defined in the 1983 MAR remained consistent, significant changes to the soil sampling activity were recommended by the 1988 MAR committee.¹⁴ The major proposed revision was to eliminate routine soil sampling and replace it with special studies on an as-needed basis. The rationale for this recommendation is twofold: (a) the number of samples collected are probably insufficient for valid data interpretation, and (b) the addition of new soil cover during recontouring of the SDA in 1986 invalidates comparison with past data. RESP began collecting data on the new soil cover on a triennial basis to establish a baseline. This effort began in 1991 at RWMC and in 1992 at SWEPP. The need for routine soil sampling will be evaluated after two sample sets have been collected from each location.

1992 SWEPP Radiochemical Analysis

Baseline samples were collected within the SWEPP area during 1992 (see Figure 30). Specific alpha- and beta-emitting radionuclide results are provided in this year's report because the results were not available for the 1992 Annual Report. Sr-90, Pu-239,-240, and Am-241 were detected in the soils at or near the lower limit of detection for radiochemical analysis. The Sr-90 concentration was less than 11% of the Environmental Concentration Guidelines (ECG) (see Appendix D for discussion on ECG and their use). The Pu-239,-240, and Am-241 concentrations were less than 1% of their respective ECGs.

Waste Experimental Reduction Facility

During 1993, soil samples were collected from the 11 locations shown in Figure 31 near WERF. Control samples were collected near the Main Gate, Building 603 (see Figure 10). Only one

gamma-emitting radionuclide, Cs-137, was detected in the WERF soil samples. The maximum concentration was $8.0 \pm 0.4 \text{ E-1 pCi/g}$, collected from Location 11. This concentration is comparable to previous samples collected at WERF and is approximately equal to the Cs-137 concentrations attributed to fallout on surface soils in the INEL region.

Biotic Surveillance

Plants and animals are potential pathways for migration of radionuclides away from the facility. Several studies by RESL have indicated that small burrowing mammals, such as deer mice, transport radionuclides.¹⁵ Uptake of radionuclides by vegetation at the RWMC has also been documented by RESL.¹⁶

Routine biotic monitoring was not conducted prior to 1983. Some preliminary data on radionuclide concentrations in deer mice and crested wheatgrass were collected by EG&G Idaho during fiscal year 1982. Visual biotic inspections began in April 1983.

A detailed long-range plan for biotic monitoring, including procedures for routine monitoring, was completed in the fall of 1983.¹⁷ The sampling design involved sampling at the five major areas designated for soil sampling.

The specific objectives of the routine biotic surveillance are to: (a) determine if biota are transporting radionuclides from buried waste or contaminated soil, (b) identify biotic conditions which may compromise waste confinement at waste storage and disposal facilities, and (c) detect and report significant trends in the radionuclide and concentrations in biotic samples.

Figure 30. General SWEPP soil locations.

Figure 31. WERF TLD soil and vegetation locations.

Vegetation

Three subsamples are collected from each of the sampling locations and combined into one composite sample. The method of collection and species alternates each year. Crested wheatgrass is collected in odd-numbered years and is clipped at ground level within a 1 x 1-m frame. Russian thistle is collected in even-numbered years, and the entire plant is pulled up within a 1 x 1-m frame (see Figure 32). Either rabbitbrush or sagebrush is collected in odd-numbered years by clipping 20% of the branches from the designated plants. Thus, the same plant can be sampled biennially.

The samples are oven-dried, milled, and weighed before they are submitted to the RML for gamma spectrometry analyses. Based on gamma analyses, selected samples are submitted to the Bioassay Group for specific alpha and beta analyses.

Prior to 1990, the only samples submitted for specific radiochemical analysis was the sample with the highest Am-241 concentration as identified by gamma spectroscopy. If Am-241 was not detected, then one sample from the previously flooded area was submitted. RESP identified the lack of available data for making comparison to past data. As a result, at least one sample from each of the five major areas is submitted for specific radiochemical analysis. This will provide a basis for comparison of data from each area.

RWMC. Crested wheatgrass was collected in 1993 from five major areas of the RWMC (see Figure 29). Control samples were collected near Frenchman's Cabin, located approximately 11 km south of the SDA at the base of the Big Southern Butte. Results for gamma analysis of the RWMC crested wheatgrass samples showed concentrations less than or equal to background levels and at or near the lower limit of detection.

Samples selected for specific alpha- and beta-emitting radionuclides contained concentrations

of Sr-90 that exceeded the levels found in the control sample; however, the concentrations were less than concentrations previously measured in these samples of crested wheatgrass collected at the RWMC. These concentrations were also within the range of results reported by RESL for vegetation samples collected at the RWMC.¹⁶

WERF. Vegetation collection at WERF began in 1984 and is performed every three years. Sagebrush samples were collected in 1993 at 11 sample locations at WERF (see Figure 31). Control samples were collected from the Tractor Flats area which is located adjacent to U.S. Highway 20 approximately five miles east of the Argonne National Laboratory entrance. No man-made, gamma-emitting radionuclides that can be attributed to waste operations were detected in the WERF samples.

Radioactivity in Small Mammals

The RESP has routinely sampled small mammals at the RWMC to evaluate confinement integrity of buried waste. Recently, the population of the small mammals has decreased to a point where it is not possible to ensure collection of a representative sample. The declining population is due to increasing operational activity and disturbance of ground cover in and around the SDA. There have also been concerns raised about the Hantavirus and its possible connection to deer mice. As a result of these problems, a programmatic decision was made to temporarily discontinue small mammal sampling. The program will re-evaluate this situation annually.

Soil Excavated by Small Mammals

Samples of soil excavation by burrowing animals were scheduled to be collected during 1993 at the RWMC from each of the five major areas (see Figure 29). No samples were collected due to recontouring activities and due to the diminishing population of small mammals at the facility.

Figure 32. Vegetation collection at the RWMC.

Penetrating Radiation

TLDs are used to measure cumulative exposures to ambient ionizing radiation. Figure 33 shows the placement of a TLD.

The TLDs are sensitive to beta energies greater than 200 KeV and to gamma energies greater than 10 KeV. The TLD packets contain five lithium fluoride chips and are located about 1 m above the ground at specified locations. The five chips provide replicate measurements at each location. The TLD packets are replaced in May and November of each year. The sampling periods for

1993 were from November 1992 to May 1993, and from May to November 1993.

The specific objectives of the penetrating radiation monitoring activity are to: (a) demonstrate compliance with the limit for direct penetrating radiation established in RWMC Project Directive 6.1, Radiation and Contamination Control (1 mR/hr at 3 ft above ground), (b) characterize direct radiation levels at specific points of interest at EG&G Idaho Waste Management facilities, and (c) detect and report significant trends in measured levels of penetrating radiation.

Figure 33. Placement of a TLD at a facility perimeter station.

Trend Analysis

TLD cumulative 6-month exposure data for 1986 through 1993 from RWMC, SDA, SWEPP, and WERF are presented in Figure 34. (Data from the distant communities are excluded from the trend chart.) Data in the graph were smoothed using negative exponential smoothing to indicate the general trend in values over time. The data are plotted on a logarithmic scale to give a clearer picture of the trends. Although there has been some cycling of values, the general trend in the graph indicates a gradual decline in TLD exposures over time.

Comparisons by Facility

A table of summary statistics (e.g., means, medians, maximum, and minimum values) for 1993 TLD exposures are given in Table 2. Addi-

tionally, Box and Whisker plots of the TLD exposure by facility (including the distant communities) are provided for both 1992 and 1993 (see Figures 35 and 36). The 1992 TLD exposures are included to provide an indication of short term changes in levels.

The median 1993 exposure values for the distant communities and for all of the facility groupings decreased from the median exposure values calculated for 1992. The Kruskal-Wallis test for differences in medians indicated that the changes from 1992 to 1993 were statistically significant (at the .05 level) for the distant communities, as well as for all of the facility groupings except for SWEPP. Limited SWEPP data are available; for both 1992 and 1993, the SWEPP data are based on a total of four data points (spring and fall data from only two locations).

Seasonal Change

The Box and Whisker plot of the 1993 TLD exposure data by season (including all facilities and the distant communities) indicates that the median exposure value for the fall measurement period ending in November of 1993 was greater than that of the spring measurement period ending in May of 1993 (see Figure 37). Additionally, the difference (tested using the Kruskal-Wallis test) was found to be statistically significant (at the .05 level).

Radioactive Waste Management Complex

RESP placed TLD packets at five locations around the RWMC and at two locations on the TSA fence. TLD packets were placed at 24 locations by RESL. (See Figure 38 for all locations.) The locations at Stations 1, 31, 33, and 35 were changed slightly in November 1988 and are now labeled 1B, 31B, 33B, and 35B. RESL Locations 3A through 31A were moved in May 1988 because a new fence was installed and the dike was raised around the SDA. Two additional locations, Stations 46 and 47, were added to the perimeter of the RWMC in May 1989, and thus, a total of 31 locations were monitored.

T94 0552

Figure 34. TLD exposure data using negative exponential smoothing.

Table 2. Summary statistics for 1993 TLD 6-month exposures (all concentration values are mR).

Facility	Season	N	Mean	Median	Minimum	Maximum
SDA	Spring	5	69.4	66.0	51	93
	Fall	4	89.2	83.5	73	117
SWEPP	Spring	2	58.0	58.0	47	69
	Fall	2	80.5	80.5	69	92
WERF	Spring	9	51.0	50.0	45	56
	Fall	11	56.0	65.0	57	74
RWMC	Spring	21	63.7	62.0	55	79
	Fall	23	74.9	72.0	65	91
Distant Communities	Spring	6	52.0	51.5	48	57
	Fall	6	59.5	59.0	51	69

Figure 35. 1992 Box and Wisker plots of the TLD exposure by facility.

Figure 36. 1993 Box and Wisker plots of the TLD exposure by facility.

Figure 37. Exposure trends for the spring and fall average TLD measurements.

Figure 38. RWMC TLD locations.

Background exposure results from penetrating radiation from natural terrestrial sources (rocks and soil), cosmic radiation, fallout from testing of nuclear weapons, and local industrial processes. The background exposures used in this report are the averages of exposures measured by TLDs in the seven communities on the Snake River Plain located outside the INEL boundary. Background exposures were measured at Aberdeen, Blackfoot, Craters of the Moon National Monument, Idaho Falls, Minidoka, Rexburg, and Roberts.

Station 33B at the RWMC showed the highest exposures in both reporting periods of 1993. Stations 1, 33, and 35 have frequently shown the highest exposure. These stations measure exposures associated with the active disposal pit and operational activities at the RWMC.

Figures 39 through 46 show the six-month exposures for the past 10 years as measured by TLDs along the following RWMC SDA borders: northwest, northeast, south, southwest, southeast, west, and east. Average distant-community background exposure is shown on each graph for comparison.

Several general observations can be made about the data presented in Figures 39 through 46. First, there is a decreasing trend in exposures over time at most locations around the SDA, especially from 1974 through 1980. (Refer to the 1991 Annual Report for plotted data beginning approximately in 1973.) Decreases can generally be attributed to the following: (a) changes in operational activities, (b) placement of additional soil over pits and trenches, and (c) radioactive decay of the radionuclides in waste already buried. Many exposures have decreased to near background exposures and tend to vary directly with background exposures.

Approximately 0.6 m of soil cover was added to the northern half of the SDA in 1976. From 0.3 to 2 m of cover was added to most of the remaining portion of the SDA in the early 1980s. In the late 80s and early 90s, recontouring projects have

increased the soil cover over the majority of the SDA.

The second observation indicates that in past years, exposures are generally lower from November through May than from May through November. Lower exposures are attributed to decreased waste handling, increased snow cover, and increased soil moisture. During the past several years, a drought has affected this variance. In 1993, the difference between spring and fall exposures is more pronounced because of the relatively high precipitation during the year.

Figure 39 presents plots of exposures measured at Stations 9, 11, and 13 (along the northwest SDA border). Station 9 is located near the west end of Pad A, and Stations 11 and 13 are located along the northern part of the original burial ground (operated from 1952 through 1957). This area contains buried LLW intermixed with TRU waste. The exposures at Station 9 have generally decreased over time. The elevated exposures during 1983 and the first half of 1984 are attributed to the temporary parking of vehicles carrying waste shipments on the west side of Pad A. Exposures have decreased at Stations 9, 11, and 13 over the years and remain at or near background levels for both 1993 reporting periods.

Exposures measured at Stations 3, 5, and 7 (northeast SDA border) are plotted in Figure 40. Station 3 is located near Pit 9, which contains TRU waste, and Station 5 is located near Pit 8, which contains LLW. Both pits were closed in 1969. Station 7 is located near the east end of Pad A. Except for 1974 and 1978, exposures consistently have been around twice the background exposures. Exposure rates returned to twice the background levels of 1989. However, during 1985 through 1988, waste was temporarily stored east of these locations and contributed to the increase exposure rate during these years. Data collected during 1993 shows exposures near background levels, and waste is no longer being stored in that area. This trend is due to increased soil cover in the active area.

R94 0493

Figure 39. Six-month exposures measured by TLDs on the west end of the north border of the SDA.

R94 0492

Figure 40. Six-month exposures measured by TLDs on the east end of the north border of the SDA.

Figure 41 shows exposures measured at Stations 23 and 25, which are located along the south central border of the SDA. The trenches near these stations contain LLW intermixed with TRU waste and were closed in 1959. The exposures at these stations have generally decreased and are now at or near background exposure levels.

Figure 42 shows exposures measured at Stations 19 and 21, which are located along the southwest border of the SDA. These stations are located near soil vaults, which are cylindrical holes drilled into the ground. Soil vaults have been designed for disposal of special wastes with radiation levels exceeding 500 mR/h at 0.91 m. The soil vaults in this area have been closed since 1979. Since 1982, exposures continue to be consistently near the background exposure levels.

The exposures plotted in Figure 43 are for Stations 27 and 29, which are located on the south-east border of the SDA, south of Pit 17 (which is active). Since the early 1980s, before Pit 17 was actively used, the exposures at 27 and 29 remained consistent at two times the background exposure levels. No exposure data were available for the first period in 1993 at Station 27. Exposures have decreased and are approaching background levels due to increased soil cover at the active pit.

Figure 44 presents plots of exposures measured at Stations 15 and 17, which are located on the west SDA border (next to the original burial ground). Recent exposures have been variable due to operational activities but generally have decreased over time. Current exposures remain consistent and are at or near background levels.

Figures 45 and 46 show that exposures at Stations 1, 31, 33, and 35 have been decreasing. These are the closest stations to the pits that have

been active since 1974. Generally exposures measured at these stations have been the highest observed at the SDA and vary with the proximity and intensity of operational activity. No more data are available from Stations 1, 31, 33, and 35 due to construction in the area. Data are reported for the second half of 1989 through present at Stations 1B, 31B, 33B, and 35B. These locations are 15 m east of the original locations and are closer to the ILTSF at TSA. Current exposures are approximately two times background exposures. Even though these stations are in close proximity to the active pit area, recent exposures have been decreasing due to the additional soil cover.

Figures 47 through 51 are plots of exposures measured by TLDs along the north, south, and east borders of the TSA, respectively.

Exposures measured at Stations 37, 39, and SWEPP 1, which are located along the north border of the TSA, are plotted in Figure 47. The exposures at these locations are variable over time. These stations are near an area where incoming shipments are placed until the waste can be disposed. These waste shipments are, in effect, point sources of radiation. Another factor in the variability of the past years exposures at these stations was the temporary storage of waste on the asphalt pad in the TSA area during the late 1980s. Exposures at Station 37, located in the area of the active pit, have been decreasing and are approaching background levels. No waste has been stored in this area for the past three years. The exposures at Station 39 and SWEPP 1 have been consistent during the past three years at approximately one and a half times the background level.

Exposures measured at Stations 42, 43, 45, and SWEPP 5, which are located along the south and southeast borders of the TSA, are shown in Figures 48 and 49. These exposures are consistently low and usually vary directly with background exposures. No waste is stored near these stations.

Figure 41. Six-month exposures measured by TLDs on the south border of the SDA.

Figure 42. Six-month exposures measured by TLDs on the southwest border of the SDA.

Figure 43. Six-month exposures measured by TLDs on the southeast border of the SDA.

Figure 44. Six-month exposures measured by TLDs on the west border of the SDA.

R94 0498

Figure 45. Six-month exposures measured by two of the four TLDs on the east border of the SDA near the active pits.

R94 0500

Figure 46. Six-month exposures measured by two of the four TLDs on the east border of the SDA near the active pits.

R94 0501

Figure 47. Six-month exposures measured by TLDs on the north border of the TSA.

R94 0503

Figure 48. Six-month exposures measured by two of the four TLDs on the south and southeast borders of the TSA.

Figure 49. Six-month exposures measured by TLDs on the south border of the TSA.

Exposures measured at Stations 40 and 41, which are located along the east and northeast borders of the TSA, are shown in Figure 50. Station 41 exposures are fairly consistent and are close to background exposures. Station 40 showed a large increase during the second half of 1987, and then returned to its typical range. The 1987 increase has been attributed to the temporary storage of drums near the drum venting station during that year. Current exposures are at or near background exposures. Exposure data

were not reported for Station 41 during the spring collection because the TLD could not be located during the collection.

Figure 51 shows exposures measured at Stations 46 and 47, located along the north border of TSA. In May 1989, the security fence was increased in size, and these two stations were added by RESL since the security fence had been expanded. These exposures are fairly consistent with background exposures.

Figure 50. Six-month exposures measured by TLDs on the east and northeast borders of the TSA.

Figure 51. Six-month exposures measured by TLDs north of TSA.

Waste Experimental Reduction Facility

Figure 32 shows the locations of the 11 TLD stations located around the WERF. Figures 52 through 56 show the six-month exposures measured by TLDs located in the WERF area.

Figures 52 and 53 show the exposures measured at Stations 1, 2, 3, and 4, which are located northeast of WERF along the predominant wind direction. Stations 1, 2, 3, and 4 are located 500 m, 400 m, 300 m, and 200 m from WERF, respectively. These exposure levels remain at or near background.

Figures 54 and 55 show the exposures measured at Stations 5, 6, 7, and 8, which are located 50 m from WERF in the following directions, respectively: northeast, southeast, southwest, and northwest. Stations 5 and 8 are located near an area where waste is stored prior to processing. Some variability in exposures, especially at Stations 5 and 8, is due to temporary parking and

storage of waste shipments in those areas; these waste shipments are, in effect, point sources of radiation. This accounts for the increase in exposures at Stations 5 and 8 during 1988 and the continued increase at Station 5 during 1989. Waste stored in the storage area adjacent to Station 8 was removed during the second half of 1989. Part of the waste stored near Station 5 was removed in 1990. Station 5 was removed during 1992 due to construction in the area. This TLD station was relocated during 1993. Exposures at Stations 5 and 8 are close to background exposures, and Stations 6 and 7 have been consistently close to background exposures over time.

Figure 56 shows the exposures measured at Stations 9, 10, and 11, which are located 400 m from the WERF area in the following directions, respectively: northwest, southwest, and southeast. The exposures at each of these stations have remained fairly consistent over time and remain consistent with background exposures.

Figure 52. Six-month exposures measured by TLDs located 500 m and 400 m northeast of WERF.

Figure 53. Six-month exposures measured by TLDs located 300 m and 200 m northeast of WERF.

Figure 54. Six-month exposures measured by TLDs located northeast and southeast of the 50-m perimeter around WERF.

R94 0490

Figure 55. Six-month exposures measured by TLDs located southwest and northwest of the 50-m perimeter around WERF.

R94 0491

Figure 56. Six-month exposures measured by TLDs at 440-m perimeter around WERF.

Surface Radiation

To conduct the surface gamma-radiation surveys, a vehicle-mounted roadway monitor-1 (VRM-1) gamma-radiation detector system using plastic scintillation detectors (shown in Figure 57) was mounted 0.9 m above the ground on the front of a four-wheel-drive vehicle. The vehicle was driven at approximately 5 km/h across each area. As radiation levels greater than background levels were identified, the vehicle was stopped and the area was surveyed with a gamma-sensitive portable instrument. Any areas exceeding the facility limits were marked with flagged stakes for subsequent covering with additional soil.

Radioactive Waste Management Complex

The contact radiation readings of the 1993 spring and fall surveys at the RWMC are shown in Figure 58. All areas surveyed outside of the active pit were below the limit of 1 mR/h at 0.9 m, as specified by the RWMC Project Directives.¹⁸ The 1-mR/h criteria at 0.9 m ensures that personnel are not subjected to significant radiation exposure. [Background radiation levels were (0.007 mR/h) exceeded in several locations.] The locations of these areas were documented and will be surveyed again in the future. The highest reading noted in both surveys was 1.50 mR/h at contact and 0.40 mR/h at 0.91 m. This location was found along Soil Vault Row 7.

Figure 57. Pinpointing areas of increased radiation levels using the VRM-1 and HHD-440 meter radiation detector system.

R94 0449

NOTE: All values are in mR/h.

Figure 58. Results of 1993 spring and fall RWMC surface radiation surveys.

The elevated radiation levels shown on the sides of Pit 17 were a result of the large amount of exposed waste in the pit. In one area, elevated radiation levels were measured in the spring survey but not in the fall survey. This decrease was caused by changes in soil depth covering waste in that area.

Stationary Low-Power Reactor No. 1

The SL-1 area location is shown in Figure 1. Results of the spring and fall surface radiation surveys of the SL-1 surplus area identified no areas that exceeded the action level of 20 mR/h gamma at near contact.

Organic-Moderated Reactor Experiment

Thirteen areas exceeding background (0.007 mR/h) were identified during the annual surface radiation survey at OMRE (see Figure 59). None of these areas exceeded the action level of 1 mR/h at contact. All areas with elevated radiation levels were consistent with those found during previous area surveys. Many of these areas were close to or at the ambient background level. The highest reading was 0.64 mR/h at contact and 0.05 mR/h at 0.9 m and was one of only two areas which exceeded twice the background.

Subsurface Water

The USGS routinely samples subsurface water from monitoring wells located in and adjacent to the RWMC (see Figure 60). Immediately surrounding the RWMC are USGS Wells 87, 88,

89, 90, 117, 119, and 120, which penetrate the aquifer approximately 178 m beneath the surface. USGS Well 92, located in the west central portion of the SDA, is used for collecting water samples and monitoring the depth to perched water. In 1973, the well was sealed with expanding concrete at a dense basaltic zone about 65 m below the surface, so that perched water could accumulate. Due to the removal of water during sampling, the water level varies between 63.3 and 64.0 m below the surface.

Each quarter the USGS measures specific conductance, pH, temperature, and chlorides as well as H-3 and Sr-90. During 1993, samples from Wells 87, 88, 89, 90, 119, and 120 were analyzed for gamma-emitting radionuclides [i.e., Co-60 and Cs-137], and TRU (Pu-238, Pu-239, -240, and Am-241). The RWMC Production Well is sampled monthly for purgeable/organic compounds while all other wells, except Well 92, are sampled quarterly. However, Well 92 was not sampled during 1993 for any constituents due to the limited amount of sample media available in the perched water well.

Since operations began in the 1950s, waste water disposal at the INEL has increased the specific conductance of groundwater in the SRPA in the vicinity of INEL facilities. The background specific conductance of water from the SRPA at the INEL generally ranged from 178 – 860 $\mu\text{S}/\text{cm}$.¹⁹ This range was compared to the specific conductance measurements of water samples collected from wells at the RWMC in 1993 (see Table 3). These specific conductance measurements are comparable to those made in previous years.

Figure 59. OMRE surface gamma radiation survey area and areas exceeding background levels.

Figure 60. USGS well locations.

Table 3. Results of chemical analyses of subsurface water at the RWMC in 1993.

Well	Month Sampled	Specific Conductance $\mu\text{S}/\text{cm}$	Concentration (mg/L)	
			Cl^-	Na^+
87	January	340	13	—
	April	342	14	—
	July	352	13	—
	October	345	14	10
88	January	567	89	—
	April	578	87	—
	July	565	84	—
	October	574	81	44
89	February	360	42	—
	April	382	41	—
	July	376	41	—
	October	381	37	13
90	May	360	14	—
	October	365	12	—
117	January	265	14	—
	July	265	12	—
	October	275	13	8.6
119	April	278	10	—
	July	279	8.8	—
	October	281	8.9	11
120	January	420	24	—
	April	425	21	—
	June	452	23	—
	September	481	27	19

Table 3. (continued).

Well	Month Sampled	Specific Conductance $\mu\text{S}/\text{cm}$	Concentration (mg/L)	
			Cl^-	Na^+
RWMC Production Well	January	360	16	—
	February	360	—	—
	March	362	—	—
	April	360	15	—
	May	371	—	—
	June	370	—	—
	July	368	14	—
	August	371	—	—
	September	369	—	—
	October	370	14	8.5
	November	373	—	—
	December	373	—	—
92 perched Natural background ^a (of aquifer)	April	1080	89	—
	—	300–325	8–15	10

a. J. R. Pittman et al., *Hydrologic Conditions at the Idaho National Engineering Laboratory*, Idaho, 1982–1985 update, 89–4008, 1988.

— No sample taken

During October of 1993, analyses for stable Na–22 were performed (see Table 3). Water from some of the RWMC monitoring wells contained sodium concentrations higher than the background level of 10 mg/L. Sodium concentrations have fluctuated in water from these wells. One possible cause for these fluctuations is the method used to construct the wells. During construction, the wells were pressure-concreted to prevent water from cascading from perched zones down to the SRPA. The cement could contribute to higher sodium concentrations.

The chloride concentration (see Table 3) was above background levels also but well below the

chloride secondary maximum contaminant level (MCL), which is 250 mg/L. These concentrations may be from the same process described for sodium. Both the chloride and sodium concentrations are comparable to previous concentrations of past years at these well locations.

Approximately 334,594 L of organic waste were disposed prior to 1970 at the RWMC.²⁰ These buried wastes included about 92,354 L of carbon tetrachloride, 147,615 L of lubricating oil, and about 94,625 L of other organic compounds, including trichloroethane, trichloroethylene, perchloroethylene, toluene, and benzene.

Table 4 shows the 1993 concentrations of volatile organic compounds (VOCs) at USGS monitoring wells. The 1993 results are comparable to previous data. No MCLs for VOCs or radiological constituents were exceeded during 1993.

The results of the gamma spectrometry analysis performed on well samples taken in 1993 showed no positive detection of any gamma-emitting radionuclide.

Tritium was detected in Wells 87 and 90 and in the RWMC Production Well (see Table 5). No

other radionuclides were detected in the wells in any quarter. The maximum concentrations of tritium in Wells 87 and 90 and in the RWMC Production Well were 1.1, 1.3, and 1.7 pCi/mL, respectively, with a standard deviation of 0.2 pCi/mL. These concentrations are well below the DCG for the public (less than 0.1% of the DCG, as shown in Appendix D, Table D-1). Tritium concentrations in these wells are plotted in Figure 61. The source of the tritium is attributed to past disposal of waste water from operations at the Idaho Chemical Processing Plant and Test Reactor Area as reported by Orr and Cecil.¹⁹

Table 4. Concentrations (µg/L) of selected volatile organic compounds in groundwater.

[illegible]

Table 4. (continued).

Well Identifier	Date Sampled	Carbon Tetra-chloride	Chloroform	1,1,1-Trichloro-ethane	Trichloro-ethylene	Tetrachloro-ethylene	Dichloro-difluoro-methane	Toluene	1,1-Dichloro-ethane	1,1-Dichloro-ethylene
120	1/93	0.5	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	4/93	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	7/93	0.9	<0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	10/93	0.9	<0.2	0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2
RWMC Production Well	1/93	2.6	0.5	0.4	1.2	<0.2	<0.2	<0.2	<0.2	<0.2
	2/93	3.1	0.4	0.5	1.4	0.2	<0.2	<0.2	<0.2	<0.2
	3/93	2.0	0.4	0.4	1.1	<0.2	<0.2	<0.2	<0.2	<0.2
	4/93	2.0	0.3	0.4	1.1	<0.2	<0.2	<0.2	<0.2	<0.2
	5/93	2.8	0.3	0.5	1.3	<0.2	<0.2	<0.2	<0.2	<0.2
	6/93	2.1	0.4	0.5	1.1	<0.2	<0.2	<0.2	<0.2	<0.2
	7/93	2.4	0.3	0.4	1.1	<0.2	<0.2	<0.2	<0.2	<0.2
	8/93	1.6	0.2	0.3	0.9	<0.2	<0.2	<0.2	<0.2	<0.2
	9/93	2.3	0.3	0.5	1.0	<0.2	<0.2	<0.2	<0.2	<0.2
	10/93	2.1	0.4	0.4	1.0	<0.2	<0.2	<0.2	<0.2	<0.2
	11/93	2.5	0.3	0.4	1.2	<0.2	<0.2	<0.2	<0.2	<0.2
	12/93	2.2	0.3	0.4	1.1	<0.2	<0.2	<0.2	<0.2	<0.2

— No samples were collected.

a. Tests specific to pumps and instrumentation were conducted on well 88 during February 1992. The results of these tests are reported in a USGS report titled *Purgeable Organic Compounds in the Ground Water at the Idaho National Engineering Laboratory, 1990–1992*.²⁰

Table 5. Results of radiochemical analyses of RWMC subsurface water.

Well	Month Sampled	Radionuclide ^a	Concentration ^b (10 ⁻⁶ μ Ci/mL)	Percentage of DCG ^c
87	January	H-3	1.0 $\pm$ 0.2	0.005
	April	H-3	1.0 $\pm$ 0.2	0.005
	July	H-3	1.0 $\pm$ 0.2	—
88 ^d	—	—	—	—
89 ^d	—	—	—	—
90	January	H-3	1.3 $\pm$ 0.2	0.007
117 ^d	—	—	—	—
119 ^d	—	—	—	—
120 ^d	—	—	—	—
RWMC Production Well	January	H-3	1.3 $\pm$ 0.2	0.007
	April	H-3	1.2 $\pm$ 0.2	0.006
	July	H-3	1.7 $\pm$ 0.2	0.009
Natural Background ^e	—	H-3	0.05 $\pm$ 0.1	NA

H-3 = Tritium NA = Not applicable

a. No radionuclides detected other than tritium. (See Tables B-1, B-2, and B-3 for limits of detection for other radionuclides.)

b. The $\pm$ values are experimental random uncertainties in the counting measurement process and represent one standard deviation.

c. Derived concentration guide values for the public are based on the dose conversion factors provided in DOE Order 5400.5, "Radiation Protection of the Public and the Environment," February 8, 1990.

d. All radionuclides were below the limit of detection.

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Figure 61. Tritium concentrations in RWMC wells.

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APPENDIX A
QUALITY ASSURANCE

APPENDIX A

QUALITY ASSURANCE

The objectives of the QA Program for the Radiological Environmental Surveillance Program's activities at EG&G Idaho Waste Management facilities at the INEL are to identify deficiencies in the sampling and measurement processes so that corrective action can be taken, and to ensure that the results of the monitoring programs are valid.

Specific elements used to ensure that the objectives of the QA Program are met include:

- Organizational structure and responsibilities of managerial and program personnel
- Program description and objectives
- Program basis and design
- Documented procedures that describe the materials and equipment needed, specific precautions, prerequisites, and step-by-step sampling procedures for monitoring activities
- Data quality objectives
- Document-control processes for the preparation, revision, and approval of procedures
- Sample custody
- Maintenance of records pertaining to monitoring activities, such as planning documents, data sheets, sample results, and calibration records
- Proper calibration and preventive maintenance
- Data reduction and independent validation procedures
- Analysis of quality control samples (known standards, blank samples, split samples, replicates, and resubmitted samples) to assess accuracy and precision of monitoring results
- Planned and periodic audits, as well as self-assessments.

Radioanalytical laboratories provide acceptable results on quality control samples. Program personnel determine whether the analytical results for the control samples are acceptable. The sample media, activity in the quality control sample, and type of analysis are taken into consideration. Each set of known values and laboratory results receives individual consideration. Quality control samples representative of the EM Program air particulate, soil, biota, and water samples are submitted for each sample type. Quality control samples, prepared by EG&G Idaho Radiochemistry, reflect the concentration levels found in environmental samples.

APPENDIX B

DETECTION LIMITS

APPENDIX B

DETECTION LIMITS

RADIOCHEMICAL ANALYSIS DETECTION LIMITS

Approximate detection limits of present methods used to analyze samples discussed in this report are listed in Tables B-1, B-2, and B-3 for a variety of radionuclides. The limits are based on sample sizes and forms as described in this report. Actual detection limits may vary depending upon background, yield, counting time, and sample volume.

The detection limits given in Table B-1 in terms of activity per unit weight or volume are derived from the total activities in microcuries (μCi) that must be present in the sample aliquot. The detection limits are calculated under the following conditions: a counting time of 1000 minutes, a counting efficiency of about 25%, a chemical yield of about 80%, a clean detector and reagent blanks giving not more than about 5 counts in 1000 minutes in any given energy interval, and calculated according to the definition of detection limits given by L. A. Currie. The detection limit equals $(2.71 + 4.66 B^{1/2}) / (t \times E \times Y \times 2.22E + 6)$ total μCi , where "B" is the total background and blank correction; "t" is the counting time in minutes; "E" is the counting efficiency as a fraction; "Y" is the chemical yield as a fraction, and $2.22 E+6$ is the $\text{dpm}/\mu\text{Ci}$. These absolute detection limits, in terms of total microcuries per sample, are about $3 E-6$ for Sr-90, and about $3 E-8$ for all alpha-emitting nuclides. To determine the detection limits as activity concentration, as given in Table B-1, the absolute detection limits must be divided by the sample size taken for analysis. On samples, the activity found is divided by the actual sample size analyzed or reported in terms of total activity per sample.

Quality assurance samples are prepared as nearly identically to the real samples as possible. Air samples are simulated by spotting known quantities of activity as uniformly as possible over the filters and drying. Water solutions will

contain known quantities of water-soluble tracer solutions.

For soils, 25-g samples of real, minus 200 mesh soil containing exactly known quantities of the radionuclides of interest homogeneously distributed throughout the sample are submitted, of which 10-g samples are analyzed. For dried vegetation and animal tissue, vegetation (avg wt 100 g), mice (avg wt 55 g), or ground squirrels (avg wt 85 g) are spiked inhomogeneously with known quantities of radionuclides evaporated to dryness on about 100 mg of clean, dry, minus 100-mesh soil to obtain quantitative transfer without wetting the samples. These samples may not be subdivided without complete dissolution because of their fundamental inhomogeneity.

Two levels of activity are necessary to check both the stated detection limits and to determine the accuracy and precision with which larger activities can be measured. The lower level consists of activities from about 1.5 to 5 times the stated absolute detection limit to maximize the influence of backgrounds, blanks, and incomplete separation of interferences from the sample on the net activity being measured. No attempt is made to verify stated detection limits by analysis of blank samples. This is due to the statistical uncertainty of a net result obtained by subtracting a reagent blank from a sample that is also blank. Also, several different types of problems can give a blank result even when considerable activity is present. For example, there could be a complete loss of the radionuclide being determined in the absence of a tracer, complete exchange, or sample dissolution, or failure to turn up the high voltage to the detector or power up the instrument. The higher level consists of activities sufficiently high to distinguish clearly the true result being obtained from results that are vastly different because of poor statistics. This precision requires from 500

to 2500 counts under the conditions described, or about 1 to 6 pCi per sample. The precision of measuring the higher level of activity is not affected significantly by small activities of contamination in tracers and blanks. Therefore, it is incorrect to define the higher level in terms of multiples of the stated detection limit.

In barren rocks, water, air dusts, blanks, etc., the detection limits for U-238, U-235, and U-234 are essentially the same as those quoted above for other alpha-emitting nuclides. However, the entire crust of the earth contains about $2.5 \times 10^{-4}\%$ natural uranium, which is equivalent to about 1 pCi/g each of U-238 and U-234 and about 5×10^{-2} pCi/g of U-235. This is 333 times the ideal detection limit for a 10-g sample of soil and would render both U-238 and U-234 detectable in air dusts, water smears, etc., containing more than 30 mg of average soil. Consequently,

analytical detection limits are meaningless for such types of samples already containing uranium naturally. In addition, the natural level of uranium can vary by a factor of 5- to 10-fold from the average, either up or down, so that levels of at least 5 to 10 pCi/g would be required to give some confidence that uranium had been detected above the natural levels. An almost catastrophic accident would be required in order for this much uranium to be released over any significant area from a burial site, processing plant, etc. Also, low-grade uranium ores containing 100 times the average are common, such as phosphate rock used in the manufacture of elemental phosphorous. The practical detection limit for air dusts, vegetation, animal tissues, water, etc., depends on how much soil is present in the samples. Isotopic ratios of U-238 to U-234 would be of some assistance but both enriched (in U-234) and depleted uranium occur commonly in nature.

GAMMA SPECTROMETRIC ANALYSIS DETECTION LIMITS

Tables B-2 and B-3 give absolute detection limits in the right-hand column for each sample type. The absolute detection limits are the total activities that should be present in the sample aliquot taken for analysis to be detected under the counting conditions described and calculated according to the definition of L. A. Currie. This definition is: detection limit = $(2.71 + 4.66 B^{1/2}) / (t \times E \times P \times 2.22)$ where "B" is the total correction in counts (Compton, background, blanks, etc., for the same counting time); "t" is the counting time in minutes; "E" is the counting efficiency as a fraction; "P" is the gamma-ray emission probability for the particular gamma ray being measured, and 2.22 is the dpm/pCi.

The figures in the left-hand column of each sample type give the same detection limits expressed in terms of pCi/unit weight or volume for the average sample sizes expected to be analyzed. Because the absolute detection limits must remain constant for a given counting time and efficiency, the detection limits in terms of concentrations become higher or lower as the sample size actually used in the analysis becomes smaller or larger. Shown in Table B-4 are descriptions of environmental monitoring samples for gamma spectrometry analysis and counting conditions for stated detection limits.

Quality assurance samples are prepared as identical to the real samples as possible. Air samples are simulated by spotting known quantities

of activity as uniformly as possible over the filters and drying. Water solutions will contain known quantities of water-soluble tracers in dilute nitric acid. For soils, approximately 700 g of barren soil are spiked with soil standards containing exact known quantities of the radionuclides of interest homogeneously distributed throughout the sample. For dried vegetation and animal tissue, vegetation (avg wt 100 g), mice (avg wt 55 g), and ground squirrels (avg wt 85 g) are spiked as homogeneously as possible with exactly known quantities of tracer solutions evaporated to dryness on about 100 mg of clean, dry minus 100-mesh soil to enable quantitative transfer to the samples without wetting.

Two levels of activity are necessary to check both the stated detection limits and to determine the accuracy and precision with which larger activities can be measured. The lower level consists of activities from about 1.5 to 5 times the stated absolute detection limits to maximize the influence of backgrounds, blanks, and interferences from the sample on the net activity being measured. Specifically, no attempt is made to verify stated detection limits by analysis of blanks due to the large statistical uncertainties of net results obtained from subtracting blanks from samples that are also blank. The higher level consists of sufficient activity to permit relative standard deviations of 1 to 5% to minimize statistical uncertainties and make clearer the precision and accuracy being obtained.

Table B-1. RESP samples for radiochemical analysis.

Media	Sample Description	Method of Treatment	Detection Limits ($\mu\text{Ci/g}$ or mL)	
Air	Sampled approximately at 4 cfm for 2 weeks on Versapor 1200 filters, 6 filters per quarter for a total of $\sim 1.7 \times 10^{10}$ cc of air.	Dry ash, dissolve and analyze the total sample of 6 filters.	Sr-90	2×10^{-16}
			Pu-238	2×10^{-18}
			Pu-239	2×10^{-18}
			Am-241	2×10^{-18}
Water	4-L collapsible polyethylene container containing 25 mL of conc. HNO_3 and 2 Whatman ashless filter tablets for 4000 mL water.	Separate and dissolve paper pulp, reconstitute sample, and boil down to 100 mL. Analyze 1/2 sample or 2-L equivalent.	Sr-90	2×10^{-9}
			Pu-238	2×10^{-11}
			Pu-239	2×10^{-11}
			Am-241	2×10^{-11}
Soil	At least 25 g in appropriate container. Larger quantities are permissible if convenient.	Analyze 10-g sample.	Sr-90	3×10^{-7}
			Pu-238	3×10^{-9}
			Pu-239	3×10^{-9}
			Am-241	3×10^{-9}
Vegetation	16-oz squat jar filled to rim below threads (avg wt 150 g).	Dry ash and dissolve the total sample completely. Analyze the equivalent of 50 g of original sample.	Sr-90	6×10^{-8}
			Pu-238	6×10^{-10}
			Pu-239	6×10^{-10}
			Am-241	6×10^{-10}
Animal Tissue	16-oz squat jar containing 10 dried deer mice, or 1 dried ground squirrel (avg wts: mice, 170 g; squirrel, 100 g).	Dry ash, dissolve, and analyze the equivalent of 50 g of the original sample.	Sr-90	3×10^{-8}
			Pu-238	3×10^{-10}
			Pu-239	3×10^{-10}
			Am-241	3×10^{-10}

Table B-2. RESP air, water, and soil samples for gamma spectrometry.

Radionuclides	Air Filters		Water Filtrate		Water Insoluble		Soils	
	10 ⁻⁹ pCi/mL	Total pCi	10 ⁻² pCi/mL	Total pCi	10 ⁻⁴ pCi/mL	Total pCi	pCi/g	Total pCi
Sc-46	1	6	0.2	8	5	2	0.19	120
Cr-51	5	30	1.1	44	20	8	0.5	300
Mn-54	0.5	3	0.5	20	3	1.2	0.1	60
Co-58	0.5	3	0.09	3.6	4	1.6	0.1	60
Fe-59	0.9	5.4	1.5	60	7	2.8	0.11	60
Co-60	0.8	4.8	0.8	32	6	2.4	0.2	120
Zn-65	1	6	0.5	20	15	6	0.2	120
Nb-94	0.5	3	0.15	6	4	1.6	0.1	0.6
Nb-95	0.5	3	0.11	4.4	80	32	0.1	0.6
Zr-95	0.8	4.8	0.3	8	7	2.8	0.11	0.6
Ru-103	0.7	4.2	0.16	6.4	4	1.6	0.1	0.6
Ru-106	5	30	0.12	4.8	40	1.6	0.5	300
Ag-110m	0.5	3	0.15	6	5	20	0.1	60
Sb-124	0.5	3	0.13	5.2	5	2	0.1	60
Sb-125	1.5	9	0.3	12	15	6	0.2	120
Cs-134	0.6	3.6	0.09	3.6	4	1.6	0.1	60
Cs-137	0.8	4.8	0.3	12	20	8	0.1	60
Ce-141	0.9	5.4	0.3	12	6	2.4	0.1	60
Ce-144	5	30	1.0	40	20	8	0.4	240
Eu-152	2	12	0.5	20	15	6	0.2	120
Eu-154	2	12	0.3	12	15	6	0.3	180
Eu-155	2	12	0.8	32	10	4	0.3	180
Hf-181	0.6	3.6	0.12	4.8	6	2.4	0.1	60
Ta-182	0.9	12	0.5	20	20	8	0.4	240
Hg-203	0.5	3	0.15	6	2	0.8	0.1	60
Am-241	4	24	1.5	60	40	16	1.2	700
Gross Beta	9.5							
Gross Alpha	3.3							

Table B-3. RESP biotic samples for gamma spectrometry.

Radionuclides	Small Mammals		Vegetation	
	pCi/g	Total pCi	pCi/g	Total pCi
Sc-46	0.2	12	0.07	12
Cr-51	1.4	84	0.4	67
Mn-54	0.18	11	0.05	8.4
Co-58	0.3	18	0.05	8.4
Fe-59	0.6	36	0.08	14
Co-60	1	60	0.1	17
Zn-65	0.7	42	0.13	22
Nb-94	0.2	12	0.05	8.4
Nb-95	0.2	12	0.04	6.7
Zr-95	0.3	18	0.07	8.4
Ru-103	0.2	120	0.04	6.7
Ru-106	2	12	0.5	8.4
Ag-110m	0.2	12	0.05	8.4
Sb-124	0.2	12	0.04	6.7
Sb-125	0.7	42	0.11	18
Cs-134	0.3	18	0.04	6.7
Cs-137	1.3	78	0.13	22
Ce-141	0.2	12	0.05	8.4
Ce-144	1.1	66	0.16	27
Eu-152	0.6	36	0.1	17
Eu-154	0.7	42	0.15	25
Eu-155	0.6	36	0.1	17
Hf-181	0.2	12	0.04	6.7
Ta-182	1.1	66	0.3	50
Hg-203	0.16	96	0.05	8.4
Am-241	2	120	0.3	50

Table B-4. Description of RESP samples for gamma spectrometry analysis.

Media	Sample Description	Conditions of Counting
Air	Sampled at approximately 4 cfm for 2 weeks on 4-in. Versapor 1200 membrane filters for a total of 3×10^9 cc per filter.	Monthly composite samples of two 4-in. filters containing a total of about 6×10^9 cc of air are held flat over the detector and counted for 12 to 16 hours dependency on the detector system used.
Water	4-L collapsible polyethylene container containing 25 mL of conc. HNO_3 and two Whatman ashless filter paper tablets for 4000 mL of water.	The sample is shaken vigorously to dislodge all material from the sides and bottom of the container and filter. The filtrate is transferred to a 4-L Marinelli beaker and counted for 16 hours. The filter and paper pulp are also counted for 16 hours in contact with detector. Sample size, 4000 mL.
Soil	16-oz squat jar filled to the bead below the threads after settling.	The sample is counted in the squat jar for 2 hours with the jar being rotated as close to the detector as possible. Sample size approximately 700 g.
Vegetation	16-oz squat jar filled to the bead below the threads after settling.	The dry sample is counted in the squat jar for 16 hours with the jar being rotated as close to the detector as possible. Sample size about 150 g, average.

APPENDIX C
STATISTICAL ANALYSIS METHODS

AIM

Association for Information and Image Management

1100 Wayne Avenue Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

2 of 2

APPENDIX C

STATISTICAL ANALYSIS METHODS

GENERAL

Statistical considerations are important in sampling program design, whether for large or small sampling efforts, and all sampling data must be interpreted in light of the inherent statistical nature of the sampling and analytical processes. This appendix summarizes the statistical methods used in the analysis of RESP data. These methods are detailed in Blackwood¹ and are designed to be consistent with RESP data quality objectives (DQOs).

DATA PRETREATMENT AND VALIDATION

Prior to using data for comparative purposes, data are prescreened to ensure no gross data errors occur, such as transcription errors, needlessly missing values, data points out of range, and data points that do not meet other specific criteria. Initial screening includes eliminating data from instruments not meeting minimum required operating characteristics as specified in the DQOs. DQOs state that laboratory analytical uncertainties on each measurement must have a coefficient of variation (CV) of $\leq 33\%$ if data are to be used to report a quantitative result for comparison to action levels for the various monitoring activities. A CV of between 33% and 50% is required for use in trend analysis. A CV greater than 50% is taken to indicate a measurement is indistinguishable from zero. For individual measurements, these are suitable guidelines. For measurements combined for calculating means or trends, these restrictions are unnecessary, as long as the uncertainties are taken into account in the analysis.

Once the basic checks for errors and operating criteria are complete, the data are screened for outliers. Graphical techniques (e.g. probability plots, stem and leaf plots, box plots, and other

exploratory data analysis techniques) are the primary tools used for detecting potential data outliers. In cases where outliers are traceable to a specific error, a corrected value may be used to replace the outlier. If no correction is possible, then the point is deleted from the data set. Rarely are outliers with unattributable causes eliminated from the data set. Such outliers may be truly accurate data measurements indicative of unusual but important phenomena. In these cases, two sets of analyses are performed with the outlier(s), one with and one without providing results that can be compared.

DISTRIBUTIONAL ANALYSIS

Most of the preferred methods for uncertainty interval calculation and other analyses of data using classical statistical methods assume a normal distribution for the data. The power and versatility of these techniques makes their use preferable if the normality assumption can be met. If the data are not normally distributed but a mathematical transformation of the data produces values that are normally distributed, then the same techniques can be applied to the transformed data. If no suitable transformation can be found, the usual alternative is to use nonparametric analysis (although parametric techniques for non-normally distributed data are sometimes available). Nonparametric techniques are generally not as powerful as parametric techniques performed on normally distributed data, but are often more powerful than normal based techniques used on non-normal data. Given these considerations, an important first step in the detailed analysis of each type of monitoring data is to attempt to determine the proper distribution for the data.

Two aspects of distributions of measurements are of interest. First is the distribution of sampling or measurement error associated with individual observations. This distribution is important in determining individual measure-

ment confidence intervals. The second distribution is the distribution among multiple measurements over time at a specific location. This distribution is required for trend analysis and comparisons among measurements. As described below, the distribution across measurements is affected by the distribution of the sampling or measurement error.

Distributional tests are always based on at least ten measurements. Data from several recent years are sometimes combined to provide more power in the distributional tests. The number of points from the past to use depends in part on whether there are trends in the data. Data can be used without problem for as far back in time as there appears to be no significant trends. If there are obvious trends in the data, the distributional tests are performed on detrended data (i.e., residuals after fitting models with trend effects). Adequate estimation of trends for the purpose of distributional analysis can be obtained using least squares methods of estimation, although the usual tests of significance for trends will be suspect unless the data are approximately normal. In examining the data for trends, both the raw data and log transformed data are sometimes plotted; trends may appear more readily in the log transformed data.

While tests on small sets of monitoring data may indicate an adequate fit of the normal distribution to data collected over time at a specific location, such results may be due to lack of power in the test. Other distributions may fit better, even when an adequate fit to a normal is indicated. Thus the focus in the distributional analysis is on comparing the fit of the untransformed data to a normal distribution to the fit obtained after various data transformations. The logarithmic transformation (resulting in the lognormal distribution if the transformed data are normally distributed) is the obvious first choice among transformations, but others may apply as well. A measurement model developed for monitoring data and analysis of previous years data for several of the monitoring activities indicates that better normal fits will often be obtained after some form of transformation. For example, analysis of 90-91

data for gross alpha and gross beta air monitor data indicate that the normality assumption is never valid, and that either a square root or logarithmic transformation applied to the data is best for achieving normality.

Basic distributional testing of the monitoring data consists of examining normal probability plots for at least the raw data, logarithmic transformed data, and square root transformed data. The Shapiro-Wilk test for normality is also performed for each of the three distributions to determine the best fitting distribution for the data. Other transformations may be considered as deemed necessary.

The coefficient of variation for the raw data is also sometimes used as an indicator of the type of distribution to expect. Positive valued data with a CV of greater than 50% are unlikely to be normal. Conversely, data sets with large numbers of negative values cannot be considered lognormally distributed or square root normal, since neither distribution allows negative values. The logarithmic or square root transformed data can be used if there are only a few negative values and the transformed positive values fit a normal distribution well. (In some cases it may make sense to substitute small positive values—such as 1/2 the detection limit—for the negative values to be able to include all the points in an analysis on the transformed data.)

COMPARISON OF INDIVIDUAL MEASUREMENTS TO SPECIFIC LIMITS

Most of the monitoring activities have as an objective the comparison of measured values to specific stated limits. These limits are generally derived concentration guides, regulatory standards, or action levels based on directives or standard operating procedures. (For simplicity, the discussion that follows uses the term action level generically to refer to all three types of limits.)

Comparisons to action levels are distinguished from comparisons to other measured values because the action levels are fixed quantities,

without error. (Comparing two measured values involves error in both values). Comparing individual values to action levels is achieved by calculating a 95% confidence interval for the measurement and comparing it to the action level. If the action level for that measurement is greater than the upper bound of the confidence interval, then we can conclude with 95% confidence that the measured value is significantly lower than the action level. Since the concern is always whether or not the observed level exceeds the corresponding limit, a one sided confidence interval is used.

In calculating confidence intervals, two issues are of concern: estimating the size of the errors in the sampling or measurement process and the distribution of those errors. Analytical or measurement error alone (the value reported by the analysis laboratory) should rarely be used to infer a confidence interval for any of the monitoring measurements. Analytical error is only one component of the overall error. The other major component is sampling error which includes variability due to sample preparation, sample variability (e.g., due to extracting only a portion of an air filter for analysis), sample handling, sample processing, etc. Analytical error is in fact often the smallest component of the overall measurement error.

Sampling and measurement error estimates are based on replicate data whenever possible. For example, for gross alpha and gross beta air monitor measurements, replicates are available by using the paired data for locations at which two samplers have been located. Replicate data for penetrating radiation monitoring is obtainable from the five thermoluminescent dosimeter chips placed at each measurement location.

TREND ANALYSIS

Short Term Trends or Changes

The DQOs for the various monitoring activi-

ties generally refer to evaluation of trends in relation to background levels. Background levels may be location specific (i.e., the background locations at RWMC and WERF) or general (i.e., RESL's background locations). Comparing current measurement values at each location to the value for the previous recording period is a form of trend analysis (perhaps more appropriately called change analysis), suitable for looking for abrupt changes during the year.

Statistical comparison of current measurement values to previous values at a specific location is obtained using sampling or measurement error variance estimates (as described in Blackwood¹) and an estimate of the covariance of sequential measurements. (It is assumed here that the data exhibit positive autocorrelation. That is, current and previous measurement values at a specific location are positively correlated). Formulas for calculating autocovariance and tests of significance for sequential measurements are given in Blackwood.¹

Long Term Trends

General evaluation of long term trends is primarily achieved graphically, by plotting values for specific locations and for appropriate background locations on the same graph. Even when the data test to be different from lognormal, longer term trends will be most influenced by the lognormal characteristics of the true values (e.g., changes will more likely be multiplicative rather than additive in nature); therefore, the trend data is plotted using a logarithmic measurement axis. Since the focus is on comparative changes relative to background, another graphical alternative is to calculate the differences (or ratios in the case of lognormal data) between location measurements and background. These values will be detrended with regard to cyclical and other variations affecting background and site locations equally, so that any observable trend will be immediately attributable to a change in the site location relative to the background location.

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APPENDIX D

ENVIRONMENTAL STANDARDS

APPENDIX D

ENVIRONMENTAL STANDARDS

RADIOLOGICAL MONITORING AT WASTE MANAGEMENT FACILITIES

Radionuclide concentrations in air and subsurface water samples collected at the RWMC, the WERF, and the MWSF are compared with DCG values for air and water.¹ The DCG values listed are provided as reference values for conducting radiological protection programs at operational DOE facilities and sites. The DCG values for internal exposure are based on a committed effective dose equivalent (EDE) of 100 mrem for the radionuclide taken into the body by ingestion or inhalation during one year. Radionuclide concentrations in soil samples are compared to environmental concentration guidelines for soils, based on an onsite "homesteader."

Table D-1 lists applicable DCGs. The DCGs represent the concentrations of radioactivity in air inhaled or water ingested continuously during a year that resulted in a 100-mrem, 50-year committed EDE. The DCGs are used as a point of reference only. Comparison of individual measurements to the DCGs gives the maximum dose a person could receive at the location where the sample was collected, given the following two assumptions: (1) that the concentration was at the DCG level continuously for the entire year,

and (2) the person receiving the exposure was at that location for the entire year, continually drinking the water or inhaling the air. In practice, DCGs are rarely, if ever, exceeded for even a short period during the year. In addition, the radionuclide concentration at any area accessible to the public will be even less due to the dispersion from the facility boundary (where the sample was taken) to the site boundary (the closest location where the public has unrestricted access).

Table D-2 lists environmental concentration guidelines for the radionuclides in soil that are most likely to be found in environmental samples collected at the RWMC. The concentration guides in Table D-2 are based on a homestead scenario. This scenario considers the radiation dose to the homesteader from inhalation and ingestion of radionuclides, as well as external radiation. Since the hypothetical homesteader is living on the contaminated area, this scenario results in very conservative concentration guides. The homestead scenario provides overestimates of the actual doses that would be received by off-homestead individuals from waste radionuclides in soil at the RWMC.

SUBSURFACE WATER

The environmental regulations that apply to the drinking water monitoring program are as follows: the Federal Safe Drinking Water Act, Code of Federal Regulations (40 CFR Parts 141-143); the Idaho Regulations for Public Drinking Water Systems, IDAPA 16.01.08000-.08999;³ DOE Order 5400.5, Part D; and Environmental Compliance Planning Manual (see Table D-3).

In addition to the eighteen regulated VOCs,

unregulated organic compounds are monitored and reported.

The INEL is a nuclear facility, which implies that radiological contamination of the drinking water is a possibility. Because of the possibility of radiological contaminants, EG&G Idaho monitors for gross alpha/beta and tritium (see Table D-4) as recommended in IDAPA 16.01.08100,06.

Table D-1. Derived concentration guides (DCGs).

Radionuclide	DCGs for the Public ^{a,b}	
	DCG for Air ($\mu\text{Ci/mL}$)	DCG for Water ($\mu\text{Ci/mL}$)
H-3	1×10^{-7}	2×10^{-3}
Sc-46	6×10^{-10}	2×10^{-5}
Cr-51	5×10^{-8}	1×10^{-3}
Mn-54	2×10^{-9}	5×10^{-5}
Co-58	2×10^{-9}	4×10^{-5}
Fe-59	8×10^{-10}	2×10^{-5}
Co-60	8×10^{-11}	5×10^{-6}
Zn-65	6×10^{-10}	9×10^{-6}
Sr-90	9×10^{-12}	1×10^{-6}
Nb-95	3×10^{-9}	6×10^{-5}
Zr-95	6×10^{-10}	4×10^{-5}
Ru-103	2×10^{-9}	5×10^{-5}
Ru-106	3×10^{-11}	6×10^{-6}
Ag-110m	2×10^{-10}	1×10^{-5}
Sb-125	1×10^{-9}	5×10^{-5}
I-129	7×10^{-11}	5×10^{-7}
I-131	4×10^{-10}	3×10^{-6}
Cs-134	2×10^{-10}	2×10^{-6}
Cs-137	4×10^{-10}	3×10^{-6}
Ce-141	1×10^{-9}	5×10^{-5}
Ce-144	3×10^{-11}	7×10^{-6}
Eu-152	5×10^{-11}	2×10^{-5}
Eu-154	5×10^{-11}	2×10^{-5}
Ra-226	1×10^{-12}	1×10^{-7}
Pu-238	3×10^{-14}	4×10^{-8}
Pu-239 ^c	2×10^{-14}	3×10^{-8}
Am-241	2×10^{-14}	3×10^{-8}
U-235	1×10^{-13}	6×10^{-7}
U-238	1×10^{-13}	6×10^{-7}
Gross Alpha ^c	2×10^{-14}	
Gross Beta ^c	9×10^{-12}	

a. This table contains the air and water DCGs based on concentrations that could be continuously inhaled or ingested, respectively, and do not exceed an effective dose equivalent of 100 mR/yr.

b. DCGs apply to radionuclide concentrations in excess of those occurring naturally or due to fallout.

c. The DCGs of Pu-239 and Sr-90 are the most restrictive for alpha- and beta-emitting nuclides, respectively, and are appropriate to use for gross alpha and gross beta DCGs.

Table D-2. Environmental concentration guidelines for common radionuclides found in environmental soil samples collected at the RWMC.

Radionuclide	Environmental Concentration Guides for Soil ^a ($\mu\text{Ci/g}$)
Mn-54	4×10^{-6}
Co-58	4×10^{-6}
Co-60	1×10^{-6}
Ru-106	2×10^{-5}
Sb-125	8×10^{-6}
Cs-134	2×10^{-6}
Cs-137	6×10^{-6}
Ce-144	6×10^{-5}
Eu-152	3×10^{-6}
Am-241	4×10^{-5}
Sr-90	6×10^{-6}
U-232	2×10^{-6}
U-233	2×10^{-4}
U-234	2×10^{-4}
U-235	2×10^{-5}
U-238	1×10^{-4}
Pu-238	8×10^{-5}
Pu-239,-240	8×10^{-5}

a. See Reference 2. Concentrations correspond to a 50-yr dose commitment of 100 mrem/yr to a homesteader beginning in the first year after release of facility. This concentration assumes uniform contamination of an area adequate for subsistence farming.

Table D-3. Standards for volatile organic compounds.

REGULATED VOCs	
Parameter	Maximum Contaminant Level (mg/L)
Benzene	0.005
Vinyl Chloride	0.002
Carbon Tetrachloride	0.005
1,2-Dichloroethane	0.005
Trichloroethylene	0.005
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.200
para-Dichlorobenzene	0.075
cis-1,2-Dichloroethylene	0.07
1,2-Dichloropropane	0.005
Ethylbenzene	0.7
Monochlorobenzene	0.1
o-Dichlorobenzene	0.6
Styrene	0.1
Tetrachloroethylene	0.005
Toluene	1.0
Trans-1,2-Dichloroethylene	0.1
Xylenes (total)	10.0
UNREGULATED VOCs WITH NO MCL	
Chloroform	o-Chlorotoluene
Bromodichloromethane	p-Chlorotoluene
Chlorodibromomethane	Bromobenzene
Bromoform	1,3-Dichloropropene
m-Dichloromethane	Ethylene Dibromide
Dichloromethane	1,2-Dibromo-3-Chloropropane
Dibromomethane	1,2,4-Trimethylbenzene
1,1-Dichloropropane	1,2,4-Trichlorobenzene
1,1,1,2-Tetrachloroethane	1,1-Dichloroethane
Chloroethane	1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane	1,3-Dichloropropane
2,2-Dichloropropane	Chloromethane
Bromomethane	Isopropylbenzene
1,2,3-Trichlorobenzene	Tert-Butylbenzene
n-Butylbenzene	SEC-Butylbenzene
Napthalene	Fluorotrichloromethane
Hexachlorobutadiene	Dichlorodifluoromethane
1,3,5-Trimethylbenzene	Bromochloromethane
p-Isopropylbenzene	1,2,3-Trichloropropane

Table D-4. Applicable radiological drinking water standards.

Parameter	Maximum Contaminant Level (pCi/L)
Gross Alpha	15
Gross Beta	50
Tritium	20,000

REFERENCES

1. Department of Energy, "Radiation Protection of the Public and the Environment," DOE Order 5400.5, February 8, 1990.
2. EG&G Idaho, Inc., *Development of Criteria for Release of Idaho National Engineering Laboratory Sites Following Decontamination and Decommissioning*, EGG-2400, August 1986.
3. Idaho Regulations for Public Drinking Water Systems, IDAPA 16.01.08000-.08999, December 5, 1992

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