AN OVERVIEW OF ENVIRONMENTAL SURVEILLANCE OF WASTE MANAGEMENT ACTIVITIES AT THE IDAHO NATIONAL ENGINEERING LABORATORY[a]

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ABSTRACT

The Idaho National Engineering Laboratory (INEL), in southeastern Idaho, is a principal center for nuclear energy development for the Department of Energy (DOE) and the U.S. Nuclear Navy. Fifty-two reactors have been built at the INEL, with 15 still operable.

Extensive environmental surveillance is conducted at the INEL by DOE's Radiological Environmental Sciences Laboratory (RESL), the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), EG&G Idaho, Inc., and Westinghouse Idaho Nuclear Company (WINCO). Surveillance of waste management facilities is integrated with the overall INEL Site surveillance program. Air, water, soil, biota, and environmental radiation are monitored or sampled routinely at the INEL.

Results to date indicate very small or no impacts from the INEL on the surrounding environment. Environmental surveillance activities are currently underway to address key environmental issues at the INEL.

INTRODUCTION

Extensive environmental surveillance is conducted at the Idaho National Engineering Laboratory (INEL) of the Department of Energy (DOE). Surveillance of waste management facilities is integrated with the overall INEL Site surveillance program.

The following four components of the surveillance program will be briefly discussed in this paper. (1) Continuing surveillance of environmental impacts on the Site, at the Site boundary, and at nearby communities is performed by DOE's Radiological and Environmental Sciences Laboratory (RESL). (2) The Snake River Plain aquifer, which underlies the INEL, is monitored by the U.S. Geological Survey (USGS). (3) Surveillance at INEL facilities, including waste management facilities, is conducted by their respective operating contractors. (4) Special surveillance studies are conducted. The discussion focuses on monitoring the environmental impacts of waste management activities, rather than on monitoring facility releases for purposes of showing regulatory compliance.

DESCRIPTION OF SITE

The INEL Site, in southeastern Idaho, is a principal DOE center for nuclear energy development and for support of the U.S. Nuclear Navy. Through 1984, 52 reactors had been built at the INEL; 15 are operating or operable. Also included is a fuel reprocessing facility, the Idaho Chemical Processing Plant (ICPP). See Fig. 1 for locations of major facilities.

Abbreviations:

ANL-W	Argonne National Laboratory-West
ARA	Auxiliary Reactor Area
CFA	Central Facilities Area
EBR	Experimental Breeder Reactor
ICPP	Idaho Chemical Processing Plant
LOFT	Loss-of-Fluid Test Facility
NRF	Naval Reactors Facility
PBF	Power Burst Facility
PREPP	Process Experimental Pilot Plant
RWMC	Radioactive Waste Management Complex
SWEPP	Stored Waste Examination Pilot Plant
TAN	Test Area North
TRA	Test Reactor Area
WERF	Waste Experimental Reduction Facility

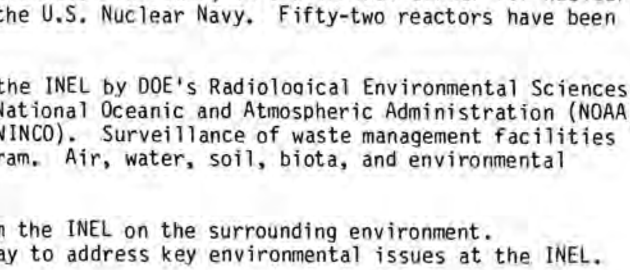

Fig. 1. Major Facilities at the INEL.

Operation of these facilities generates several types of waste. High-level liquid waste is stored in stainless-steel tanks at the ICPP, calcined on a campaign basis, then stored in stainless-steel bins encased in concrete vaults. *Transuranic* (*TRU*) waste, generated mostly at other DOE sites, is stored at the Radioactive Waste Management Complex (RWMC), in the southwest corner of the Site. The waste will be shipped to the Waste Isolation Pilot Plant in

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New Mexico, after certification in the Stored Waste Examination Pilot Plant (SWEPP) and processing, if necessary, in the Process Experimental Pilot Plant (PREPP). Low-level solid waste is processed, if appropriate, at the Waste Experimental Reduction Facility (WERF), then disposed of by shallow-land burial at the RWMC. Some low-level liquid waste is processed in an evaporator at the ICPP, with the concentrate managed as high-level waste. Other such waste is disposed of in seepage ponds at the ICPP and the Test Reactor Area (TRA).

The 2300-km^2 (890-mi^2) INEL Site is in a cool desert shrub biome at an average elevation of 1500 m (4900 ft). Land immediately beyond the boundaries is either desert or agricultural land. The surface is a combination of basaltic lava outcroppings and alluvial sedimentary deposits. No surface streams exit the Site, but the Snake River Plain aquifer, source of drinking and irrigation water for much of southeastern and south-central Idaho, lies beneath the Site. The Site is situated in a sparsely populated area.

ENVIRONMENTAL ISSUES

For the most part, surveillance shows that INEL activities have a very small impact on the environment, even close to facilities. However, two issues exist concerning the potential impacts of INEL operations on the environment. The first issue concerns subsurface migration of radionuclides from the TRU waste buried at the RWMC. At that location, the Snake River Plain aquifer lies 177 m (580 ft) below the land surface. The second issue is contamination of the aquifer by radioactive wastewater discharged routinely to disposal wells and shallow ponds since 1952, although only to seepage ponds at present. (The ICPP injection well was recently replaced by a seepage pond. The other injection wells were closed earlier.) The scope of INEL surveillance activities includes tasks which address these issues.

CONTINUING SURVEILLANCE ACTIVITIES

Monitoring Outside Facility Fences and Off Site

The RESL maintains a scheduled environmental monitoring program outside facility fences on site,[1] as well as off site[2] to evaluate the environmental impacts, if any, of contaminants released by INEL facilities. This is accomplished by sampling air, water, soil, and foodstuffs; measuring environmental radiation; and calculating impacts based on the quantities of contaminants released.

Filters from the RESL low-volume air sampler network are analyzed weekly. Monthly average concentrations of airborne beta-emitting particulates are plotted in Fig. 2 for INEL stations and three distant locations. The INEL and distant averages are similar; the primary influence on both has been foreign atmospheric nuclear testing.

Specific radionuclide activity in air is compared for INEL, boundary, and distant locations. For the last seven years, the only difference between boundary and distant-community averages attributable to INEL operations was in the fourth quarter of 1980. At that time, Sb-125 from the ICPP was detected at on-site and boundary stations at a maximum concentration of 0.003% of the uncontrolled area Radioactivity Concentration Guides (RCGs) of the DOE.

Nonradiological pollutants in the air at the INEL are quite low. In 1984, sulfur dioxide concentrations near the Central Facilities Area averaged 3.9 $\mu g/m^3$, or 5% of the annual primary ambient air quality standard. Nitrogen dioxide concentrations in 1984 at the same location were 5.8 $\mu g/m^3$, or 5.8% of the primary ambient air quality standard. Suspended particulate matter is usually below the annual ambient air quality standard for on-site and off-site stations. Most particulates are windblown dust from the desert floor.

Community water supplies are sampled semiannually. Alpha or beta activity is rarely detected, and then only at concentrations less than the U.S. EPA maximum contaminant levels for public community drinking water systems. Tritium has not been detected in off-site water supplies.[2]

Off-site surface soils contain natural radionuclides and radionuclides from past atmospheric nuclear testing. Due to low rainfall (22 cm per year) and to the relatively slow movement of these radionuclides through soil columns,[2] the majority of the manmade radionuclides are still in the top 5 cm in undisturbed soil.

Soils are sampled every seven years around facilities which may have contaminated soil. For example, Fig. 3 shows the Pu-239 concentration in soil near the RWMC. The presence of Pu-239 beyond the facility fence is attributed to past surface runoff due to rapid snowmelt and wind transport.

Concentrations of radionuclides in milk, wheat, lettuce, beef cattle, and sheep for the past ten years have been attributed to atmospheric testing, not INEL activities. Iodine-131 has been detected following atmospheric testing by the People's Republic of China, especially in September 1977, when one milk sample measured 200 pCi/L.

Game species (ducks, mourning dove, sage grouse, pronghorn antelope, and fish) are sampled routinely and as part of research programs.

Ambient radiation is monitored by thermoluminescent dosimeters (TLDs) at 106 on-site locations outside nuclear facilities, 36 other on-site locations, 6 boundary locations, and 6 distant locations. Many on-site locations show radiation dose rates equal to those at distant locations, but some dosimeters near waste management and other facilities show rates well above background. Since 1977, there have been no statistically significant differences between boundary and background location averages, indicating no measurable contribution from INEL activities.

Meteorology Program

RESL maintains a 26-station meteorological telemetry system to aid in predicting off-site concentrations of INEL pollutants. The National Oceanic and Atmospheric Administration (NOAA) also maintains weather towers at key INEL facilities. A windfield model (MESODIF) is used to predict pollutant recirculation caused by diurnal winds on the Snake River Plain. The model output is used to calculate dose commitments to off-site populations.

Since 1977, the potential annual whole-body dose commitment to an off-site individual residing continuously at the Site boundary has been 0.1 mrem

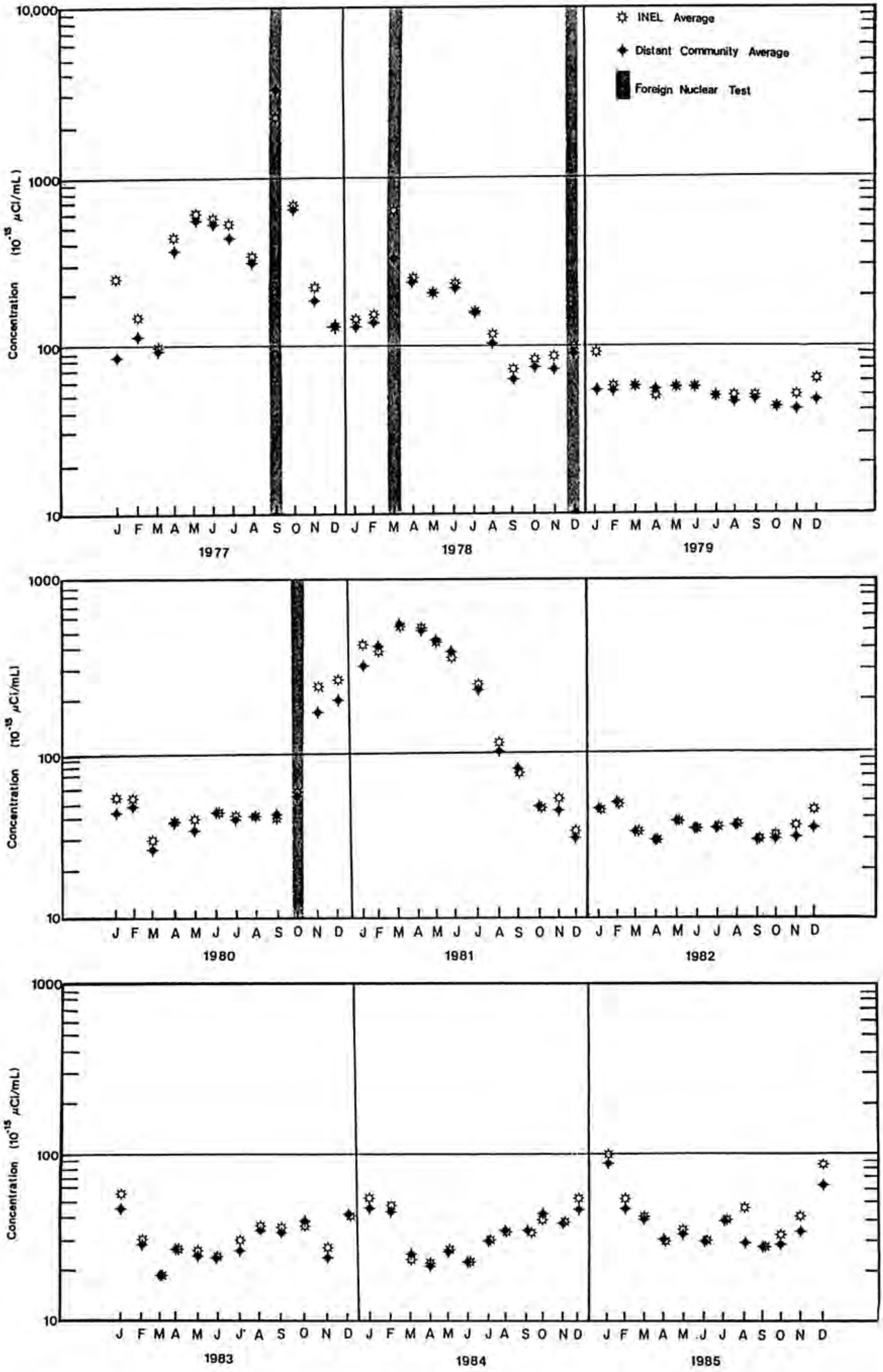


Fig. 2. Particulate Beta Concentrations In Air at INEL and Distant Locations (1977-1985).

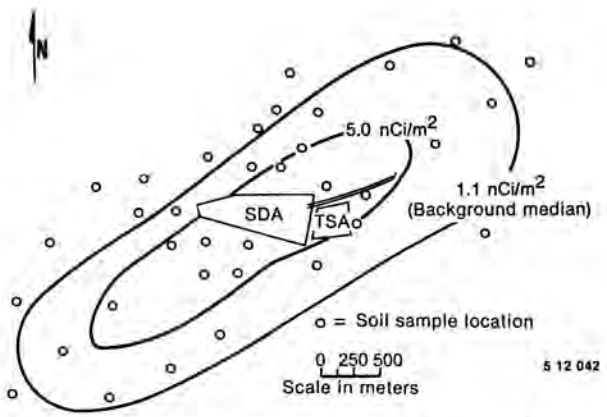


Fig. 3. 1978 Pu-239 Concentrations in Surface Soil (0-5 cm) at the Radioactive Waste Management Complex.

or less. That calculated dose is about 0.07% of the local background radiation dose rate (terrestrial, cosmic, and internal) of 140 mrem per year.

Groundwater Monitoring

The USGS routinely monitors groundwater levels and the chemical and radiological quality of the groundwater at the INEL. Radionuclide movements are traced in the Snake River Plain aquifer and bodies of perched water. Data from this program, extending back to 1950, track the degree of groundwater contamination.

Water samples are collected at approximately 140 wells and surface-water sites on the INEL and in adjacent areas to define the radionuclide content and chemical quality of groundwater entering and leaving the INEL. The type and frequency of sampling depend on disposal rates and practices, and changes in the localized inflow to, or outflow from, the aquifer and perched groundwater zones.

The water samples are analyzed for tritium, chromium-51, cobalt-60, strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/-240, americium-241, total chromium, chloride, sulfate, nitrate, and about 30 other chemical constituents.

The lateral migration distance and the area of selected waste plumes in the Snake River Plain aquifer are listed in Table I. The tritium plume is the largest, due to the disposal of wastewater to wells and ponds. It extends from ICPP and TRA to near the INEL southern boundary (Fig. 4). From 1961 (when tritium monitoring began) to 1981, 8,370 curies of tritium were discharged at ICPP. Most of the tritiated water was injected directly into the aquifer through a deep disposal well. Prior to 1967, a small part of the tritium was discharged to a waste disposal pit. Tritiated water accounts for about 99 percent of the radioactivity that was disposed of through the ICPP disposal well. Based on first-arrival times at downgradient monitoring wells, the apparent velocity of tritium migration from either the TRA radioactive waste ponds or the ICPP disposal well has ranged from 4 to 5 feet per day since disposal operations began in 1952 and 1953.[3]

Facility Monitoring

INEL facilities monitor their effluents in accordance with the type of activities at each facility.

TABLE I

Lateral Migration Distance and Area of Selected Waste Plumes in the Snake River Plain Aquifer in the South-Central Part of the INEL

Constituent	Date	Lateral Waste Migration Distance, in miles, from: ICPP	TRA	NRF	Area of Waste Plume, in Square Miles
Tritium	October 1981	7.6	7.9	0	42.1
Strontium-90	Same	2.1	0	0	2.0
Iodine-129	Same	6.2	0	0	9.5
Specific conductance	Same	5.5	6.1	11.2	27.6
Sodium	Same	3.6	--b	--b	7.9
Chloride	Same	5.3	0	10.6	26.2
Nitrate	October-December 1981	4.8	0	0	10.1

a. Adapted from Reference 3.

b. Not determined.

However, this discussion will focus on environmental monitoring (not effluent monitoring) at or near specific facilities.

Continuing environmental monitoring activities are conducted at many INEL facilities. The results indicate very small or no impacts on the immediate environment. These monitoring activities provide complementary information to the RESL monitoring, which assesses effects on site and beyond the INEL boundary.

Monitoring at EG&G Idaho Waste Management Facilities

Routine monitoring is conducted at waste management facilities operated by EG&G Idaho: The RWMC (including SWEPP), PREPP, WERF, and two completed INEL decontamination and decommissioning projects.[4] Airborne particulates, surface water, soil, plants, and animal tissues are monitored for radioactivity at the RWMC. Surface radiation surveys and perimeter radiation monitoring are also conducted. The extent of monitoring at the other EG&G-operated waste management facilities depends on the waste inventory and the extent of operations.

Generally speaking, at the above-mentioned facilities, air filters are collected and analyzed weekly for gross alpha and gross beta activity and analyzed quantitatively each month for selected gamma-emitting radionuclides. The gamma spectrometry results occasionally show extremely small concentrations of Cs-137 and other common radionuclides.

Routine surface-soil samples are collected biennially at the RWMC and less frequently at the other waste management facilities. Excavated soil from small-mammal burrows is also sampled. The soil samples are analyzed by gamma spectroscopy and radiochemistry. Radionuclides most commonly detected include Cs-137, Sr-90, Co-60, Am-241, and Pu-239, -240.

Five composite samples (depth of 0-5 cm) are collected in each of five major areas at the RWMC (designated Areas 1 to 5) and one control location (Area 7). Figure 5 shows the mean concentrations for each area for Cs-137, Sr-90, and Pu-239/-240. Areas 1 and 5 represent current operational areas; Areas 2, 3, and 4 are inactive areas. Most concentrations are less than those for the control location, because much of the RWMC surface has been covered with lakebed soil uncontaminated by fallout.

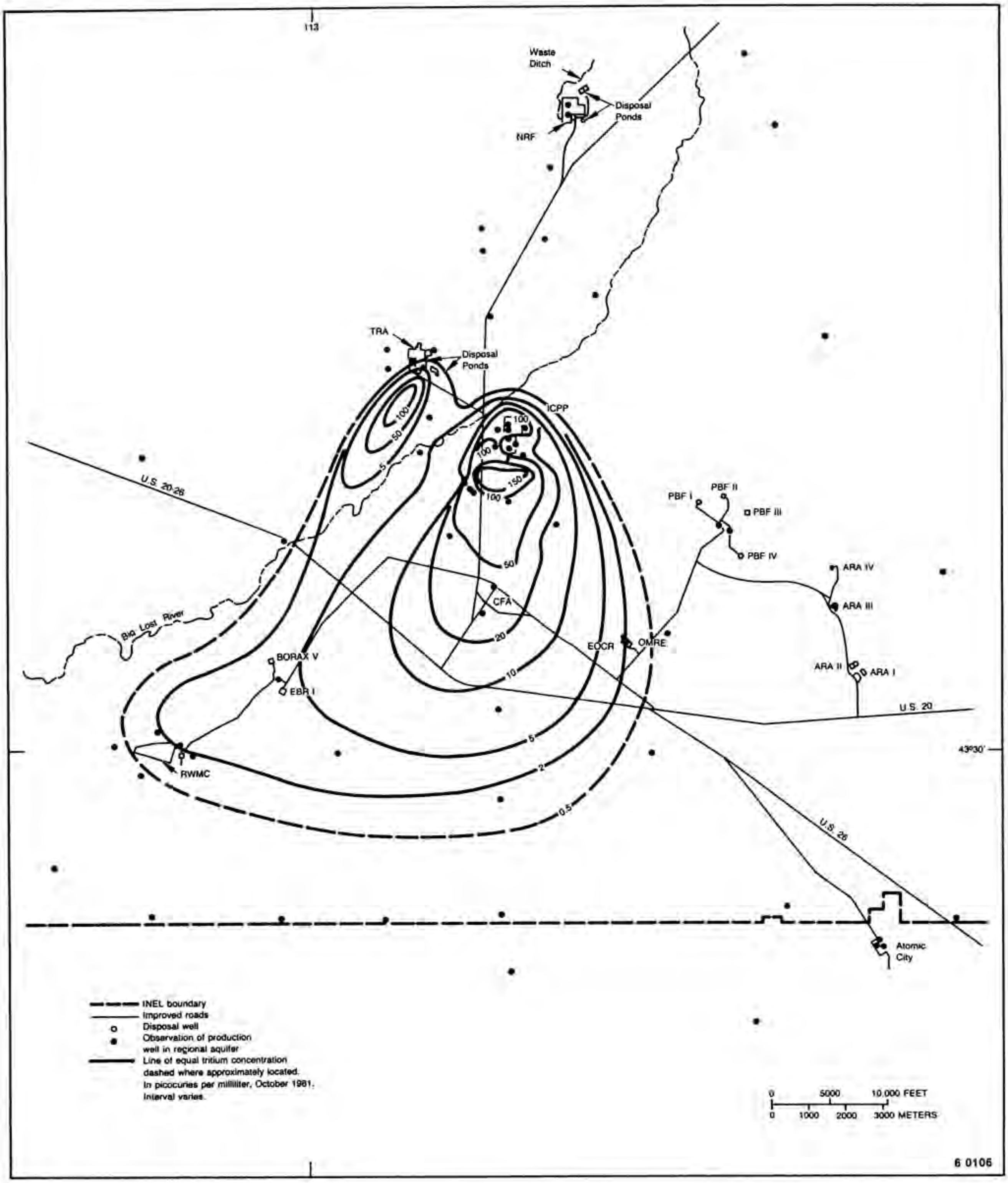


Fig. 4. Distribution of Tritium in the Snake River Plain Aquifer in the South-Central Part of INEL, October 1981 (from Reference 3.)

Surface water runoff following periods of rainfall or snowmelt is collected at RWMC locations. Cs-137, Am-241 and Pu-239, -240 are occasionally identified in both liquid and particulate fractions at near-background concentrations. RWMC runoff water does not lead directly to any potable water source.

TLD data developed by RESL and surface radiation surveys indicate that radiation levels are above background near current waste disposal and storage areas at the RWMC and other waste management facilities. Figure 6 shows that maximum six-month exposures measured by RWMC perimeter TLDs have

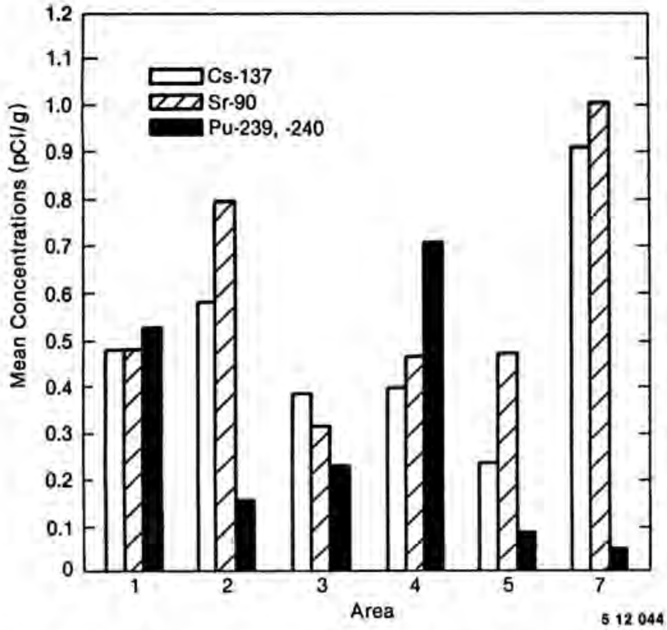
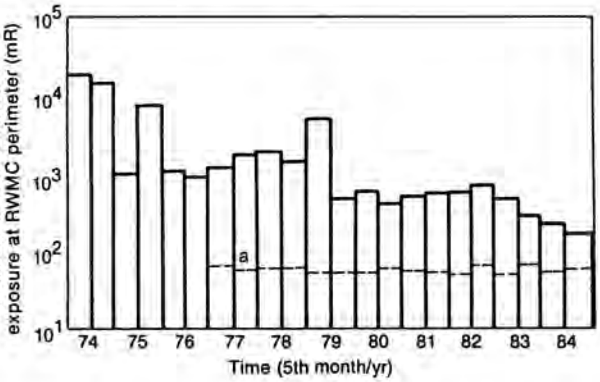


Fig. 5. Mean Radionuclide Concentrations in RWMC Surface Soils By Area.



[a]Dotted line indicates background measured at distant community stations.

5 12 045

Fig. 6 Annual Maximum RWMC Perimeter TLD Results from 1974 to 1984.

generally decreased since 1974, however, due to improved waste operational practices.

Sampling of plants and small mammals has indicated limited biotic intrusion into the waste or contaminated soil areas. In 1984, two Russian thistle plants and two summer cypress plants in the RWMC were identified with concentrations of Sr-90, Cs-137, Pu-238, and Am-241 three to four orders of magnitude higher than previously sampled plants.[5] Root uptake of radionuclides from subsurface soils or waste appeared to be the predominant source of the elevated concentrations.

Monitoring at Other INEL Facilities

Less extensive environmental monitoring is conducted at other EG&G-operated facilities. EG&G Idaho and RESL cooperate in collection and analyses of TLDs within perimeter fences of EG&G Idaho facilities. Monitoring at these facilities is being expanded.

Westinghouse Idaho Nuclear Company (WINCO) monitors ambient air at the ICPP, both continuously and on a temporary basis when work in progress might impact air quality. Water samples are collected at the production wells and analyzed for radionuclides and chemical constituents. Results are reported quarterly.

The Argonne National Laboratory-West (ANL-W) facility and the Naval Reactors Facility (NRF) also have environmental monitoring programs. Each prepares an annual environmental report.

Special Surveillance Activities

The RESL also conducts studies in radioecology and ecology. Summaries of 23 current waste management research projects and a bibliography of 59 publications have recently been published.[5] Examples of current studies include radionuclide movement and transport by biological media near liquid and solid radioactive waste areas, plutonium specification of pond liquids, trace elements in environmental media near a reprocessing plant and near coal-fired generating plants, biological intrusion at subsurface waste disposal areas, root depth of native and introduced vegetation suitable for reclamation of waste management areas, and evapotranspiration in an arid environment.

Radioecological research conducted in 1978 and 1979 at the RWMC Subsurface Disposal Area (SDA) has determined the concentrations of radionuclides in various media.[6] From these data and biomass data from other studies at the SDA, inventories of these nuclides in various potential ecological vectors for radionuclide transport were determined (Table II).

TABLE II

Radionuclide Inventories (Ci) Occurring in Ecosystem Pathways at the Subsurface Disposal Area

Pathway	Mass (kg)	^{137}Cs, ^{90}Sr	$^{238,239,240}Pu$, ^{241}Am	Total
Small-mammal soil excavations	11700	14.6	30.5	45.1
Vegetation (above ground)	36300	68.2	8.7	76.9
Coyote feces[a]	1134	6.2	1.0	7.2
Small mammals[b]	346	32.8	0.02	32.8
Cottontail rabbits[b]	23	0.01	4.3×10^{-4}	0.01

a. Feces deposited within a 6.3 km radius of SDA.

b. Tissue radionuclide inventory only.

Excavations during burrowing by small mammals is one of the more important biological pathways for radionuclide transport at the SDA. Research on radiation doses to small mammals demonstrated that approximately 50% of the deer mice population had been in burrows adjacent to buried waste or contaminated soils.[7] Current efforts seek to identify ecological conditions which enhance or reduce rodent densities.

Animal burrows may also increase water infiltration. Initial measurements of burrow characteristics in undisturbed habitats showed a maximum length, volume, and depth recorded of 9.3 m, 30 L, and 1.4 m, respectively.[5] Additional data are being collected to determine the effects of size and density of burrows on soil moisture at various depths for use in hydraulic models describing water movement in soil.

In semiarid environments, potential evapotranspiration from vegetation cover and soil surfaces of waste caps can prevent water accumulation in waste trenches. INEL studies of vegetation planted over simulated waste trenches initially indicate that 1.2 m of fill soil are probably adequate to store the annual precipitation to evapotranspiration. To adequately understand the effects of various vegetation species, movement and potential contaminant transport, information is being gathered, in both disturbed and undisturbed habitats, on root depths of native and imported species that might be planted or eventually invade INEL waste disposal areas.

Experimental plots have been established to compare the effects of different species of vegetation on surface erosion and to develop a predictive model of erosion rates on vegetated disposal areas.

To address the issue of subsurface radionuclide migration at the RWMC, subsurface studies are underway to assess migration to date and to project future migration. This ten-year program, conducted jointly by the USGS and EG&G Idaho, consists of approximately 25 interrelated studies. Three major studies underway are discussed below.

Two simulated waste trenches have been constructed near the RWMC. Sections of culvert occupy parts of these trenches and are accessible through vertical culverts. These structures allow personnel access for observation and maintenance of instrumentation installed in waste-cover materials. Instrumented containers simulating waste packages will occupy the remainder of the trenches, so that soil-moisture migration may be observed in relation to waste containers.

Shallow drilling was conducted in and around the RWMC in 1985, using rigorous procedures to minimize cross-contamination. Fifteen auger holes were drilled up to 8 m (25 ft) through surficial sediments to the uppermost basalt layer. Using a split-spoon drive sampler, continuous core samples were collected for evaluation and radionuclide analyses. All holes were instrumented with gypsum blocks, psychrometers, tensiometers, and lysimeters to monitor soil water conditions in the unsaturated zone. Twenty-five additional shallow wells are planned for future drilling campaigns.

Beginning in 1986, 30 wells adjacent to closed waste pits and trenches will be drilled through interbedded sediments and basalt flows to an approximate depth of 79 m (260 ft). Samples for laboratory determination of specific radionuclide concentrations will be taken from the basalt by coring, and from the sediments by coring or drive-tube sampling. Downhole instrumentation will be installed.

Results to date from the current shallow-drilling activity indicate contamination by Cs-137, Pu-238, Pu-239/-240, and Am-241 in a few surface and near-surface, shallow-drilling samples at the RWMC. However, contamination levels are comparable to typical levels in surface soils at those locations. Infiltration of surface runoff due to three incidents of rapid spring snowmelt is the likely mechanism for the radionuclide migration.

INEL personnel use several computer codes to evaluate environmental transport of radionuclides. The DOSTOMAN code has been adapted to specific environmental pathways at the RWMC. Obtained from DOE's Savannah River Laboratory, DOSTOMAN is a simplified multi-pathway transient model. The model was revised extensively to include RWMC-specific environmental compartments, waste inventories, and transfer coefficients. The model is being used to identify dominant transport pathways and indicate whether additional monitoring or modeling of those pathways might be advisable.

CONCLUSIONS

The foregoing discussion leads to these conclusions: (1) An extensive program of environmental surveillance is conducted by DOE, USGS, NOAA, and INEL contractors. (2) The data indicate very small or no impacts of the INEL on the surrounding environment. (3) Environmental surveillance activities are underway to collect the necessary data to address the key environmental issues.

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