DOE/ID-22144

DISTRIBUTION OF SELECTED RADIOCHEMICAL AND CHEMICAL CONSTITUENTS IN PERCHED GROUND WATER, IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO, 1989–91

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS REPORT 98-4028

Prepared in cooperation with the U.S. DEPARTMENT OF ENERGY

USGS
science for a changing world

Distribution of Selected Radiochemical and Chemical Constituents in Perched Ground Water, Idaho National Engineering Laboratory, Idaho, 1989–91

by Betty J. Tucker *and* Brennon R. Orr

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 98-4028

Prepared in cooperation with the

U.S. DEPARTMENT OF ENERGY

Idaho Falls, Idaho

January 1998

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

For additional information write to:

U.S. Geological Survey
INEEL, MS 4148
P.O. Box 2230
Idaho Falls, ID 83403-2230

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Box 25286, Federal Center
Denver, CO 80225

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS FOR UNITS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
foot squared per day (ft^2/day)	0.09290	meter squared per day
gallon (gal)	3.785	liter
pound (lb)	0.4536	kilogram
curie (Ci)	3.7×10^{10}	becquerel
picocurie/milliliter (pCi/mL)	0.037	becquerel/milliliter
picocurie/liter (pCi/L)	0.037	becquerel/liter

Metric units used in this report that do not have commonly used inch-pound equivalents are mL (milliliter); µS/cm (microsiemens per centimeter at 25°C); µg/L (microgram per liter); mg/L (milligram per liter)

Distribution of Selected Radiochemical and Chemical Constituents in Perched Ground Water, Idaho National Engineering Laboratory, Idaho, 1989–91

By Betty J. Tucker *and* Brennon R. Orr

Abstract

Radioactive and chemical wastes generated at facilities at the Idaho National Engineering Laboratory (INEL) have been contained in wastewater discharged to infiltration ponds at the Test Reactor Area (TRA) and the Idaho Chemical Processing Plant (ICPP) since 1952. Radioactive and chemical wastes also have been buried at the Radioactive Waste Management Complex (RWMC). Discharge of wastewater to ponds and infiltration of surface-water runoff at waste-burial sites have resulted in formation of perched ground water in basalts and sedimentary interbeds above the Snake River Plain aquifer. Perched ground water is an integral part of the pathway along which waste constituents migrate to the aquifer.

The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, maintains a continuous monitoring network at the INEL to determine hydrologic trends and to monitor the movement of wastewater discharged from facilities. This report presents an analysis of water-level and water-quality data collected from selected wells completed in perched ground water at the INEL during 1989–91.

About 470 curies (Ci) of tritium was discharged to the TRA warm-waste ponds during 1989–91. In 1991, concentrations of tritium greater than the reporting level in water from wells completed in deep perched ground water ranged from 1.3±0.2 to 785±12 picocuries per milliliter (pCi/mL). Variability in tritium concentrations in water from wells in perched ground water at the TRA during 1989–91 was related to variable tritium disposal rates, distance of the wells from the warm-waste ponds, and the depth to water below the ponds.

In April 1991, concentrations of strontium-90 in water from seven wells completed in the deep perched ground water were from 11±2 to 171±9 picocuries per liter (pCi/L). Variations in strontium-90 concentrations are attributed to chemical equilibrium between strontium-90 sorbed to sediments and strontium-90 in solution in shallow perched ground water.

In October 1991, dissolved chromium concentrations in deep perched ground water at the TRA were from 2 to 90 micrograms per liter (mg/L). The distribution of chromium indicates that perched ground water in outlying wells to the west and south of the TRA contained constituents that were discharged to the warm-waste ponds before 1965.

In October 1991, sodium concentrations in deep perched ground water at the TRA were from 10 to 1,300 milligrams per liter (mg/L). Sulfate concentrations in October 1990 were from 35 to 4,300 mg/L. Sulfate wasn't sampled for in 1991. The largest concentrations of sodium and sulfate during these years were in water from a well near the chemical-waste ponds. These large concentrations indicate that concentrations in perched ground water to the north and northwest of the TRA were dominated by wastewater discharged to the chemical-waste pond.

During 1989–91, tritium concentrations in perched ground water from wells near the infiltration ponds at the ICPP decreased because of a significant decrease in the disposal rate of tritium from earlier years. In October 1991, tritium concentrations in perched ground water from wells near the infiltration ponds ranged from less than a

reporting level of 3 times the sample standard deviation to 32.3±0.8 pCi/mL.

In October 1991, strontium-90 concentrations in perched ground water near the ICPP infiltration ponds ranged from less than the reporting level to 13±2.0 pCi/L. Concentrations were largest in surficial sediments and decreased with distance from the ponds and with depth. Decreases are attributed to sorption of strontium-90 to surficial and interbed sediments.

During 1989–91, concentrations of chloride and sulfate in perched ground water from wells near the ICPP infiltration ponds were similar to the concentrations in the wastewater discharged to the ponds.

During 1989–91, no radiochemical constituents were above the reporting level in water samples from a well completed in perched ground water at the RWMC. One water sample collected from the well in January 1990 contained 230 mg/L of carbon tetrachloride, 300 mg/L of chloroform, 72 mg/L of trichloroethene, 37 mg/L of 1,1,1-trichloroethane, 5.6 mg/L of 1,1-dichloroethane, and 4.5 mg/L of tetrachloroethane.

INTRODUCTION

The Idaho National Engineering Laboratory (INEL), encompasses about 890 mi^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1). Facilities at the INEL are operated by the U.S. Department of Energy (DOE). INEL facilities are used in the development of peacetime atomic-energy applications, nuclear-safety research, defense programs, and advanced energy concepts. Radioactive and chemical wastes generated at these facilities have been contained in wastewater discharged to infiltration ponds since 1952. Radioactive and chemical wastes also have been buried at the INEL. Discharge of wastewater to infiltration ponds and infiltration of surface-water runoff at waste-burial sites have resulted in formation of perched ground water in basalts and sedimentary interbeds that overlie the Snake River Plain aquifer. Perched ground water is an integral part of the pathway along which waste constituents migrate to the aquifer.

The DOE requires information about the mobility of dilute radioactive and chemical-waste constituents in perched ground water at the INEL to monitor the movement of these constituents to the Snake River Plain aquifer. Waste-constituent mobility is, in part, determined by (1) hydraulic properties of saturated and unsaturated basalts and sedimentary interbeds, (2) the location, quantity, and method of waste disposal, (3) waste-constituent chemistry, and (4) the geochemical processes taking place in perched ground water. This study was conducted by the U.S. Geological Survey (USGS) in cooperation with the DOE's Idaho Operations Office.

Purpose and Scope

In 1949, the U.S. Atomic Energy Commission, predecessor of the DOE, requested that the USGS describe the water resources of the area now known as the INEL to characterize these resources prior to the development of nuclear reactor testing facilities. Since 1949, the USGS has maintained a monitoring network at the INEL to determine hydrologic trends and to delineate the movement of facility-related radioactive and chemical wastes in the Snake River Plain aquifer and perched ground water zones.

This report presents an analysis of water-level and water-quality data collected from selected wells completed in perched ground water at selected INEL facilities during 1989–91 as part of the continuing hydrogeologic investigation at the INEL. The report describes the distribution and concentration of selected radiochemical and chemical constituents in perched ground water at the Test Reactor Area (TRA), Idaho Chemical Processing Plant (ICPP), and Radioactive Waste Management Complex (RWMC). Perched ground water also has been detected beneath infiltration ponds and ditches at other facilities at the INEL. They are not discussed in this report because of the relatively small quantity of wastewater and chemical constituents discharged at the facilities.

Acknowledgments

The DOE Radiological and Environmental Sciences Laboratory (RESL) provided radiochemical

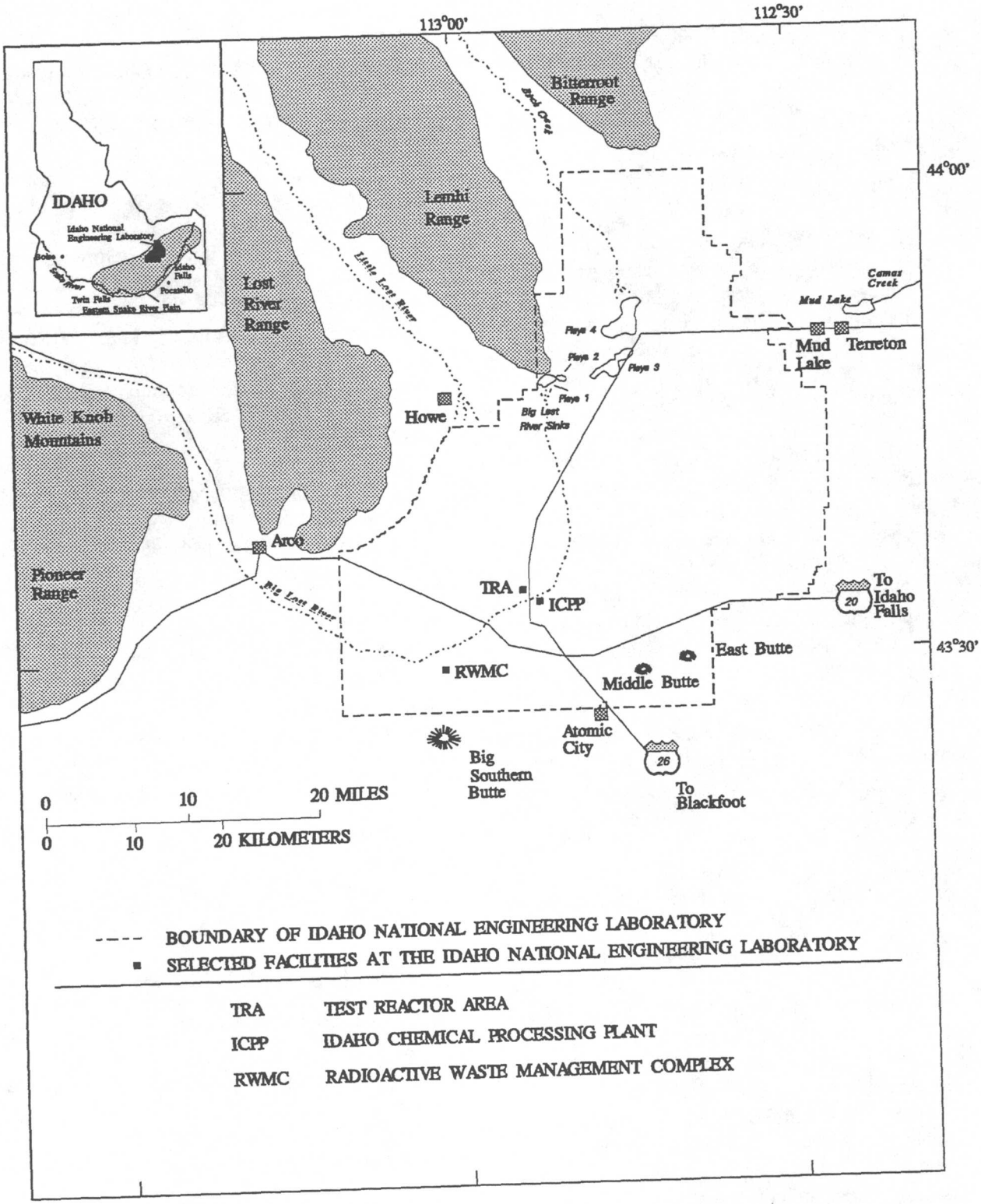

Figure 1. Location of the Idaho National Engineering Laboratory and selected facilities.

analyses of water samples. Technical staff at the RESL during 1989–91 were under the supervision of T.F. Gesell, Director, and D.B. Martin, Chief, Analytical Chemistry Branch. The authors are grateful to R.C. Bartholomay and S. Shakofsky, hydrologists with the USGS, for technical review of the manuscript.

Previous Investigations

Descriptions of the extent of perched ground water at the TRA and the distribution of selected wastewater constituents in perched ground water are presented in a series of reports describing the hydrology of the National Reactor Testing Station. The series includes reports by Barraclough and others (1967a and 1967b). An analysis of perched ground water at the TRA is presented in a comprehensive discussion of conditions related to the disposal of liquid waste to the subsurface at the INEL (Robertson and others, 1974). Later reports present perched ground water data for the TRA, ICPP, and RWMC. These include reports by Barraclaugh and others (1981), describing hydrologic conditions for 1974–78; Lewis and Jensen (1984), describing hydrologic conditions for 1979–81; and Pittman and others (1988), describing hydrologic conditions for 1982–85.

Hull (1989) developed a conceptual model that describes migration pathways for wastewater and constituents from the warm-waste ponds at the TRA. Cecil and others (1991) discussed perching mechanisms responsible for formation of perched ground water at the TRA and ICPP, and described the distribution of chemical and radionuclide constituents in perched ground water during 1986–88 at the TRA, ICPP, and RWMC.

Anderson and Lewis (1989) and Anderson (1991) correlated geophysical logs to describe a complex sequence of basalt flows and sedimentary interbeds in the unsaturated zone underlying the RWMC, TRA, and ICPP. This stratigraphic correlation provides an understanding of the geologic framework within which perched ground water has formed. Ackerman (1991) analyzed data from 43 aquifer tests conducted in 22 wells to estimate transmissivity of basalts and sedimentary interbeds containing perched ground water beneath the TRA and ICPP.

Robertson (1977) used a numerical model to simulate flow and transport of chemical and radionuclide constituents through perched ground water at the TRA. The model includes effects of convection, hydrodynamic dispersion, radioactive decay, and adsorption.

Ground-Water Monitoring Networks

Ground-water monitoring networks are maintained at the INEL to characterize the occurrence, movement, and quality of water in perched ground water beneath INEL facilities. These networks consist of wells from which water-level and water-quality data periodically are obtained. Data from the monitoring networks are on file at the USGS INEL Project Office.

Water-level monitoring network.—The INEL perched-water-level network was designed to determine the extent of perched ground water and the volume of perched ground water in storage. Water levels in 42 wells were monitored during 1989–91 (fig. 2). At the TRA, the network included 21 wells monitoring deep perched ground-water levels and 11 wells to monitor shallow perched ground-water levels. At the ICPP, the network included eight shallow wells to monitor perched ground-water levels around the ICPP infiltration ponds and one well to monitor water-level changes in deep perched ground water beneath the ICPP. Perched ground water in one well at the RWMC was monitored. The location of the wells and the frequency of water-level measurements as of December 1991 are shown on figure 2.

Water-quality monitoring network.—The radiochemical and chemical character of water in perched ground water beneath INEL facilities is determined from analyses of water samples collected as part of a comprehensive sampling program to identify contaminant concentrations and to define the pattern of waste migration in the perched ground water and to the Snake River Plain aquifer.

The type, frequency, and depth of ground-water sampling generally depend on the information needed in a specific area. Water samples routinely

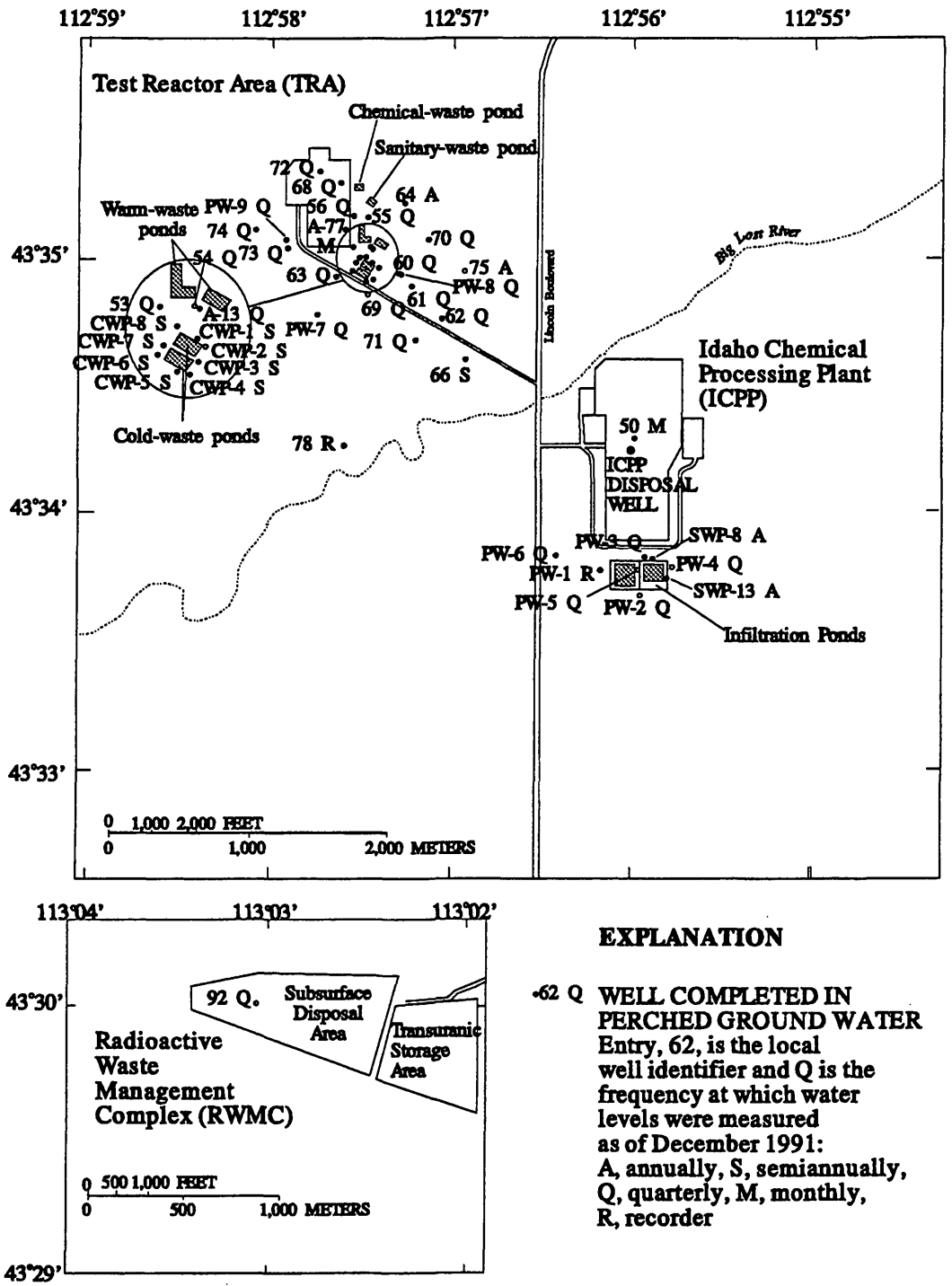

Figure 2. Location of selected wells and the frequency of water-level measurements (as of December 1991) in perched ground water at the Test Reactor Area, Idaho Chemical Processing Plant, and Radioactive Waste Management Complex.

are collected and analyzed for concentrations of tritium, strontium-90, cobalt-60, cesium-137, plutonium-238, the sum of plutonium-239 and plutonium-240 (undivided), americium-241, dissolved and hexavalent chromium, sodium, chloride, and nitrate, and for measurements of specific conductance, pH, and temperature. Water samples were analyzed for radiochemical constituents at the RESL and for chemical constituents at the National Water Quality Laboratory (NWQL) in Arvada, Colo. The location of wells in the water-quality monitoring network for perched ground water beneath INEL facilities during 1989–91 and the frequency of sample collection are shown in figure 3 and in table 1.

The methods used in sampling for selected constituents generally follow the guidelines established by the USGS (Goerlitz and Brown, 1972; Stevens and others, 1975; Wood, 1981; Claassen, 1982; W.L. Bradford, USGS, written commun., 1985; Wershaw and others, 1987; and Fishman and Friedman, 1989). Water samples analyzed by the NWQL and RESL are collected in accordance with a quality-assurance plan for quality-of-water activities conducted by personnel at the INEL Project Office; the plan was implemented in October 1987, finalized in June 1989, revised in March 1992, and is available for inspection at the USGS's Project Office at the INEL. In general, about 10 percent of the samples collected are for quality assurance. Quality-assurance samples include blanks, equipment blanks, splits, duplicates, and replicates. A comparative study to determine agreement between analytical results for individual water-sample pairs by laboratories involved in the INEL Project Office quality-assurance program was summarized by Wegner (1989). Additional quality-assurance studies done by personnel at the INEL Project Office include an evaluation of field sampling and preservation methods for strontium-90 (Cecil and others, 1989); a study comparing different pump types used for sampling purgeable organic compounds (Knobel and Mann, 1993); and a study analyzing tritium and strontium-90 concentrations in water from wells after purging different numbers of borehole volumes (Bartholomay, 1993).

Guidelines for Interpreting Results of Radiochemical Analyses

Concentrations of radionuclides are reported with an estimated sample standard deviation, s, that is obtained by propagating sources of analytical uncertainty in measurements. The following guidelines for interpreting analytical results are based on an extension of a method proposed by Currie (1984).

In the analysis for a particular radionuclide, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and the blank vary randomly. Therefore, it is essential to distinguish between two key aspects of the problem of detection: (1) the instrument signal for the sample must be larger than the signal observed for the blank before the decision can be made that the radionuclide was detected; and (2) an estimation must be made of the minimum radionuclide concentration that will yield a sufficiently large observed signal before the correct decision can be made for detection or nondetection of the radionuclide. The first aspect of the problem is a qualitative decision based on an observed signal and a definite criterion for detection. The second aspect of the problem is an estimation of the detection capabilities of a given measurement process.

In the laboratory, instrument signals must exceed a critical level of 1.6s before the qualitative decision can be made as to whether the radionuclide was detected. At 1.6s, there is about a 95-percent probability that the correct conclusion—not detected—will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentrations larger than or equal to 1.6s, which were concluded as being detected, might not contain the radionuclide. These measurements are referred to as false positives and are errors of the first kind in hypothesis testing.

Once the critical level of 1.6s has been defined, the minimum detectable concentration may be determined. Concentrations that equal 3s represent a measurement at the minimum detectable concentration. For true concentrations of 3s or larger, there is a 95-percent or larger probability that the radionuclide was detected in a sample. In a large

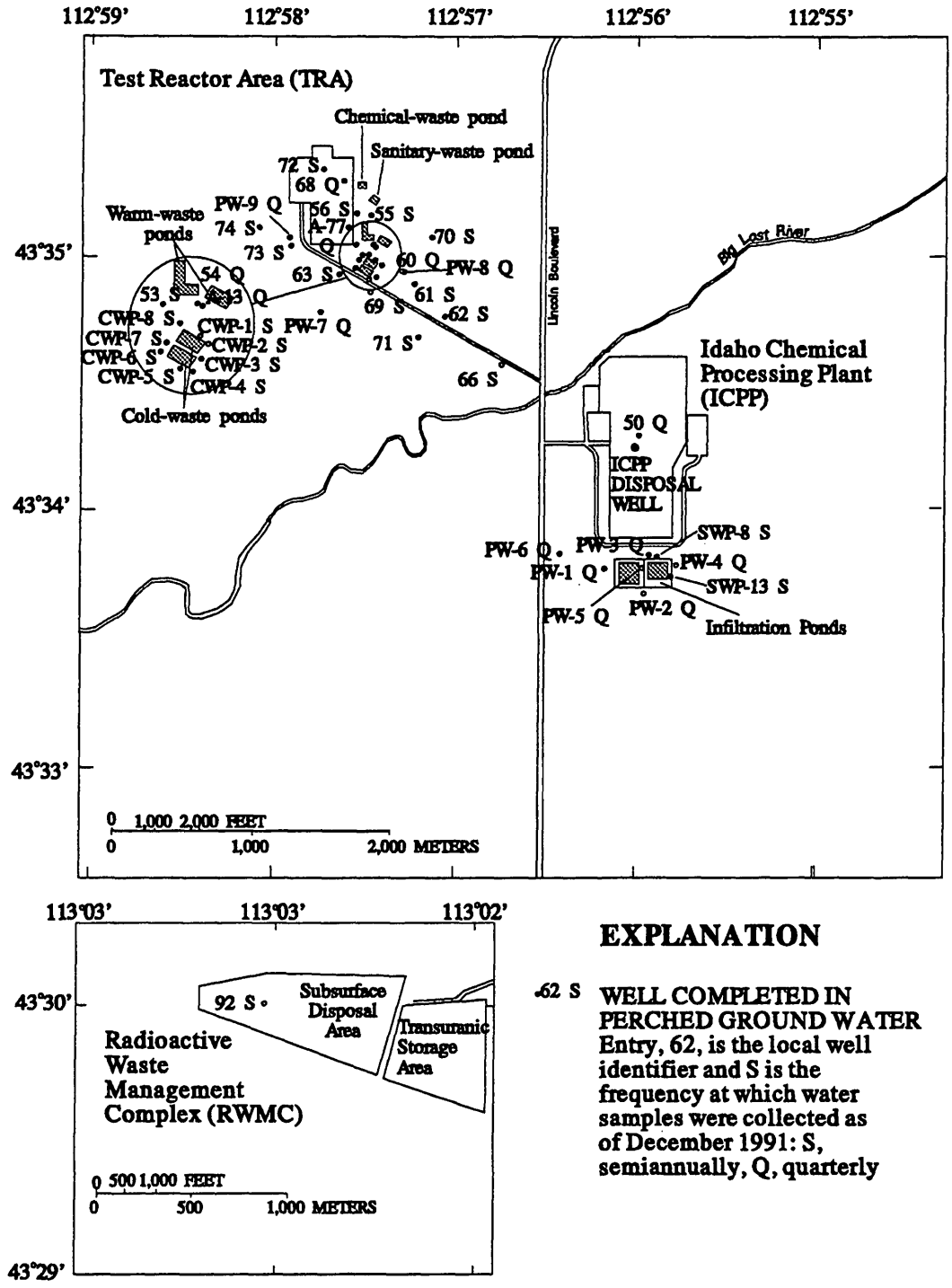

Figure 3. Location of selected wells and the frequency of water-quality sample collection (as of December 1991) in perched ground water at the Test Reactor Area, Idaho Chemical Processing Plant, and Radioactive Waste Management Complex.

number of samples, the conclusion—not detected—will be made in 5 percent of the samples that contain true concentrations at the minimum detectable concentration of 3s. These measurements are referred to as false negatives and are errors of the second kind in hypothesis testing.

True radionuclide concentrations between 1.6s and 3s have larger errors of the second kind. That is, there is a larger-than-5-percent probability of false negative results for samples with true concentrations between 1.6s and 3s. Although the radionuclide might have been detected, such detection may not be considered reliable; at 1.6s, the probability of a false negative is about 50 percent.

The critical level and minimum detectable concentration are based on counting statistics alone and do not include systematic or random errors inherent in laboratory procedures. The values 1.6s and 3s vary slightly with background or blank counts, with the number of gross counts for individual analyses, and for different radionuclides. In this report, radionuclide concentrations less than 3s are considered to be below a "reporting level." The critical level, minimum detectable concentration, and reporting level aid the reader in the interpretation of analytical results and do not represent absolute concentrations of radioactivity which may or may not have been detected.

Geohydrologic Setting

The eastern Snake River Plain is a northeast oriented structural basin about 200 mi long and 50 to 70 mi wide. The plain consists of alluvial and eolian sediments and basalt outcrops underlain by a layered sequence of basalt flows and sedimentary interbeds. Individual basalt flows are from 10 to 50 ft thick, although the average thickness is from 20 to 25 ft (Mundorff and others, 1964, p. 143). Surficial sediments and sedimentary interbeds consist of sand, silt, and clay, and lesser amounts of gravel. Locally, rhyolitic lava flows and tuffs are exposed at the land surface or exist at depth.

The top of the Snake River Plain aquifer is about 450 ft below land surface at the TRA and ICPP and about 600 ft below land surface at the RWMC. The unsaturated zone beneath these facilities consists of alluvial and eolian sediments, basalt flows, and sedimentary interbeds and is typical of the stratigraphy at the INEL. Anderson and Lewis (1989), Anderson (1991), and Anderson and Bowers (1995) described the stratigraphic sequence of the unsaturated zone and uppermost part of the Snake River Plain aquifer at selected INEL facilities. This sequence was formed by extrusion and cooling of lava followed by periods of quiescence and sedimentary deposition (Nace and others, 1975, p. 16). Vertical and horizontal fractures developed as lava flows cooled. These fractures and interflow rubble zones are primary conduits through which water is transmitted.

Locally, perched ground water has formed in the basalt and in sedimentary interbeds in response to recharge from wastewater infiltration ponds and from localized infiltration of snowmelt and rain. Perched ground water also results from infiltration of Big Lost River water. Transmissivity estimates from 22 wells completed in perched ground water range from 1.0 to 15,000 ft^2/day (Ackerman, 1991, p. 10). Differences in the vertical hydraulic conductivity of basalt layers and sedimentary interbeds in the unsaturated zone provide mechanisms for the development of perched ground water (Cecil and others, 1991, p. 17). The vertical hydraulic conductivity of a sedimentary interbed typically is smaller than that of an overlying basalt layer. Perched ground water is closely associated with the sedimentary interbeds beneath the TRA, ICPP, and RWMC. Alterations in the baked zones between two basalt layers may contribute to reduced vertical hydraulic conductivity. Dense, unfractured basalt or sedimentary and chemical filling of fractures near the upper contact of a basalt layer may limit the capability of the basalt to transmit water.

DISTRIBUTION OF SELECTED RADIOCHEMICAL AND CHEMICAL CONSTITUENTS IN PERCHED GROUND WATER

Radiochemical, inorganic-chemical, and organic-chemical constituents in wastewater migrate to the Snake River Plain aquifer through perched ground water beneath wastewater infiltration ponds at the TRA and ICPP. Beneath the RWMC, moist but unsaturated zones that result

from infiltration of snowmelt and rain may contain constituents leached from buried radiochemical and organic-chemical wastes.

Wastewater-disposal sites at INEL facilities are the principal sources of radiochemical- and chemical-waste constituents in perched ground water. Wastewater-disposal sites at the INEL have included infiltration ponds and ditches, drain fields, and disposal wells. From 1989 to 1991, wastewater was discharged to infiltration ponds and drain fields. Waste materials buried at the RWMC (fig. 1) also are a source of some constituents in ground water. Radiochemical-waste-disposal data for 1989–91 presented in this report were obtained from a series of radioactive-waste-management information reports (Litteer and Reagan, 1990; Litteer and others, 1991b; Litteer and others, 1993). Chemical-waste-disposal data were obtained from a series of industrial-waste-management information reports (Litteer and Peterson, 1990; Litteer and others, 1991a; Litteer and others, 1992). The radioactive- and chemical-waste-disposal data for each facility were collected by a DOE contractor.

Test Reactor Area

Deep and shallow perched ground water have formed at the TRA in response to wastewater disposal to the warm-waste ponds, chemical-waste pond, cold-waste ponds, and sanitary-waste pond. Selected radiochemical and inorganic-chemical constituents contained in wastewater have been monitored in deep and shallow perched ground water since the early 1960's. During 1989–91, approximately 354 million gal/yr of wastewater was discharged to infiltration ponds at the TRA.

The average annual discharge to the warm-waste ponds (fig. 3) was about 139 million gal during 1960–91. The volume of wastewater and the curies of tritium discharged to the warm-waste ponds during this period are shown on figure 4. Discharge to the ponds was 18.3 million gal in 1988 and 28.7 million gal in 1991. The average annual discharge for 1989–91 was 23.6 million gal, markedly less than the average annual discharge for 1960–91.

Water samples were collected routinely during 1989–91 from 19 wells (53 through 56, 60 through 63, 66, 68 through 74, PW-7, PW-8, and PW-9) completed in deep perched ground water beneath the TRA (fig. 3). Samples were analyzed for selected radiochemical and chemical constituents on the basis of waste-disposal history at the TRA. Water samples also were collected from 10 wells (A-13, A-77, and CWP-1 through CWP-8) completed in shallow perched ground water near the TRA (fig. 3). Radiochemical constituents selected for routine analysis during 1989–91 included tritium, strontium-90, cesium-137, chromium-51, and cobalt-60. Chemical constituents included chromium, sodium, chloride, sulfate, and fluoride. The distribution of these selected constituents in water from deep and shallow perched ground water is summarized in the following sections.

Tritium.—During 1952–91, approximately 10,200 Ci of tritium was contained in wastewater discharged to the warm-waste ponds at the TRA. Until 1980, tritium generally accounted for less than 20 percent of the total radioactivity discharged to the ponds (fig. 4). Since 1981, tritium accounted for more than 90 percent of the total radioactivity. During 1989–91, about 97 percent of the total radioactivity was from tritium. About 470 Ci was discharged to the ponds during 1989–91; the annual amount was 156 Ci. Tritium has a half-life of 12.3 years (Walker and others, 1989, p. 20). Most other radioactive constituents discharged to the ponds have very short half-lives.

Wells 53, 54, 55, and 56, completed in deep perched ground water at the TRA, are in an area where contaminated soil around the warm-waste ponds was being cleaned up as the ponds were being decommissioned. This decommissioning and clean-up was the third phase of the waste-reduction program. During this phase, no access was allowed; consequently, no samples were collected from these wells in October 1991 because of snowfall, wet conditions, and the possibility of spreading contaminants into other areas. In October 1991, tritium concentrations in water from 10 wells completed in deep perched ground water at the TRA were above reporting levels. These concentrations, and concentrations in samples collected in April 1991 from wells 53, 54, 55, and 56, are shown on

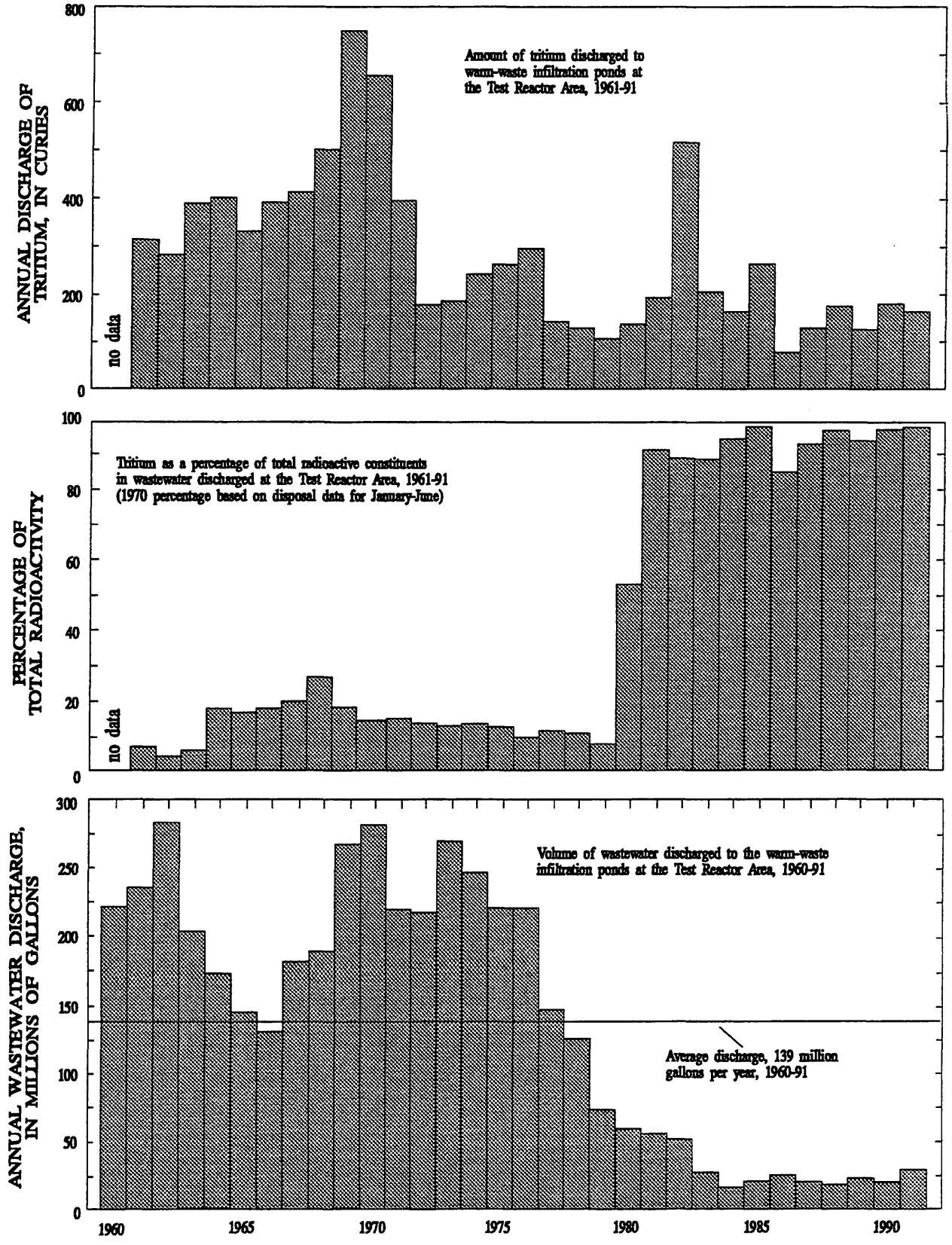

Figure 4. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the warm-waste infiltration ponds at the Test Reactor Area, 1960–91.

figure 5. Tritium concentrations ranged from 1.3±0.2 pCi/mL in well 62 to 785±12 pCi/mL in well 56. Water from six of these wells contained tritium concentrations ranging from 95.3±1.8 to 785±12 pCi/mL. Tritium concentrations in water from eight other wells ranged from 1.3±0.2 to 13.4±0.5 pCi/mL.

Wells 53 and 56 are near the west side of the warm-waste ponds. Well 56 is approximately 500 ft northeast of the TRA retention basin, into which radioactive wastewater was circulated before it was discharged to the warm-waste ponds. Some wastewater reportedly has leaked to the subsurface from cracks in the retention basin (U.S. Department of Energy, Environmental Sciences Branch, Radiological and Environmental Sciences Laboratory, 1991, written commun.). The large tritium concentrations in well 56 may be related to this leakage.

Water samples collected in October 1991 from wells 73, 74, and PW-9 contained 208±3, 95.3±1.8, and 233±4 pCi/mL of tritium, respectively. These wells are more than 1,500 ft west of the warm-waste ponds. The relatively large tritium concentrations in water from these wells indicates that perched ground water west of the TRA in 1991 probably originated from the warm-waste ponds.

Water-level changes in wells (fig. 6) indicate that wastewater discharge to the cold-waste ponds since 1982 has dominated perched ground-water flow to the west and south of the TRA. The effect of discharge to the cold-waste ponds was attenuated in water levels in well 70, to the east of the TRA. Because of the effect of discharge to the cold-waste ponds on water levels, tritium concentrations in perched ground water west of the TRA probably will decrease as nonradioactive wastewater from the cold-waste ponds displaces wastewater from the warm-waste ponds.

Tritium concentrations in water from 13 wells completed in the deep perched ground water were moderately constant during 1989–91. Tritium concentrations remained at or below reporting levels in water from wells PW-7, 60, 63, 68, 69, and 72 (table 2). Concentrations in water from wells 68 and 69 were less than reporting levels. Concentrations in wells 61, 62, 66, 71, and PW-8 all were above reporting levels but less than 22 pCi/mL. The tritium concentrations in water from wells 74 and PW-9 were from 91.2±1.6 to 111±2.0 pCi/mL and 219±4 to 257±4 pCi/mL, respectively.

In contrast, tritium concentrations in water from wells 53, 54, 55, 56, 70, and 73 varied during 1989–91. For example, the tritium concentration in water from well 53 ranged from 179±3 to 1,060±20 pCi/mL (table 2). Wells 53, 54, 55, and 56 are directly adjacent to the warm-waste ponds (fig. 3). Variations in tritium concentrations in water from these wells are attributed to fluctuations in discharge rates. Wells 70 and 73 are about 900 ft east and 1,500 ft west of the warm-waste ponds. Variations in tritium concentrations in water from these wells may have resulted from mixing of water derived from the warm-waste and cold-waste ponds.

Tritium concentrations in water from selected wells and monthly tritium-disposal rates during 1986–91 were plotted to define the distribution of tritium in deep perched ground water and to determine factors that affect this distribution (fig. 7). The amount of tritium discharged to the ponds during 1989–91 peaked in September 1990. Based on corresponding increases in tritium concentrations in water from wells 56 and 73, the variability in concentrations during this time may have been related, in part, to variable tritium-disposal rates. During 1986–91, increases and decreases in tritium concentrations in water from well 73 (table 2) may have lagged from 3 to 13 months behind increases and decreases in well 56. This time lag suggested that water may move from the warm-waste ponds to well 73 in approximately 8 months. Although concentrations in water from well 55 were much smaller, increases and decreases in concentrations corresponded to those in well 56 with no apparent time lag.

Increases and decreases in tritium concentrations in water from wells 53, 54, and 70 did not correspond directly to monthly changes in tritium disposal. This lack of correspondence indicates that other factors, including hydraulic effects and dilution from the cold-waste ponds, affect tritium concentrations in water from these wells. Changes in concentrations in water from well 70 were

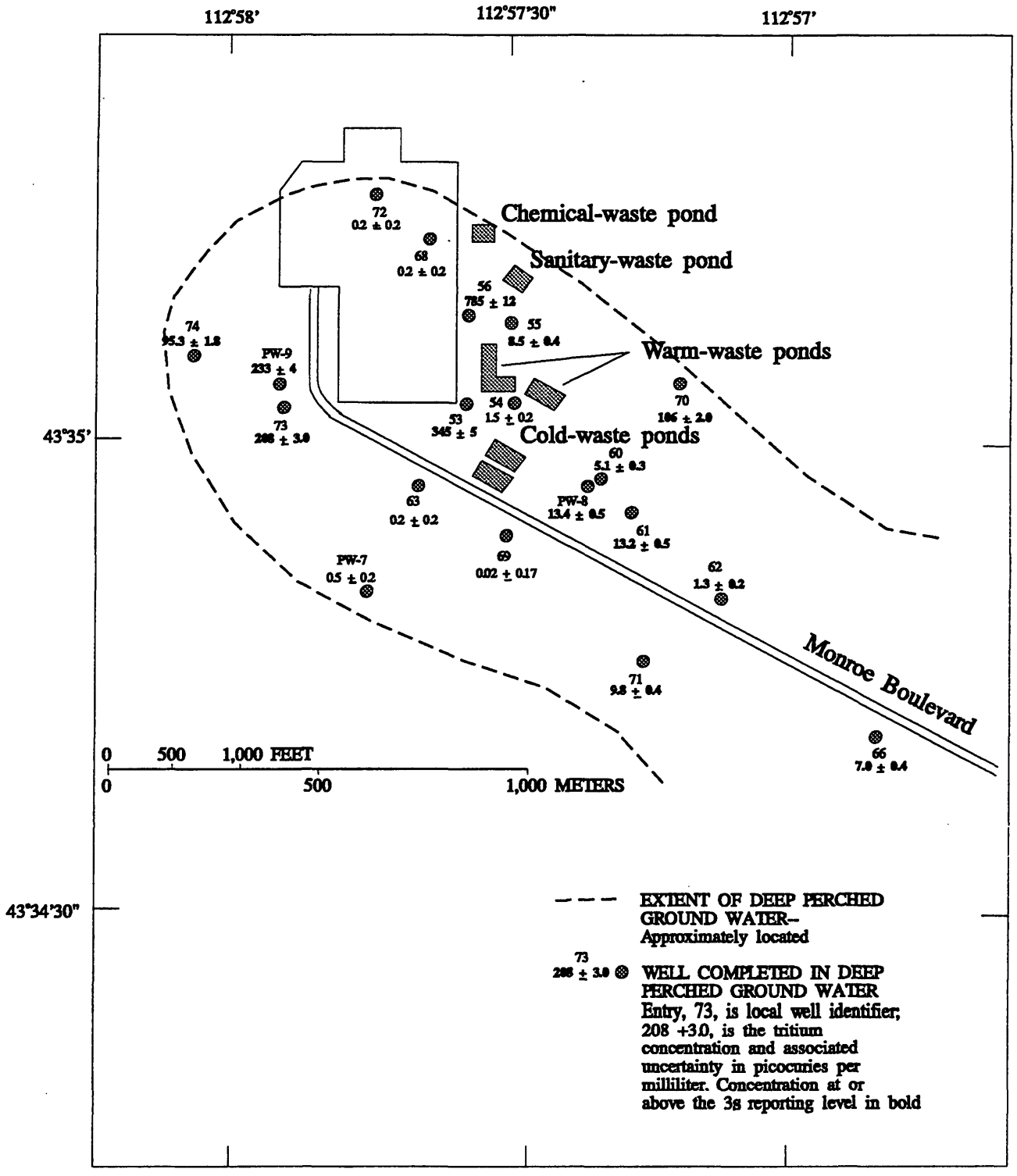

Figure 5. Tritium concentrations in water from wells completed in deep perched ground water at the Test Reactor Area, April-October 1991.

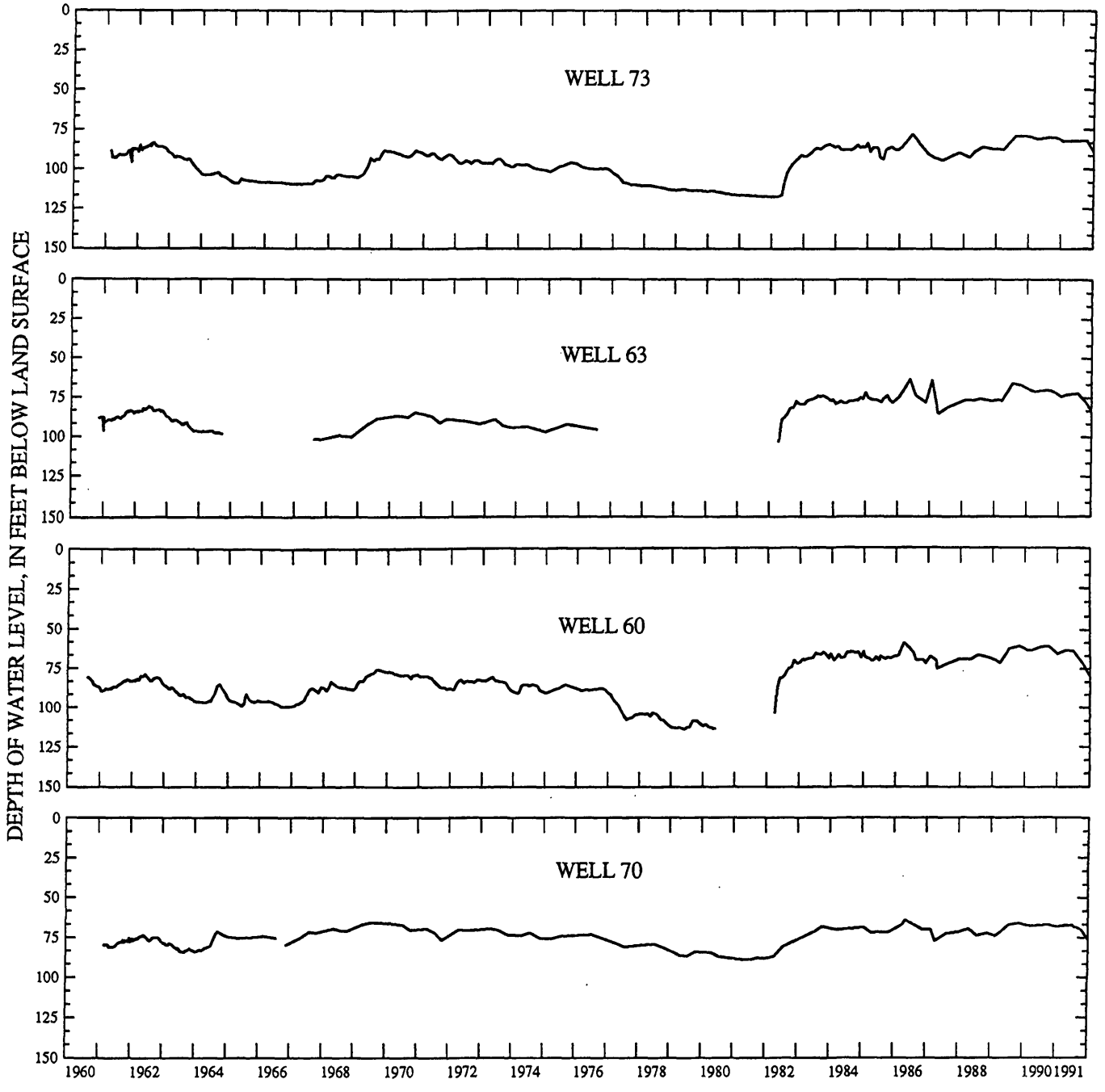

Figure 6. Water-level changes in selected monitoring wells completed in perched ground water, Test Reactor Area, 1960–91.

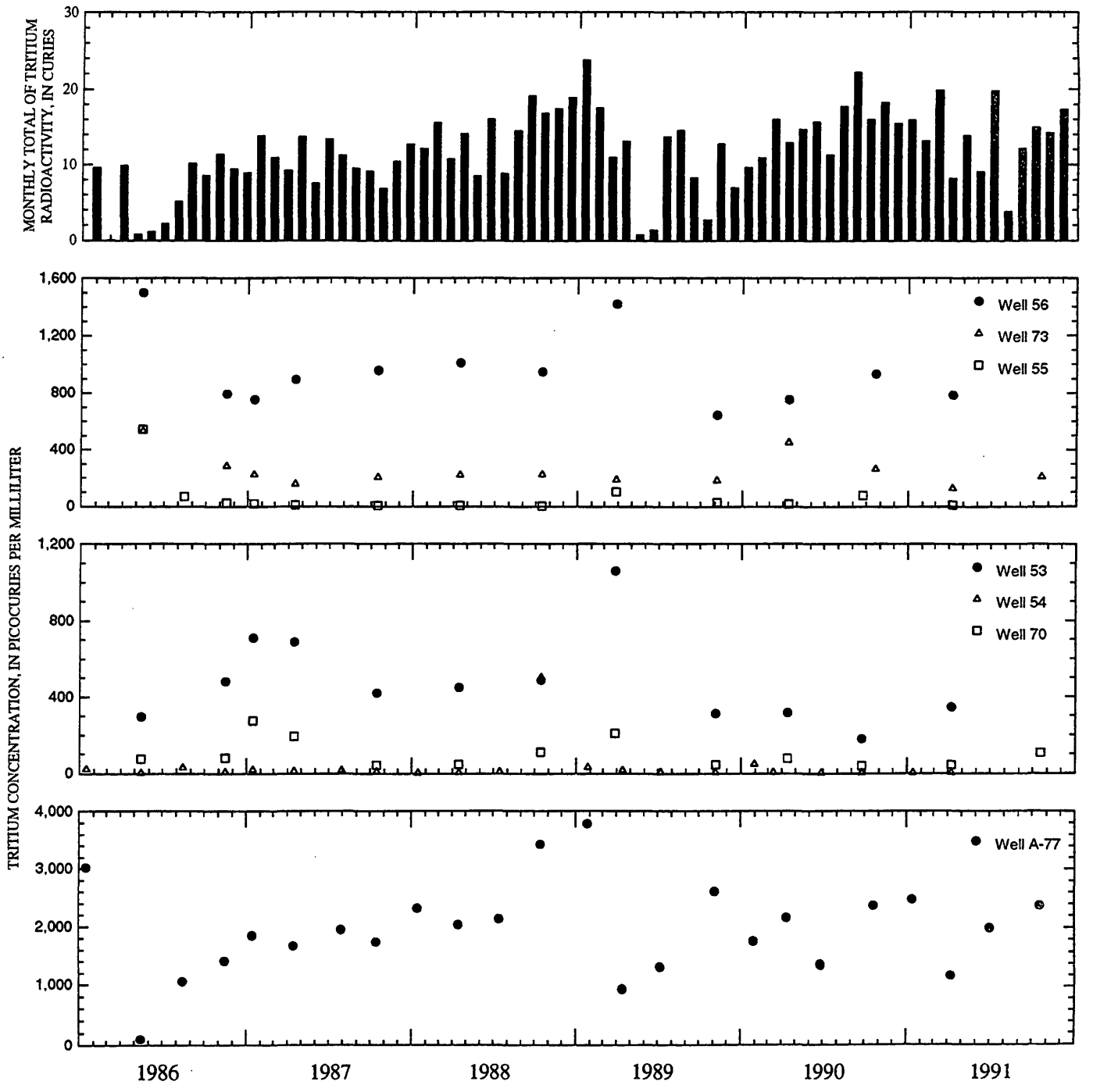

Figure 7. Monthly total of tritium radioactivity discharged to the Test Reactor Area warm-waste ponds, and tritium concentrations in water from selected wells, 1986–91.

comparable to those in well 53 (fig. 7). Tritium concentrations increased in both wells early in 1987 and again in the spring of 1989. The 1989 increase corresponded to a similar increase in well 56; the 1987 increase did not correspond directly to trends in water from other wells. Changes in concentrations in water from well 54, located between the warm-waste ponds and the cold-waste ponds, clearly showed the effect of dilution from the cold-waste ponds. During 1989–91, tritium concentrations in water from well 54 were consistently much smaller than those in water from other wells near the warm-waste ponds.

Well A-77 is completed in shallow perched ground water in alluvium and is near the TRA retention basin. The largest tritium concentration in water from well A-77 during 1986–88 was 3,430±50 pCi/mL. In 1989, the largest tritium concentration increased slightly to 3,790±50 pCi/mL (table 2). In October 1991, the tritium concentration in water from well A-77 was 2,370±30 pCi/mL. The variability in concentrations corresponded to short-term variations in disposal rates because of the shallow depth and proximity of the well to the leaking retention basin.

The largest tritium concentration in water from well A-13, also completed in shallow perched ground water, was 1.1±0.3 pCi/mL during 1986–88; during 1989–91, tritium concentrations were less than the reporting level. Well A-13 is between the warm-waste ponds and the cold-waste ponds; tritium concentrations in this well were affected by the large quantity of water discharged to the cold-waste ponds.

During 1989–91, tritium was not detected in water from wells CWP-1 through CWP-8, which monitor shallow perched ground water around the cold-waste ponds at the TRA. Water from well CWP-9, completed in a mixing zone between the cold-waste ponds and warm-waste ponds, was not sampled during 1989–91. The absence of detectable concentrations of tritium in most of the CWP wells is attributed to the large quantity of nonradioactive water discharged to the cold-waste ponds since 1982 that has diluted any residual warm-waste pond water.

Several factors have affected the concentrations of tritium in perched ground water in wells at the TRA since 1982. These factors include proximity of the well to the warm-waste ponds, the depth of the water, and variability in the tritium-disposal rate. The most prominent factor affecting tritium concentrations has been dilution from the cold-waste ponds. The replacement of the warm-waste ponds with evaporation ponds in 1993 probably will result in continued decreases in tritium concentrations. Streamflow infiltration during years of flow in the Big Lost River also has diluted tritium concentrations in perched ground water southeast of the TRA.

Strontium-90.—During 1952–88, approximately 78 Ci of strontium-90 was contained in wastewater discharged to the warm-waste ponds at the TRA, an average of 2.1 Ci/yr. In December 1991, 0.0011 Ci of strontium-90 was discharged to the ponds (Litteer and others, 1993, p. TRA-15). Strontium-90 has a half-life of 29.1 years (Walker and others, 1989, p. 29).

In April 1991, concentrations of strontium-90 in water from wells 53, 54, 55, 56, 63, 70, and PW-8, completed in deep perched ground water at the TRA (figs. 3 and 8) were above reporting levels. Concentrations were from 11±2 pCi/L in water from well 55 to 171±9 pCi/L in water from well 54. Wells 53, 54, 55, and 56 are next to the warm-waste ponds and were not sampled in October 1991 because of snowfall and wet conditions in the soil-contamination area around the warm-waste ponds. The distribution of strontium-90 concentrations in perched ground water during 1989–91 is attributed to chemical equilibrium between strontium-90 sorbed to sediments beneath the warm-waste ponds and strontium-90 in solution in water passing through those sediments. Strontium-90 has not been detected in water from the Snake River Plain aquifer beneath the TRA (Bartholomay and others, 1995, p. 26-29); the absence of detectable concentrations indicates that strontium-90 is sorbed to sediments.

During 1989–91, strontium-90 concentrations in water from wells 53, 54, 55, 56, 63, 70, and PW-8 were variable (table 2). Concentrations in water from samples collected from well 53 and 54

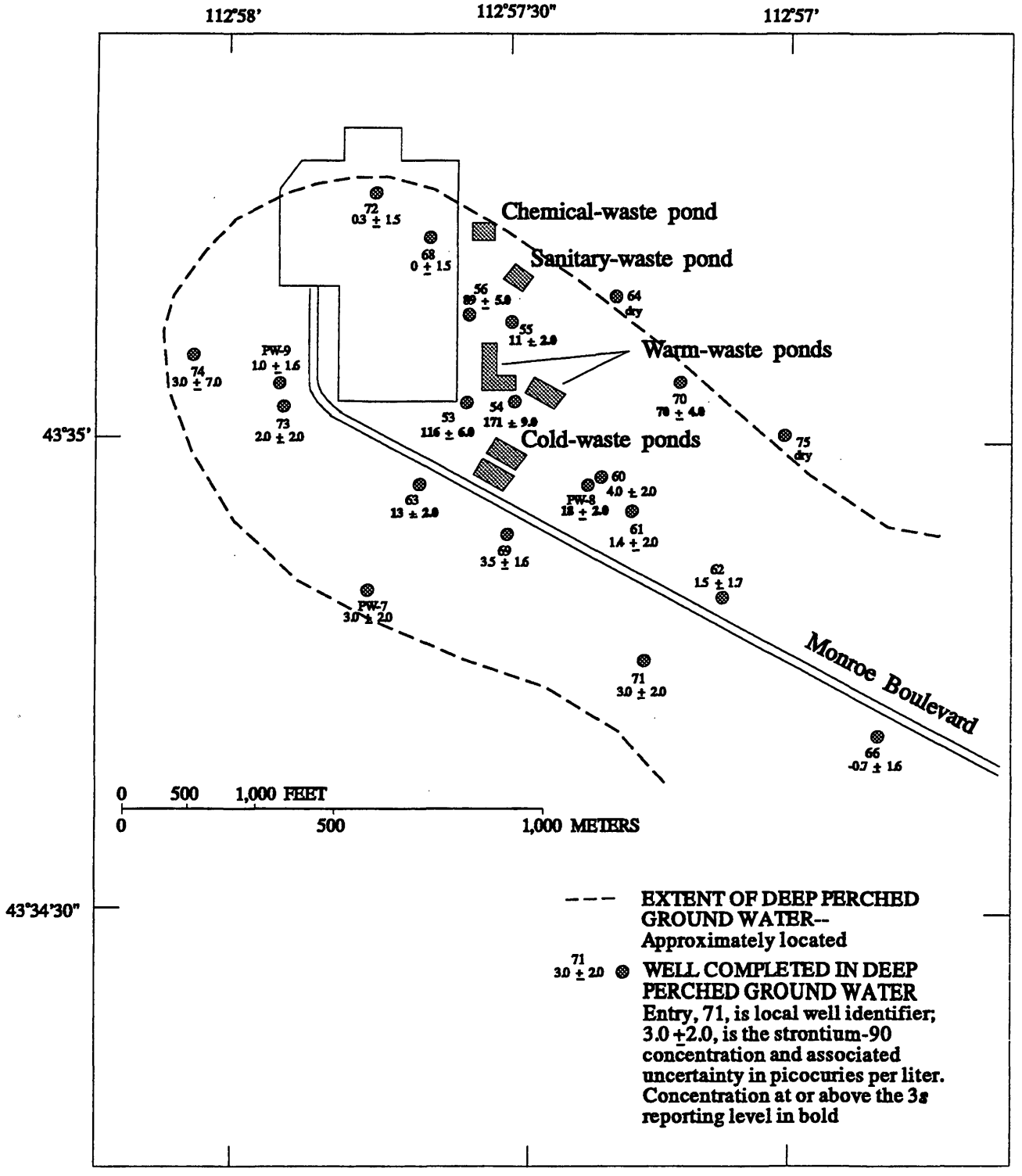

Figure 8. Strontium-90 concentrations in water from wells completed in deep perched ground water at the Test Reactor Area, April 1991.

ranged between 100 and 160 pCi/L and 170 and 190 pCi/L, respectively. These slight fluctuations could not be correlated with the discharge rates of strontium-90 to the warm-waste ponds because strontium-90 was discharged only in December 1991.

During 1989–91, strontium-90 also was detected in water from well A-77 (table 2), completed in shallow perched ground water near the TRA retention basin. The large range of concentrations in water from well A-77 is not directly attributable to strontium-90 disposal rates because strontium-90 was discharged only in December 1991. Water samples were unfiltered; therefore, the range of strontium-90 concentrations may have been the result of the presence of suspended sediment in the samples.

Cesium-137.—About 139 Ci of cesium-137 was contained in wastewater discharged to the warm-waste ponds at the TRA from 1952 through 1991. The average discharge rate decreased from 2.6 Ci/yr during 1979–81 to 0.65 Ci/yr during 1982–85 (Pittman and others, 1988, p. 35). The average discharge rate during 1986–88 was 0.23 Ci/yr (Cecil and others, 1991, p. 36); the rate decreased during 1989–91 to 0.02 Ci/yr. Cesium-137 has a half-life of 30.17 years (Walker and others, 1989, p. 34).

With the exception of well A-77, no concentrations of cesium-137 were detected in deep or shallow perched ground water during 1982–91. The cesium-137 concentration in water from well A-77 was 2,700±120 pCi/L in October 1991. The absence of detectable concentrations of cesium-137 in perched ground water at the TRA is attributed to a decrease in discharge rates and to sorption of cesium-137 to minerals in the surficial alluvium and sediments. The presence of cesium-137 in water from well A-77 is attributed to the proximity of the well to the leaking retention basin.

Chromium-51.—A total of 2,381 Ci of chromium-51 was discharged to the warm-waste ponds during 1979–85. The average discharge rate from 1979 through 1981 was 766 Ci/yr (Pittman and others, 1988). A total of 25.7 Ci of chromium-51 or an average of 8.6 Ci/yr was discharged during 1986–88. A total of 11.6 Ci/yr, or an average of 3.9 Ci/yr was discharged during 1989–91. The half-life of chromium-51 is 27.7 days (Walker and others, 1989, p. 24).

Because of the decrease in the amount of chromium-51 discharged and the relatively short half-life, chromium-51 was not detected in water from wells completed in deep perched ground water during 1986–88. No concentrations of chromium-51 were detected in water from wells A-13 and CWP-1 through CWP-9 during 1982–88. During 1989–91, chromium-51 was detected only in water from wells A-77, 53, and 56. The largest chromium-51 concentration in water from well A-77 during 1989–91 was 44,000±2,000 pCi/L (April 1989). The chromium-51 concentration in well 53 was 4,100±1,200 pCi/L (March 89). Chromium-51 was detected in one sample from well 56 (April 1990) and the concentration was 8,500±900 pCi/L. The presence of detectable chromium-51 in these wells is attributed to the proximity of the wells to the warm-waste ponds and to the leaking retention basin.

Cobalt-60.—Approximately 442 Ci of cobalt-60 was contained in wastewater discharged to the warm-waste ponds at the TRA during 1952–88. The average discharge rate for cobalt-60 decreased from 2.3 Ci/yr during 1979–81 to 1 Ci/yr during 1982–85 (Pittman and others, 1988, p. 35). The average discharge rate of cobalt-60 during 1986–88 was 2.2 Ci/yr and during 1989–91 decreased to 0.15 Ci/yr. The half-life of cobalt-60 is 5.27 years (Walker and others, 1989, p. 25).

Cobalt-60 was detected only in wells A-77 and 56 during 1989–91. During 1989–91, the cobalt-60 concentration in water from well A-77 was from 660±90 to 39,800±1,600 pCi/L. Cobalt-60 was detected in one sample from well 56 during 1989–91 (March 1989) and the concentration was 190±30 pCi/L.

Chromium.—Wastewater from TRA cooling-tower operations containing an estimated 24,000 lb of nonradioactive chromium was discharged to the warm-waste ponds during 1952–64 (Mann and Knobel, 1988, p. 7-10). During 1965–72, the disposal well at the TRA was used to discharge

chromium directly to the Snake River Plain aquifer. In October 1972, chromium was replaced by a polyphosphate as a corrosion inhibitor in cooling-tower operations. No disposal of chromium to the subsurface has been reported since 1972.

Before October 1989, chromium analyses were performed by RESL; subsequently, they were performed by the NWQL. During 1989–90, analytical results were reported for total recoverable chromium and some dissolved chromium. After July 1990, results were reported only for dissolved chromium. During 1989–91, dissolved chromium concentrations were detected in water from 19 wells completed in deep perched ground water at the TRA (table 3). The largest concentration of dissolved chromium was 170 mg/L in water from well 74 (November 1989). In October 1991, dissolved chromium concentrations in water from deep perched ground water at the TRA ranged from 2 mg/L in wells 69 and PW-7 to 90 mg/L in wells 74 and PW-9 (fig. 9). The largest concentrations were in water from wells west of the warm-waste ponds (73, 74, and PW-9) and from wells south and east of the ponds (70 and 71). Wells 53, 54, 55, and 56 were not sampled in October 1991 because of wet conditions in the soil-contamination zone around the warm-waste ponds. Water samples from wells 55 and 56 contained 60 mg/L of chromium in April 1991. Water from wells 53 and 54 contained 30 and 6 mg/L of chromium, respectively. No sample was collected from well 66 in October 1991. The distribution of chromium during April-October 1991 indicates that perched ground water in outlying wells to the west, south, and east of the TRA contained constituents that were discharged to the warm-waste ponds before 1965. The dissolved chromium concentration in water from shallow perched ground water ranged from less than 1 mg/L in wells CWP-2, CWP-4, and A-13 to 60 mg/L in well A-77. The presence of chromium in water from wells A-77, 55, and 56 is attributed to chemical equilibrium between chromium sorbed to sediment in the bottom of warm-waste ponds and chromium dissolved in perched ground water.

In addition to dissolved-chromium analyses, samples were analyzed for dissolved hexavalent chromium because of its potential toxic effect on living organisms. During 1989–91, concentrations of dissolved hexavalent chromium in water from wells completed in deep perched ground water ranged from less than 1 to 110 mg/L (table 3). In October 1991, concentrations ranged from less than 1 mg/L in wells 62, 69, 72, PW-7, and PW-8 to 65 mg/L in PW-9 and were 10 to 100 percent of total dissolved chromium. Dissolved hexavalent chromium in water from wells completed in shallow perched ground water ranged from less than 1 to 9 mg/L.

Sodium.—Approximately 513,000 lb of sodium was discharged to the chemical-waste pond during 1989–91; the annual average was 171,000 lb. The average sodium concentration in wastewater discharged to the chemical-waste pond was 2,500 mg/L.

During 1989–91, sodium concentrations in water from 18 wells completed in deep perched ground water were determined. In October 1991, sodium concentrations ranged from 10 mg/L in wells 69, 71, and PW-7 to 1,300 mg/L in well 68 (table 3). The large concentration in water from well 68 reflects the large concentrations of sodium in wastewater discharged to the chemical-waste pond. Sodium concentrations in shallow perched ground water ranged from 1.0 mg/L in well A-77 to 20 mg/L in well A-13.

Chloride.—During 1989–91, approximately 4,800 lb of chloride was discharged to the chemical-waste and sanitary-waste ponds. Of this amount, about 3,650 lb was discharged to the chemical-waste pond; the annual average was about 1,215 lb. Chloride discharged to the sanitary-waste pond was curtailed after 1989.

During 1989–91, chloride concentrations in water from wells completed in the deep perched ground water ranged from 5.9 mg/L (well PW-8) to 83 mg/L (well 72) (table 3). Water from 14 deep wells was sampled in October 1991; concentrations ranged from 16 to 36 mg/L. In water from wells completed in the shallow perched ground water, chloride concentrations ranged from 0.3 to 91 mg/L during 1989–91.

Sulfate.—Wastewater that contained sulfate was discharged into the chemical-waste and cold-waste ponds at TRA during 1989–91. Approxi-

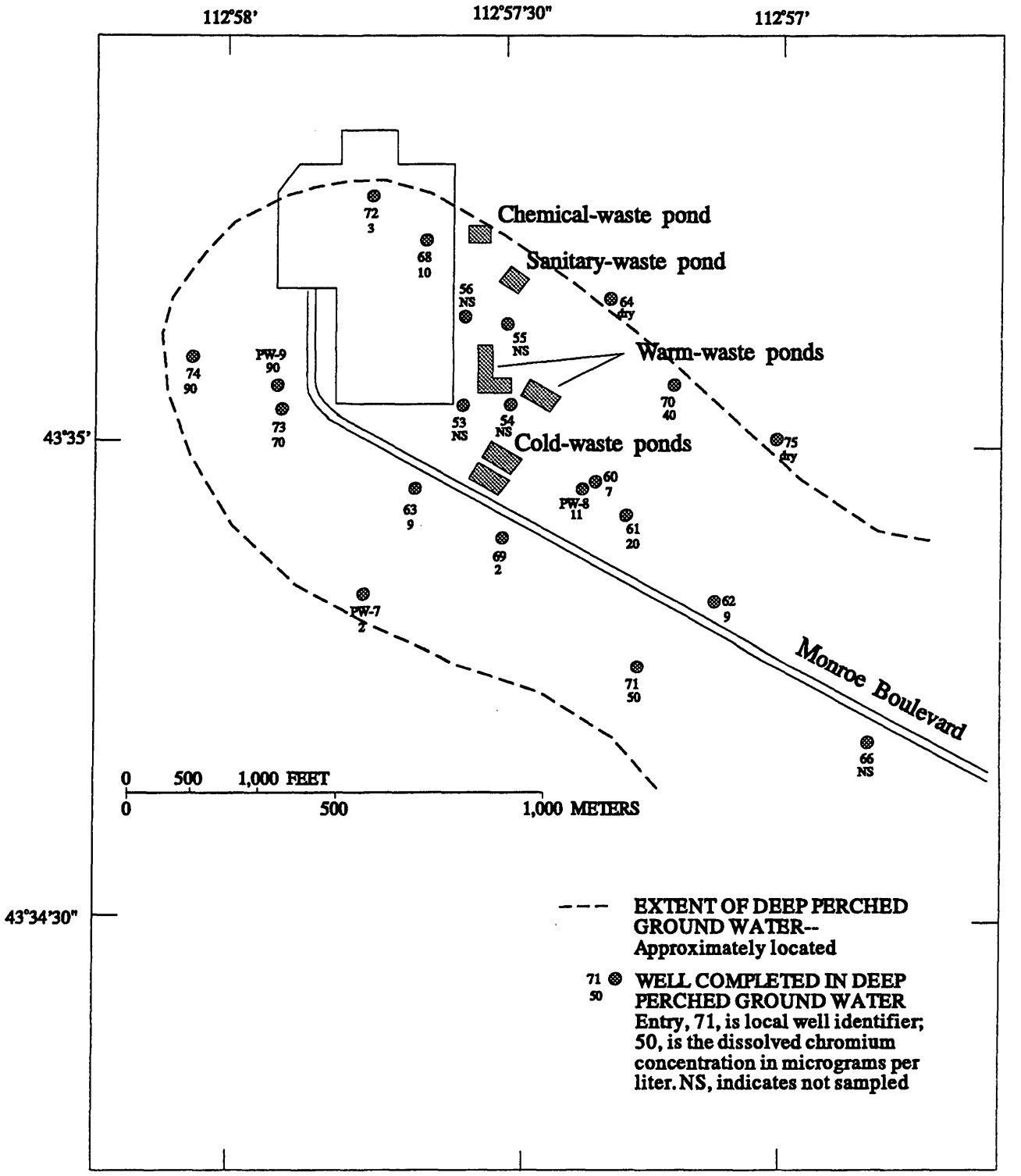

Figure 9. Concentrations of dissolved chromium in water from wells completed in deep perched ground water at the Test Reactor Area, October 1991.

mately 2,760,000 lb was discharged during this period; the average was 920,000 lb/yr. Before 1989, sulfate concentrations in ground water were not monitored routinely at the INEL. Because of expanded laboratory schedules and special studies, water samples were analyzed for sulfate during 1990–91.

During 1990–91, the sulfate concentration in water from wells completed in deep perched ground water ranged from 35 mg/L in well 56 to 4,300 mg/L in well 68 (table 3). The large concentration in water from well 68 reflects the large concentrations of sulfate in wastewater discharged to the chemical-waste pond. Bartholomay and others (1995, p. 15) reported that the average annual sulfate concentration in wastewater discharged to the chemical-waste pond was 7,500 mg/L. Based on sodium and sulfate concentrations in well 68, waste-constituent concentrations in perched ground water to the north and northwest of the TRA were dominated by wastewater discharged to the chemical-waste pond. The largest concentration in water from wells completed in shallow perched ground water was 320 mg/L in wells CWP-1 and CWP-5 (October 1990). These concentrations reflect sulfate discharged to the cold-waste ponds. Although similar amounts of sulfate were discharged to the cold-waste ponds and to the chemical-waste pond, the volume of water discharged to the cold-waste ponds diluted the sulfate concentration in shallow perched ground water near the ponds. The smallest concentration was in water from well A-77 (January 1991) and was 5.0 mg/L.

Fluoride.—Water samples were collected for fluoride analyses from wells completed in perched ground water at the TRA during September and October 1990 and January 1991. Fluoride concentrations ranged from less than 0.10 to 0.40 mg/L except for the concentration in water from well 68, which was 2.7 mg/L.

Idaho Chemical Processing Plant

Two wastewater-infiltration ponds were constructed south of the ICPP in 1984 to replace the ICPP disposal well (fig. 3). Wastewater infiltrating from these ponds has formed perched ground water in the basalt and sedimentary interbeds above the eastern Snake River Plain aquifer. The volumes of wastewater discharged to the well and infiltration ponds during 1962–91 are shown on figure 10. The total annual discharge to the well and ponds ranged from 260 million gal in 1963 to 620 million gal in 1990 and averaged 416 million gal/yr. The average discharge during 1989–91 was about 540 million gal/yr. Perched ground water also has been identified in other areas beneath the ICPP and may be attributed to other ICPP infiltration ponds, leaking wastewater pipelines, leach fields, ruptured casing in the upper part of the ICPP disposal well, and landscape irrigation. INEL contractors operate monitoring networks inside the ICPP.

Many shallow wells were constructed in auger holes in 1983 to obtain geohydrologic and engineering data at the site of the planned ICPP infiltration ponds. Two of these wells (SWP-8 and SWP-13) subsequently were used to monitor shallow perched ground water in surficial sediment at the ponds. Wells PW-1, PW-2, PW-3, PW-4, PW-5, and PW-6 were completed in 1986 to monitor water-level and water-quality changes in deep perched ground water underlying the ICPP infiltration ponds (fig. 3). Well 50 was used to monitor perched ground water near the ICPP disposal well. Water from these wells was sampled quarterly during 1989–91 (table 1). Concentrations of selected constituents in water from these wells are summarized in the following sections.

Tritium.—Approximately 960 Ci of tritium was discharged to the ICPP infiltration ponds during 1984–88. During 1986–88, the average rate of tritium discharged was 185 Ci/yr. In 1989, tritium was not discharged to the ponds (Litteer and Reagan, 1990, p. CPP-9); during 1990–91, 2.7 Ci of tritium was discharged.

During 1989–91, the largest tritium concentration in water from wells completed in perched ground water underlying the infiltration ponds was 39.4±0.9 pCi/mL in well PW-3 (table 4). Tritium concentrations in water from wells near the infiltration ponds were significantly smaller than concentrations during 1986–88, when discharge of tritium was about 185 Ci/yr. In October 1991, tritium concentrations in perched ground water near the

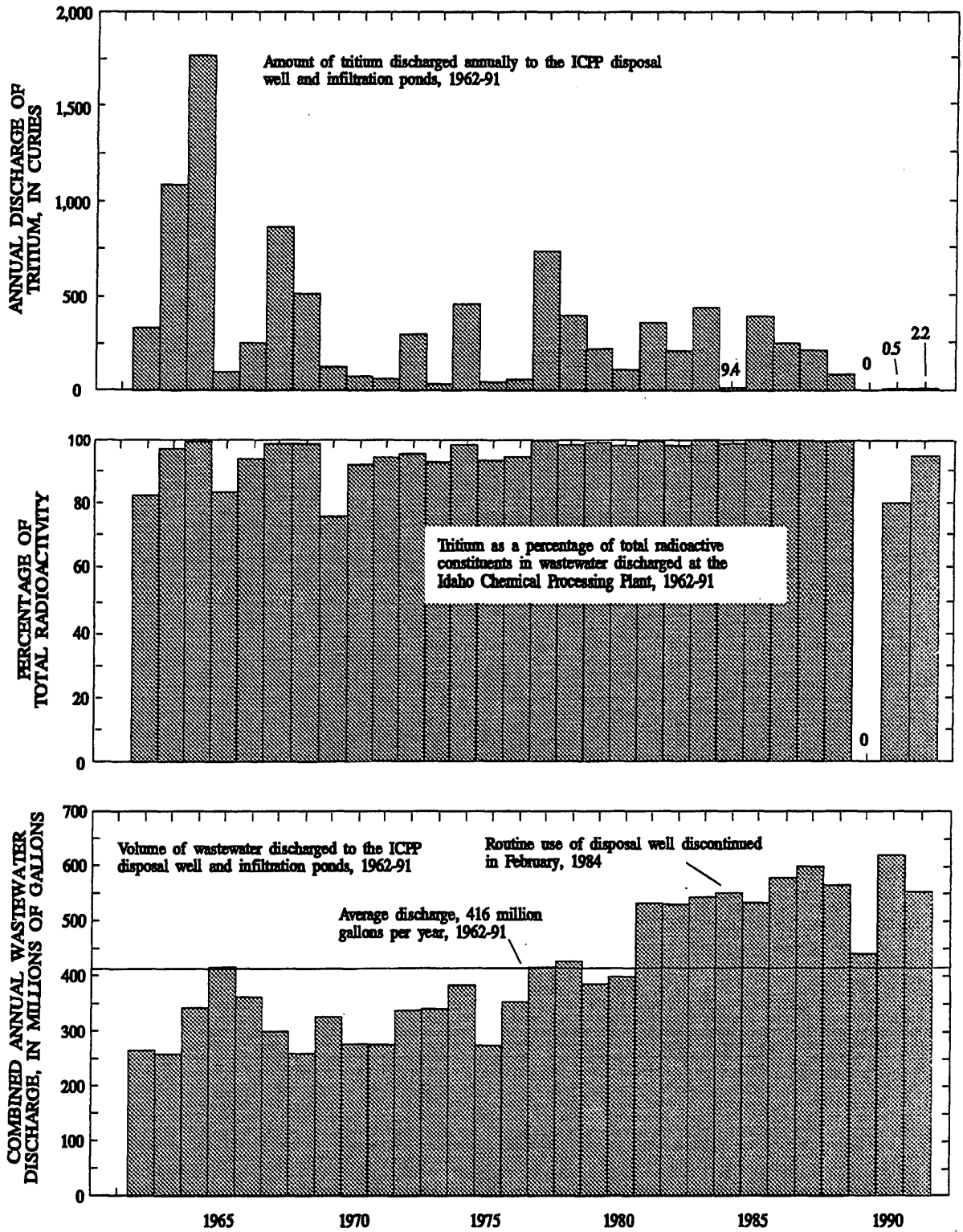

Figure 10. Amount of tritium discharged, tritium as a percentage of total radioactive constituents in wastewater discharged, and volume of wastewater discharged to the disposal well and infiltration ponds at the Idaho Chemical Processing Plant, 1962–91.

infiltration ponds ranged from less than the 3s reporting level (PW-1) to 32.3±0.8 pCi/mL (PW-6) (fig. 11). The tritium concentration in well SWP-8 was 2.3±0.2 pCi/mL in April 1991 (table 4). The tritium concentration in well SWP-13 ranged from below the reporting level in April 1991 to 4.6±0.3 pCi/mL in April 1990.

During 1989–91, tritium concentrations in water from wells PW-1 through PW-5, near the ponds, generally decreased or remained less than 10 pCi/mL (table 4) and reflected the large decrease in discharge of tritium to the ponds. Fluctuations in tritium concentrations are attributed to changes in discharge from one pond to the other. Since 1988, tritium concentrations in water from well PW-6 have remained about 30 pCi/mL. Tritium concentrations in the other wells near the ponds decreased from those reported in November 1988 (Cecil and others, 1991, p. 47).

During 1989–91, tritium concentrations in water from well 50 generally decreased from 111±2.0 pCi/mL (February 1989) to 86±1.6 pCi/mL (October 1991). Radionuclide concentrations in water in the vicinity of well 50 may have originated from leakage of wastewater from the ruptured ICPP disposal well casing or from buried, leaking wastewater pipelines at the ICPP.

Strontium-90.—Approximately 0.29 Ci of strontium-90 was contained in wastewater discharged to the ICPP infiltration ponds during 1984–91. Approximately 0.07 Ci of strontium-90 was discharged to the ponds during 1989–91; the average was about 0.02 Ci/yr. This rate of discharge reflects a slight decrease from the 1986–88 rate of 0.04 Ci/yr (Cecil and others, 1991, p. 42). Other sources of strontium-90 in perched ground water at the ICPP may include the more than 33 Ci of strontium-90 reported to have been discharged to a pit at the ICPP in 1962–63 and leakage of radioactive liquids from pipelines.

During 1989–91, concentrations of strontium-90 were detected in water from all the wells completed in deep and shallow perched ground water beneath the ICPP infiltration ponds. The largest concentration of strontium-90 in water from wells in deep perched ground water was 25±3 pCi/L from well PW-5 in July 1989 (table 4). In October 1991, strontium-90 concentrations in perched ground water near the ponds ranged from below the reporting level in water from wells PW-2 and PW-6 to 13±2.0 pCi/L in wells PW-1 and PW-3 (fig. 12). Strontium-90 concentrations in shallow perched ground water collected in April 1991 from wells SWP-8 and SWP-13 were 28±3 and 16±3 pCi/L, respectively (table 4).

Strontium-90 concentrations in perched ground water near the ICPP infiltration ponds were largest in surficial sediments and decreased with increased distance from the ponds and with depth. Decreases are attributed to sorption of strontium-90 to surficial and interbed sediments.

The largest concentrations of strontium-90 in perched ground water at the ICPP were in well 50. During 1989–91, strontium-90 concentrations in water from well 50 generally decreased from 339±12 pCi/L (February 1989) to 151±7 pCi/L (October 1991) (table 4).

Cesium-137.—Wastewater discharged to the ICPP infiltration ponds during 1984–91 contained about 0.49 Ci of cesium-137. During 1989–91, wastewater discharged to the ponds contained about 0.13 Ci of cesium-137.

During 1989–91, cesium-137 was not detected in water from any of the wells completed in perched ground water near the infiltration ponds or in well 50. The absence of detectable concentrations of cesium-137 in perched ground water at the ICPP is attributed to sorption of cesium-137 to minerals in the surficial alluvium and sedimentary interbeds.

Sodium.—Although sodium was contained in wastewater from ion-exchange units at the ICPP during 1989–91, no sodium discharge data were available. Chloride discharge records were used to estimate a volume of about 2.3 million lb of sodium that may have been discharged to the ICPP infiltration ponds (Bartholomay and others, 1995, p. 31).

During 1989–91, sodium concentrations in deep perched ground water near the infiltration ponds ranged from 120 mg/L in well PW-6 to 210 mg/L

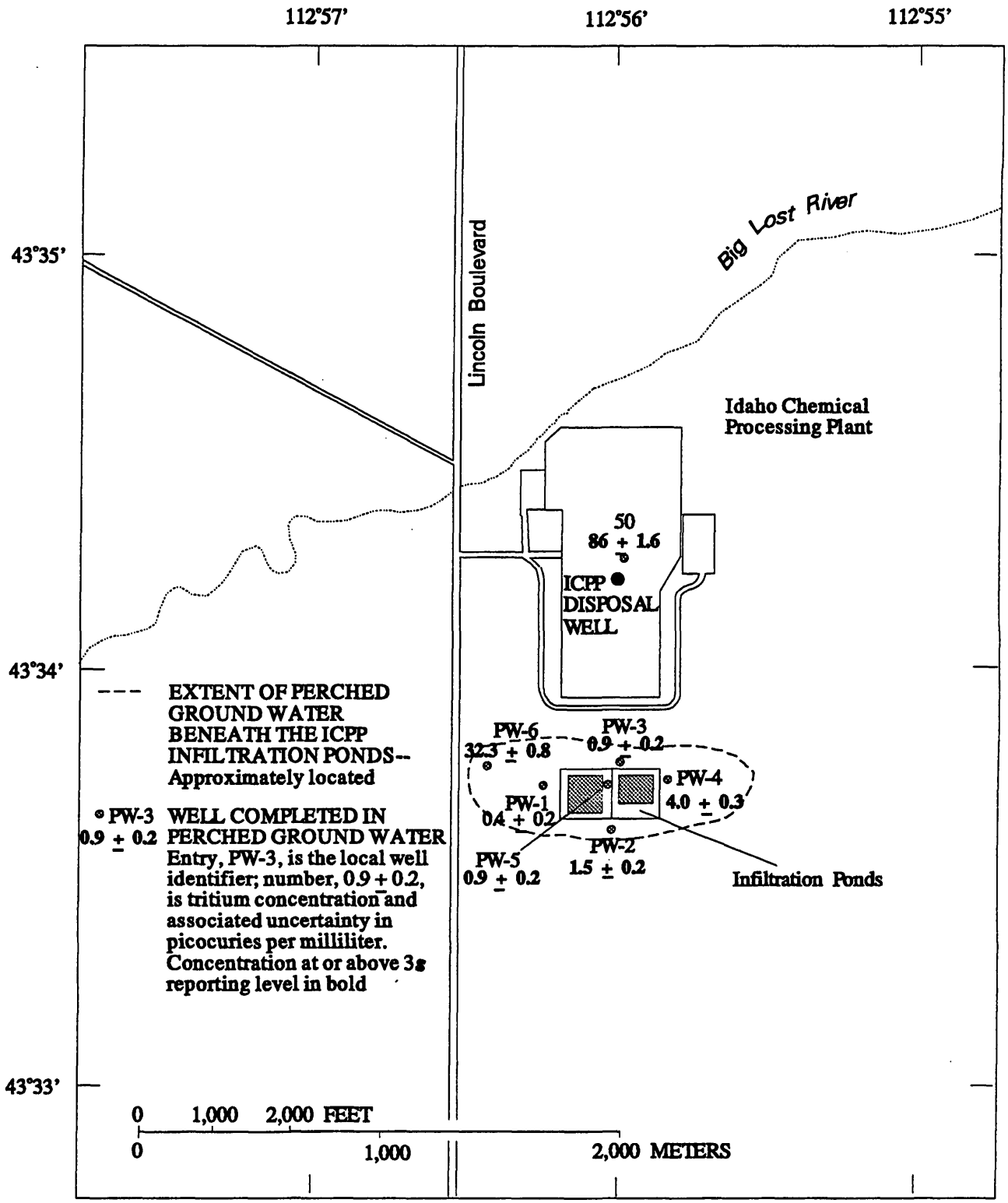

Figure 11. Tritium concentrations in water from wells completed in deep perched ground water at the Idaho Chemical Processing Plant, October 1991.

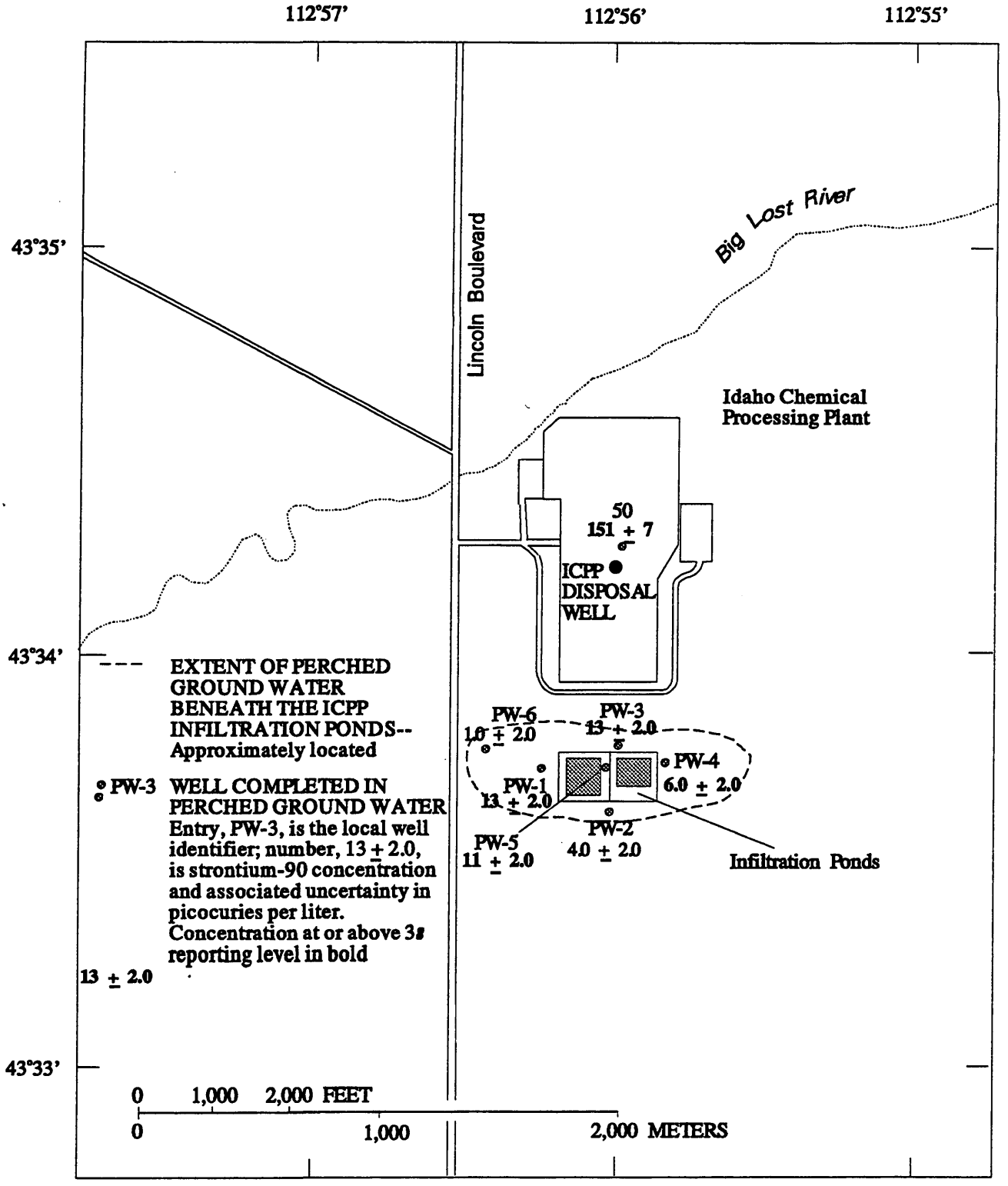

Figure 12. Strontium-90 concentrations in water from wells completed in deep perched ground water at the Idaho Chemical Processing Plant, October 1991.

in well PW-1 (table 5). In October 1991, sodium concentrations ranged from 150 mg/L in wells PW-1 and PW-2 to 180 mg/L in well PW-4. Similar concentrations in shallow perched ground water in wells SWP-8 and SWP-13 were measured.

Sodium concentrations in water from well 50 were constant during 1989–91. The concentration in October 1991 was 66 mg/L. These sodium concentrations may have originated from leakage of wastewater from the ruptured ICPP disposal well casing or from buried, leaking wastewater pipelines at the ICPP.

Chloride.—Approximately 3.6 million lb of chloride was discharged to the ICPP infiltration ponds during 1989–91. The concentration of chloride in wastewater remained relatively constant; the discharge-weighted average concentration of chloride for 1989–91 was 267 mg/L.

During 1989–91, chloride concentrations in water from wells PW-1 through PW-5 ranged from 200 to 310 mg/L (table 5); concentrations in water from well PW-6 from January 1989 to January 1991 ranged from 64 to 160 mg/L. Concentrations in two water samples from well PW-6 were 13 mg/L (May 1991) and 1,500 mg/L (July 1991). These concentrations were outside the normal range of chloride concentrations for water from this and other wells completed in the perched ground water. Specific conductance values of these two water samples were 570 and 560 µS/cm; these values were consistent with the range of specific conductance values of perched ground water during 1989–92 (355-760 µS/cm). The disparity between the May 1991 and July 1991 chloride concentrations and the other chloride concentrations indicates analytical or transcriptional error. Chloride concentrations in wells SWP-8 and SWP-13 ranged from 230 to 290 mg/L. With the exception of the two concentrations from well PW-6, chloride concentrations in deep and shallow perched ground water near the ICPP infiltration ponds reflected chloride concentrations in wastewater.

During 1989–91, chloride concentrations in water from well 50 ranged from 30 mg/L (April 1991) to 111 mg/L (February 1989) (table 5). In October 1991, the chloride concentration was 75 mg/L.

Sulfate.—Approximately 575,000 lb of sulfate was discharged to the ICPP infiltration ponds during 1989–91. Sulfate concentrations in wastewater were 73 mg/L in 1989, 35 mg/L in 1990, and 28 mg/L in 1991. The discharge-weighted average concentration for the period was 43 mg/L.

Sulfate analyses were performed on perched ground water collected from wells at the ICPP in September and October 1990 and January 1991 (table 5). Sulfate concentrations ranged from 15 mg/L in well PW-6 to 35 mg/L in well PW-2 (table 5). Water from well SWP-13 contained 27 mg/L of sulfate. Well SWP-8 was not sampled. Concentrations of sulfate in two water samples from well 50 (table 5) were 39 mg/L (October 1990) and 25 mg/L (January 1991).

Sulfate concentrations in perched ground water from wells at the ICPP reflect, in part, sulfate concentrations in wastewater during 1990–91. Concentrations smaller than the discharge-weighted average concentration in wastewater are attributed to reduction of sulfate by a microbially mediated process. Reduction of sulfate requires anaerobic conditions and the presence of the sulfate-reducing bacteria.

Fluoride.—Samples of perched ground water were collected from wells at the ICPP in September and October 1990 and January 1991 for fluoride analyses. Fluoride concentrations ranged from less than 0.10 to 0.50 mg/L (table 5).

Nutrients.—Samples of perched ground water were collected from selected wells at the ICPP in October and November 1989, October 1990, and October 1991 for dissolved-nutrient analyses (table 6). Ammonia (as nitrogen) concentrations ranged from 0.01 to 0.041 mg/L. Nitrite (as nitrogen) concentrations ranged from less than 0.01 to 0.01 mg/L. Nitrite plus nitrate (as nitrogen) concentrations ranged from 0.9 mg/L in well SWP-13 to 62 mg/L in well 50. Orthophosphate (as phosphorus) concentrations ranged from 0.03 to 0.09 mg/L.

Radioactive Waste Management Complex

Solid and liquid radioactive and chemical wastes have been buried in trenches and pits excavated in the surficial sediment at the Subsurface Disposal Area (SDA) at the RWMC (fig. 3) since 1952. Before 1970, little or no sediment was retained between the excavation bottoms and the underlying basalt. Since 1970, a layer of sediment has been retained in trenches and pits to inhibit downward migration of waste constituents. These constituents include transuranic wastes (disposed of in trenches until 1970), other radiochemical and inorganic-chemical constituents, and organic compounds.

About 550 Ci of plutonium-238, 21,000 Ci of plutonium-239, 4,900 Ci of plutonium-240, 165,000 Ci of plutonium-241, and 51,000 Ci of americium-241 were buried at the SDA during 1954–70 (Barraclough and others, 1976, p. 11). Organic compounds also have been buried in the SDA. An estimated 88,400 gal of organic compounds was disposed of before 1970 (Mann and Knobel, 1987, p. 1). These buried wastes included about 24,400 gal of carbon tetrachloride, 39,000 gal of lubricating oil, and 25,000 gal of other organic compounds, including trichloroethane, trichloroethylene, perchloroethylene, toluene, and benzene.

Perched ground water in sedimentary interbeds in basalt beneath the RWMC is attributed, in part, to local infiltration of snowmelt and rain.

Well 92 (fig. 3) at the SDA is completed in a deep sedimentary interbed (Anderson and Lewis, 1989, p. 29) 214 ft below land surface. This well monitors water that has moved to the perched zone through overlying alluvium, basalt, and interbeds and that may contain waste constituents leached from radiochemical and organic chemical wastes buried at the SDA. Small amounts of water in well 92 frequently precluded collection of an adequate sample for analyses. Samples were collected in April 1989, April 1990, and October 1991.

During 1989–91, no radiochemical constituents were above the reporting level in water samples from well 92. Tritium, strontium-90, cesium-137, plutonium-238, plutonium-239-240, and americium-241 concentrations were less than reporting levels in the samples collected from well 92 (table 7).

Chloride concentrations in water collected from well 92 ranged from 80 to 150 mg/L during 1989–91 (table 7). The chloride concentration in October 1991 was 89 mg/L.

In 1987, nine purgeable organic compounds were detected in water from well 92 (Mann and Knobel, 1987, p. 16-17). A water sample collected in January 1990 contained 230 mg/L of carbon tetrachloride, 300 mg/L of chloroform, 72 mg/L of trichloroethene, 37 mg/L of 1,1,1-trichloroethane, 5.6 mg/L of 1,1-dichloroethane, and 4.5 mg/L of tetrachloroethane (J.M. Cleveland, USGS, written commun., 1990).

One water sample was collected from well 92 in June 1989 for analyses of 54 extractable acid and base/neutral organic compounds. None of the 54 compounds were detected at concentrations exceeding their respective reporting levels, but several tentatively identified organic compounds were detected (Knobel and others, 1992, p. 37-38).

SUMMARY

Deep and shallow perched ground water are present in basalt and sedimentary interbeds beneath the TRA in response to discharge of low-level radioactive, chemical, and sanitary wastewater to infiltration ponds since 1952. During 1989–91, approximately 354 million gal/yr of wastewater was discharged to infiltration ponds at the TRA.

About 470 Ci of tritium was discharged to the TRA warm-waste ponds during 1989–91. Tritium concentrations in water from wells 62 and 56, completed in deep perched ground water, ranged from 1.3±0.2 pCi/mL to 785±12 pCi/mL. The largest tritium concentrations may have been related to leakage to the subsurface through cracks in the TRA retention basin. Though the distribution of tritium in 1991 indicates that perched ground water west of the TRA originated from the warm-waste ponds, discharge to the cold-waste ponds since 1982 has controlled water-level changes in wells to the west and south of the TRA.

Variability in tritium concentrations in perched ground water at the TRA during 1989–91 was related, in part, to variable tritium disposal rates. Tritium concentrations also were related to the proximity of the wells sampled to the warm-waste ponds and the depth of the water below the ponds. The most prominent factor affecting tritium concentrations has been recharge from the cold-waste ponds since 1982.

During 1952–88, approximately 78 Ci of strontium-90 was contained in wastewater discharged to the TRA warm-waste ponds. Only 0.0011 Ci was discharged to the ponds during 1989–91. In April 1991, concentrations of strontium-90 in water from seven wells completed in deep perched ground water were above reporting levels. Concentrations of strontium-90 ranged from 11±2.0 pCi/L to 171±9.0 pCi/L. This distribution of strontium-90 and the small amount of strontium-90 discharged during 1989–91 indicate that concentration variations may have been related to chemical equilibrium between strontium-90 sorbed to sediments beneath the warm-waste ponds and strontium-90 in solution in water passing through those sediments.

The absence of detectable concentrations of cesium-137 in perched ground water at the TRA during 1989–91 is attributed to a decrease in discharge rates and to sorption of cesium-137 to minerals in surficial sediments and sedimentary interbeds. The presence of cesium-137 in water from a shallow well is attributed to the proximity of the hole to the leaking warm-waste pond retention basin.

Wastewater from TRA cooling-tower operations containing an estimated 24,000 lb of chromium was discharged to the warm-waste ponds during 1952–64. In October 1991, concentrations of dissolved chromium in water from the deep perched ground water at the TRA ranged from 2 to 90 mg/L. The largest concentrations were in water from wells west, south, and east of the warm-waste ponds. This distribution of chromium indicates that water in outlying wells completed in perched ground water contained constituents that were discharged to the warm-waste ponds before 1965. The presence of chromium in water from wells near the warm-waste ponds is attributed to chemical equilibrium between chromium sorbed to pond-bottom sediments and chromium dissolved in perched water.

Approximately 513,000 lb of sodium was discharged to the TRA chemical-waste pond during 1989–91. In October 1991, sodium concentrations in deep perched ground water ranged from 10 to 1,300 mg/L. The largest concentration was in water from a well near the chemical-waste pond and indicates that perched ground water to the north and northwest was dominated by discharge to the chemical-waste pond.

Wastewater that contained 2,760,000 lb of sulfate was discharged to the chemical-waste and cold-waste ponds at TRA during 1989–91. During 1989–91, the sulfate concentration in deep perched ground water ranged from 35 mg/L to 4,300 mg/L. The largest concentration was in water from a well near the chemical-waste pond and reflects the large concentrations of sulfate in wastewater discharged to the chemical-waste pond.

Two wastewater-infiltration ponds were constructed south of the ICPP in 1984 to replace the ICPP disposal well. Wastewater leakage from these ponds formed perched ground water in the basalt and sedimentary interbeds above the eastern Snake River Plain aquifer. Perched ground water also has been identified in other areas beneath the ICPP. Sources for the perched ground water may include other infiltration ponds, leaking wastewater pipelines, leach fields, ruptured casing in the upper part of the ICPP disposal well, and landscape irrigation.

Approximately 960 Ci of tritium was discharged to the ICPP infiltration ponds during 1984–88. During 1986–88, the average rate of tritium discharged was 185 Ci/yr. In 1989, tritium was not discharged to the ponds. During 1990–91, 2.7 Ci of tritium was discharged to the ponds. Tritium concentrations in water from wells near the infiltration ponds were significantly smaller than concentrations during 1986–88, when discharge of tritium was about 185 Ci/yr. In October 1991, tritium concentrations in water from the perched zones underlying the infiltration ponds ranged from less than the reporting level to

32.3±0.8 pCi/mL. Tritium and other radiochemical and inorganic chemical constituents in perched water near the ICPP disposal well may have originated from leakage of wastewater from the ruptured disposal well casing or from buried, leaking wastewater pipelines.

Approximately 0.29 Ci of strontium-90 was contained in wastewater discharged to the ICPP infiltration ponds during 1984–91. During 1989–91, concentrations of strontium-90 were detected in water from all the wells completed in deep and shallow perched ground water beneath the ICPP infiltration ponds. The largest concentration in water from wells in deep perched ground water was 25±3 pCi/L. Strontium-90 concentrations in perched ground water near the ICPP infiltration ponds were largest in surficial sediments and decreased with distance from the ponds and with depth. Decreases are attributed to sorption of strontium-90 to surficial and interbed sediments.

Wastewater discharged to the ICPP infiltration ponds during 1984–91 contained about 0.49 Ci of cesium-137. During 1989–91, wastewater discharged to the ponds contained about 0.13 Ci of cesium-137. During 1989–91, there were no detectable concentrations of cesium-137 in water from any of the wells completed in the perched ground water near the infiltration ponds. The absence of detectable concentrations of cesium-137 in perched ground water at the ICPP is attributed to sorption of cesium-137 to minerals in the surficial sediments and sedimentary interbeds.

No sodium discharge data were available for ICPP wastewater during 1989–91. Chloride discharge records were used to estimate a volume of about 2.3 million lb of sodium that may have been discharged to the ICPP infiltration ponds from ion-exchange units. During 1989–91, sodium concentrations in deep perched ground water near the infiltration ponds ranged from 120 to 210 mg/L. Concentrations in shallow perched ground water were similar. The sodium concentration in perched ground water from a well near the disposal well was 66 mg/L. These concentrations may have originated from leakage of wastewater from the ruptured disposal well casing or from buried, leaking waste-water pipelines at the ICPP.

Approximately 3.6 million lb of chloride was discharged to the ICPP infiltration ponds during 1989–91. The discharge-weighted average concentration of chloride for 1989–91 was 267 mg/L. During 1989–91, chloride concentrations in water from wells completed in perched ground water ranged from 200 to 310 mg/L. Chloride concentrations in the deep and shallow perched ground water near the ICPP infiltration ponds reflected chloride concentrations in wastewater.

Approximately 575,000 lb of sulfate was discharged to the ICPP infiltration ponds during 1989–91. The discharge-weighted average concentration was 43 mg/L. Sulfate concentrations in water from wells completed in perched ground water beneath the ICPP infiltration ponds ranged from 15 mg/L to 35 mg/L. These sulfate concentrations in perched ground water reflect, in part, sulfate concentrations in wastewater during 1990–91. Concentrations smaller than the discharge-weighted average concentration in wastewater are attributed to reduction of sulfate by a microbially mediated process.

Perched ground water beneath the RWMC in sedimentary interbeds in basalt is attributed, in part, to local infiltration of snowmelt and rainfall and may contain waste constituents leached from radiochemical and organic chemical wastes buried at the RWMC. During 1989–91, no radiochemical constituents were above the reporting level in samples collected from well 92 at the RWMC. One water sample collected from well 92 in January 1990 contained 230 mg/L of carbon tetrachloride, 300 mg/L of chloroform, 72 mg/L of trichloroethene, 37 mg/L of 1,1,1-trichloroethane, 5.6 mg/L of 1,1-dichloroethane, and 4.5 mg/L of tetrachloroethane.

SELECTED REFERENCES

Ackerman, D.J., 1991, Transmissivity of perched aquifers at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 91-4114 DOE/ID-22099, 27 p.

Anderson, S.R., 1991, Stratigraphy of the unsaturated zone and uppermost part of the Snake River Plain aquifer at the Idaho Chemical Pro-

cessing Plant and Test Reactors Area, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 91-4010 DOE/ID-22095, 71 p.

Anderson, S.R., and Bowers, B., 1995, Stratigraphy of the unsaturated zone and uppermost part of the Snake River Plain aquifer at Test Area North, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 95-4130 DOE/ID-22122, 47 p.

Anderson, S.R., and Lewis, B.D., 1989, Stratigraphy of the unsaturated zone at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 89-4065 DOE/ID-22080, 54 p.

Barraclough, J.T., and Jensen, R.G., 1976, Hydrologic data for the Idaho National Engineering Laboratory site, Idaho, 1971 to 1973: U.S. Geological Survey Open-File Report 75-318 IDO-22055-USGS, 52 p.

Barraclough, J.T., Lewis, B.D., and Jensen, R.G., 1981, Hydrologic conditions at the Idaho National Engineering Laboratory, Idaho, emphasis–1974–1978: U.S. Geological Survey Water-Resources Investigations Open-File Report 81-526 IDO-22060-USGS, 116 p.

Barraclough, J.T., Robertson, J.B., and Janzer, V.J., 1976, Hydrology of the solid waste burial ground, as related to the potential migration of radionuclides, Idaho National Engineering Laboratory, *with a section on* Drilling and sample analyses, by L.G. Saindon: U.S. Geological Survey Open-File Report 76-471 IDO-22056-USGS, 183 p.

Barraclough, J.T., Teasdale, W.E., and Jensen, R.G., 1967a, Hydrology of the National Reactor Testing Station, Idaho, 1965: U.S. Geological Survey Open-File Report IDO-22048-USGS, 107 p.

Barraclough, J.T., Teasdale, W.E., Robertson, J.B., and Jensen, R.G., 1967b, Hydrology of the National Reactor Testing Station, Idaho, 1966: U.S. Geological Survey Open-File Report IDO-22049-USGS, 95 p.

Bartholomay, R.C., 1990a, Digitized geophysical logs for selected wells on or near the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Open-File Report 90-366 DOE/ID-22088, 347 p.

----- 1990b, Mineralogical correlation of surficial sediment from area drainages with selected sedimentary interbeds at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 90-4147 DOE/ID-22092, 18 p.

----- 1993, Concentrations of tritium and strontium-90 in water from selected wells at the Idaho National Engineering Laboratory after purging one, two, and three borehole volumes: U.S. Geological Survey Water-Resources Investigations Report 93-4201 DOE/ID-22111, 21 p.

Bartholomay, R.C., and Knobel, L.L., 1989, Mineralogy and grain size of surficial sediment from the Little Lost River and Birch Creek drainages, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Open-File Report 89-385 DOE/ID-22082, 19 p.

Bartholomay, R.C., Knobel, L.L., and Davis, L.C., 1989, Mineralogy and grain size of surficial sediment from the Big Lost River drainage and vicinity, with chemical and physical characteristics of geologic materials from selected sites at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Open-File Report 89-384, DOE/ID-22081, 74 p.

Bartholomay, R.C., Orr, B.R., Liszewski, M.J., and Jensen, R.G., 1995, Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, Idaho National Engineering Laboratory, Idaho, 1989 through 1991: U.S. Geological Survey Water-Resources Investigations Report 95-4175 DOE/ID-22123, 47 p.

Bennett, C.M., 1990, Streamflow losses and ground-water level changes along the Big

Lost River at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 90-4067 DOE/ID-22091, 47 p.

Busenberg, Eurybiades, Weeks, E.P., Plummer, L.N., and Bartholomay, R.C., 1993, Age dating ground water by use of chlorofluorocarbons (CCl_3F and CCl_2F_2), and distribution of chlorofluorocarbons in the unsaturated zone, Snake River Plain aquifer, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 93-4054 DOE/ID-22107, 47 p.

Cecil, L.D., Knobel, L.L., Wegner, S.J., and Moore, L.L., 1989, Evaluation of field sampling and preservation methods for strontium-90 in ground water at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 89-4146 DOE/ID-22083, 24 p.

Cecil, L.D., Orr, B.R., Norton, T., and Anderson, S.R., 1991, Formation of perched groundwater zones and concentrations of selected chemical constituents in water, Idaho National Engineering Laboratory, Idaho, 1986–88: U.S. Geological Survey Water-Resources Investigations Report 91-4166 DOE/ID-22100, 53 p.

Claassen, H.C., 1982, Guidelines and techniques for obtaining water samples that accurately represent the water chemistry of an aquifer: U.S. Geological Survey Open-File Report 82-1024, 49 p.

Currie, L.A., 1984, Lower limit of detection-definition and elaboration of a proposed position for radiological effluent and environmental measurements: U.S. Nuclear Regulatory Commission NUREG/CR-4007, 139 p.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Goerlitz, D.F., and Brown, Eugene, 1972, Methods for analysis of organic substances in water: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 40 p.

Hull, L.C., 1989, Conceptual model and description of the affected environment for the TRA warm waste pond (Waste Management Unit TRA-03): E.G.& G. Idaho Informal Report EGG-ER-8644, 125 p.

Idaho Department of Health and Welfare, 1977, Idaho regulations for public drinking water systems: Idaho Department of Health and Welfare, Division of Environment Publication Title 1, Chapter 8, 44 p.

Jones, P.H., 1961, Hydrology of waste disposal, National Reactor Testing Station, Idaho, an interim report: U.S. Atomic Energy Commission, Idaho Operations Office Publication IDO-22042-USGS, 152 p.

Knobel, L.L., Bartholomay, R.C., Cecil, L.D., Tucker, B.J., and Wegner, S.J., 1992, Chemical constituents in the dissolved and suspended fractions of ground water from selected sites, Idaho National Engineering Laboratory and vicinity, Idaho, 1989: U.S. Geological Survey Open-File Report 92-51 DOE/ID-22101, 56 p.

Knobel, L.L., and Mann, L.J., 1988, Radionuclides in ground water at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Open-File Report 88-731 DOE/ID-22077, 37 p.

Knobel, L.L., and Mann, L.J., 1993, Sampling for purgeable organic compounds using positive-displacement piston and centrifugal submersible pumps—a comparative study: Ground Water Monitoring Review, Spring 1993, p. 142-148.

Lewis, B.D., and Jensen, R.G., 1984, Hydrologic conditions at the Idaho National Engineering Laboratory, Idaho, 1979–1981 update: U.S. Geological Survey Hydrologic Investigations Atlas HA-674, 2 sheets.

Liszewski, M.J., and Mann, L.J., 1992, Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho, 1990 and 1991: U.S. Geological Survey Open-File Report 92-174 DOE/ID-22104, 19 p.

----- 1993, Concentrations of 23 trace elements in ground water and surface water at and near the Idaho National Engineering Laboratory, Idaho, 1988–91: U.S. Geological Survey Open-File Report 93-126 DOE/ID-22110, 44 p.

Litteer, D.L., and Peterson, C.N., 1990, Idaho National Engineering Laboratory industrial waste management information for 1989 and record-to-date: U.S. Department of Energy, Waste Management Programs Division, Idaho Operations Office Publication DOE/ID-10057 (89), [117] p.

Litteer, D.L., Peterson, C.N., and Sims, A.M., 1991a, Idaho National Engineering Laboratory industrial waste management information for 1990 and record-to-date: U.S. Department of Energy, Waste Management Programs Division, Idaho Operations Office Publication DOE/ID-10057 (90), [121] p.

-----1991b, Idaho National Engineering Laboratory radioactive waste management information for 1990: U.S. Department of Energy, Waste Management Programs Division, Idaho Operations Office Publication DOE/ID-10055 (90), [595] p.

-----1992, Idaho National Engineering Laboratory nonradiological waste management information for 1991 and record-to-date: U.S. Department of Energy Waste Management Programs Division, Idaho Operations Office Publication DOE/ID-10057 (91), [variously paged].

-----1993, Idaho National Engineering Laboratory radioactive waste management information for 1991 and record-to-date: U.S. Department of Energy, Waste Management Programs Division, Idaho Operations Office Publication DOE/ID-10054 (91), [569] p.

Litteer, D.L., and Reagan, B.D., 1990, Idaho National Engineering Laboratory radioactive waste management information for 1989: U.S. Department of Energy, Waste Management Programs Division, Idaho Operations Office Publication DOE/ID-100545 (89) [503] p.

Lucius, J.E., Olhoeft, G.R., Hill, P.L., and Duke, S.K., 1989, Properties and hazards of 108 selected substances: U.S. Geological Survey Open-File Report 89-491, 538 p.

Mann, L.J., 1990, Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho—1988 and 1989: U.S. Geological Survey Open-File Report 90-367 DOE/ID-22089, 17 p.

Mann, L.J., and Cecil, L.D., 1990, Tritium in ground water at the Idaho National Engineering Laboratory: U.S. Geological Survey Water-Resources Investigations Report 90-4090 DOE/ID-22090, 35 p.

Mann, L.J., and Knobel, L.L., 1987, Purgeable organic compounds in ground water at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Open-File Report 87-766 DOE/ID-22074, 23 p.

-----1988, Concentrations of nine trace metals in ground water at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Open-File Report 88-332 DOE/ID-22075, 17 p.

Morris, D.A., Barraclough, J.T., Chase, G.H., Teasdale, W.E., and Jensen, R.G., 1965, Hydrology of subsurface waste disposal, National Reactor Testing Station, Idaho, annual progress report, 1964: U.S. Atomic Energy Commission, Idaho Operations Office Publication IDO-22047-USGS, 186 p.

Morris, D.A., Barraclough, J.T., Hogenson, G.M., Shuter, Eugene, Teasdale, W.E., Ralston, D.A., and Jensen, R.G., 1964, Hydrology of subsurface waste disposal, National Reactor Testing Station, Idaho, annual progress report, 1963: U.S. Atomic Energy Commission,

Idaho Operations Office Publication IDO-22046-USGS, 97 p.

Morris, D.A., Hogenson, G.M., Shuter, Eugene, and Teasdale, W.E., 1963, Hydrology of waste disposal, National Reactor Testing Station, Idaho, annual progress report, 1962: U.S. Atomic Energy Commission, Idaho Operations Office Publication IDO-22044-USGS, 99 p.

Mundorff, M.J., Crosthwaite, E.G., and Kilburn, Chabot, 1964, Ground water for irrigation in the Snake River Basin in Idaho: U.S. Geological Survey Water-Supply Paper 1654, 224 p.

Nace, R.L., Voegeli, P.T., Jones, J.R., and Deutsch, Morris, 1975, Generalized geologic framework of the National Reactor Testing Station, Idaho: U.S. Geological Survey Professional Paper 725-B, 49 p.

Olmsted, F.H., 1962, Chemical and physical character of ground water in the National Reactor Testing Station, Idaho: U.S. Atomic Energy Commission, Idaho Operations Office Publication IDO-22043-USGS, 142 p.

Orr, B.R., and Cecil, L.D., 1991, Hydrologic conditions and distribution of selected chemical constituents in water, Snake River Plain aquifer, Idaho National Engineering Laboratory, Idaho, 1986 to 1988: U.S. Geological Survey Water-Resources Investigations Report 91-4047 DOE/ID-22096, 56 p.

Orr, B.R., Cecil, L.D., and Knobel, L.L., 1991, Background concentrations of selected radionuclides, organic compounds, and chemical constituents in ground water in the vicinity of the Idaho National Engineering Laboratory: U.S. Geological Survey Water-Resources Investigations Report 91-4015 DOE/ID-22094, 52 p.

Pittman, J.R., Jensen, R.G., and Fischer, P.R., 1988, Hydrologic conditions at the Idaho National Engineering Laboratory, 1982 to 1985: U.S. Geological Survey Water-Resources Investigations Report 89-4008 DOE/ID-22078, 73 p.

Pritt, J.W., and Jones, B.E., eds., 1989, 1990 National Water Quality Laboratory services catalog: U.S. Geological Survey Open-File Report 89-386, pts 1-5.

Robertson, J.B., 1977, Numerical modeling of subsurface radioactive solute transport from waste-seepage ponds at the Idaho National Engineering Laboratory: U.S. Geological Survey Open-File Report 76-717 IDO-22057-USGS, 68 p.

Robertson, J.B., Schoen, Robert, and Barraclough, J.T., 1974, The influence of liquid waste disposal on the geochemistry of water at the National Reactor Testing Station, Idaho, 1952-1970: U.S. Geological Survey Open-File Report IDO-22053-USGS, 231 p.

Stevens, H.H., Jr., Ficke, J.F., and Smoot, G.F., 1975, Water temperature—influential factors, field measurement, and data presentation: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. D1, 65 p.

U.S. Environmental Protection Agency, 1989, Protection of environment, Code of Federal Regulations 40: Parts 100 to 149, Washington, D.C., Office of the Federal Register, National Archives and Records Administration, 948 p.

U.S. Geological Survey, 1985, National water summary, 1984—hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

Walker, E.H., 1964, Subsurface geology of the National Reactor Testing Station, Idaho: U.S. Geological Survey Bulletin 1133-E, 22 p.

Walker, F.W., Parrington, J.R., and Feiner, Frank, 1989, Nuclides and isotopes, chart of the nuclides (14th ed.): General Electric Company, Nuclear Energy Operations, 57 p.

Wegner, S.J., 1989, Selected quality assurance data for water samples collected by the U.S. Geological Survey Water-Resources Investigations Report 89-4168 DOE/ID-22085, 91 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water -Resources Investigations, book 5, champ. A3, 80 p.

Wood, W.W., 1981, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, book 1, chap. D2, 24 p.

Table 1. Location, construction, and sample-collection method and frequency of wells completed in perched ground water at the Idaho National Engineering Laboratory

[Well identifier: see figure 3 for location of wells. Sampling method: Pump - sample collected with a portable pump; sampling depth indicated; Bailer - sample collected with a bail sampler. Sampling frequency: S - semiannual; Q quarterly; T - three times annually. Symbols: <, less than; ft, feet]

Well identifier	Location		Well construction		Water-sample collection	
	Latitude	Longitude	Well diameter (inches)	Well depth (feet)	Sampling method	Sampling frequency
CWP-1	43°34'59"	112°57'26"	10	66.0	Pump 65 ft	S
CWP-2	43°34'58"	112°57'24"	10	52.5	Pump 52 ft	S
CWP-3	43°34'55"	112°57'25"	10	60.5	Pump 60 ft	S
CWP-4	43°34'54"	112°57'26"	10	61.0	Pump 60 ft	S
CWP-5	43°34'55"	112°57'29"	10	53.5	Pump 53 ft	S
CWP-6	43°34'56"	112°57'33"	10	52.5	Pump 52 ft	S
CWP-7	43°34'58"	112°57'32"	10	53.5	Pump 53 ft	S
CWP-8	43°35'00"	112°57'30"	10	66.0	Pump 65 ft	S
PW-1	43°33'49"	112°56'08"	10	120	Pump 105 ft	Q
PW-2	43°33'45"	112°55'57"	10	131	Pump 115 ft	Q
PW-3	43°33'51"	112°55'58"	10	125	Pump 121 ft	Q
PW-4	43°33'49"	112°55'49"	10	150	Pump 115 ft	Q
PW-5	43°33'49"	112°55'57"	10	129	Pump 115 ft	Q
PW-6	43°33'53"	112°56'22"	10	125	Pump 130 ft	Q
PW-7	43°34'47"	112°57'47"	10	237	Pump 220 ft	Q
PW-8	43°34'57"	112°57'21"	10	170	Pump 145 ft	Q
PW-9	43°35'01"	112°57'55"	10	200	Pump 195 ft	Q
SWP-8	43°33'51"	112°55'54"	8	26	Bailer	T
SWP-13	43°33'49"	112°55'57"	8	32.5	Bailer	T
TRA A-13	43°35'02"	112°57'28"	1.5	58.8	Bailer	Q
TRA A-77	43°35'07"	112°57'38"	2	34	Bailer	Q
50	43°34'19"	112°56'02"	6	405	Bailer	Q
53	43°35'02"	112°57'35"	6	70.5	Pump 80 ft	S
54	43°35'02"	112°57'28"	6	91	Pump 80 ft	Q
55	43°35'09"	112°57'29"	6	79	Pump 75 ft	S
56	43°35'09"	112°57'35"	6	80	Pump 75 ft	S
60	43°34'57"	112°57'20"	6	117	Pump 90 ft	Q
61	43°34'53"	112°57'16"	10	123	Pump 105 ft	S

Table 1. Location, construction, and sample-collection method and frequency of wells completed in perched ground water at the Idaho National Engineering Laboratory—Continued

Well identifier	Location		Well construction		Water-sample collection	
	Latitude	Longitude	Well diameter (inches)	Well depth (feet)	Sampling method	Sampling frequency
62	43°34'46"	112°57'06"	8	165	Pump 150 ft	S
63	43°34'55"	112°57'40"	10	97	Pump 95 ft	S
66	43°34'39"	112°56'57"	6	475	Pump <185 ft	S
68	43°35'15"	112°57'39"	10	128	Pump 85 ft	Q
69	43°34'50"	112°57'29"	10	115	Pump 100 ft	S
70	43°35'03"	112°57'11"	8	100	Pump 85 ft	S
71	43°34'40"	112°57'15"	8	184	Pump 170 ft	S
72	43°35'19"	112°57'46"	6	177	Pump <150 ft	S
73	43°35'01"	112°57'54"	6	127	Pump 100 ft	S
74	43°35'05"	112°58'06"	6	192	Bailer	S
92	43°30'01"	113°02'53"	6	214	Bailer	S

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91

[Analyses were performed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1s. Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in boldface type. Abbreviations: (m/d/y), month/day/year; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter. Symbol: NR indicates analysis not requested]

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
CWP-1	4/26/89	-.01±0.15	-1.6±1.7	NR
	11/01/89	.16±0.16	NR	NR
	03/22/90	-.13±0.17	NR	NR
	10/03/90	-.10±0.20	0±2.0	NR
	4/17/91	-.10±0.16	-.1±1.5	NR
CWP-2	11/01/89	.01±0.15	NR	NR
	3/22/90	.10±0.20	NR	NR
	10/05/90	0±0.20	-1.6±1.9	NR
	4/23/91	.09±0.16	-4.0±4.0	NR
	10/21/91	0±0.20	1.0±2.0	NR
CWP-3	4/25/89	.11±0.16	-1.9±1.4	NR
	11/01/89	.01±0.15	NR	NR
	3/22/90	-.14±0.17	NR	NR
	10/09/90	.16±0.18	-1.3±2.1	NR
	4/17/91	.04±0.16	-5.0±5.0	NR
CWP-4	4/25/89	-.01±0.15	2.0±1.4	NR
	11/01/89	.03±0.15	NR	NR
	3/22/90	-.10±0.20	NR	NR
	10/09/90	0±0.20	0±2.0	NR
	4/17/91	.05±0.16	-4.9±1.5	NR
	10/21/91	-.10±0.16	-1.0±2.0	NR
CWP-5	4/25/89	-.06±0.15	3.7±1.6	NR
	11/01/89	.08±0.15	NR	NR
	3/22/90	-.14±0.17	NR	NR
	10/12/90	-.10±0.20	-1.7±2.0	NR
	4/24/91	.07±0.16	0±2.0	NR

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
CWP-6	4/25/89	-.01±0.15	-.1±1.4	NR
CWP-7	4/26/89	.14±0.16	.8±1.5	NR
	3/23/90	0±0.20	NR	NR
CWP-8	4/26/89	.10±0.16	-2.5±1.5	NR
	11/01/89	.11±0.16	NR	NR
	3/23/90	.14±0.18	NR	NR
	10/15/90	-.10±0.20	-1.3±2.1	NR
	4/23/91	-.01±0.16	-3.0±2.0	NR
TRA A-13	2/17/89	.17±0.17	**319±12**	NR
	4/25/89	.29±0.16	**141±6.0**	NR
	7/07/89	.13±0.16	NR	NR
	11/03/89	.10±0.16	NR	0±20
	1/30/90	.07±0.16	NR	NR
	3/13/90	-.10±0.20	NR	-15±37
	6/27/90	.12±0.18	NR	NR
	9/24/90	.12±0.18	**77±5.0**	60±30
	1/14/91	-.13±0.18	NR	NR
	4/04/91	.10±0.16	**94±5.0**	10±30
	7/01/91	.10±0.20	**106±6.0**	-30±30
TRA A-77	2/01/89	**3,790±50**	NR	NR
	4/27/89	**959±14**	NR	**1,000±80**
	7/20/89	**1,320±20**	NR	NR
	11/13/89	**2,610±40**	NR	**8,500±400**
	1/18/90	**1,760±30**	NR	NR
	4/16/90	**2,160±30**	NR	**180±50**
	7/17/90	**1,370±20**	NR	NR
	10/11/90	**2,370±30**	**2,770±80**	**2,840±160**
	1/18/91	**2,480±40**	NR	NR
	4/25/91	**1,200±20**	**4,950±140**	**6,270±240**

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
TRA A-77 - cont.	7/02/91	**1,990±30**	**3,660±110**	**4,750±190**
	10/30/91	**2,370±30**	**1,870±60**	**2,700±120**
PW-7	1/02/90	.40±0.20	NR	NR
	4/10/90	.50±0.20	NR	-30±40
	7/02/90	**.70±0.20**	NR	NR
	10/22/90	.40±0.20	0±2.0	NR
	1/11/91	.30±0.20	NR	NR
	4/22/91	**.60±0.20**	3.0±2.0	11±26
	7/11/91	**.70±0.20**	3.0±2.0	-20±30
	10/29/91	.50±0.20	-1.3±2.1	NR
PW-8	1/26/89	**9.3±0.40**	-1.3±1.7	NR
	3/24/89	**9.3±0.40**	**23±3.0**	-20±20
	7/06/89	**2.5±0.20**	NR	NR
	10/30/89	**1.5±0.20**	NR	NR
	1/29/90	**1.7±0.20**	NR	NR
	3/21/90	**2.5±0.20**	NR	-10±40
	6/27/90	**1.0±0.20**	NR	NR
	9/26/90	**.80±0.20**	**13±2.0**	NR
	1/04/91	**3.3±0.30**	NR	NR
	4/05/91	**3.6±0.30**	**18±2.0**	20±40
	7/01/91	**2.7±0.20**	**14±3.0**	17±28
	10/22/91	**13.4±0.50**	**15±3.0**	NR
PW-9	4/08/89	**257±4**	.3±1.5	-13±33
	7/19/89	**226±4**	NR	NR
	11/06/89	**226±4**	NR	NR
	1/31/89	**221±3**	NR	NR
	4/10/90	**247±4**	NR	12±40
	7/02/90	**230±4**	NR	NR
	10/22/90	**219±4**	**14±3.0**	NR
	1/14/91	**241±4**	NR	NR

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW-9 - cont.	4/24/91	**223±4**	1.0±1.6	-20±30
	7/01/91	**227±4**	2.0±2.0	30±30
	10/29/91	**233±4**	1.3±2.2	NR
53	3/28/89	**1,060±20**	**105±5.0**	14±32
	11/06/89	**312±5**	NR	NR
	4/13/90	**316±5**	NR	-50±40
	9/24/90	**179±3**	**160±7.0**	NR
	4/08/91	**345±5**	**116±6.0**	-30±30
54	1/27/89	**30.8±0.7**	**194±8.0**	NR
	4/14/89	**15.1±0.5**	NR	NR
	7/07/89	**4.5±0.3**	NR	NR
	11/03/89	**3.2±0.2**	NR	NR
	1/30/90	**46.7±1.0**	NR	NR
	3/13/90	**4.6±0.3**	NR	10±48
	6/27/90	**1.9±0.2**	NR	NR
	9/24/90	**2.0±0.2**	**177±7.0**	NR
	1/14/91	**1.4±0.2**	NR	NR
	4/03/91	**1.0±0.2**	**171±9.0**	-15±35
	7/01/91	**1.5±0.2**	**184±8.0**	-20±30
55	3/21/89	**99.5±1.8**	**8.0±2.0**	20±30
	11/03/89	**24.8±0.6**	NR	NR
	4/13/90	**14.7±0.5**	NR	60±50
	9/24/90	**74.8±1.4**	**17±3.0**	NR
	4/04/91	**8.5±0.4**	**11±2.0**	0±30
56	3/28/89	**1,420±20**	**12±2.0**	20±30
	11/15/89	**645±10**	NR	NR
	4/18/90	**752±11**	NR	-5.0±16
	10/22/90	**934±14**	**72±5.0**	NR
	4/15/91	**785±12**	**89±5.0**	0±30

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
60	1/26/89	**0.8±0.2**	-0.6±1.6	NR
	3/24/89	**1.6±0.2**	2.0±1.6	30±30
	7/06/89	.06±0.16	NR	NR
	10/30/89	.11±0.16	NR	NR
	1/29/90	.06±0.16	NR	NR
	3/21/90	0±0.2	NR	-90±40
	6/26/90	0±0.2	NR	NR
	9/25/90	.1±0.2	0±2.0	NR
	1/04/91	0±0.2	NR	NR
	4/05/91	.3±0.2	4.0±2.0	20±30
	7/01/91	.08±0.17	-3.0±2.0	-10±30
	10/22/91	**5.1±0.3**	0±2.0	NR
61	3/24/89	**15.1±0.5**	-.9±1.5	-30±30
	10/25/89	**17.6±0.5**	NR	NR
	4/18/90	**16.7±0.5**	NR	10±30
	9/27/90	**14.7±0.5**	0±2.0	NR
	4/09/91	**14.7±0.5**	1.4±2.0	-20±30
	10/23/91	**13.2±0.5**	-1.1±2.0	NR
62	3/20/89	**2.7±0.2**	NR	10±20
	10/26/89	**1.5±0.2**	NR	NR
	4/13/90	**1.7±0.2**	NR	16±27
	10/09/90	**1.9±0.2**	0±2.0	NR
	4/08/91	**1.6±0.2**	1.5±1.7	20±30
	10/23/91	**1.3±0.2**	1.0.±2.0	NR
63	3/22/89	.25±0.16	2.4±1.6	-50±40
	10/31/89	-.10±0.15	NR	NR
	4/10/90	.10±0.18	NR	13±36
	10/12/90	**1.8±0.2**	3.3±1.5	NR
	4/08/91	**1.0±0.2**	**13±2.0**	-20±30
	10/23/91	.2±0.2	4.0±2.0	NR

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
66	4/07/89	**7.4±0.3**	-0.8±1.5	-10±40
	11/07/89	**6.7±0.3**	NR	NR
	4/26/90	**9.9±0.4**	NR	30±20
	10/22/90	**8.3±0.4**	2.0±2.0	NR
	4/22/91	**8.6±0.4**	-.7±1.6	-60±30
	10/29/91	**7.0±0.4**	1.2±2.3	NR
68	2/01/89	-.12±0.16	NR	NR
	4/27/89	.01±0.15	-3.0±2.0	NR
	7/20/89	-.02±0.16	NR	NR
	11/13/89	-.01±0.15	NR	NR
	1/18/90	-.11±0.15	NR	NR
	4/16/90	-.10±0.20	NR	0±40
	7/16/90	-.10±0.20	NR	NR
	10/11/90	.10±0.20	0±2.0	NR
	1/18/91	-.12±0.18	NR	NR
	4/25/91	-.07±0.16	0±1.5	-10±30
	7/02/91	-.05±0.16	6.0±2.0	20±30
	10/30/91	.20±0.20	2.0±2.0	NR
69	3/22/89	.07±0.16	-1.4±1.5	60±30
	10/31/89	.01±0.15	NR	NR
	4/09/90	0±0.2	NR	0±30
	10/05/90	.20±0.2	2.0±2.0	NR
	4/08/91	.09±0.16	3.5±1.6	10±30
	10/24/91	.02±0.17	-3.0±2.0	NR
70	3/28/89	**209±3.0**	**78±5.0**	30±30
	11/14/89	**42.7±0.9**	NR	NR
	4/04/90	**76.5±1.5**	NR	20±40
	10/03/90	**38.4±0.9**	**76±5.0**	NR
	4/11/91	**42.8±1.0**	**70±4.0**	-70±20
	10/18/91	**106±2.0**	**60±4.0**	NR

Table 2. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
71	4/07/89	**21.4±0.6**	2.0±2.0	0±30
	11/07/89	**12.2±0.4**	NR	NR
	4/26/90	**14.8±0.5**	NR	-20±30
	10/18/90	**13.5±0.5**	1.0±2.0	NR
	4/22/91	**13.3±0.5**	3.0±2.0	10±40
	10/29/91	**9.8±0.4**	0±2.0	NR
72	4/08/89	.13±0.16	-.3±1.5	0±40
	11/13/89	**2.9±0.2**	NR	NR
	4/16/90	.15±0.18	NR	20±30
	10/11/90	0±0.2	1.4±2.1	NR
	4/25/91	.07±0.16	.3±1.5	-50±40
	10/30/91	.2±0.2	2.0±2.0	NR
73	3/22/89	**185±3.0**	-1.4±1.4	20±30
	11/15/89	**181±3.0**	NR	NR
	4/10/90	**351±5.0**	NR	-30±40
	10/22/90	**263±4.0**	1.0±2.0	NR
	4/15/91	**126±2.0**	2.0±2.0	20±30
	10/24/91	**208±3.0**	2.0±2.0	NR
74	4/01/89	**108±2.0**	-2.2±1.4	40±30
	11/06/89	**91.2±1.6**	NR	NR
	4/26/90	**111±2.0**	NR	30±30
	10/22/90	**106±2.0**	1.0±2.0	NR
	4/26/91	**104±2.0**	3.0±7.0	-60±30
	10/28/91	**95.3±1.8**	2.0±2.0	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91

[Analyses were performed by the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory. Abbreviations: (m/d/y), month/day/year; µg/L, microgram per liter; mg/L, milligram per liter; <, less than; >, greater than. Symbol: NR indicates analysis not requested]

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
CWP-1	4/26/89	<50	NR	NR	12	13	NR	NR
	11/01/89	NR	NR	6	NR	27	NR	NR
	11/01/89	NR	NR	NR	NR	31	NR	NR
	3/22/90	NR	NR	4	NR	8.7	NR	NR
	10/03/90	7	5	NR	NR	28	320	<.10
	4/17/91	3	1	NR	NR	14	NR	NR
CWP-2	11/01/89	NR	NR	1	NR	15	NR	NR
	3/22/90	NR	NR	2	NR	18	NR	NR
	10/05/90	<1	<1	NR	NR	20	200	<.10
	4/23/91	1	<1	NR	NR	22	NR	NR
	10/21/91	<1	<1	NR	NR	24	NR	NR
CWP-3	4/25/89	<50	NR	NR	14	14	NR	NR
	11/01/89	NR	<1	NR	NR	19	NR	NR
	3/22/90	NR	NR	6	NR	11	NR	NR
	10/09/90	3	<1	NR	NR	27	190	<.10
	4/17/91	4	<1	NR	NR	17	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
CWP-4	4/25/89	<50	NR	NR	13	15	NR	NR
	11/01/89	NR	NR	7	NR	17	NR	NR
	3/22/90	NR	NR	6	NR	12	NR	NR
	10/09/90	1	<1	NR	NR	17	180	.20
	4/17/91	<1	<1	NR	NR	20	NR	NR
	10/21/91	<1	<1	NR	14	14	NR	NR
CWP-5	4/25/89	<50	NR	NR	12	14	NR	NR
	11/01/89	NR	NR	12	NR	25	NR	NR
	3/22/90	NR	NR	5	NR	9.7	NR	NR
	10/12/90	7	4	NR	NR	26	320	.20
	4/24/91	4	<1	NR	NR	12	NR	NR
CWP-6	4/25/89	<50	NR	NR	10	13	NR	NR
CWP-7	4/26/89	<50	NR	NR	9.0	11	NR	NR
	3/23/90		NR	5	NR	9.2	NR	NR
CWP-8	4/26/89	<50	NR	NR	8.0	8.0	NR	NR
	11/01/89	NR	NR	<1	NR	13	NR	NR
	3/23/90	NR	NR	9	NR	22	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
CWP-8 - cont.	10/15/90	<1	<1	NR	NR	17	180	.20
	4/23/91	2	2	NR	NR	91	NR	NR
TRA A-13	2/17/89	<50	NR	NR	NR	29	NR	NR
	4/25/89	<50	NR	NR	16	14	NR	NR
	7/07/89	<50	NR	NR	NR	20	NR	NR
	11/03/89	NR	NR	<1	17	22	NR	NR
	11/03/89	NR	NR	NR	14	24	NR	NR
	1/30/90	NR	NR	44	NR	39	NR	NR
	3/13/90	NR	NR	41	NR	3.3	NR	NR
	6/27/90	NR	NR	12	NR	19	NR	NR
	9/24/90	<1	<1	NR	20	25	210	<.10
	1/14/91	<1	<1	NR	NR	33	300	.30
	4/04/91	4	<1	NR	NR	31	NR	NR
	7/01/91	19	<1	NR	NR	32	NR	NR
TRA A-77	2/01/89	<50	NR	NR	NR	1.0	NR	NR
	4/27/89	<50	NR	NR	NR	1.0	NR	NR
	7/20/89	60	NR	NR	NR	1.0	NR	NR
	11/13/89	NR	NR	1,300	2.6	1.5	NR	NR
	1/18/90	NR	NR	1,300	NR	NR	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
TRA A-77 - cont.	4/16/90	NR	NR	20	NR	1.5	NR	NR
	7/17/90	NR	NR	47	NR	2.5	NR	NR
	10/11/90	41	6	NR	6.7	1.6	5.9	<.10
	1/18/91	8	<1	NR	NR	0.3	5.0	<.10
	4/25/91	24	<1	NR	NR	1.1	NR	NR
	7/02/91	6	<1	NR	NR	1.1	NR	NR
	10/31/91	53	9	NR	1.0	1.2	NR	NR
PW-7	1/02/90	NR	NR	200	NR	15	NR	NR
	4/10/90	NR	NR	87	NR	15	NR	NR
	7/02/90	NR	NR	26	NR	17	NR	NR
	10/22/90	5	3	NR	11	18	160	.30
	1/11/91	2	<1	NR	NR	21	150	.30
	4/22/91	5	3	NR	NR	19	NR	NR
	7/11/91	<3	<1	NR	NR	15	NR	NR
	10/29/91	2	<1	NR	10	16	NR	NR
PW-8	1/26/89	<50	NR	NR	NR	32	NR	NR
	3/24/89	<50	NR	NR	NR	22	NR	NR
	7/06/89	<50	NR	NR	NR	19	NR	NR
	10/30/89	NR	NR	6	15	17	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
PW-8 - cont.	1/29/90	NR	NR	5	NR	17	NR	NR
	3/21/90	NR	NR	2	NR	5.9	NR	NR
	6/27/90	NR	NR	8	NR	21	NR	NR
	9/26/90	6	2	NR	17	24	250	.10
	1/04/91	8	4	NR	NR	23	250	.20
	4/05/91	7	5	NR	NR	22	NR	NR
	7/01/91	6	<1	NR	NR	21	NR	NR
	10/22/91	11	<1	NR	16	20	NR	NR
PW-9	4/08/89	50	NR	NR	NR	33	NR	NR
	7/19/89	50	NR	NR	NR	27	NR	NR
	11/06/89	NR	NR	240	23	27	NR	NR
	1/31/90	NR	NR	190	NR	30	NR	NR
	4/10/90	NR	NR	190	NR	27	NR	NR
	7/02/90	NR	NR	99	NR	34	NR	NR
	10/22/90	21	17	NR	23	29	120	.20
	1/14/91	90	50	NR	NR	30	120	.30
	4/24/91	70	40	NR	NR	25	NR	NR
	7/01/91	70	20	NR	NR	28	NR	NR
	10/29/91	90	65	NR	23	29	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
53	3/28/89	140	NR	NR	NR	15	NR	NR
	11/06/89	NR	NR	NR	15	17	NR	NR
	11/06/89	<50	NR	NR	NR	18	NR	NR
	4/13/90	NR	NR	55	NR	19	NR	NR
	9/24/90	20	.8	NR	17	23	250	.10
	4/08/91	30	20	NR	NR	16	NR	NR
54	1/27/89	<50	NR	NR	NR	27	NR	NR
	4/14/89	<50	NR	NR	16	21	NR	NR
	7/07/89	<50	NR	NR	NR	21	NR	NR
	11/03/89	NR	NR	NR	17	19	NR	NR
	11/03/89	<50	NR	NR	NR	NR	NR	NR
	1/30/90	NR	NR	14	NR	22	NR	NR
	3/13/90	NR	NR	15	NR	23	NR	NR
	6/27/90	NR	NR	11	NR	23	NR	NR
	9/24/90	9	2	NR	19	26	300	<.10
	1/14/91	8	<1	NR	NR	29	280	.40
	4/03/91	6	6	NR	NR	19	NR	NR
	7/01/91	8	1	NR	NR	22	NR	NR
55	3/21/89	60	NR	NR	NR	25	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
55 - cont.	11/03/89	NR	NR	NR	29	31	NR	NR
	11/03/89	130	NR	NR	NR	NR	NR	NR
	4/13/90	NR	NR	130	NR	32	NR	NR
	9/24/90	130	>25	NR	29	31	51	<.10
	4/04/91	60	48	NR	NR	31	NR	NR
56	3/28/89	100	NR	NR	NR	8.0	NR	NR
	11/15/89	NR	NR	91	16	12	NR	NR
	4/18/90	NR	NR	61	NR	11	NR	NR
	10/22/90	80	>25	NR	12	8.9	35	.20
	4/15/91	60	54	NR	NR	8.9	NR	NR
60	1/26/89	<50	NR	NR	NR	33	NR	NR
	3/24/89	<50	NR	NR	NR	22	NR	NR
	7/06/89	<50	NR	NR	NR	15	NR	NR
	10/30/89	NR	NR	4	7.9	17	NR	NR
	1/29/90	NR	NR	4	NR	20	NR	NR
	3/21/90	NR	NR	6	NR	22	NR	NR
	6/26/90	NR	NR	6	NR	21	NR	NR
	9/25/90	6	3	NR	17	24	270	.20
	1/04/91	5	6	NR	NR	22	230	.40

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
60 - cont.	4/05/91	5	5	NR	NR	21	NR	NR
	7/01/91	4	<1	NR	NR	21	NR	NR
	10/22/91	7	3	NR	15	19	NR	NR
61	3/24/89	<50	NR	NR	NR	13	NR	NR
	10/25/89	NR	NR	18	15	19	NR	NR
	10/25/89	<50	NR	NR	NR	NR	NR	NR
	4/18/90	NR	NR	21	NR	19	NR	NR
	9/27/90	20	15	NR	15	19	150	<.10
	4/09/91	20	11	NR	NR	16	NR	NR
	10/23/91	20	5	NR	14	18	NR	NR
62	3/20/89	<50	NR	NR	NR	23	NR	NR
	10/26/89	NR	NR	11	17	17	NR	NR
	10/26/89	<50	NR	NR	NR	NR	NR	NR
	4/13/90	NR	NR	13	NR	21	NR	NR
	10/09/90	9	9	NR	17	20	210	.20
	4/08/91	8	7	NR	NR	22	NR	NR
	10/23/91	9	<1	NR	16	19	NR	NR
63	3/22/89	<50	NR	NR	NR	19	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
63 - cont.	10/31/89	NR	7	8	15	17	NR	NR
	10/31/89	<50	NR	NR	NR	NR	NR	NR
	4/10/90	NR	NR	9	NR	22	NR	NR
	10/12/90	20	18	NR	17	22	230	.20
	4/08/91	9	8	NR	NR	22	NR	NR
	10/23/91	9	4	NR	15	18	NR	NR
66	4/07/89	<50	NR	NR	NR	25	NR	NR
	11/07/89	NR	NR	100	17	23	NR	NR
	4/26/90	NR	NR	47	NR	22	NR	NR
	10/22/90	7	2	NR	16	19	190	.20
	4/22/91	10	10	NR	NR	20	NR	NR
68	2/01/89	<50	NR	NR	NR	38	NR	NR
	4/27/89	<50	NR	NR	1,000	33	NR	NR
	7/20/89	50	NR	NR	NR	35	NR	NR
	11/13/89	NR	12	13	1,100	37	NR	NR
	11/13/89	<50	NR	NR	NR	NR	NR	NR
	1/18/90	NR	NR	17	NR	42	NR	NR
	4/16/90	NR	NR	28	NR	42	NR	NR
	7/16/90	NR	NR	21	NR	36	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
68 - cont.	10/11/90	20	9	NR	1,100	41	4,300	2.7
	1/18/91	20	<1	NR	NR	43	4,000	2.7
	4/25/91	20	8	NR	NR	9.0	NR	NR
	7/02/91	20	<1	NR	NR	47	NR	NR
	10/30/91	10	1	NR	1,300	29	NR	NR
69	3/22/89	<50	NR	NR	NR	20	NR	NR
	10/31/89	NR	NR	3	36	17	NR	NR
	4/09/90	NR	NR	7	NR	21	NR	NR
	10/05/90	4	1	NR	10	21	150	<.10
	4/08/91	3	<1	NR	NR	21	NR	NR
	10/24/91	2	<1	NR	10	22	NR	NR
70	3/28/89	<50	NR	NR	NR	19	NR	NR
	11/14/89	NR	16	15	16	18	NR	NR
	11/14/89	<50	NR	NR	NR	NR	NR	NR
	4/04/90	NR	NR	20	NR	17	NR	NR
	10/03/90	20	11	NR	18	23	230	<.10
	4/11/91	20	17	NR	NR	19	NR	NR
	10/18/91	40	23	NR	15	18	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
71	4/07/89	70	NR	NR	NR	23	NR	NR
	11/07/89	NR	44	71	8.3	18	NR	NR
	11/07/89	50	NR	NR	NR	NR	NR	NR
	4/26/90	NR	NR	71	NR	22	NR	NR
	10/18/90	70	20	NR	9.6	18	160	.20
	4/22/91	60	58	NR	NR	20	NR	NR
	10/29/91	50	30	NR	10	19	NR	NR
72	4/08/89	<50	NR	NR	NR	18	NR	NR
	11/13/89	NR	NR	32	NR	83	NR	NR
	4/16/90	NR	NR	50	NR	17	NR	NR
	10/11/90	<1	<1	NR	NR	22	36	<.10
	4/25/91	2	2	NR	NR	15	NR	NR
	10/30/91	3	<1	NR	NR	16	NR	NR
73	3/22/89	60	NR	NR	NR	64	NR	NR
	11/15/89	NR	29	34	18	23	NR	NR
	11/15/89	<50	NR	NR	NR	NR	NR	NR
	4/10/90	NR	NR	46	NR	19	NR	NR
	10/22/90	70	>25	NR	18	30	55	.20
	4/15/91	90	110	NR	NR	24	NR	NR

Table 3. Concentrations of selected dissolved ions and total recoverable chromium in perched ground water from selected wells in the vicinity of the Test Reactor Area, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Chromium, dissolved (µg/L)	Hexavalent chromium, dissolved (µg/L)	Total recoverable chromium, (µg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Fluoride, dissolved (mg/L)
73-cont.	10/24/91	70	24	NR	21	36	NR	NR
74	4/01/89	130	NR	NR	NR	29	NR	NR
	11/06/89	NR	62	160	19	25	NR	NR
	11/06/89	170	NR	NR	NR	NR	NR	NR
	4/26/90	NR	NR	110	NR	27	NR	NR
	10/22/90	100	>25	NR	22	26	150	.20
	4/26/91	100	100	NR	NR	23	NR	NR
	10/28/91	90	50	NR	22	27	NR	NR

Table 4. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91

[Analyses were performed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1s. Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in boldface type. Abbreviations: (m/d/y), month/day/year; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; -, minus. Symbol: NR indicates analysis not requested]

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW-1	1/30/89	**1.6±0.2**	**22±3.0**	NR
	4/24/89	**1.5±0.2**	**20±2.0**	-40±30
	7/13/89	**10.8±0.4**	**16±2.0**	NR
	10/27/89	**4.9±0.3**	**18±2.0**	NR
	1/31/90	**4.0±0.3**	**13±2.0**	NR
	4/12/90	**1.5±0.2**	**14±2.0**	-10±30
	7/03/90	**1.4±0.2**	**19±2.0**	NR
	9/28/90	0.4±0.2	**13±2.0**	NR
	1/07/91	**1.1±0.2**	**14±2.0**	NR
	4/30/91	**3.9±0.3**	**12±2.0**	40±30
	7/26/91	**2.7±0.2**	**13±2.0**	NR
	10/16/91	0.4±0.2	**13±2.0**	NR
PW-2	3/21/89	**5.1±0.3**	1.1±1.6	11±33
	7/14/89	**4.7±0.3**	0.7±1.7	NR
	10/27/89	**15.2±0.5**	3.0±2.0	NR
	2/02/90	**15.7±0.5**	1.9±1.7	NR
	4/02/90	**10.6±0.4**	3.3±1.6	-40±40
	6/28/90	**4.4±0.3**	4.0±2.0	NR
	10/16/90	**2.5±0.2**	**8.0±2.0**	NR
	1/08/91	**25.7±0.7**	6.0±2.0	NR
	4/29/91	**11.1±0.4**	5.0±2.0	-14±25
	7/26/91	**9.3±0.4**	2.0±2.0	NR
	10/16/91	**1.5±0.2**	4.0±2.0	NR
PW-3	1/30/89	**4.3±0.3**	**9.0±2.0**	NR
	3/20/89	**3.0±0.2**	**14±2.0**	-30±30
	7/14/89	**3.7±0.3**	**11±2.0**	NR
	11/02/89	**39.4±0.9**	**12±2.0**	NR

Table 4. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW-3 - cont.	2/01/90	**15.6±0.5**	**14±2.0**	NR
	3/30/90	**20.2±0.6**	**12±2.0**	10±30
	6/28/90	**1.4±0.2**	**12±3.0**	NR
	10/16/90	**1.2±0.2**	**11±2.0**	NR
	1/08/91	**2.9±0.3**	4.0±2.0	NR
	5/01/91	**4.3±0.3**	**7.0±2.0**	-30±30
	7/31/91	**2.5±0.2**	3.0±3.0	NR
	10/16/91	**0.9±0.2**	**13±2.0**	NR
PW-4	3/28/89	**13.7±0.5**	**15±2.0**	10±30
	7/17/89	**12.1±0.4**	**13±2.0**	NR
	10/27/89	**10.5±0.4**	**9.0±2.0**	NR
	2/02/90	**2.3±0.2**	3.8±1.7	NR
	3/30/90	**7.0±0.4**	**7.0±2.0**	-60±40
	6/29/90	**4.5±0.3**	4.0±2.0	NR
	10/17/90	**5.0±0.3**	**8.0±2.0**	NR
	1/07/91	**1.4±0.2**	**9.0±2.0**	NR
	4/29/91	**3.5±0.3**	**8.0±2.0**	11±26
	7/16/91	**4.0±0.3**	3.0±2.0	NR
	10/18/91	**4.0±0.3**	6.0±2.0	NR
PW-5	3/30/89	**1.6±0.2**	**14±2.0**	-30±30
	7/18/89	**7.4±0.3**	**25±3.0**	NR
	10/30/89	**3.9±0.3**	**10±2.0**	NR
	2/01/90	**2.5±0.2**	**11±2.0**	NR
	4/02/90	**2.9±0.3**	**7.0±2.0**	-40±40
	7/06/90	**2.0±0.2**	**13±2.0**	NR
	10/10/90	**1.2±0.2**	**14±3.0**	NR
	4/04/91	**1.4±0.2**	**8.0±2.0**	-60±30
	7/31/91	**1.4±0.2**	**8.0±2.0**	NR
	10/17/91	**0.9±0.2**	**11±2.0**	NR

Table 4. Concentrations of tritium, strontium-90, and cesium-137 in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)
PW-6	1/30/89	**34.4±0.8**	3.0±2.0	NR
	3/21/89	**31.2±0.7**	-0.1±1.4	80±40
	6/28/90	**28.8±0.7**	**21±3.0**	NR
	10/18/90	**29.0±0.7**	0±2.0	NR
	1/14/91	**34.3±0.8**	-1.3±1.4	NR
	5/01/91	**33.4±0.8**	4.4±1.7	16±28
	7/11/91	**33.9±0.8**	-4.0±2.0	NR
	10/29/91	**32.3±0.8**	1.0±2.0	NR
SWP-8	11/14/89	**1.3±0.2**	4.0±2.0	-30±30
	4/23/91	**2.3±0.2**	**28±3.0**	50±30
SWP-13	11/14/89	0.2±0.16	**10±2.0**	30±30
	4/30/90	**4.6±0.3**	**7.0±2.0**	-20±40
	10/10/90	**0.8±0.2**	7.0±3.0	20±30
	4/04/91	0.4±0.2	**16±3.0**	0±20
50	2/17/89	**111±2.0**	**339±12**	15±29
	4/06/89	**110±2.0**	**291±11**	0±20
	7/19/89	**101±2.0**	**258±10**	-30±20
	11/06/89	**100±2.0**	**202±8**	NR
	1/19/90	**96.4±1.7**	**229±9**	10±30
	4/23/90	**104±2.0**	**257±10**	-10±50
	7/24/90	**101±2.0**	**298±11**	-14±25
	10/31/90	**95.5±1.7**	**238±9**	NR
	1/17/91	**97.7±1.8**	**273±10**	-20±20
	4/25/91	**90.9±1.7**	**242±10**	30±30
	7/19/91	**88±1.6**	**227±10**	30±20
	10/28/91	**86±1.6**	**151±7**	-20±30

Table 5. Concentrations of selected dissolved ions in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91

[Analyses were performed by the National Water Quality Laboratory and by the Radiological and Environmental Sciences Laboratory. Abbreviations: (m/d/y), month/day/year; mg/L, milligram per liter; <, less than. Symbol: NR indicates analysis not requested]

Well identifier	Date sampled (m/d/y)	Sodium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)
PW-1	1/30/89	NR	300	NR	NR
	4/24/89	NR	250	NR	NR
	7/13/89	NR	240	NR	NR
	10/27/89	150	260	NR	NR
	1/31/90	NR	240	NR	NR
	4/12/90	NR	250	NR	NR
	7/03/90	NR	310	NR	NR
	9/28/90	210	300	27	<.10
	1/07/91	NR	250	31	.30
	4/30/91	NR	300	NR	NR
	7/26/91	NR	310	NR	NR
	10/16/91	150	270	NR	NR
PW-2	3/21/89	NR	200	NR	NR
	7/14/89	NR	250	NR	NR
	10/27/89	160	270	NR	NR
	2/02/90	NR	230	NR	NR
	4/02/90	NR	240	NR	NR
	6/28/90	NR	250	NR	NR
	10/16/90	190	310	23	.30
	1/08/91	NR	260	35	.40
	4/29/91	NR	290	NR	NR
	7/26/91	NR	270	NR	NR
	10/16/91	150	250	NR	NR
PW-3	1/30/89	NR	240	NR	NR
	3/20/89	NR	220	NR	NR
	7/14/89	NR	240	NR	NR
	11/02/89	160	240	NR	NR
	2/01/90	NR	240	NR	NR

Table 5. Concentrations of selected dissolved ions in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Sodium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)
PW-3 - cont.	3/30/90	NR	230	NR	NR
	6/28/90	NR	270	NR	NR
	10/16/90	180	280	23	.20
	1/08/91	NR	250	33	.50
	5/01/91	NR	280	NR	NR
	7/31/91	NR	260	NR	NR
	10/16/91	160	280	NR	NR
PW-4	3/28/89	NR	200	NR	NR
	7/17/89	NR	260	NR	NR
	10/27/89	150	250	NR	NR
	2/02/90	NR	250	NR	NR
	3/30/90	NR	270	NR	NR
	6/29/90	NR	230	NR	NR
	10/17/90	190	300	25	.20
	1/07/91	NR	260	31	.20
	4/29/91	NR	280	NR	NR
	7/16/91	NR	310	NR	NR
	10/18/91	180	300	NR	NR
PW-5	3/20/89	NR	210	NR	NR
	7/18/89	NR	290	NR	NR
	10/30/89	160	240	NR	NR
	2/01/90	NR	230	NR	NR
	4/02/90	NR	210	NR	NR
	7/06/90	NR	250	NR	NR
	10/10/90	190	310	22	.20
	4/04/91	NR	270	NR	NR
	7/31/91	NR	270	NR	NR
	10/17/91	160	260	NR	NR
PW-6	1/30/89	NR	90	NR	NR

Table 5. Concentrations of selected dissolved ions in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91—Continued

Well identifier	Date sampled (m/d/y)	Sodium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Fluoride (mg/L)
	3/21/89	NR	64	NR	NR
	6/28/90	NR	95	NR	NR
	10/18/90	120	160	15	.20
	1/14/91	NR	130	24	.10
	5/01/91	NR	13	NR	NR
	7/11/91	NR	1,500	NR	NR
SWP-8	11/14/89	160	250	NR	NR
	4/23/91	NR	270	NR	NR
SWP-13	11/14/89	150	240	NR	NR
	4/30/90	NR	230	NR	NR
	10/10/90	180	290	27	<.10
	4/04/91	NR	270	NR	NR
50	2/17/89	NR	111	NR	NR
	4/06/89	NR	84	NR	NR
	7/19/89	NR	80	NR	NR
	11/06/89	68	86	NR	NR
	1/19/90	NR	81	NR	NR
	4/23/90	NR	86	NR	NR
	7/24/90	NR	81	NR	NR
	10/31/90	69	81	39	.20
	1/17/91	NR	78	25	.30
	4/25/91	NR	30	NR	NR
	7/19/91	NR	78	NR	NR
	10/28/91	66	75	NR	NR

Table 6. Concentrations of dissolved nutrients in perched ground water from selected wells in the vicinity of the Idaho Chemical Processing Plant, 1989–91

[Analyses were performed by the National Water Quality Laboratory. Abbreviations: (m/d/y), month/day/year; mg/L, milligram per liter; <, less than]

Well identifier	Date sampled (m/d/y)	Ammonia (as nitrogen) (mg/L)	Nitrite (as nitrogen) (mg/L)	Nitrite plus nitrate (as nitrogen) (mg/L)	Ortho-phosphate (as phosphorus) (mg/L)
PW-1	10/17/89	0.03	<0.01	1.9	0.07
SWP-8	11/14/89	.01	.01	2.9	.03
SWP-13	11/14/89	.01	<.01	2.1	.09
	10/10/90	.021	<.01	.901	.07
50	11/06/89	.041	<.01	41	.05
	10/31/90	.03	<.01	62	.03
	10/28/91	.03	<.01	38	.04

Table 7. Concentrations of selected radiochemical constituents and dissolved chloride in perched ground water from a selected well in the vicinity of the Radioactive Waste Management Complex, 1989–91

[Analyses were performed by the Radiological and Environmental Sciences Laboratory. Analytical uncertainties are reported as 1s. Concentrations that meet or exceed the reporting level of 3 times the 1s value are shown in boldface type. Abbreviations: (m/d/y), month/day/year; pCi/mL, picocurie per milliliter; pCi/L, picocurie per liter; mg/L, milligram per liter; -, minus. Symbol: NR indicates analysis not requested]

Well identifier	Date sampled (m/d/y)	Tritium (pCi/mL)	Strontium-90 (pCi/L)	Cesium-137 (pCi/L)	Americium-241 (pCi/L)	Plutonium-238 (pCi/L)	Plutonium-239, 240 (pCi/L)	Chloride (mg/L)
92	4/3/89	0.2±0.16	-1.3±1.5	20±30	0.02±0.05	-0.017±0.06	0.0±0.04	80±8
	4/23/90	0±0.20	1±2	NR	NR	NR	NR	150
	10/31/91	0.4±0.20	1±1.8	0±20	0.0±0.03	0.01±0.02	0.0±0.15	89