

RADIONUCLIDES, CHEMICAL CONSTITUENTS, AND ORGANIC COMPOUNDS IN WATER
FROM DESIGNATED WELLS AND SPRINGS FROM THE SOUTHERN BOUNDARY OF
THE IDAHO NATIONAL ENGINEERING LABORATORY
TO THE HAGERMAN AREA, IDAHO, 1989

By

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CONVERSION FACTORS AND ABBREVIATED WATER QUALITY UNITS

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi ²)	2.590	square kilometer
acre-foot (acre-ft)	1,233	cubic meter
millirem (mrem)	0.010	millisievert
picrocurie per liter (pCi/L)	37.00	becquerel per milliliter

Temperature can be converted from degrees Celsius (°C) to degrees Fahrenheit (°F) by the equation: °F = (°C × 1.8) + 32

Abbreviated water-quality units used in report: µg/L (microgram per liter); mg/L (milligram per liter); mL (milliliter); and µS/cm (microsiemens per centimeter at 25 degrees Celsius).

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ABSTRACT

The U.S. Geological Survey and the Idaho Department of Water Resources, in response to a request from the U.S. Department of Energy, have completed the initial phase of a long-term project to monitor the quality of water in the Snake River Plain aquifer from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho. Fifty-five water samples were collected and analyzed for manmade pollutants and naturally occurring contaminants. The samples were collected from 26 irrigation wells, 13 domestic wells, 5 springs, 4 stock wells, 3 dairy wells, 2 observation wells, 1 commercial well, and 1 public-supply well. Six quality assurance samples also were collected and analyzed. All water samples were analyzed for selected radionuclides, chemical constituents, and organic compounds.

The maximum contaminant level established by the U.S. Environmental Protection Agency for gross alpha-particle radioactivity was exceeded in one sample; the maximum contaminant level for mercury also was exceeded in one sample. Both sampling locations are downgradient from many of the sampling locations in which gross-alpha radioactivity and mercury concentrations were less than maximum contaminant levels. Concentrations of diazinon and malathion exceeded the reporting level in two water samples. One water sample and its quality assurance replicate contained reportable concentrations of DDT.

INTRODUCTION

Recently, much concern has been expressed by the public regarding waste disposal practices at the INEL (Idaho National Engineering Laboratory) and the impact these practices might have on the ground-water quality in the Snake River Plain aquifer. The U.S. Department of Energy requested that the U.S. Geological Survey conduct two studies to respond to the public's concern about ground-water quality and to gain a greater understanding of the chemical quality of the water in the Snake River Plain aquifer. The first study was a one-time sampling event in the eastern part of the A & B Irrigation District in Minidoka County (Mann and Knobel, 1990). The second study, an ongoing sampling effort in the area between the southern boundary of the INEL and Hagerman, Idaho (fig. 1), is being conducted in cooperation with the Idaho Department of Water Resources. This report summarizes the analyses of water samples collected from 55 sites during August and September 1989, the initial year of that sampling effort. In the future, about 18 of the sites will be sampled annually. Therefore, all sites will be sampled at least once every 3 years.

The INEL includes about 890 mi² of the northeastern part of the eastern Snake River Plain, and is about 110 mi northeast of the Hagerman area (fig. 1). Wastewater containing chemical and radiochemical wastes generated at the INEL was discharged to ponds and wells from 1952 to 1984. Since 1984, most aqueous wastes have been discharged to infiltration ponds. Many of the constituents in the wastewater enter the aquifer indirectly following percolation through the unsaturated zone (Pittman and others, 1988).

Chemical and radioactive wastes have migrated up to about 9 mi southwest of the disposal areas at the INEL (Pittman and others, 1988, p. 51). Tritium, which is one of the most conservative constituents in wastewater entering the aquifer, was detected periodically at concentrations of 3,400±200 pCi/L or less in water from three wells along the southern boundary of the INEL during 1983-85. Since April 1986, tritium concentrations in water from wells along the southern boundary have been less than the analytical method detection limit of 500 pCi/L (Mann and Cecil, 1990).

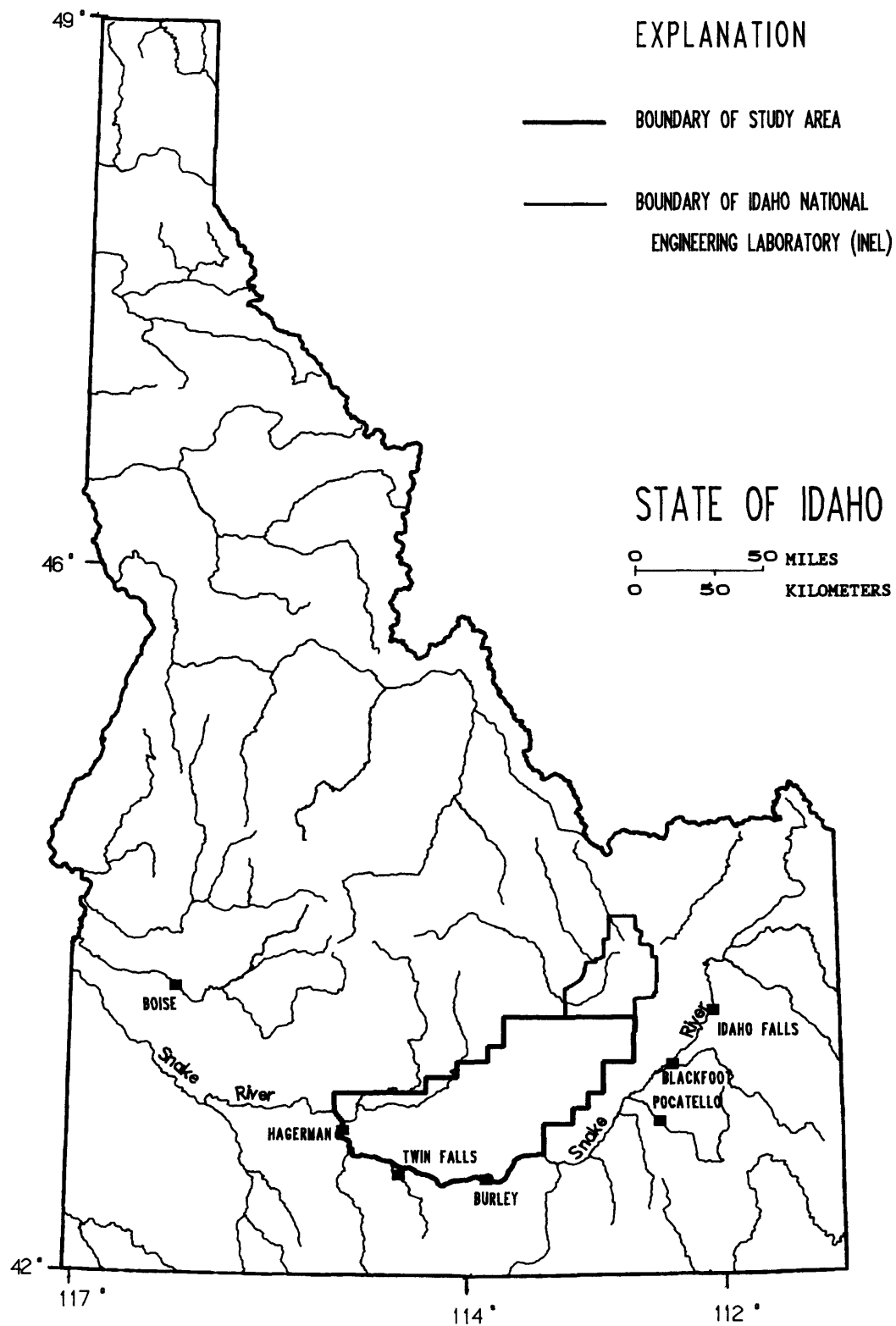


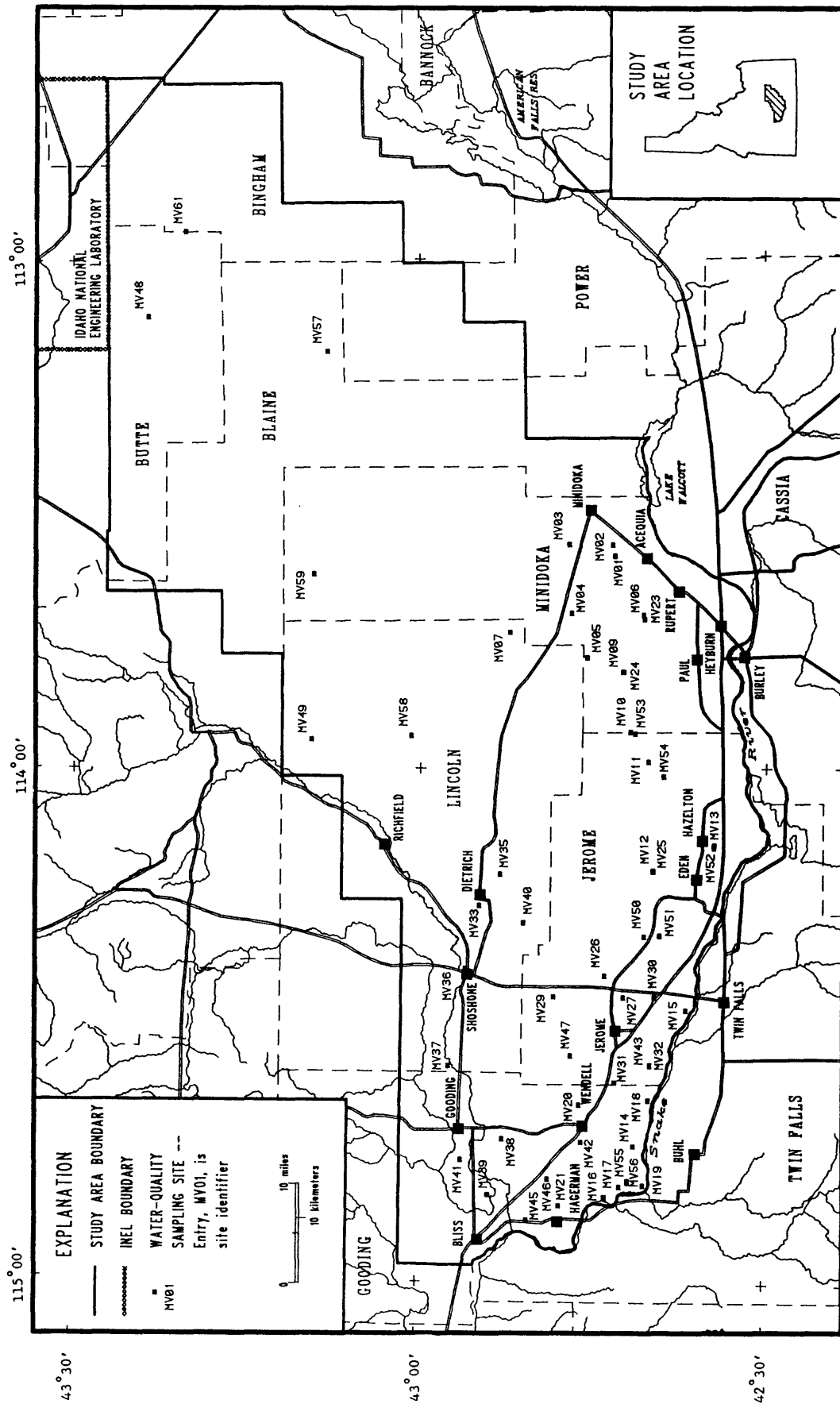
Figure 1.--Location of the study area between the Idaho National Engineering Laboratory and Hagerman, Idaho.

Water samples from 55 sites were analyzed for selected radionuclides, trace metals, purgeable organic compounds, carbamate and organophosphorus insecticides, organochlorine insecticides, gross PCB's (polychlorinated biphenyls), gross PCN's (polychlorinated naphthalenes), triazine and chlorophenoxy acid herbicides, and surfactants. Samples were collected and analyzed from 26 irrigation wells, 13 domestic wells, 5 springs, 4 stock wells, 3 dairy wells, 2 observation wells, 1 commercial well, and 1 public-supply well (fig. 2). Five replicate water samples and one quality assurance blank sample also were collected and analyzed. Analytical services were provided by the U.S. Geological Survey's NWQL (National Water Quality Laboratory) in Arvada, Colorado. Replicate tritium samples were collected at each site and analyzed by the ISU (Idaho State University) Environmental Monitoring Laboratory, Pocatello, Idaho.

Geohydrologic Setting

The eastern Snake River Plain is a northeast-trending structural basin about 200 mi long and 50 to 70 mi wide. The basin, bounded by faults on the northwest and downwarping and faulting on the southeast, has been filled with basalt lava flows interbedded with terrestrial sediments (Whitehead, 1986). Individual basalt flows average 20 to 25 ft in thickness with an aggregate thickness in places of several thousand feet. In areas of alluvial fan deposits, the sediments are composed primarily of sand and gravel; in the areas where streams were dammed by basalt flows, the sediments are predominantly silt and clay (Garabedian, 1986). Rhyolitic lava flows and tuffs are exposed at the surface in places and may be present at depth under most of the eastern plain. A 10,365-ft-deep testhole at the INEL penetrated about 2,160 ft of basalt and sediment and 8,200 ft of tuffaceous and rhyolitic volcanic rocks (Mann, 1986).

Movement of water in the aquifer is generally from the northeast to the southwest. Water moves horizontally through basalt interflow zones and vertically through joints and interfingering edges of the interflow zones.



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Figure 2.--Location of selected water-quality sampling sites on the eastern Snake River Plain.

Infiltration of surface water, heavy pumpage, geologic conditions, and seasonal fluxes in recharge and discharge locally affect the movement of ground water (Garabedian, 1986).

The Snake River Plain aquifer is recharged by seepage from the Snake River, tributaries, and canals; infiltration from irrigation and precipitation; and underflow from tributary valleys on the perimeter of the plain. Discharge from the aquifer is primarily from irrigation pumpage and spring flow to the Snake River (Mann and Knobel, 1990). Between 1902 and 1980, spring flow to the Snake River increased about 1.2 million acre-ft/year, largely as a result of increased recharge from infiltration of irrigation water (Mann, 1989, p. 5).

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Methods and Quality Assurance

The methodology used in sampling for selected chemicals generally followed the guidelines established by the U.S. Geological Survey (Goerlitz and Brown, 1972; Stevens and others, 1975; Skougstad and others, 1979; Wood, 1981; Claassen, 1982; W.L. Bradford, U.S. Geological Survey, written commun., 1985; and Wershaw and others, 1987). Field methods and quality assurance practices are outlined in the following sections.

Sample Containers and Preservatives

Sample containers and preservatives differ depending on the constituent(s) analyzed. Samples analyzed by the NWQL were collected and preserved in accordance with laboratory requirements specified by Feltz and others (1985). Containers and preservatives were supplied by the NWQL and had undergone a rigorous quality control procedure (Pritt, 1989, p. 75) to eliminate sample contamination. Water samples analyzed by ISU were collected in accordance with laboratory requirements specified by the director of the Environmental Monitoring Program at ISU. Containers and preservatives used for this study are listed on table 1.

Sample Collection

The 55 sampling sites were selected based on geographic location, ease of sample collection, and long-term access. The irrigation wells and the public-supply well were equipped with turbine pumps. Nine of the irrigation wells discharged into stilling ponds and were sampled near the discharge pipe. The rest of the irrigation wells and the public supply well were sampled from spigots in discharge lines near pumps. The domestic, stock, observation, dairy, and commercial wells were all equipped with submersible pumps. The domestic, dairy, and commercial wells were sampled from the closest spigots available to pumps. The stock wells were sampled at water-tank inlet pipes. The observation wells were sampled at well heads. All the wells either were pumping on arrival of the sampling team or were started on arrival and, when possible, pumped long enough to ensure that pressure tanks and pumping systems had been thoroughly flushed as evidenced by stable pH, specific conductance, and temperature measurements. The five springs were sampled as near the source as possible using the mid-channel dip method.

Chemical and physical characteristics monitored at the water-sampling sites included pH, specific conductance, and temperature. These characteristics were monitored during pumping using methods described by Wood (1981), and Hardy and others (1989). A water sample was collected when

Table 1.--Containers and preservatives used for water-sample collection

[Abbreviations: L, liter; mL, milliliter; μm , micrometer; HgCl_2 , mercuric chloride; NaCl , sodium chloride; HNO_3 , nitric acid; $\text{K}_2\text{Cr}_2\text{O}_7$, potassium dichromate; HCl , hydrochloric acid; $^\circ\text{C}$, degrees Celsius. Samples were shipped by overnight-delivery mail. Analyzing laboratory: NWQL--U.S. Geological Survey's National Water Quality Laboratory; ISU--Idaho State University's Environmental Monitoring Laboratory.]

Type of constituent	Container		Preservative		Other treatment	Laboratory providing analyses
	Type	Size	Type	Size		
Pesticides	Glass, baked	1 L	None	None	Chill 4 $^\circ\text{C}$	NWQL
Nutrients	Polyethylene, brown	250 mL	$\text{HgCl}_2/\text{NaCl}$	1 mL	0.45 μm filter, chill 4 $^\circ\text{C}$	NWQL
Purgeable organic compounds	Glass, baked	40 mL	None	None	Chill 4 $^\circ\text{C}$	NWQL
Metals	Polyethylene, acid-rinsed	500 mL	HNO_3	2 mL	0.45 μm filter	NWQL
Mercury	Glass, acid-rinsed	250 mL	$\text{K}_2\text{Cr}_2\text{O}_7/\text{HNO}_3$	10 mL	0.45 μm filter	NWQL
Tritium	Polyethylene	250 mL	None	None	None	NWQL
	Polyethylene	250 mL	None	None	None	ISU
Radium	Polyethylene, acid-rinsed	1 L	HCl	5 mL	0.45 μm filter	NWQL
Radon-222	Glass vials	20 mL	Scintillation cocktail	10 mL	None	NWQL
Uranium	Polyethylene, acid-rinsed	1 L	HCl	5 mL	0.45 μm filter	NWQL
Other radio-nuclides	Polyethylene, acid-rinsed	1 L	None	None	None	NWQL

measurements of these characteristics indicated probable hydraulic and chemical stability. After collection, sample containers were sealed with laboratory film, labeled, and packed into ice chests for shipment by overnight-delivery mail to the NWQL. The tritium samples collected for the ISU laboratory were stored in a secured area until they were hand-delivered for analysis.

Measurements of pH, specific conductance, and water temperature are shown on table 2. Measured pH of water from sampling sites ranged from 7.3 to 8.4, within the U.S. Environmental Protection Agency's recommended range of 6.5 to 8.5 for community water systems (1987b). Specific conductance measurements ranged from 248 to 1,020 $\mu\text{S}/\text{cm}$. The IDHW (Idaho Department of Health and Welfare) has established a maximum contaminant level for community water systems of 750 $\mu\text{S}/\text{cm}$ (Idaho Department of Health and Welfare, 1989). Samples from 12 sites exceeded this level. Measurements of temperature ranged from 11.0 to 17.1 $^{\circ}\text{C}$. The IDHW has established a secondary maximum contaminant level for temperature of 26.6 $^{\circ}\text{C}$. All of the temperature measurements were below this level.

Conditions at the sampling site during sample collection were recorded in a field logbook and a chain-of-custody record was used to track the samples from the time of collection until delivery to the analyzing laboratory. These records are available for inspection at the U.S. Geological Survey Project Office at the INEL.

Quality Assurance

Detailed descriptions of internal quality control and overall quality assurance practices used by the U.S. Geological Survey's NWQL are provided in reports by Friedman and Erdmann (1982) and Jones (1987). Ten percent of the water samples were quality assurance samples. Samples MV-8, 28, 34, 44, and 60 are replicates of samples MV-7, 27, 33, 43, and 61, respectively. Sample MV-22 was a blank of bottled distilled water. In addition, replicates of all tritium samples were collected for the ISU Environmental Monitoring Laboratory.

Table 2. -- Results of field measurements of pH, specific conductance, and temperature of water from designated wells and springs, eastern Snake River Plain

[Site identifier: see figure 2 for location of sites. Site use: I -- irrigation; H -- domestic; D -- dairy; C -- commercial; P -- public supply; O -- observation; S -- stock; Sp -- spring; QA -- quality assurance (see Quality Assurance section in text for explanation). pH: negative base-10 logarithm of hydrogen-ion activity in moles per liter. Specific conductance: microsiemens per centimeter at 25 °C (degrees Celsius). Temperature: °C]

Site identifier	Site use	Date sampled mo/da/yr	pH	Specific conductance	Temperature
MV-1	I	08/14/89	7.9	690	13.5
MV-2	H	08/14/89	7.8	620	14.0
MV-3	I	08/15/89	7.8	490	13.5
MV-4	I	08/15/89	7.9	710	12.0
MV-5	I	08/15/89	7.9	750	12.5
MV-6	I	08/15/89	7.7	640	15.0
MV-7	I	08/16/89	8.0	350	13.5
MV-8	QA	08/16/89	8.0	350	13.5
MV-9	I	08/16/89	7.7	1010	14.0
MV-10	I	08/16/89	7.8	840	14.5
MV-11	I	08/16/89	7.8	930	14.5
MV-12	D	08/17/89	7.8	670	14.5
MV-13	I	08/17/89	7.8	640	15.5
MV-14	D	08/17/89	7.8	580	14.5
MV-15	Sp	08/18/89	7.5	645	16.0
MV-16	Sp	08/18/89	7.8	410	14.5
MV-17	Sp	08/18/89	7.9	415	15.0
MV-18	Sp	08/18/89	8.0	695	14.5
MV-19	Sp	08/18/89	7.9	495	14.5
MV-20	I	08/19/89	7.7	435	14.5
MV-21	D	08/19/89	8.0	355	16.0
MV-22	QA	08/19/89	6.9	35	19.5
MV-23	I	08/21/89	7.6	620	15.0
MV-24	H	08/21/89	7.6	1020	15.5
MV-25	H	08/22/89	7.7	730	14.5
MV-26	I	08/15/89	8.2	495	14.5
MV-27	I	08/15/89	7.3	750	15.0
MV-28	QA	08/15/89	7.3	750	15.0
MV-29	I	08/16/89	7.9	360	14.0

Table 2. -- Results of field measurements of pH, specific conductance and temperature of water from designated wells and springs, eastern Snake River Plain -- Continued

Site iden- tifier	Site use	Date sampled mo/da/yr	pH	Specific conductance	Temperature
MV-30	C	08/16/89	7.7	775	15.0
MV-31	I	08/16/89	7.8	685	16.0
MV-32	H	08/16/89	7.5	810	16.0
MV-33	H	08/17/89	7.8	315	15.5
MV-34	QA	08/17/89	7.8	315	15.5
MV-35	I	08/17/89	7.6	322	15.5
MV-36	P	08/17/89	7.3	515	15.0
MV-37	H	08/18/89	7.6	530	16.5
MV-38	I	08/18/89	7.9	400	15.5
MV-39	I	08/18/89	7.5	778	15.5
MV-40	I	08/18/89	8.1	398	15.0
MV-41	I	08/21/89	7.4	830	15.0
MV-42	H	08/21/89	7.4	512	16.0
MV-43	I	08/22/89	7.6	762	15.5
MV-44	QA	08/22/89	7.6	762	15.5
MV-45	I	08/22/89	7.8	445	16.5
MV-46	I	08/22/89	8.1	360	16.5
MV-47	D	09/07/89	7.8	370	14.5
MV-48	O	09/13/89	8.0	355	12.5
MV-49	S	09/21/89	7.6	390	11.0
MV-50	I	08/14/89	8.0	838	15.0
MV-51	H	08/15/89	7.6	734	14.5
MV-52	H	08/22/89	7.7	620	16.0
MV-53	H	08/21/89	7.7	830	17.0
MV-54	H	08/21/89	7.7	880	15.0
MV-55	I	08/22/89	7.8	415	15.5
MV-56	H	08/22/89	7.8	415	17.0
MV-57	S	09/26/89	8.4	248	13.0
MV-58	S	09/26/89	8.4	285	12.0
MV-59	S	09/27/89	8.2	300	16.5
MV-60	QA	09/14/89	8.2	380	15.5
MV-61	O	09/14/89	8.2	380	15.5

RADIONUCLIDES

Water samples were analyzed for radon-222, strontium-90, tritium, gross alpha- and gross beta-particle radioactivity, total uranium, radium-226, and radium-228. In addition, gamma-emitting radionuclides were identified. The samples were analyzed using methods described by Thatcher and others (1977) and the U.S. Environmental Protection Agency (1987a). Maximum contaminant levels for the types of radioactivity and for selected radionuclides are listed on table 3.

For each radionuclide concentration determined by a laboratory, an associated analytical uncertainty, s , is calculated such that there is a 67-percent probability that the true concentration is in the range of the reported concentration of a selected radionuclide plus or minus the analytical uncertainty. For example, given an analytical result of 100 ± 20.0 pCi/L, there is a 67-percent probability that the true concentration is in the range of 80.0 to 120.0 pCi/L. The laboratories used in this study report the analytical uncertainty as $2s$. At $2s$, there is a 95-percent probability that the true concentration in the above example is in the range of 60.0 to 140.0 pCi/L.

Guidelines for interpreting analytical results are based on an extension of the method described by Currie (1968) and are modified from a similar discussion by Mann and Cecil (1990). In radiochemical analyses, laboratory measurements are made on a target sample and a prepared blank. Instrument signals for the sample and 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 greater than the signal for the blank before the decision can be made that there was a detection, and (2) an estimation must be made of the minimum concentration that will yield a sufficiently large signal before the correct decision for detection or nondetection can be made most of the time. The first aspect of the problem is a qualitative decision based on signals and a definite criterion for detection. The second aspect of the problem is an estimation of the detection capabilities of a complete measurement process that includes hypothesis testing.

Table 3. -- Maximum contaminant levels for types of radioactivity and selected radionuclides in drinking water

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1987a) for community water systems and are for comparison purposes only. The maximum contaminant level given for gross alpha-particle radioactivity includes radium-226 but excludes radon and uranium. The maximum contaminant level given for gross beta-particle radioactivity excludes radioactivity from natural sources and should be used only for comparison. Maximum contaminant level values listed for strontium-90 and tritium are average annual concentrations assumed to produce a total body or organ dose of 4 mrem/year (millirem per year) of beta-particle radiation; a maximum contaminant level has not been established for gross gamma radiation, radon-222, or total uranium. Abbreviations: pCi/L -- picocuries per liter. Symbols: -- indicates that a maximum contaminant level has not been established for that radionuclide or type of radioactivity]

Type of radioactivity or radionuclide	Maximum contaminant level
Gross alpha-particle radioactivity	15 pCi/L
Gross beta-particle radioactivity	4 mrem/year
Gross gamma radioactivity	--
Radium-226 plus radium-228	5 pCi/L
Radon-222	--
Strontium-90	8 pCi/L
Total uranium	--
Tritium	20,000 pCi/L

In the laboratory, instrument signals must exceed a critical level before the qualitative decision can be made as to whether the radionuclide or radioactivity was detected. Concentrations that equal $1.6s$ meet this criterion; at $1.6s$ there is about a 95-percent probability that the correct decision--not detected--will be made. Given a large number of samples, as many as 5 percent of the samples with measured concentrations greater than or equal to $1.6s$, which were concluded as being detected, might not contain the radioactive constituent. 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 can be established. Concentrations that equal $3s$ represent a measurement at the minimum detectable concentration. For true concentrations of $3s$ or greater, there is a 95-percent-or-greater probability of correctly concluding that the radioactive constituent was detected in a sample. Given a large number of samples, as many as 5 percent of the samples with true concentrations greater than or equal to $3s$, which were concluded as being nondetected, could contain the radioactive constituent at the minimum detectable concentration. 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 greater-than-5-percent probability of false negative results for samples with true concentrations between $1.6s$ and $3s$ and, although the radionuclide or radioactivity might have been detected, such detection may not be considered reliable; at $1.6s$, the probability of a false negative is about 50 percent.

These guidelines 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, and with the number of gross counts for individual analyses. The use of the critical level and minimum detectable concentration aids the reader in the interpretation of analytical results and does not represent absolute concentrations of radioactivity that may or may not have been detected. In this report, if the concentration of a selected radionuclide is less than $3s$, the

concentration is considered to be below a "reporting level." The reporting level should not be confused with the analytical method detection limit, which is based on laboratory procedures. At small concentrations, the reporting level approaches the analytical method detection limit; however, at larger concentrations, they may be significantly different.

Radon-222

Radon-222 is a naturally-occurring radioactive gas that results from the decay of radium-226. Fifteen water samples and two replicate samples (MV-8, 9, 12, 13, 29, 32, 38, 39, 42, 43, 44, 45, 47, 49, 50, 51, and 59) contained concentrations of radon-222 ranging from 45 ± 28 to 196 ± 34 pCi/L (table 4). All other water samples contained concentrations of radon-222 that were less than the reporting level. No maximum contaminant level has been established for radon-222.

Strontium-90

Strontium-90 is a fission product that was widely distributed in the environment during atmospheric weapons tests. Strontium-90 generally is present in ground water as a result of these tests and from nuclear industry disposal. Eight water samples (sites MV-7, 13, 18, 21, 27, 33, 58, and 61) contained dissolved strontium-90 concentrations greater than the reporting level (table 4), ranging from 0.152 ± 0.046 to 2.93 ± 0.40 pCi/L. The strontium-90 concentrations in MV-7 (1.150 ± 0.260) and MV-61 (2.93 ± 0.40) were not verified by quality assurance samples MV-8 and MV-60. The strontium-90 replicate sample collected from MV-61 and analyzed by the RESL was less than background. These sites will be resampled in subsequent sampling rounds to verify the strontium-90 concentration. All concentrations measured in the water samples were less than the maximum contaminant level of 8 pCi/L (table 3).

Table 4. -- Concentrations of radon-222, strontium-90, and tritium in water from designated wells and springs, eastern Snake River Plain

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory (NWQL) and the Idaho State University (ISU) Environmental Monitoring Laboratory using the following methods: radon-222 and tritium by liquid scintillation; strontium-90 by chemical separation and precipitation. Analytical results and uncertainties -- for example, 12±37 -- in pCi/L (picocuries per liter). Analytical uncertainties are reported as 2s. Site identifier: see figure 2 for location of sites. Symbols: * indicates QA sample (see Quality Assurance section in text for explanation); -- indicates no analysis available]

Site identifier	Radon-222	Strontium-90	NWQL tritium	ISU tritium
MV-1	12±37	0.206±0.240	86.4±25.6	160.0±220.0
MV-2	2±32	0.019±0.050	48.0±25.6	-20.0±220.0
MV-3	18±30	-0.026±0.207	-12.8±25.6	100.0±220.0
MV-4	38±31	0.180±0.180	3.2±25.6	-210.0±220.0
MV-5	0±29	0.209±0.220	22.4±25.6	-130.0±220.0
MV-6	36±32	0.290±0.220	89.6±25.6	30.0±220.0
MV-7	8±29	1.150±0.260	-3.2±25.6	-120.0±220.0
MV-8 *	49±26	0.130±0.191	3.2±25.6	40.0±220.0
MV-9	64±26	0.190±0.190	99.2±25.6	-160.0±220.0
MV-10	55±46	-0.111±0.049	35.2±25.6	60.0±220.0
MV-11	29±63	0.140±0.240	124.8±25.6	-140.0±220.0
MV-12	74±48	-0.260±0.208	32.0±25.6	-50.0±220.0
MV-13	103±42	0.239±0.056	64.0±25.6	40.0±220.0
MV-14	32±38	-0.136±0.057	6.4±25.6	-40.0±220.0
MV-15	-7±44	0.130±0.187	54.4±25.6	-10.0±220.0
MV-16	0±42	0.303±0.275	3.2±25.6	-20.0±220.0
MV-17	15±47	0.124±0.226	12.8±25.6	-130.0±220.0
MV-18	51±40	0.361±0.237	92.8±25.6	-0.0±220.0
MV-19	15±43	0.055±0.047	6.4±25.6	-0.0±220.0
MV-20	2±48	-0.051±0.046	38.4±25.6	-90.0±220.0
MV-21	15±45	0.183±0.047	25.6±25.6	-80.0±220.0
MV-22 *	11±49	0.060±0.200	41.6±25.6	80.0±220.0
MV-23	23±35	-0.098±0.051	86.4±25.6	140.0±220.0
MV-24	27±38	0.095±0.182	89.6±25.6	60.0±220.0
MV-25	-6±37	-0.024±0.044	73.6±25.6	200.0±220.0
MV-26	1±26	0.240±0.170	-6.4±25.6	30.0±220.0
MV-27	12±36	0.270±0.170	44.8±25.6	70.0±220.0
MV-28 *	-19±34	0.090±0.170	64.0±25.6	-260.0±220.0
MV-29	45±28	-0.439±0.281	3.2±25.6	-30.0±220.0
MV-30	11±30	0.210±0.160	134.4±25.6	320.0±220.0

Table 4. -- Concentrations of radon-222, strontium-90, and tritium in water from designated wells and springs, eastern Snake River Plain -- Continued

Site identifier	Radon-222	Strontium-90	NWQL tritium	ISU tritium
MV-31	22±26	0.050±0.200	60.8±25.6	-80.0±220.0
MV-32	149±47	0.060±0.170	67.2±25.6	-70.0±220.0
MV-33	43±47	0.270±0.160	3.2±25.6	-210.0±220.0
MV-34 *	39±45	0.160±0.170	3.2±25.6	-70.0±220.0
MV-35	24±48	0.300±0.240	3.2±25.6	-10.0±220.0
MV-36	64±43	0.004±0.190	57.6±25.6	20.0±220.0
MV-37	29±59	-0.306±0.218	89.6±25.6	40.0±220.0
MV-38	86±48	0.120±0.120	70.4±25.6	-40.0±220.0
MV-39	72±46	-0.060±0.051	70.4±25.6	70.0±220.0
MV-40	42±51	-0.113±0.046	22.4±25.6	10.0±220.0
MV-41	58±40	-0.511±0.082	83.2±25.6	80.0±220.0
MV-42	124±38	-0.140±0.370	41.6±25.6	-10.0±220.0
MV-43	80±39	0.010±0.051	LOST	-90.0±220.0
MV-44 *	104±40	-0.060±0.170	73.6±25.6	110.0±220.0
MV-45	196±34	-0.080±0.170	19.2±25.6	-80.0±220.0
MV-46	32±33	-0.110±0.170	25.6±25.6	-80.0±220.0
MV-47	49±27	0.160±0.180	6.4±25.6	-100.0±220.0
MV-48	7±27	0.080±0.170	38.4±25.6	-40.0±220.0
MV-49	51±28	0.308±0.256	73.6±25.6	-40.0±220.0
MV-50	163±34	-0.316±0.239	80.0±25.6	-140.0±220.0
MV-51	80±26	-0.136±0.187	86.4±25.6	-40.0±220.0
MV-52	32±38	-0.023±0.200	96.0±25.6	-70.0±220.0
MV-53	38±38	0.116±0.198	83.2±25.6	130.0±220.0
MV-54	5±36	-0.043±0.207	92.8±25.6	120.0±220.0
MV-55	-15±35	0.112±0.184	3.2±25.6	-20.0±220.0
MV-56	1±34	0.008±0.055	3.2±25.6	-100.0±220.0
MV-57	-19±27	0.086±0.195	-9.6±25.6	-110.0±220.0
MV-58	-9±26	0.152±0.046	41.6±25.6	20.0±220.0
MV-59	79±23	0.133±0.264	-6.4±25.6	30.0±220.0
MV-60 *	-8±23	0.060±0.180	19.2±25.6	-30.0±220.0
MV-61	5±24	2.93±0.40	3.2±25.6	-100.0±220.0

Tritium

Tritium, a radioactive isotope of hydrogen, is formed in nature by interactions of cosmic rays with gases in the upper atmosphere. Tritium also is produced in thermonuclear detonations and is a waste product of the nuclear power industry. Two water samples were collected at each site for tritium and submitted to the Environmental Monitoring Laboratory at ISU and the U.S. Geological Survey's NWQL Isotope Fractionation Laboratory, Reston, Virginia. Although both laboratories used the liquid scintillation technique, the analytical method detection limits differed, mainly because of differences in counting times in the liquid scintillation unit and background concentrations of tritium in the laboratory as affected by elevation. The analytical method detection limit for the ISU laboratory was 350 pCi/L using a 200-minute counting period, and that for the NWQL was 26 pCi/L using a 1,200-minute counting period.

Tritium concentrations in the water samples are shown on table 4. Tritium concentrations in all water samples analyzed by the ISU laboratory were below the analytical method detection limit. Thirty-three of the sixty-one water samples analyzed by the NWQL contained concentrations of tritium larger than the reporting level, ranging from 38.4 ± 25.6 to 134.4 ± 25.6 pCi/L. The maximum concentration was less than half of the ISU analytical method detection limit. For comparison, the maximum contaminant level for tritium in drinking water is 20,000 pCi/L (table 3).

Gross Alpha-Particle Radioactivity

Gross alpha-particle radioactivity is a measure of the total radioactivity given off as alpha particles during the radioactive decay process. Laboratories normally report the radioactivity as if it were all given off by one radionuclide. In this report, concentrations are reported both as natural uranium in $\mu\text{g/L}$ and as thorium-230 in pCi/L. However, only the latter can be compared directly to the maximum contaminant level listed on table 3.

The gross alpha-particle radioactivity in the dissolved fraction of 56 of the 60 water samples was greater than the reporting level (table 5). The concentrations reported as thorium-230 ranged from 1.07 ± 0.59 to 18.70 ± 2.40 pCi/L. Concentrations of gross alpha-particle radioactivity reported as thorium-230 in the suspended fractions of the water samples from sites MV-31, 49, 53, 57, 59, and 61 ranged from 0.078 ± 0.048 to 0.567 ± 0.147 pCi/L. The sum of the dissolved and suspended concentrations of gross alpha-particle radioactivity in water from site MV-45 exceeded the maximum contaminant level of 15 pCi/L (table 3). Site MV-45 is downgradient from many of the sampling locations. All other samples contained total concentrations less than the maximum contaminant level.

Gross Beta-Particle Radioactivity

Gross beta-particle radioactivity is a measure of the total radioactivity given off as beta particles during the radioactive decay process. Laboratory instruments for these measurements are calibrated to a single radionuclide, cesium-137, or a chemically similar pair of radionuclides in equilibrium, strontium-90 in equilibrium with yttrium-90. In this report, concentrations are reported in two ways: as cesium-137 in pCi/L and as strontium-90 in equilibrium with yttrium-90 in pCi/L. Reporting of the concentrations of gross beta-particle radioactivity in either one of these ways is for reference purposes only and does not imply that the radioactivity is attributed to these specific isotopes. The average annual concentrations of cesium-137 and strontium-90 in drinking water that produce a 4-mrem/year dose are 120 pCi/L and 8 pCi/L, respectively. Gross beta-particle radioactivity measurements should not be compared directly to these concentrations.

Gross beta-particle radioactivity was measured in both the dissolved and suspended fractions of the water samples. All water samples except MV-22 contained dissolved concentrations of gross beta-particle radioactivity greater than the reporting levels (table 6), ranging from 3.37 ± 0.65 to 22.21 ± 2.85 pCi/L reported as cesium-137, and from 2.83 ± 0.54 to 19.03 ± 2.44 pCi/L reported as strontium-90 in equilibrium with yttrium-90. Suspended

Table 5. -- Concentrations of gross alpha-particle radioactivity in water from designated wells and springs, eastern Snake River Plain

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using a residue procedure. Analytical results and uncertainties -- for example, 1.92 ± 0.55 -- in indicated units. Abbreviations: $\mu\text{g/L}$ -- micrograms per liter; pCi/L -- picocuries per liter. Analytical uncertainties are reported as 2s. Site identifier: see figure 2 for location of sites. Symbols: * indicates QA sample (see Quality Assurance section in text for explanation); -- indicates no analysis available]

Site identifier	Dissolved as uranium ($\mu\text{g/L}$)	Dissolved as thorium-230 (pCi/L)	Suspended as uranium ($\mu\text{g/L}$)	Suspended as thorium-230 (pCi/L)
MV-1	1.92 ± 0.55	2.11 ± 0.61	-0.045 ± 0.059	-0.044 ± 0.058
MV-2	2.50 ± 0.63	2.75 ± 0.69	0.070 ± 0.069	0.069 ± 0.067
MV-3	2.40 ± 0.60	2.62 ± 0.65	-0.056 ± 0.053	-0.054 ± 0.052
MV-4	3.73 ± 0.77	4.09 ± 0.84	-0.003 ± 0.029	-0.003 ± 0.028
MV-5	4.25 ± 0.78	4.65 ± 0.85	0.075 ± 0.059	0.073 ± 0.057
MV-6	1.71 ± 0.46	1.88 ± 0.50	0.027 ± 0.027	0.027 ± 0.027
MV-7	2.22 ± 0.56	2.46 ± 0.62	0.006 ± 0.013	0.006 ± 0.012
MV-8 *	1.73 ± 0.79	1.91 ± 0.87	-0.003 ± 0.046	-0.003 ± 0.046
MV-9	4.15 ± 0.74	4.51 ± 0.80	0.007 ± 0.013	0.007 ± 0.013
MV-10	2.60 ± 0.59	2.87 ± 0.65	0.000 ± 0.000	0.000 ± 0.000
MV-11	2.77 ± 0.60	3.05 ± 0.66	0.037 ± 0.046	0.036 ± 0.043
MV-12	2.44 ± 0.60	2.70 ± 0.66	0.038 ± 0.062	0.037 ± 0.061
MV-13	4.65 ± 0.89	5.12 ± 0.97	0.041 ± 0.037	0.041 ± 0.037
MV-14	2.64 ± 0.59	2.94 ± 0.65	0.015 ± 0.022	0.015 ± 0.021
MV-15	2.53 ± 0.59	2.30 ± 0.54	0.061 ± 0.041	0.060 ± 0.040
MV-16	1.97 ± 0.56	2.32 ± 0.66	-0.032 ± 0.064	-0.031 ± 0.062
MV-17	0.96 ± 0.53	1.07 ± 0.59	0.009 ± 0.032	0.009 ± 0.031
MV-18	3.06 ± 0.69	3.41 ± 0.76	0.000 ± 0.043	0.000 ± 0.042
MV-19	2.61 ± 0.61	2.85 ± 0.67	0.040 ± 0.033	0.039 ± 0.032
MV-20	0.98 ± 0.47	1.08 ± 0.52	-0.038 ± 0.055	-0.037 ± 0.054
MV-21	2.47 ± 0.59	2.67 ± 0.64	0.027 ± 0.031	0.027 ± 0.032
MV-22 *	1.14 ± 0.35	1.23 ± 0.38	0.038 ± 0.045	0.037 ± 0.044
MV-23	1.68 ± 0.44	1.85 ± 0.48	0.022 ± 0.048	0.022 ± 0.047
MV-24	3.88 ± 0.86	4.41 ± 0.98	0.013 ± 0.071	0.013 ± 0.070
MV-25	4.39 ± 0.83	4.80 ± 0.90	0.048 ± 0.036	0.047 ± 0.036
MV-26	2.11 ± 0.56	2.32 ± 0.62	0.038 ± 0.062	0.037 ± 0.061
MV-27	3.73 ± 0.73	4.09 ± 0.80	0.025 ± 0.042	0.025 ± 0.041
MV-28 *	2.24 ± 0.51	2.45 ± 0.56	0.007 ± 0.015	0.007 ± 0.015
MV-29	1.02 ± 0.35	1.12 ± 0.38	0.068 ± 0.055	0.066 ± 0.053
MV-30	3.40 ± 0.66	3.72 ± 0.73	0.051 ± 0.039	0.050 ± 0.038

Table 5. -- Concentrations of gross alpha-particle radioactivity in water from designated wells and springs, eastern Snake River Plain -- continued

Site iden- tifier	Dissolved as uranium ($\mu\text{g/L}$)	Dissolved as thorium-230 (pCi/L)	Suspended as uranium ($\mu\text{g/L}$)	Suspended as thorium-230 (pCi/L)
MV-31	2.77 \pm 0.66	3.04 \pm 0.72	0.080 \pm 0.049	0.078 \pm 0.048
MV-32	5.44 \pm 0.94	6.00 \pm 1.04	0.101 \pm 0.086	0.100 \pm 0.084
MV-33	0.62 \pm 0.42	0.68 \pm 0.46	0.031 \pm 0.042	0.030 \pm 0.041
MV-34 *	1.90 \pm 0.46	2.07 \pm 0.51	0.034 \pm 0.030	0.033 \pm 0.030
MV-35	2.08 \pm 0.55	2.28 \pm 0.61	0.044 \pm 0.046	0.043 \pm 0.045
MV-36	4.59 \pm 0.89	5.12 \pm 1.00	-0.029 \pm 0.058	-0.028 \pm 0.057
MV-37	4.11 \pm 0.86	4.75 \pm 0.99	0.004 \pm 0.056	0.004 \pm 0.055
MV-38	1.70 \pm 0.46	1.86 \pm 0.51	0.022 \pm 0.025	0.021 \pm 0.025
MV-39	4.51 \pm 0.86	5.01 \pm 0.96	-0.003 \pm 0.053	-0.003 \pm 0.052
MV-40	2.09 \pm 0.51	2.28 \pm 0.56	0.056 \pm 0.060	0.055 \pm 0.059
MV-41	4.27 \pm 0.88	4.76 \pm 0.98	0.085 \pm 0.061	0.084 \pm 0.060
MV-42	1.91 \pm 0.50	2.08 \pm 0.55	0.032 \pm 0.063	0.031 \pm 0.061
MV-43	4.62 \pm 0.85	5.01 \pm 0.92	0.003 \pm 0.033	0.003 \pm 0.032
MV-44 *	5.06 \pm 0.91	5.56 \pm 1.00	0.025 \pm 0.041	0.024 \pm 0.040
MV-45	17.10 \pm 2.20	18.70 \pm 2.40	0.031 \pm 0.061	0.030 \pm 0.060
MV-46	1.66 \pm 0.48	1.82 \pm 0.53	0.059 \pm 0.052	0.058 \pm 0.050
MV-47	1.53 \pm 0.47	1.66 \pm 0.51	0.041 \pm 0.071	0.040 \pm 0.070
MV-48	1.93 \pm 0.53	2.12 \pm 0.57	0.087 \pm 0.069	0.085 \pm 0.067
MV-49	0.00 \pm 0.44	0.00 \pm 0.70	0.404 \pm 0.143	0.397 \pm 0.141
MV-50	6.93 \pm 1.19	7.74 \pm 1.33	-0.891 \pm 0.177	-0.871 \pm 0.183
MV-51	2.63 \pm 0.60	2.92 \pm 0.67	0.010 \pm 0.035	0.010 \pm 0.034
MV-52	3.46 \pm 0.67	3.80 \pm 0.73	0.052 \pm 0.039	0.050 \pm 0.038
MV-53	2.96 \pm 0.63	3.25 \pm 0.69	0.187 \pm 0.101	0.183 \pm 0.098
MV-54	3.55 \pm 0.68	3.87 \pm 0.75	0.023 \pm 0.038	0.022 \pm 0.037
MV-55	2.15 \pm 0.59	2.38 \pm 0.65	0.027 \pm 0.027	0.026 \pm 0.026
MV-56	1.78 \pm 0.53	1.97 \pm 0.59	0.031 \pm 0.052	0.031 \pm 0.052
MV-57	0.02 \pm 0.26	0.03 \pm 0.29	0.364 \pm 0.127	0.359 \pm 0.125
MV-58	1.87 \pm 0.49	2.08 \pm 0.54	0.175 \pm 0.162	0.172 \pm 0.138
MV-59	0.28 \pm 0.24	0.31 \pm 0.26	0.576 \pm 0.149	0.567 \pm 0.147
MV-60 *	2.69 \pm 0.57	2.94 \pm 0.63	-0.032 \pm 0.081	-0.031 \pm 0.080
MV-61	10.20 \pm 1.50	11.20 \pm 1.60	0.148 \pm 0.080	0.145 \pm 0.078

Table 6. -- Concentrations of gross beta-particle radioactivity in water from designated wells and springs, eastern Snake River Plain

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using a residue procedure. Analytical uncertainties reported as 2s. Analytical results and uncertainties -- for example, 7.80±1.21 -- in picocuries per liter. Site identifier: see figure 2 for location of sites. Abbreviations: Sr-90/Y-90 -- strontium 90 in equilibrium with yttrium-90. Symbols: * indicates QA sample (see Quality Assurance section in text for explanation); -- indicates no analysis available]

Site identifier	Dissolved as cesium-137	Dissolved as Sr-90/Y-90	Suspended as cesium-137	Suspended as Sr-90/Y-90
MV-1	7.80±1.21	6.85±1.06	-0.214±0.270	-0.217±0.273
MV-2	10.65±1.65	9.00±1.40	-0.093±0.266	-0.092±0.265
MV-3	4.88±0.77	4.07±0.70	0.199±0.264	-0.207±0.276
MV-4	6.54±1.20	6.19±1.14	0.154±0.249	0.161±0.260
MV-5	7.36±1.29	6.52±1.15	-1.160±0.230	-1.210±0.240
MV-6	6.12±1.02	6.32±1.06	0.192±0.285	0.200±0.298
MV-7	4.62±0.77	3.94±0.66	0.138±0.278	0.144±0.290
MV-8 *	3.37±0.65	2.83±0.54	-0.137±0.257	-0.143±0.268
MV-9	10.60±2.00	9.11±1.71	0.369±0.250	0.385±0.261
MV-10	10.60±1.70	9.33±1.50	1.160±0.350	1.140±0.340
MV-11	11.50±1.90	10.10±1.70	0.503±0.300	0.525±0.313
MV-12	7.26±1.25	6.36±1.09	-0.091±0.222	-0.094±0.231
MV-13	9.31±1.50	8.19±1.31	-0.253±0.262	-0.246±0.255
MV-14	5.36±1.17	4.44±0.96	0.134±0.276	0.134±0.274
MV-15	8.25±1.39	7.04±1.19	0.336±0.302	0.424±0.381
MV-16	4.39±0.73	3.85±0.64	-0.023±0.260	0.024±0.272
MV-17	4.64±0.79	4.10±0.70	-0.078±0.260	-0.081±0.271
MV-18	7.73±1.38	6.77±1.21	0.294±0.252	0.307±0.263
MV-19	6.80±1.07	5.91±0.93	-0.236±0.244	-0.246±0.255
MV-20	6.17±1.01	5.30±0.87	1.200±0.360	1.160±0.350
MV-21	4.98±0.80	4.41±0.70	-0.099±0.257	-0.098±0.254
MV-22 *	0.19±0.32	0.17±0.28	-0.015±0.263	-0.016±0.275
MV-23	9.37±1.53	7.89±1.30	-0.285±0.264	-0.280±0.259
MV-24	12.80±2.20	11.00±1.90	0.070±0.288	0.067±0.276
MV-25	22.21±2.85	19.03±2.44	0.839±0.313	0.875±0.327
MV-26	5.99±0.92	5.68±0.87	0.329±0.254	0.343±0.265
MV-27	6.81±1.04	6.65±1.02	-0.157±0.268	-0.164±0.280
MV-28 *	6.47±1.17	5.67±1.02	0.000±0.260	0.000±0.272
MV-29	5.43±0.90	4.60±0.76	0.360±0.274	0.376±0.286
MV-30	7.16±1.22	6.95±1.19	0.551±0.299	0.575±0.312

Table 6. -- Concentrations of gross beta-particle radioactivity in water from designated wells and springs, eastern Snake River Plain -- Continued

Site iden- tifier	Dissolved as cesium-137	Dissolved as Sr-90/Y-90	Suspended as cesium-137	Suspended as Sr-90/Y-90
MV-31	6.80±1.22	6.57±1.18	0.227±0.258	0.236±0.270
MV-32	8.38±1.38	8.24±1.36	0.640±0.293	0.628±0.288
MV-33	4.82±0.78	4.30±0.70	0.008±0.256	0.008±0.267
MV-34 *	4.92±0.77	4.45±0.70	0.044±0.248	0.046±0.259
MV-35	5.16±0.79	4.62±0.71	0.435±0.292	0.453±0.305
MV-36	5.44±0.91	4.73±0.79	-0.085±0.260	-0.088±0.271
MV-37	6.83±1.07	5.95±0.93	0.353±0.262	0.368±0.273
MV-38	3.65±0.69	3.10±0.58	0.319±0.248	0.333±0.258
MV-39	8.56±1.52	7.31±1.30	0.365±0.271	0.381±0.283
MV-40	5.93±0.90	5.01±0.76	-0.358±0.249	-0.374±0.260
MV-41	6.39±1.04	5.81±0.95	0.362±0.270	0.378±0.282
MV-42	6.00±0.94	5.84±0.91	0.538±0.275	0.561±0.287
MV-43	10.10±1.71	8.61±1.46	0.095±0.240	0.099±0.251
MV-44 *	11.90±2.00	11.20±1.90	0.172±0.249	0.180±0.260
MV-45	4.69±0.78	4.49±0.75	0.281±0.251	0.293±0.262
MV-46	4.49±0.73	3.98±0.65	0.250±0.249	0.261±0.260
MV-47	4.82±0.76	4.42±0.70	0.112±0.251	0.116±0.262
MV-48	4.20±0.71	3.76±0.64	0.313±0.250	0.311±0.248
MV-49	3.62±0.70	3.23±0.63	0.358±0.295	0.356±0.293
MV-50	7.51±1.25	6.65±1.11	-0.176±0.255	-0.183±0.266
MV-51	8.06±1.53	6.76±1.28	0.120±0.241	0.125±0.251
MV-52	9.56±1.44	8.44±1.27	0.092±0.280	0.096±0.292
MV-53	9.43±1.58	8.36±1.40	-0.288±0.258	-0.301±0.270
MV-54	8.82±1.52	8.98±1.39	-0.197±0.252	-0.206±0.263
MV-55	4.80±0.92	4.00±0.77	-0.074±0.257	-0.078±0.269
MV-56	4.89±0.86	4.24±0.75	-0.198±0.268	-0.192±0.260
MV-57	4.11±0.67	3.50±0.57	0.083±0.247	0.080±0.237
MV-58	5.62±0.92	4.61±0.75	0.928±0.302	0.940±0.305
MV-59	5.35±0.83	4.61±0.72	0.261±0.239	0.256±0.234
MV-60 *	3.86±0.72	3.37±0.62	0.183±0.265	0.180±0.260
MV-61	4.65±0.85	3.96±0.72	0.353±0.268	0.357±0.271

concentrations in water samples from MV-10, 11, 20, 25, 30, 32, and 42 ranged from 0.503 ± 0.300 to 1.160 ± 0.350 pCi/L reported as cesium-137 and from 0.525 ± 0.313 to 1.160 ± 0.350 pCi/L reported as strontium-90 in equilibrium with yttrium-90.

Total Uranium

Uranium is a widely distributed element that has three naturally occurring radioactive isotopes: uranium-238, uranium-235, and uranium-234. These isotopes undergo a complex series of radioactive decay that results in their ultimate conversion to stable isotopes of lead (Haglund, 1972). Total uranium is a measurement of the combined concentrations of these three isotopes. Total uranium concentrations larger than the reporting levels (table 7) were detected in all water samples except MV-22 and 57. The dissolved total uranium concentrations ranged from 0.02 ± 0.01 to 7.00 ± 1.05 $\mu\text{g/L}$. A maximum contaminant level has not been established for individual isotopes of uranium or for total uranium.

Radium

Radium-224 and radium-228 are naturally occurring radioactive decay products of thorium-232; radium-226 is a naturally occurring decay product of uranium-238. Thirty-six water samples, one replicate sample, and one blank sample contained concentrations of dissolved radium-224 larger than the reporting levels (table 7). The radium-224 concentrations ranged from 0.217 ± 0.101 to 3.340 ± 0.710 pCi/L. No maximum contaminant level has been established for radium-224. Concentrations of radium-226 were greater than the reporting level in all of the water samples analyzed, ranging from 0.026 ± 0.012 to 0.369 ± 0.145 pCi/L. Water samples from MV-6, 39, and 41 contained concentrations of dissolved radium-228 ranging from 1.360 ± 0.750 to 2.690 ± 1.010 pCi/L (table 7). The sum of radium-226 and radium-228 concentrations in all the water samples was less than the maximum contaminant level of 5 pCi/L (table 3).

Potassium-40, Thorium-234, Lead-212, and Bismuth-212

Gamma spectrometry involves using a series of detectors to simultaneously determine the concentrations of a variety of radionuclides by the detection of their characteristic gamma emissions. In addition to radium-224, discussed in the previous section, four radionuclides were detected in the suspended fraction of water samples by gamma spectrometry.

Potassium makes up approximately 2.6 percent of the Earth's continental crust, and about 0.0119 percent of all potassium is the naturally occurring radioactive isotope potassium-40 (Kretz, 1972). Potassium-40 was detected in 22 water samples and 2 replicate samples in concentrations greater than the reporting levels (table 8). Concentrations of potassium-40 ranged from 0.22 ± 0.12 to 9.96 ± 2.05 pCi/L.

Thorium-234 is a naturally occurring unstable decay product of uranium-238. Thorium-234 was detected in 17 water samples and 1 replicate sample in concentrations greater than the reporting levels. Concentrations of thorium-234 ranged from 2.54 ± 0.94 to 10.06 ± 1.13 pCi/L (table 8).

Lead-212 is a naturally occurring decay product of radium-224 in the thorium-232 decay series. Lead-212 was detected in 20 water samples and 1 replicate sample in concentrations larger than the reporting level, ranging from 0.186 ± 0.086 to 0.961 ± 0.383 pCi/L (table 8). When concentrations of lead-212 exceeded the reporting level, concentrations of radium-224 also exceeded the reporting level with the exception of sample MV-56.

Bismuth-212 is a naturally occurring member of the thorium-232 decay series. Bismuth-212 was detected in the sample from MV-20, but was less than the reporting level (table 8).

CHEMICAL CONSTITUENTS

Water samples were analyzed for selected chemical constituents. These constituents included trace metals and nutrients. In this report, reporting

Table 7. -- Concentrations of total uranium and selected radium isotopes in water from designated wells and springs, eastern Snake River Plain

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using the following methods: total uranium by extraction and laser-induced phosphorimetry, radium-224 by gamma-spectroscopy, radium-226 by radon emanation, and radium-228 by separation and beta-counting. Analytical results and uncertainties -- for example, 2.66 ± 0.40 -- in indicated units. Analytical uncertainties are reported as 2s. Site identifier: see figure 2 for location of sites. Abbreviations: $\mu\text{g/L}$ -- micrograms per liter; pCi/L -- picocuries per liter. Symbols: .. indicates that the radionuclide was not detected in that sample; * indicates QA sample (see Quality Assurance section in text for explanation); -- indicates no analysis available]

Site identifier	Total uranium ($\mu\text{g/L}$)	Radium-224 (pCi/L)	Radium-226 (pCi/L)	Radium-228 (pCi/L)
MV-1	2.66 ± 0.40	0.301 ± 0.116	0.091 ± 0.020	-0.320 ± 1.270
MV-2	2.68 ± 0.28	0.911 ± 0.176	0.026 ± 0.012	0.941 ± 0.722
MV-3	2.60 ± 0.50	0.650 ± 0.193	0.080 ± 0.020	-0.180 ± 0.790
MV-4	4.65 ± 0.63	..	0.062 ± 0.014	0.252 ± 0.600
MV-5	4.50 ± 0.61	0.245 ± 0.122	0.095 ± 0.023	-0.600 ± 0.790
MV-6	3.03 ± 0.32	0.613 ± 0.192	0.083 ± 0.017	1.360 ± 0.750
MV-7	1.78 ± 0.33	1.020 ± 0.220	0.112 ± 0.024	0.170 ± 0.590
MV-8 *	1.86 ± 0.29	0.965 ± 0.164	0.147 ± 0.026	0.030 ± 0.620
MV-9	5.25 ± 0.75	0.266 ± 0.109	0.058 ± 0.013	0.403 ± 1.930
MV-10	4.16 ± 0.59	0.830 ± 0.169	0.049 ± 0.013	0.715 ± 0.838
MV-11	4.76 ± 0.66	0.770 ± 0.193	0.052 ± 0.015	0.247 ± 0.599
MV-12	3.61 ± 0.54	0.946 ± 0.180	0.369 ± 0.145	0.136 ± 0.652
MV-13	5.16 ± 0.87	0.260 ± 0.111	0.067 ± 0.016	0.539 ± 0.616
MV-14	3.46 ± 0.54	0.302 ± 0.120	0.075 ± 0.019	0.369 ± 0.690
MV-15	4.08 ± 0.57	1.070 ± 0.440	0.101 ± 0.022	0.625 ± 0.717
MV-16	2.27 ± 0.36	0.857 ± 0.178	0.099 ± 0.025	-0.360 ± 0.790
MV-17	2.11 ± 0.32	0.230 ± 0.171	0.089 ± 0.019	0.080 ± 0.590
MV-18	4.06 ± 0.62	0.946 ± 0.169	0.033 ± 0.012	-0.837 ± 0.697
MV-19	3.76 ± 0.53	0.591 ± 0.167	0.039 ± 0.015	0.590 ± 0.807
MV-20	2.19 ± 0.24	0.895 ± 0.163	0.055 ± 0.019	0.129 ± 0.988
MV-21	3.11 ± 0.47	3.340 ± 0.710	0.038 ± 0.013	0.097 ± 0.595
MV-22 *	0.00 ± 0.00	0.850 ± 0.170	0.078 ± 0.018	0.707 ± 0.694
MV-23	2.85 ± 0.30	0.254 ± 0.100	0.050 ± 0.016	0.081 ± 0.746
MV-24	6.35 ± 0.92	0.891 ± 0.170	0.041 ± 0.015	0.067 ± 0.655
MV-25	6.00 ± 0.84	0.462 ± 0.290	0.043 ± 0.020	0.103 ± 0.946
MV-26	2.70 ± 0.28	0.870 ± 0.170	0.064 ± 0.017	0.030 ± 0.990
MV-27	3.59 ± 0.38	..	0.073 ± 0.018	0.570 ± 0.650
MV-28	3.88 ± 0.61	0.828 ± 0.202	0.064 ± 0.015	0.579 ± 1.070

Table 7. -- Concentrations of total uranium and selected radium isotopes in water from designated wells and springs, eastern Snake River Plain
-- Continued

Site identifier	Total uranium ($\mu\text{g/L}$)	Radium-224 (pCi/L)	Radium-226 (pCi/L)	Radium-228 (pCi/L)
MV-29	2.40 \pm 0.25	0.628 \pm 0.167	0.071 \pm 0.021	0.702 \pm 0.603
MV-30	4.94 \pm 0.69	..	0.097 \pm 0.019	0.620 \pm 0.595
MV-31	3.78 \pm 0.54	..	0.114 \pm 0.023	0.297 \pm 0.962
MV-32	6.24 \pm 0.97	..	0.075 \pm 0.015	0.450 \pm 0.650
MV-33	2.08 \pm 0.22	0.156 \pm 0.106	0.065 \pm 0.015	0.490 \pm 1.030
MV-34 *	1.97 \pm 0.21	..	0.048 \pm 0.013	0.464 \pm 0.691
MV-35	2.16 \pm 0.22	0.341 \pm 0.110	0.093 \pm 0.020	0.155 \pm 0.758
MV-36	4.51 \pm 0.63	0.217 \pm 0.101	0.078 \pm 0.020	-0.094 \pm 0.818
MV-37	6.92 \pm 0.99	0.266 \pm 0.108	0.056 \pm 0.013	0.864 \pm 0.728
MV-38	3.68 \pm 0.53	..	0.141 \pm 0.025	2.090 \pm 1.440
MV-39	0.47 \pm 0.05	1.110 \pm 0.440	0.061 \pm 0.016	2.690 \pm 1.010
MV-40	2.96 \pm 0.44	0.871 \pm 0.170	0.034 \pm 0.017	0.761 \pm 0.774
MV-41	3.52 \pm 0.53	..	0.088 \pm 0.017	2.110 \pm 0.700
MV-42	3.63 \pm 0.54	..	0.069 \pm 0.015	0.670 \pm 0.970
MV-43	7.00 \pm 1.05	0.875 \pm 0.511	0.091 \pm 0.022	1.430 \pm 1.050
MV-44 *	6.86 \pm 0.98	..	0.069 \pm 0.019	0.810 \pm 0.720
MV-45	3.26 \pm 0.34	..	0.081 \pm 0.021	0.166 \pm 0.652
MV-46	2.47 \pm 0.26	0.137 \pm 0.100	0.088 \pm 0.018	0.286 \pm 0.585
MV-47	2.19 \pm 0.39	..	0.114 \pm 0.022	0.242 \pm 0.645
MV-48	2.43 \pm 0.48	..	0.058 \pm 0.015	0.245 \pm 0.458
MV-49	0.02 \pm 0.01	0.330 \pm 0.120	0.047 \pm 0.016	-0.447 \pm 0.566
MV-50	2.55 \pm 0.50	..	0.113 \pm 0.024	0.760 \pm 0.900
MV-51	4.30 \pm 0.62	0.119 \pm 0.176	0.149 \pm 0.031	0.466 \pm 0.695
MV-52	5.12 \pm 0.74	..	0.078 \pm 0.015	0.229 \pm 0.575
MV-53	4.23 \pm 0.68	0.940 \pm 0.180	0.072 \pm 0.018	0.220 \pm 0.670
MV-54	5.00 \pm 0.82	0.793 \pm 0.191	0.080 \pm 0.020	0.000 \pm 0.650
MV-55	2.59 \pm 0.27	0.221 \pm 0.094	0.052 \pm 0.019	0.287 \pm 0.503
MV-56	2.53 \pm 0.26	0.076 \pm 0.165	0.076 \pm 0.019	0.816 \pm 0.640
MV-57	0.01 \pm 0.01	0.910 \pm 0.180	0.047 \pm 0.018	0.018 \pm 0.356
MV-58	1.64 \pm 0.28	..	0.076 \pm 0.018	--
MV-59	1.15 \pm 0.16	0.930 \pm 0.170	0.062 \pm 0.017	0.051 \pm 0.491
MV-60 *	2.97 \pm 0.59	..	0.096 \pm 0.019	-0.116 \pm 0.784
MV-61	2.77 \pm 0.45	..	0.085 \pm 0.017	0.618 \pm 0.623

Table 8. -- Concentrations of potassium-40, thorium-234, lead-212, and bismuth-212 in water from designated wells and springs, eastern Snake River Plain

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using gamma spectrometry. All analytical results and uncertainties -- for example, 5.01 ± 1.31 -- are for suspended concentrations in pCi/L (picocuries per liter). Analytical uncertainties are reported as 2s. Site identifier: see figure 2 for location of sites. Symbols: .. indicates that the radionuclide was not detected in that sample; * indicates QA sample (see Quality Assurance section in text for explanation); -- indicates no analysis available]

Site identifier	Potassium-40	Thorium-234	Lead-212	Bismuth-212
MV-1	..	..	..	..
MV-2	5.01 ± 1.31	..	0.780 ± 0.152	..
MV-3	8.77 ± 2.17	9.58 ± 1.25	..	..
MV-4	..	..	..	..
MV-5	6.89 ± 1.42	..	..	..
MV-6	..	..	..	..
MV-7	2.44 ± 1.51	4.09 ± 1.09	..	..
MV-8 *	1.39 ± 1.39	3.72 ± 0.94	..	..
MV-9	1.16 ± 0.13	4.04 ± 0.98	0.228 ± 0.094	..
MV-10	4.56 ± 1.22	..	0.710 ± 0.140	..
MV-11	9.96 ± 2.05	9.75 ± 1.11	0.634 ± 0.159	..
MV-12	5.93 ± 1.33	..	0.811 ± 0.154	..
MV-13	..	3.57 ± 0.93	..	..
MV-14	..	3.40 ± 0.96	0.260 ± 0.103	..
MV-15	8.16 ± 3.80	..	0.920 ± 0.383	..
MV-16	5.60 ± 1.34	..	..	..
MV-17	..	..	..	..
MV-18	5.03 ± 1.19	..	0.815 ± 0.146	..
MV-19	8.52 ± 1.90	9.70 ± 1.11	0.508 ± 0.143	..
MV-20	5.31 ± 1.28	..	0.787 ± 0.146	0.561 ± 0.545
MV-21	..	..	..	..
MV-22 *	..	..	..	..
MV-23	0.86 ± 0.13	4.34 ± 1.01	0.219 ± 0.086	..
MV-24	5.32 ± 1.30	..	0.768 ± 0.146	..
MV-25	..	..	0.400 ± 0.247	..
MV-26	..	..	..	..
MV-27	..	..	..	..
MV-28 *	9.43 ± 1.94	10.06 ± 1.13	0.683 ± 0.166	..

Table 8. -- Concentrations of potassium-40, thorium-234, lead-212, and bismuth-212 in water from designated wells and springs, eastern Snake River Plain -- Continued

Site identifier	Potassium-40	Thorium-234	Lead-212	Bismuth-212
MV-29	9.63±1.95	9.11±1.07	0.539±0.143	..
MV-30	..	..	..	..
MV-31	..	..	..	..
MV-32	..	2.54±0.94	..	..
MV-33	..	..	..	..
MV-34 *	..	..	..	..
MV-35	1.31±1.22	..	..	..
MV-36	0.22±0.12	3.66±0.94	0.186±0.086	..
MV-37	..	3.94±0.94	0.230±0.093	..
MV-38	..	..	..	..
MV-39	..	..	0.961±0.383	..
MV-40	7.01±1.51	..	..	..
MV-41	..	..	..	..
MV-42	..	..	..	..
MV-43	..	..	0.754±0.441	..
MV-44 *	..	..	..	..
MV-45	..	..	..	..
MV-46	..	..	..	..
MV-47	..	..	..	..
MV-48	..	..	..	..
MV-49	..	3.77±0.94	..	..
MV-50	1.42±1.36	3.74±0.98	..	..
MV-51	..	..	..	..
MV-52	..	..	..	..
MV-53	6.09±1.38	..	..	..
MV-54	7.38±1.76	9.67±1.11	..	..
MV-55	..	3.34±0.94	0.194±0.081	..
MV-56	..	..	0.651±0.142	..
MV-57	5.60±1.38	..	..	..
MV-58	..	..	..	..
MV-59	6.02±1.42	..	..	..
MV-60 *	2.84±1.42	..	..	..
MV-61	..	..	..	..

levels established for these constituents (Feltz and others, 1985) are not to be confused with reporting levels and analytical method detection limits for selected radionuclides.

Trace Metals

Water samples were collected and analyzed for dissolved trace metals including arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. The maximum contaminant level and reporting level for each of the eight trace metals is shown on table 9. The concentrations of dissolved trace metals are shown on table 10.

Concentrations of arsenic exceeded the reporting level in all samples except MV-22, ranging from 1 to 5 $\mu\text{g/L}$; the maximum contaminant level is 50 $\mu\text{g/L}$. Barium concentrations were greater than the reporting level in all samples except MV-22, ranging from 5 to 140 $\mu\text{g/L}$; the maximum contaminant level is 1,000 $\mu\text{g/L}$. Cadmium concentrations exceeded the reporting level in samples MV-2 and MV-10 with concentrations of 2 and 1 $\mu\text{g/L}$, respectively; the maximum contaminant level is 10 $\mu\text{g/L}$. Concentrations of chromium were greater than the reporting level in all samples, ranging from 1 to 5 $\mu\text{g/L}$; the maximum contaminant level is 50 $\mu\text{g/L}$. Lead concentrations exceeded the reporting level in 27 samples, ranging from 1 to 4 $\mu\text{g/L}$; the maximum contaminant level is 50 $\mu\text{g/L}$. Mercury concentrations were greater than the reporting level in samples MV-40, 41, 55, and 56 with concentrations of 4.7, 0.1, 0.2, and 0.1 $\mu\text{g/L}$, respectively. Only sample MV-40 exceeded the maximum contaminant level of 2 $\mu\text{g/L}$. Site MV-40 is downgradient from many of the sampling locations, none of which exceeded the maximum contaminant level. Selenium concentrations were equal to the reporting level of 1 $\mu\text{g/L}$ in 16 samples; the maximum contaminant level is 10 $\mu\text{g/L}$. Concentrations of silver were greater than the reporting level in 13 samples, ranging from 1.0 to 2.0 $\mu\text{g/L}$; the maximum contaminant level is 50 $\mu\text{g/L}$.

Table 9. -- Maximum contaminant levels and reporting levels of selected trace metals in drinking water

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1987b) for community water systems and are included only for comparison purposes. Proposed maximum contaminant levels -- shown in parentheses -- are from U.S. Environmental Protection Agency (1990). Units are in $\mu\text{g/L}$ (micrograms per liter). Reporting levels are from Feltz and others (1985)]

Constituent	Maximum contaminant level	Reporting level
Arsenic	50 (30)	1
Barium	1,000 (5,000)	2
Cadmium	10 (5)	1
Chromium	50 (100)	1
Lead	50 (5)	1
Mercury	2	0.1
Selenium	10 (50)	1
Silver	50 (*)	1

*Proposed secondary maximum contaminant level for silver is 90 $\mu\text{g/L}$.

Table 10. -- Concentrations of selected trace metals dissolved in water from designated wells and springs, eastern Snake River Plain

[Analyses by U.S. Geological Survey's National Water Quality Laboratory. Analytical results in $\mu\text{g/L}$ (micrograms per liter); <1 indicates the concentration was less than the reporting level of 1 $\mu\text{g/L}$. Site identifier: see figure 2 for location of sites. Symbols: * indicates QA sample (see Quality Assurance section in text for explanation); -- indicates no analysis available]

Site identifier	Date sampled (mo/da/yr)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
MV-1	08/14/89	3	70	<1	2	<1	<0.1	<1	<1.0
MV-2	08/14/89	3	62	2	2	1	<0.1	1	2.0
MV-3	08/15/89	3	24	<1	3	1	<0.1	<1	<1.0
MV-4	08/15/89	4	46	<1	2	<1	<0.1	1	<1.0
MV-5	08/15/89	3	55	<1	2	<1	<0.1	1	1.0
MV-6	08/15/89	3	76	<1	2	<1	<0.1	<1	1.0
MV-7	08/16/89	2	20	<1	3	2	<0.1	<1	1.0
MV-8 *	08/16/89	2	20	<1	3	1	<0.1	<1	<1.0
MV-9	08/16/89	4	140	<1	2	<1	<0.1	1	<1.0
MV-10	08/16/89	2	87	1	3	4	<0.1	1	<1.0
MV-11	08/16/89	2	110	<1	2	<1	<0.1	<1	<1.0
MV-12	08/17/89	2	51	<1	2	1	<0.1	<1	2.0
MV-13	08/17/89	3	88	<1	3	<1	<0.1	1	<1.0
MV-14	08/17/89	2	42	<1	3	1	<0.1	<1	<1.0
MV-15	08/18/89	2	82	<1	2	1	<0.1	<1	<1.0
MV-16	08/18/89	2	21	<1	4	3	<0.1	<1	<1.0
MV-17	08/18/89	2	23	<1	3	<1	<0.1	<1	1.0
MV-18	08/18/89	2	60	<1	2	<1	<0.1	<1	1.0
MV-19	08/18/89	2	33	<1	3	<1	<0.1	<1	1.0
MV-20	08/19/89	2	22	<1	3	<1	<0.1	<1	1.0

Table 10. -- Concentrations of selected trace metals dissolved in water from designated wells and springs, eastern Snake River Plain -- Continued

Site identifier	Date sampled (mo/da/yr)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
MV-21	08/19/89	2	20	<1	4	<1	<0.1	<1	<1.0
MV-22 *	08/19/89	<1	<2	<1	2	<1	<0.1	<1	<1.0
MV-23	08/21/89	3	97	<1	2	<1	<0.1	<1	<1.0
MV-24	08/21/89	3	140	<1	2	<1	<0.1	1	<1.0
MV-25	08/22/89	4	56	<1	2	1	<0.1	<1	<1.0
MV-26	08/15/89	2	26	<1	1	<1	<0.1	<1	<1.0
MV-27	08/15/89	2	53	<1	3	<1	<0.1	1	<1.0
MV-28 *	08/15/89	2	52	<1	2	1	<0.1	<1	<1.0
MV-29	08/16/89	2	19	<1	3	<1	<0.1	<1	<1.0
MV-30	08/16/89	3	70	<1	2	1	<0.1	<1	<1.0
MV-31	08/16/89	2	49	<1	3	2	<0.1	<1	<1.0
MV-32	08/16/89	2	89	<1	3	<1	<0.1	<1	<1.0
MV-33	08/17/89	2	13	<1	4	1	<0.1	<1	<1.0
MV-34 *	08/17/89	2	13	<1	4	3	<0.1	<1	<1.0
MV-35	08/17/89	2	13	<1	4	<1	<0.1	<1	<1.0
MV-36	08/17/89	1	45	<1	2	<1	<0.1	<1	2.0
MV-37	08/18/89	1	52	<1	2	<1	<0.1	<1	<1.0
MV-38	08/18/89	1	29	<1	2	<1	<0.1	<1	<1.0
MV-39	08/18/89	3	59	<1	1	1	<0.1	<1	<1.0
MV-40	08/18/89	2	18	<1	4	<1	4.7	<1	<1.0
MV-41	08/21/89	3	76	<1	2	1	0.1	<1	<1.0
MV-42	08/21/89	3	28	<1	4	<1	<0.1	<1	<1.0
MV-43	08/21/89	2	90	<1	2	1	<0.1	<1	<1.0

Table 10. -- Concentrations of selected trace metals dissolved in water from designated wells and springs, eastern Snake River Plain -- Continued

Site identifier	Date sampled (mo/da/yr)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
MV-44 *	08/22/89	2	89	<1	2	1	<0.1	<1	<1.0
MV-45	08/22/89	3	23	<1	3	1	<0.1	<1	1.0
MV-46	08/22/89	2	16	<1	3	<1	<0.1	<1	<1.0
MV-47	09/07/89	2	18	<1	3	4	<0.1	<1	2.0
MV-48	09/13/89	1	50	<1	4	<1	<0.1	1	2.0
MV-49	09/21/89	2	57	<1	3	1	<0.1	<1	<1.0
MV-50	08/14/89	2	56	<1	2	<1	<0.1	1	<1.0
MV-51	08/15/89	3	62	<1	2	1	<0.1	1	<1.0
MV-52	08/22/89	5	76	<1	2	2	<0.1	<1	<1.0
MV-53	08/21/89	2	100	<1	2	<1	<0.1	1	<1.0
MV-54	08/21/89	2	110	<1	3	<1	<0.1	1	<1.0
MV-55	08/22/89	2	22	<1	4	<1	0.2	<1	<1.0
MV-56	08/22/89	2	22	<1	4	<1	0.1	<1	<1.0
MV-57	09/26/89	2	5	<1	4	<1	<0.1	<1	<1.0
MV-58	09/26/89	2	19	<1	3	<1	<0.1	<1	<1.0
MV-59	09/27/89	2	9	<1	3	2	<0.1	1	<1.0
MV-60 *	09/14/89	3	20	<1	5	2	--	1	<1.0
MV-61	09/14/89	3	20	<1	5	2	--	1	<1.0

Nutrients

Water samples were analyzed for dissolved ammonia (as nitrogen), nitrite (as nitrogen), nitrite plus nitrate (as nitrogen), and orthophosphate (as phosphorus). Maximum contaminant levels proposed by the U.S. Environmental Protection Agency (1987b) and reporting levels for nitrite and nitrite plus nitrate are shown on table 11. A maximum contaminant level has not been established or proposed for ammonia and orthophosphate.

Concentrations of nutrients are shown on table 12. Ammonia concentrations in 13 samples, 2 replicate samples, and 1 blank sample ranged from the reporting level of 0.010 to 0.030 mg/L. Concentrations of nitrite were less than the reporting level of 0.010 mg/L. Concentrations of nitrite plus nitrate ranged from the reporting level of 0.10 to 5.00 mg/L; the maximum contaminant level is 10 mg/L (table 11). Orthophosphate concentrations in 48 samples, 3 replicate samples, and 1 blank sample ranged from the reporting level of 0.010 to 0.080 mg/L.

ORGANIC COMPOUNDS

Water samples were analyzed for selected organic compounds. These compounds included surfactants, purgeable organic compounds, insecticides, polychlorinated compounds, and herbicides. In this report, reporting levels established for these constituents (Feltz and others, 1985) are not to be confused with reporting levels and analytical method detection limits for selected radionuclides.

Surfactants

Water samples were analyzed for surfactants. Maximum contaminant levels proposed by the U.S. Environmental Protection Agency (1987b) and reporting levels for surfactants are shown on table 11.

Table 11. -- Maximum contaminant levels and reporting levels for selected nutrients and surfactants in drinking water

[The proposed maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1990) for community water systems and are included only for comparison purposes. Units are milligrams per liter (mg/L). Analytical method detection levels are from Feltz and others (1985). Symbols: -- indicates that a maximum contaminant level has not been established or proposed for that constituent]

Constituent	Proposed maximum contaminant level	Reporting level
Ammonia (as nitrogen)	--	0.010
Nitrite (as nitrogen)	1	0.010
Nitrite plus nitrate (as nitrogen)	10	0.10
Orthophosphate (as phosphorus)	--	0.010
Surfactants ¹		0.01

¹Secondary maximum contaminant level for surfactants is 0.5 mg/L (U.S. Environmental Protection Agency, 1987b, p. 593)

Concentrations of surfactants are shown on table 12. Concentrations of surfactants in 54 samples, 5 replicate samples, and 1 blank sample ranged from the reporting level of 0.01 to 0.11 mg/L; the secondary maximum contaminant level is 0.5 mg/L (U.S. Environmental Protection Agency, 1987b).

Purgeable Organic Compounds

Samples from all sites were analyzed for 36 purgeable organic compounds. The maximum contaminant levels and reporting levels for these compounds are shown on table 13. Only two of the compounds, xylene and toluene, were detected in the water samples. Table 14 shows the results of purgeable organic compound analyses for those samples in which one or more compounds were detected. Toluene concentrations in three samples and one replicate sample ranged from 0.5 to 1.7 $\mu\text{g/L}$; the proposed maximum contaminant level is 2,000 $\mu\text{g/L}$. A blank sample (MV-22) contained 0.2 $\mu\text{g/L}$ of toluene. Concentrations of xylene in 15 samples and associated replicate samples ranged from 0.2 to 1.1 $\mu\text{g/L}$; the proposed maximum contaminant level is 10,000 $\mu\text{g/L}$.

The organic compounds n-propylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene also were detected in several samples (table 14). Concentrations of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene in 11 samples and 1 replicate sample ranged from 0.5 to 2.6 $\mu\text{g/L}$ and 0.2 to 1.7 $\mu\text{g/L}$, respectively. Concentrations of n-propylbenzene ranging from 0.2 to 0.3 $\mu\text{g/L}$ were detected in four of these samples. A new garden hose was used at these 11 sites to divert the water away from pumps and associated electrical equipment.

After receipt of preliminary data, an equipment-blank sample was obtained by flushing distilled water through the hose. Detectable concentrations of n-propylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene in the equipment-blank sample indicated that the hose was the source of contamination. Five of the sites were resampled without the garden hose; xylene concentrations in these samples were at the reporting level of 0.2 $\mu\text{g/L}$ and the other three compounds were not detected.

Table 12. -- Concentrations of selected nutrients and surfactants in water from designated wells and springs, eastern Snake River Plain

[Analyses by U.S. Geological Survey's National Water Quality Laboratory. Analytical results in mg/L (milligrams per liter); <0.010 indicates the concentration was less than the analytical method detection level of 0.010 mg/L. Site identifier: see figure 2 for location of sites. Symbols: * indicates QA sample (see Quality Assurance section in text for explanation)]

Site identifier	Date sampled (mo/da/yr)	Ammonia (as nitrogen)	Nitrite plus nitrate (as nitrogen)	Nitrite (as nitrogen)	Orthophosphate (as phosphorus)	Surfactants
MV-1	08/14/89	<0.010	1.30	<0.010	0.010	0.03
MV-2	08/14/89	0.010	1.30	<0.010	0.021	0.04
MV-3	08/15/89	<0.010	1.30	<0.010	<0.010	0.02
MV-4	08/15/89	<0.010	2.10	<0.010	0.010	0.06
MV-5	08/15/89	0.010	2.10	<0.010	0.021	0.05
MV-6	08/15/89	0.010	3.50	<0.010	0.021	0.05
MV-7	08/16/89	<0.010	0.40	<0.010	0.010	0.01
MV-8 *	08/16/89	<0.010	0.45	<0.010	0.010	0.02
MV-9	08/16/89	0.010	5.00	<0.010	0.021	0.09
MV-10	08/16/89	<0.010	2.80	<0.010	0.010	0.08
MV-11	08/16/89	<0.010	4.60	<0.010	<0.010	0.10
MV-12	08/17/89	<0.010	2.20	<0.010	0.021	0.06
MV-13	08/17/89	<0.010	1.80	<0.010	0.010	0.09
MV-14	08/17/89	<0.010	1.70	<0.010	<0.010	0.06
MV-15	08/18/89	<0.010	0.62	<0.010	0.021	0.06
MV-16	08/18/89	<0.010	2.00	<0.010	0.021	0.05
MV-17	08/18/89	<0.010	0.84	<0.010	0.010	0.02
MV-18	08/18/89	<0.010	2.20	<0.010	0.010	0.04
MV-19	08/18/89	<0.010	0.90	<0.010	0.021	0.07
MV-20	08/19/89	<0.010	1.90	<0.010	0.010	0.05
MV-21	08/19/89	<0.010	0.99	<0.010	<0.010	0.02
MV-22 *	08/19/89	0.021	<0.10	<0.010	0.010	0.02
MV-23	08/21/89	<0.010	3.00	<0.010	0.041	0.06
MV-24	08/21/89	<0.010	5.00	<0.010	0.021	0.11
MV-25	08/22/89	<0.010	2.70	<0.010	0.080	0.05
MV-26	08/15/89	<0.010	0.87	<0.010	0.021	0.03
MV-27	08/15/89	0.010	1.50	<0.010	0.010	0.05
MV-28 *	08/15/89	0.010	1.50	<0.010	0.021	0.05
MV-29	08/16/89	0.030	0.52	<0.010	<0.010	0.04
MV-30	08/16/89	0.010	2.40	<0.010	0.021	0.05

Table 12. -- Concentrations of selected nutrients and surfactants in water from designated wells and springs, eastern Snake River Plain -- continued

Site iden- tifier	Date sampled (mo/da/yr)	Ammonia (as nitrogen)	Nitrite plus nitrate (as nitrogen)	Nitrite (as nitrogen)	Orthophos- phate (as phosphorus)	Surfac- tants
MV-31	08/16/89	0.010	1.40	<0.010	0.010	0.05
MV-32	08/16/89	<0.010	4.30	<0.010	0.021	0.09
MV-33	08/17/89	<0.010	0.53	<0.010	0.010	0.01
MV-34 *	08/17/89	<0.010	0.54	<0.010	<0.010	0.01
MV-35	08/17/89	<0.010	1.50	<0.010	0.021	0.04
MV-36	08/17/89	<0.010	1.50	<0.010	0.030	0.04
MV-37	08/18/89	0.010	2.20	<0.010	0.050	0.05
MV-38	08/18/89	<0.010	1.20	<0.010	0.021	0.02
MV-39	08/18/89	<0.010	2.30	<0.010	0.050	0.05
MV-40	08/18/89	<0.010	0.73	<0.010	0.021	0.03
MV-41	08/21/89	<0.010	2.60	<0.010	0.050	0.05
MV-42	08/21/89	<0.010	1.40	<0.010	0.041	0.04
MV-43	08/21/89	<0.010	4.30	<0.010	0.010	0.08
MV-44 *	08/22/89	<0.010	4.30	<0.010	0.010	0.09
MV-45	08/22/89	<0.010	0.71	<0.010	0.010	0.02
MV-46	08/22/89	<0.010	0.61	<0.010	0.021	0.02
MV-47	09/07/89	0.030	0.88	<0.010	0.021	0.02
MV-48	09/13/89	<0.010	0.69	<0.010	0.010	0.01
MV-49	09/21/89	0.010	1.50	<0.010	0.050	0.05
MV-50	08/14/89	<0.010	1.80	<0.010	0.021	0.05
MV-51	08/15/89	0.021	2.10	<0.010	0.041	0.03
MV-52	08/22/89	<0.010	2.60	<0.010	0.070	0.06
MV-53	08/21/89	<0.010	3.50	<0.010	0.010	0.09
MV-54	08/21/89	<0.010	4.40	<0.010	0.010	0.08
MV-55	08/22/89	<0.010	1.00	<0.010	0.010	0.03
MV-56	08/22/89	<0.010	1.00	<0.010	0.010	0.04
MV-57	09/26/89	<0.010	0.44	<0.010	0.010	0.08
MV-58	09/26/89	<0.010	1.50	<0.010	0.021	0.09
MV-59	09/27/89	<0.010	<0.10	<0.010	<0.010	0.08
MV-60 *	09/14/89	0.010	0.97	<0.010	<0.010	0.02
MV-61	09/14/89	0.010	0.98	<0.010	<0.010	<0.01

Table 13. -- Maximum contaminant levels and reporting levels of selected purgeable organic compounds in drinking water

[Analyses were performed by the U.S. Geological Survey's National Water Quality Laboratory using an analytical method equivalent to U.S. Environmental Protection Agency method 524 (Feltz and others, 1985). Reporting level for all compounds is 0.2 micrograms per liter (Feltz and others, 1985). Maximum contaminant level: * indicates that total trihalomethanes -- which includes bromoform, chloroform, dibromochloromethane, and dichlorobromomethane -- in community water systems serving 10,000 or more persons cannot exceed 100 micrograms per liter (U.S. Environmental Protection Agency, 1987b); Symbols: -- indicates that a maximum contaminant level has not been established or proposed for that compound. Proposed maximum contaminant levels -- shown in parentheses -- are from J. Rodin (U.S. Environmental Protection Agency, written commun., 1989) and U.S. Environmental Protection Agency (1990). Units are $\mu\text{g/L}$ (micrograms per liter)]

Compound	Maximum contaminant level	Compound	Maximum contaminant level
Benzene	5.0	Ethylbenzene	(70)
Bromoform	*	1,3-dichloropropene	--
Carbon tetrachloride	5.0	Cis-1,3-dichloropropene	--
Chlorobenzene	(100)	Styrene	(10.0)
Chloroethane	--	Methyl bromide	--
2-chloroethyl vinyl ether	--	Trans-1,3- dichloropropene	--
Chloroform	*	Chloromethane	--
Dibromochloromethane	*	Dichlorobromomethane	*
Methylene chloride	--	Toluene	(2,000)
1,1,2,2-tetrachloro- ethane	--	Trichlorofluoromethane	--
1,2-dichloroethane	(5.0)	Tetrachloroethylene	(5.0)
1,2-dichlorobenzene	(600)	1,3-dichlorobenzene	--
1,4-dichlorobenzene	75	Trichloroethylene	(5.0)
1,1,1-trichloroethane	200	1,2-trans-dichloro- ethylene	(100)
1,1,2-trichloroethane	--	Dichlorodifluoro- methane	--
1,2-dibromoethylene	--	1,2-dichloropropane	(5.0)
1,1-dichloroethane	--	Xylenes, mixed	(10,000)
Vinyl chloride	2.0	1,1-dichloroethylene	7.0

Table 14. -- Concentrations of selected purgeable organic compounds in water from designated wells, eastern Snake River Plain

[Analyses by U.S. Geological Survey National Water Quality Laboratory using an analytical method equivalent to U.S. Environmental Protection Agency method 524 (Feltz and others, 1985). Analytical results in $\mu\text{g/L}$ (micrograms per liter); <0.2 indicates the concentration was less than the reporting level of 0.2 $\mu\text{g/L}$. Site identifier: see figure 2 for location of sites. Symbols: * indicates QA sample (see Quality Assurance section in text for explanation)]

Site iden- tifier	Sample date (mo/da/yr)	Toluene (total)	Xylene (total)	n- propyl- benzene	1,2,4- trimethyl- benzene	1,3,5- trimethyl- benzene
MV-22 *	08/19/89	0.2	<0.2	<0.2	<0.2	<0.2
MV-29	08/16/89	<0.2	0.7	0.2	1.8	0.5
MV-30	08/16/89	<0.2	0.8	0.2	2.1	0.6
MV-31	08/16/89	<0.2	0.9	0.2	2.0	0.6
MV-33	08/17/89	<0.2	0.4	<0.2	1.0	0.4
MV-34 *	08/17/89	<0.2	0.2	<0.2	0.7	0.2
MV-35	08/17/89	<0.2	0.5	<0.2	1.5	0.6
MV-36	08/17/89	<0.2	0.5	<0.2	0.9	0.4
MV-38	08/18/89	<0.2	0.4	<0.2	1.4	0.5
MV-39	08/18/89	<0.2	0.3	<0.2	0.8	0.3
MV-40	08/18/89	<0.2	0.2	<0.2	0.8	0.3
MV-41	08/21/89	<0.2	0.6	<0.2	0.5	1.7
MV-43	08/21/89	<0.2	0.4	<0.2	<0.2	<0.2
MV-44 *	08/22/89	<0.2	0.4	<0.2	<0.2	<0.2
MV-45	08/22/89	<0.2	0.5	<0.2	<0.2	<0.2
MV-46	08/22/89	<0.2	0.5	<0.2	<0.2	<0.2
MV-48	09/13/89	1.7	<0.2	<0.2	<0.2	<0.2
MV-49	09/21/89	0.5	1.1	<0.2	<0.2	<0.2
MV-50	08/14/89	<0.2	0.9	0.3	2.6	0.7
MV-51	08/15/89	<0.2	<0.2	<0.2	<0.2	<0.2
MV-60 *	09/14/89	0.9	<0.2	<0.2	<0.2	<0.2
MV-61	09/14/89	1.0	<0.2	<0.2	<0.2	<0.2

Insecticides and Polychlorinated Compounds

Water samples were analyzed for concentrations of 10 carbamate insecticides, 11 organophosphorus insecticides, 15 organochlorine insecticides, gross PCB's and gross PCN's. The maximum contaminant levels and reporting levels for these compounds are shown on table 15.

No carbamate insecticides exceeded the reporting level. Samples for organophosphorus insecticides exceeded the reporting level at two sites. Samples from sites MV-24 and 25 contained 0.03 and 0.01 $\mu\text{g/L}$ of diazinon, respectively, and 0.01 $\mu\text{g/L}$ of malathion. Concentrations of the organochlorine insecticide, DDT, from MV-43 and its replicate sample exceeded the reporting level at 0.041 $\mu\text{g/L}$ each. Gross PCB and gross PCN concentrations did not exceed the reporting levels in any samples.

Herbicides

Concentrations of 12 triazine herbicides and 4 chlorophenoxy acid herbicides were determined by the NWQL. Maximum contaminant levels and reporting levels for these compounds are shown on table 16. None of the measured herbicides exceeded their respective reporting levels.

SUMMARY

The U.S. Geological Survey and the Idaho Department of Water Resources, in response to a request from the U.S. Department of Energy, have completed the initial phase of a long-term project to monitor the water quality of the Snake River Plain aquifer from the southern boundary of the Idaho National Engineering Laboratory to the Hagerman area, Idaho. Fifty-five water samples were collected and analyzed for manmade pollutants and naturally occurring contaminants. The samples were collected from 26 irrigation wells, 13 domestic wells, 5 springs, 4 stock wells, 3 dairy wells, 2 observation wells, 1 commercial well, and 1 public-supply well. Six quality assurance samples also were collected and analyzed. The samples were

analyzed for selected radionuclides, chemical constituents, and organic compounds.

Radon-222 was detected at concentrations exceeding the reporting level at 15 sites. No maximum contaminant level has been established for radon-222. Concentrations of strontium-90 in eight samples exceeded the reporting levels but none exceeded the maximum contaminant level.

Tritium concentrations were determined by the NWQL and the Environmental Monitoring Laboratory at ISU. The laboratories have different analytical method detection limits although they both use the liquid-scintillation technique. All tritium concentrations in water samples analyzed by the ISU laboratory were below the analytical method detection limit. Thirty-three water samples analyzed by the NWQL had concentrations of tritium larger than the reporting level. The maximum concentration was less than half the analytical method detection limit for the ISU laboratory and less than the maximum contaminant level set by the U.S. Environmental Protection Agency.

Fifty-six samples had concentrations greater than the reporting level of dissolved and/or suspended gross alpha-particle radioactivity; water from one site exceeded the U.S. Environmental Protection Agency maximum contaminant level. All but one sample had concentrations greater than the reporting level of dissolved and/or suspended gross beta-particle radioactivity. Total uranium concentrations were greater than the reporting level in all but two water samples. No maximum contaminant level has been established for total uranium. Radium-224 concentrations in 36 samples exceeded the reporting level; radium-226 concentrations exceeded the reporting level in all samples; radium-228 concentrations exceeded the reporting level in all samples; none exceeded the established maximum contaminant levels for radium isotopes. Four radionuclides were identified using gamma spectroscopy. Potassium-40 was identified in 22 samples, thorium-234 in 17 samples, lead-212 in 20 samples, and bismuth-212 in 1 sample. All concentrations were greater than the reporting level except bismuth-212.

Table 15. -- Maximum contaminant levels and reporting levels of selected insecticides and gross polychlorinated compounds in drinking water

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1987b) for community water systems and are included only for comparison purposes. Proposed maximum contaminant levels -- shown in parentheses -- are from J. Rodin (U.S. Environmental Protection Agency, written commun., 1989) and U.S. Environmental Protection Agency (1990). Reporting levels are from Feltz and others (1985). Units are in $\mu\text{g/L}$ (micrograms per liter). Symbols: -- indicates that a maximum contaminant level has not been established or proposed for that compound]

Carbamate insecticides: Reporting level is 0.5 $\mu\text{g/L}$			
Insecticide	Maximum contaminant level	Insecticide	Maximum contaminant level
Aldicarb	(10)	Methomyl	--
Aldicarb sulfoxide	(10)	1-Naphthol	--
Aldicarb sulfone	(40)	Oxamyl	(200)
Carbofuran	(40)	Propham	--
3-Hydroxycarbofuran	--	Carbaryl (Sevin)	--
Organophosphorus insecticides: Reporting level is 0.01 $\mu\text{g/L}$			
Insecticide	Maximum contaminant level	Insecticide	Maximum contaminant level
Chlorpyrifos; Dursban	--	Methyl parathion	--
Diazinon	--	Methyl trithion	--
Disulfoton	--	Parathion	--
Ethion	--	Phorate	--
Fonofos	--	Trithion	--
Malathion	--		

Table 15. -- Maximum contaminant levels and reporting levels of selected insecticides and gross polychlorinated compounds in drinking water
 -- Continued

Organochlorine insecticides: Reporting level is 0.01 µg/L except for chlordane and perthane (0.1 µg/L), and toxaphene (1.0 µg/L)			
Insecticide	Maximum contaminant level	Insecticide	Maximum contaminant level
Aldrin	--	Heptachlor	(0.4)
Chlordane	(2.0)	Heptachlor epoxide	(0.2)
DDD	--	Lindane	4.0
DDE	--		(0.2)
DDT	--	Methoxychlor	100
Dieldrin	--		(400)
Endosulfan	--	Mirex	--
Endrin	0.2	Perthane	--
		Toxaphene	5.0
Gross polychlorinated compounds: Reporting level is 0.1 µg/L			
Compound			Maximum contaminant level
Gross polychlorinated biphenyls (PCB's)			(0.5)
Gross polychlorinated naphthalenes (PCN's)			--

Table 16. -- Maximum contaminant levels and reporting levels of triazine and chlorophenoxy acid herbicides in drinking water

[The maximum contaminant levels were established pursuant to the recommendations of the U.S. Environmental Protection Agency (1987b) for community water systems and are included only for comparison purposes. Proposed maximum contaminant levels -- shown in parentheses -- are from J. Rodin (U.S. Environmental Protection Agency, written commun., 1989) and U.S. Environmental Protection Agency (1990). Reporting levels are from Feltz and others (1985). Symbols: -- indicates that a maximum contaminant level has not been established or proposed for that compound. Units are $\mu\text{g/L}$ (micrograms per liter)]

Triazine and other nitrogen-containing herbicides: Reporting level is 0.1 $\mu\text{g/L}$			
Herbicide	Maximum contaminant level	Herbicide	Maximum contaminant level
Alachlor	(2.0)	Prometon	--
Ametryn	--	Prometryn	--
Atrazine	(3.0)	Propazine	--
Cyanazine	--	Simazine	(1.0)
Metolachlor	--	Simetryn	--
Metribuzin	--	Trifluralin	--
Chlorophenoxy acid herbicides: Reporting level is 0.01 $\mu\text{g/L}$			
Herbicide	Maximum contaminant level	Herbicide	Maximum contaminant level
2,4-D	100 (70)	Silvex	10 (50)
2,4-DP	--	2,4,5-T	--

All of the samples contained one or more dissolved trace metals in concentrations greater than the reporting levels. One sample exceeded the established maximum contaminant level for mercury.

Water samples from 13 sites had concentrations greater than the reporting level for ammonia (as nitrogen). Concentrations of nitrite plus nitrate (as nitrogen) were greater than the reporting level in water from 54 sites. Orthophosphate (as phosphorus) in 52 of the water samples were greater than the reporting level. Nitrate (as nitrogen) was not detected in any water samples at concentrations above the reporting level. Nutrient concentrations did not exceed established maximum contaminant levels. Surfactants were detected in 54 water samples and 5 replicate samples but did not exceed secondary maximum contaminant levels.

Toluene concentrations greater than the reporting level were detected in water samples from two sites. No carbamate insecticides, gross PCB's, or gross PCN's were detected in any of the samples. Two samples exceeded the reporting level for diazinon, two samples exceeded the reporting level for malathion, and water from one site contained detectable concentrations of DDT. None of the measured herbicides were detected at concentrations exceeding their respective reporting levels.

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