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Effect of Activities at the Idaho National Engineering and Environmental Laboratory on the Water Quality of the Snake River Plain Aquifer in the Magic Valley Study

Background

Radiochemical and chemical constituents in wastewater generated at facilities of the Idaho National Engineering and Environmental Laboratory (INEEL) (figure 1) have been discharged to waste-disposal ponds and wells since the early 1950's. Public concern has been expressed that some of these constituents could migrate through the Snake River Plain aquifer to the Snake River in the Twin Falls-Hagerman area. Because of these concerns, the U.S. Department of Energy (DOE) requested that the U.S. Geological Survey (USGS) conduct three studies to gain a greater understanding of the chemical quality of water in the aquifer. One study described a one-time sampling effort for radionuclides, trace elements, and organic compounds in the eastern part of the A&B Irrigation District in Minidoka County (Mann and Knobel, 1990). Another ongoing study involves sampling for tritium from 19 springs on the north side of the Snake River in the Twin Falls-Hagerman area (Mann, 1989; Mann and Low, 1994). A third study, an ongoing annual sampling effort in the area between the southern boundary of the INEEL and Hagerman (figure 1) (hereafter referred to as the Magic Valley study area), is being conducted with the Idaho Department of Water Resources in cooperation with the DOE. Data for a variety of radiochemical and chemical constituents from this study have been published by Wegner and Campbell (1991); Bartholomay, Edwards, and Campbell (1992, 1993, 1994a, 1994b); and Bartholomay, Williams, and Campbell (1995, 1996, 1997b). Data discussed in this fact sheet were taken from these reports. An evaluation of data collected during the first four years of this study (Bartholomay, Williams, and Campbell, 1997a) showed no pattern of water-quality change for radionuclide data as concentrations randomly increased or decreased. The inorganic constituent data showed no statistical change between sample rounds.

Geohydrologic Setting

The eastern Snake River Plain is a northeast-trending structural basin about 200 miles (mi) long and 50 to 70 mi wide. The plain is underlain by a layered sequence of basaltic rocks and cinder beds and interbedded sedimentary deposits. The basaltic rocks and sedimentary deposits combine to form the Snake River Plain aquifer, which is the main source of ground water on the plain.

The Snake River Plain aquifer is one of the most productive aquifers in the United States. Recharge is principally from infiltration of irrigation water, infiltration of streamflow, and ground-water inflow from adjoining mountain drainage basins. Water in the aquifer moves principally through fractures and interflow zones in the basalt. A large proportion of the ground water moves through the upper 200 to 800 feet (ft) of basaltic rocks (Mann, 1986, p. 21). Ground water moves southwestward from the INEEL and eventually is discharged as springs along the Snake River downstream from Twin Falls, 100 mi southwest of the INEEL. About 3.7 million acre-ft of ground water was discharged in 1995 (Bartholomay, Tucker, and others, 1997, p. 20).

Estimates of ground-water flow velocities at the INEEL, based on the apparent movement of several tracer constituents in the aquifer system, range from about 4 to 20 ft/day (Mann and Beasley, 1994, p. 24). Based on these velocities, water beneath the INEEL could reach the Snake River near Twin Falls in about 70 to 350 years.

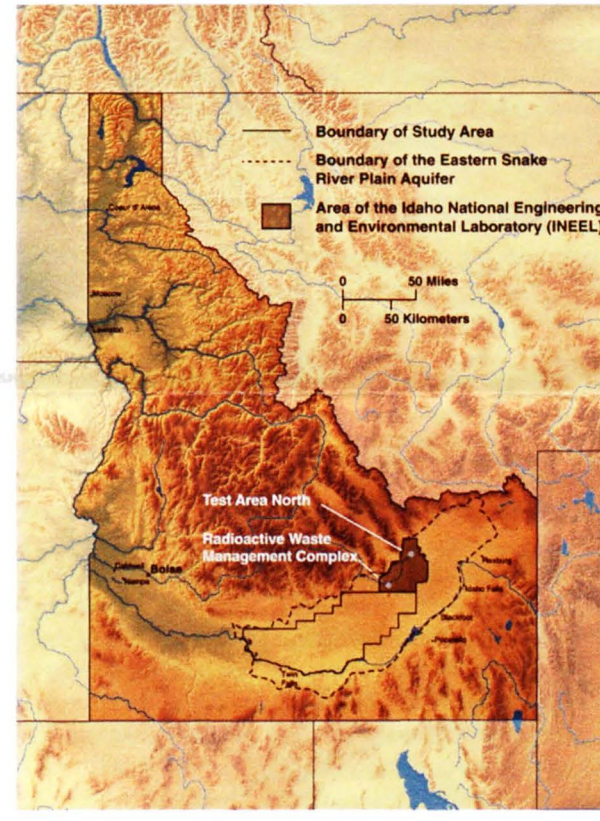

Figure 1. Location of the study area, between the Idaho National Engineering and Environmental Laboratory and Hagerman, Idaho.

Evaluation of water-quality data

To evaluate the effect INEEL activities have on water quality in the aquifer in the Magic Valley study area, the concentrations of certain constituents at the INEEL and the velocity with which those constituents move down gradient in the aquifer system need to be determined.

Most of the radioactivity in wastewater discharged at the INEEL is in the form of tritium (Bartholomay, Tucker, and others, 1997). Tritium is a naturally occurring radioactive isotope of hydrogen produced by cosmic-ray interactions and also is a waste product from atmospheric-weapons testing and nuclear reactors. Half of the radioactivity of each tritium isotope decays every 12.3 years (Walker and others, 1989, p. 20). Because tritium gets incorporated into the water molecule, it moves readily with water.

In October 1995, tritium concentrations at the INEEL that were greater than the reporting level ranged from 600 ± 200 to 25,100 ± 1,000 picocuries per liter (pCi/L) (Bartholomay, Tucker, and others, 1997, p. 27). Although the term "reporting level" can vary for different constituents, it is defined here as the smallest measured concentration of a constituent that may be reliably reported using a given analytical method. For comparison, tritium concentrations greater than the reporting level from sites in the Magic Valley study area (figure 2) were from 1.00 ± 0.58 to 134.4 ± 25.6 pCi/L during 1989–96. The maximum contaminant level (MCL) for tritium in public drinking-water supplies is 20,000 pCi/L (U.S. Environmental Protection Agency, 1995, p. 913). Long-term radioactive-decay processes, dilution by recharge water, dispersion throughout the aquifer system, and an overall decrease in tritium-disposal rates contributed to decreased concentrations of tritium and a decreased area of tritium in the aquifer at the INEEL in 1992–95 (Bartholomay, Tucker, and others, 1997). Because tritium concentrations have decreased in water from the Snake River Plain aquifer at the INEEL, any recharge water from the INEEL that may reach the Magic Valley study area should not measurably affect tritium concentrations in that area.

Strontium-90 is another radionuclide in wastewater discharged at the INEEL. Strontium-90 is a fission product that was widely distributed in the environment during atmospheric-weapons tests and has been in wastewater discharged at the INEEL since the early 1950's. Strontium-90 is very toxic because it has a tendency to concentrate uniformly throughout mineral bone tissues. The MCL in public drinking-water supplies is 8 pCi/L (U.S. Environmental Protection Agency, 1995, p. 913). Half of the radioactivity of each strontium-90 isotope decays every 29.1 years (Walker and others, 1989, p. 29).

Concentrations of strontium-90 in water samples from most wells at the INEEL have remained relatively constant since 1989. In October 1995, concentrations in water from 19 wells were greater than the reporting level and ranged from 2.6 ± 0.7 to 76 ± 3 pCi/L (Bartholomay, Tucker, and others, 1997, p. 30). For comparison, strontium-90 concentrations in water from all sites in the Magic Valley study area have been less than the reporting level since 1989. Because strontium-90 tends to sorb onto sediment and basalt material in the aquifer (Knobel and others, 1997), it is not expected to move much past its

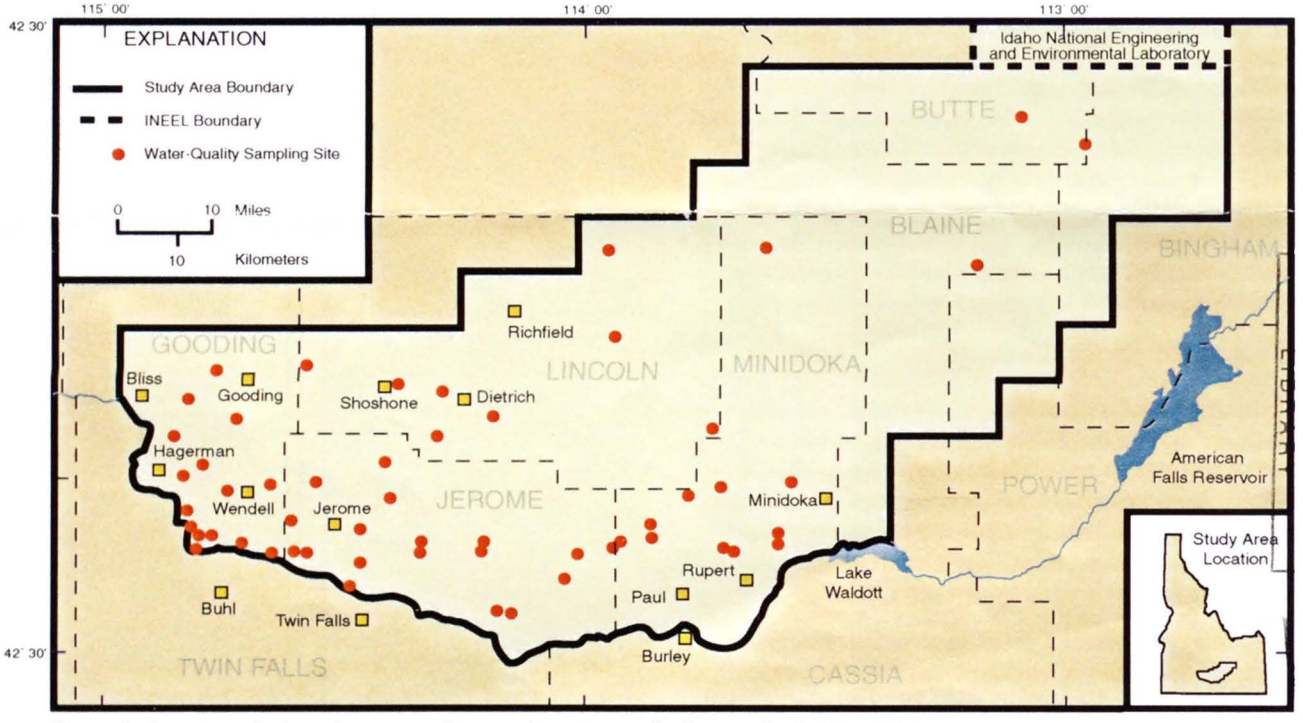

Figure 2. Location of selected water-quality sampling sites on the Eastern Snake River Plain

current location at the INEEL. Also, because of dilution, dispersion, radioactive decay, and decreased disposal rates at the INEEL, any recharge water from the INEEL that may reach the Magic Valley study area should not measurably affect strontium-90 concentrations in that area.

Gross alpha- and beta-particle radioactivity is a measure of the total radioactivity given off as alpha and beta particles during the radioactive decay process. Gross alpha and beta measurements are used to screen for radioactivity in the aquifer. The radioactivity can result from the breakdown of natural radioisotopes in the aquifer rocks or from the breakdown of radioactive waste constituents, such as those discharged to the aquifer at the INEEL.

During 1995, concentrations of gross alpha-particle radioactivity were less than the reporting levels in water from all 43 wells sampled at the INEEL. Concentrations of gross beta particle radioactivity were greater than the reporting level in water from 13 wells and ranged from 6 ± 2 to 43 ± 4 pCi/L (Bartholomay, Tucker, and others, 1997, p. 35). For comparison, during 1989–96, concentrations of gross alpha-particle radioactivity in water from sites in the Magic Valley study area that were greater than the reporting level ranged from 0.96 ± 0.53 micrograms per liter (µg/L) reported as uranium to 18.70 ± 2.40 pCi/L reported as thorium-230. During 1989–96, concentrations of gross beta-particle radioactivity in water from sites in the Magic Valley study area that were greater than the reporting level ranged from 1.93 ± 0.666 pCi/L reported as strontium-90 in equilibrium with yttrium-90 to 22.21 ± 2.85 pCi/L reported as cesium-137.

Earlier discussions on tritium and strontium-90 refute the possibility of the INEEL as the source of radioactivity in ground water in the Magic Valley study area. This indicates that gross alpha-particle radioactivity and gross beta-particle radioactivity in ground water in the Magic Valley study area probably are the result of the natural breakdown of radioisotopes in the local aquifer rocks.

Detectable concentrations of chemical constituents in water from the Snake River Plain aquifer at the INEEL were variable during 1992–95. Sodium and chloride concentrations in the southern part of the INEEL increased because of long-term increased waste-disposal rates and a lack of recharge from the Big Lost River. Nitrate concentrations remained constant during 1992–95 although waste-disposal rates decreased (Bartholomay, Tucker, and others, 1997, p. 1). In addition to sodium, chloride, and nitrate, large quantities of chromium and sulfate have been in wastewater discharged at the INEEL. During 1995, the maximum concentrations in water samples from wells at the INEEL were 79 milligrams per liter (mg/L) of dissolved sodium, 220 mg/L of dissolved chloride, 11 mg/L of dissolved nitrite plus nitrate as nitrogen, 170 µg/L of dissolved chromium, and 230 mg/L of dissolved sulfate (Bartholomay, Tucker, and others 1997, p. 35-41). For comparison, during 1989–96 concentrations in water from 55 sites in the Magic Valley study area ranged from 7.6 to 110 mg/L of dissolved sodium, 3.1 to 110 mg/L of dissolved chloride, 0.40 to 6.5 mg/L of dissolved nitrite plus nitrate as nitrogen, less than 1 to 9 µg/L of dissolved chromium, and 9.4 to 100 mg/L of dissolved sulfate. The maximum or secondary MCL's for public drinking water for chloride, nitrate as nitrogen, chromium and sulfate are 250 mg/L, 10 mg/L, 100 mg/L, and 250 mg/L, respectively (U.S. Environmental Protection Agency, 1995, p. 974; 1,055). There is no MCL for sodium.

Nitrate concentrations may be a concern to people in the Magic Valley area because of several sources of contamination in that area. Rupert (1994, p. 21) indicated that concentrations in perched ground water from some wells near Burley, Idaho, were greater than the MCL of 10 mg/L. The largest nitrate concentrations found in the Magic Valley study area were in water from wells north and northwest of Burley. Possible sources of nitrate contamination in the Magic Valley study area include agricultural fertilizers, effluent from animal-feeding operations and food-processing industries, and septic tanks (Rupert, 1994, p. 21).

Purgeable organic compounds are present in the Snake River Plain aquifer at the INEEL as a result of waste-disposal practices. In 1995, the concentration of carbon tetrachloride in water from one well at the Radioactive Waste Management Complex exceeded the MCL of 5 µg/L (Bartholomay, Tucker, and others, 1997, p. 45); concentrations downgradient were less than the reporting level.

During 1988-89, the concentrations of several purgeable organic compounds in water from wells at the Test Area North exceeded their respective MCL's (Mann, 1990). The USGS has not collected samples from those wells since 1989. Concentrations of purgeable organic compounds in water from wells downgradient from the Test Area North that were sampled during 1994-95 were below the reporting level for all of the compounds that had exceeded an MCL during 1988-89 (Bartholomay, Tucker, and others, 1997, p. 45-46). Concentrations of several purgeable organic compounds have been detected in water from sites in the Magic Valley study area, but concentrations generally have been near the reporting levels except in areas near local contaminant sources. Because purgeable organic compounds have not been detected downgradient from the facilities where the compounds were detected at the INEEL, any recharge water from the INEEL that may reach the Magic Valley study area should not measurably affect the concentrations of purgeable organic compounds in that area.

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Fact Sheet FS-052-98
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