Chapter 6: Environmental Monitoring Programs - Eastern Snake River Plain Aquifer Monitoring

CHAPTER 6

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination beneath the INL Site in the eastern Snake River Plain Aquifer. These areas are regularly monitored by the U.S. Geological Survey (USGS), and reports are published showing the extent of contamination plumes. Results for most monitoring wells within the plumes show decreasing concentrations of tritium, strontium-90, and iodine-129 over the past 20 years. The decrease is probably the result of radioactive decay, discontinued disposal, dispersion, and dilution within the aquifer.

In 2021, USGS sampled 29 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds. Eleven purgeable organic compounds were detected in at least one well. Most of the detected concentrations were less than the maximum contaminant levels (MCLs) established by the U.S. Environmental Protection Agency (EPA) for public drinking water supplies. One exception was carbon tetrachloride, detected in the production well at the Radioactive Waste Management Complex (RWMC). This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Trichloroethene was detected above the MCLs at a perched well at the RWMC and a well at Test Area North, where there is a known groundwater plume containing this contaminant being treated.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed at Waste Area Groups (WAGs) 1 – 4, WAG 7, and WAG 9 in 2021.

In addition to the Advanced Test Reactor Complex and the Materials and Fuels Complex, the INL contractor also monitors ground water at the Remote-Handled Low-Level Waste Disposal Facility for the surveillance of select radiological analytes. Groundwater samples were collected from three monitoring wells at the Remote-Handled Low-Level Waste Disposal Facility in 2021. The 2021 results show no discernable impacts to the aquifer.

There are 10 drinking water systems on the INL Site monitored by INL and Idaho Cleanup Project Core contractors. All contaminant concentrations measured in drinking water systems in 2021 were below regulatory limits.

Drinking water and springs were sampled in the vicinity of the INL Site and analyzed for gross alpha and gross beta activity and tritium. Some locations were co-sampled with the state of Idaho Department of Environmental Quality INL Oversight Program. Results were consistent with historical measurements and do not indicate any impact from historical INL Site releases.

6. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain Aquifer serves as the primary source of drinking water and crop irrigation in the upper Snake River Basin. This chapter presents the results of water monitoring conducted on and off the Idaho National Laboratory (INL) Site within the eastern Snake River Plain Aquifer hydrogeologic system. This includes the collection of water from the aquifer (including drinking water wells); downgradient springs along the Snake River where the aquifer discharges water (Figure 6-1); and an ephemeral stream (the Big Lost River), which flows through the INL Site and helps to recharge the aquifer. The purpose of the monitoring is to ensure that:

- The eastern Snake River Plain groundwater is protected from contamination from current INL Site activities
- Areas of known underground contamination from past INL Site operations are monitored and trended
- Drinking water consumed by workers and visitors at the INL Site and by the public downgradient of the INL Site is safe
- The Big Lost River, which occasionally flows through the INL Site, is not contaminated by INL Site activities before entering the aquifer via channel loss and playas on the north end of the INL Site.

Analytical results are compared to applicable regulatory guidelines for compliance and informational purposes. These include the following:

- State of Idaho groundwater primary and secondary constituent standards (Ground Water Quality Rule, IDAPA 58.01.11)
- U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCLs) for drinking water (40 Code of Federal Regulations [CFR] 141)
- U.S. Department of Energy Derived Concentration Standards for the ingestion of water (DOE 2011).

6.1 Summary of Monitoring Programs

Four organizations monitor the eastern Snake River Plain Aquifer hydrogeologic system:

- The United States Geological Survey (USGS) INL Project Office performs groundwater monitoring, analyses, and scientific studies to improve the understanding of the hydrogeological conditions that affect the movement of groundwater and contaminants in the eastern Snake River Plain Aquifer underlying and adjacent to the INL Site. The USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site as shown in Figure 6-2 and at locations throughout the eastern Snake River Plain.

  Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2021, USGS personnel collected and analyzed more than 1,200 samples for radionuclides and inorganic constituents, including trace elements, and 30 samples for purgeable organic compounds. USGS INL Project Office personnel also published four documents and two software packages covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Section 6.10.

- The Idaho Cleanup Project (ICP) Core contractor conducts groundwater monitoring at various Waste Area Groups (WAGs) delineated on the INL Site identified in Figure 6-3 for compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC) and Radioactive Waste Management Complex (RWMC). In 2021, the ICP Core contractor monitored groundwater at Test Area North (TAN), the Advanced Test Reactor (ATR) Complex, INTEC, Central Facilities Area (CFA), and RWMC (WAGs 1, 2, 3, 4, and 7 respectively). Table 6-2 summarizes the routine monitoring for the ICP Core contractor drinking water program. The ICP Core collected and analyzed 133 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, disinfection byproducts, and volatile organic compounds (VOCs) in 2021.

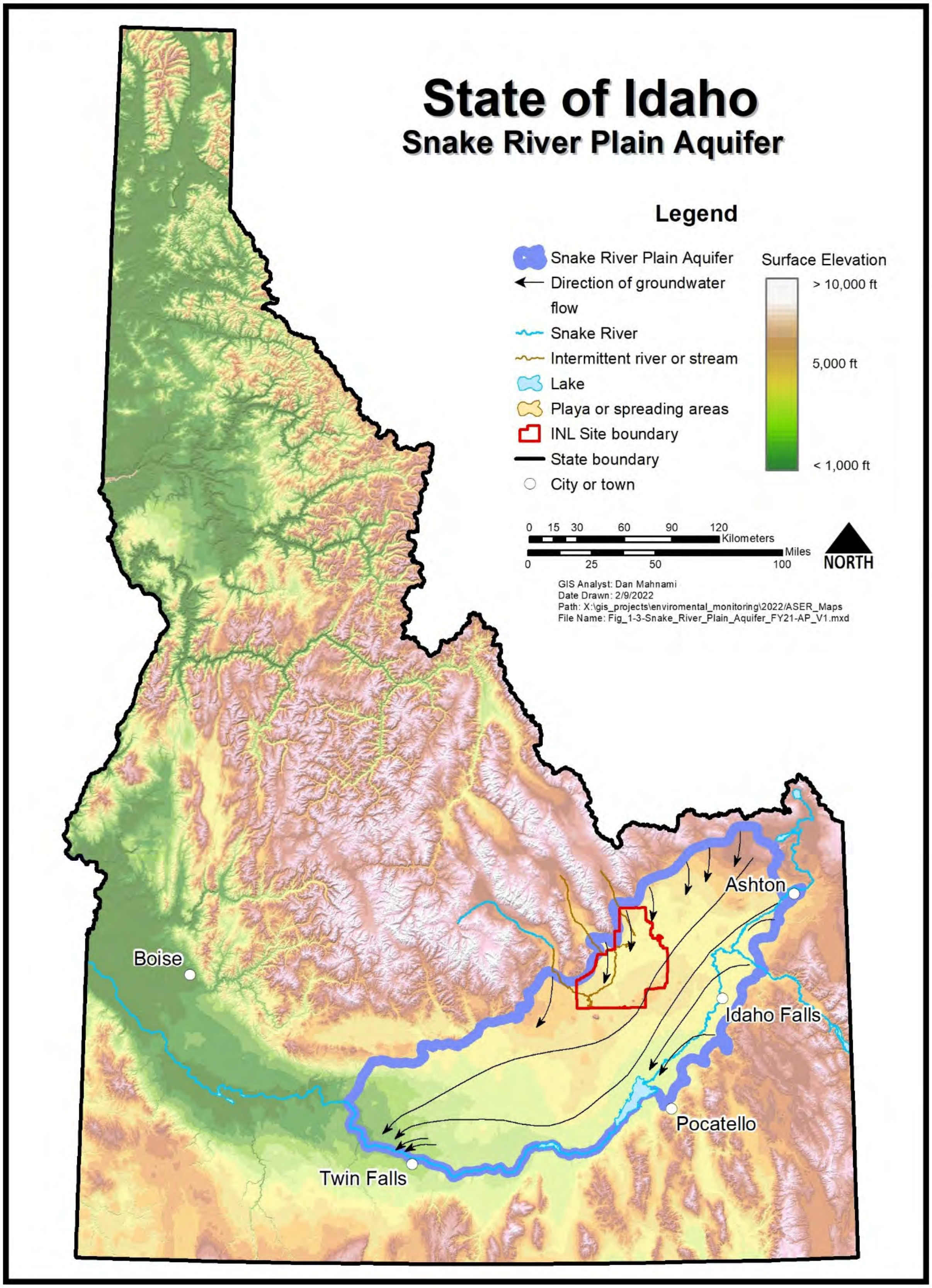


Figure 6-1. The eastern Snake River Plain Aquifer and direction of groundwater flow.

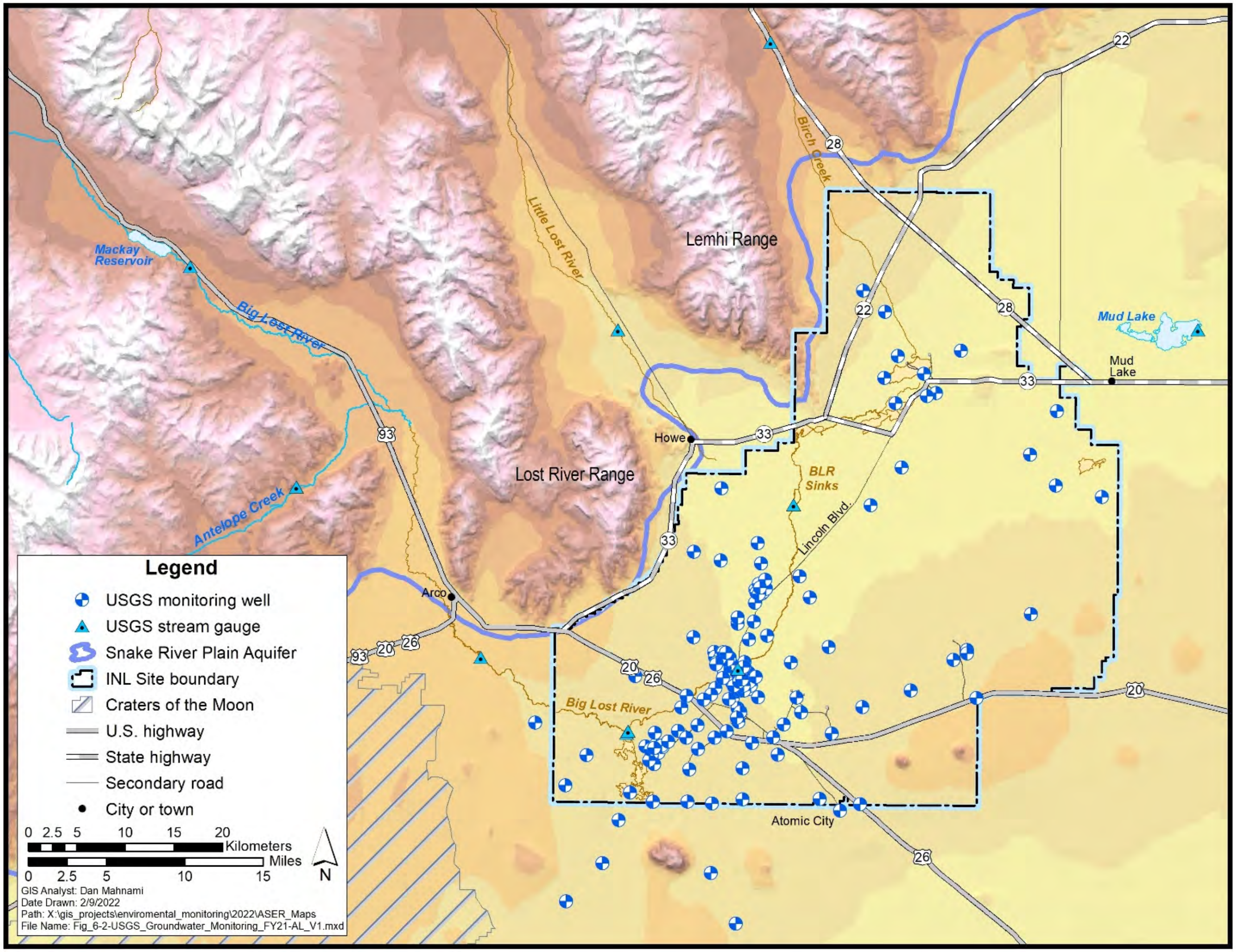


Figure 6-2. USGS groundwater monitoring locations on and off the INL Site.

Table 6-1. USGS monitoring program summary (2021).

CONSTITUENT	GROUNDWATER		SURFACE WATER		MINIMUM DETECTABLE CONCENTRATION OR ACTIVITY
	NUMBER OF SITES[a]	NUMBER OF SAMPLES	NUMBER OF SITES	NUMBER OF SAMPLES	
Gross alpha	60	68	1	1	8 pCi/L
Gross beta	60	68	1	1	3.5 pCi/L
Tritium	131	139	5	5	200 pCi/L
Gamma-ray spectroscopy	43	43	—[b]	—	—[c]
Strontium-90	63	63	—[b]	—	2 pCi/L
Americium-241	10	10	—[b]	—	0.03 pCi/L
Plutonium isotopes	10	10	—[b]	—	0.02 pCi/L
Iodine-129	31	31	—[b]	—	<1 pCi/L
Specific conductance	140	164	5	5	Not applicable
Sodium ion	129	137	—[b]	—	0.4 mg/L
Chloride ion	132	140	5	5	0.02 mg/L
Nitrates (as nitrogen)	111	119	—[b]	—	0.04 mg/L
Fluoride	6	6	—[b]	—	0.01 mg/L
Sulfate	118	126	—[b]	—	0.02 mg/L
Chromium (dissolved)	87	95	—[b]	—	1 µg/L
Purgeable organic compounds[d]	30	37	—[b]	—	Varies
Mercury	12	12	—[b]	—	0.005 µg/L
Trace elements	9	9	—[b]	—	Varies

a. Number of samples does not include 13 replicates and 5 blanks collected in 2021. Number of samples was different from the number of sites because one site for VOCs is sampled monthly, and three sites had pump problems or were dry, so they were not sampled. Number of sites does not include 24 zones from 10 wells sampled as part of the multi-level monitoring program.

b. No surface water samples collected for this constituent.

c. Minimum detectable concentration for gamma spectroscopic analyses varies depending on radionuclide.

d. Each purgeable organic compound water sample is analyzed for 61 purgeable organic compounds.

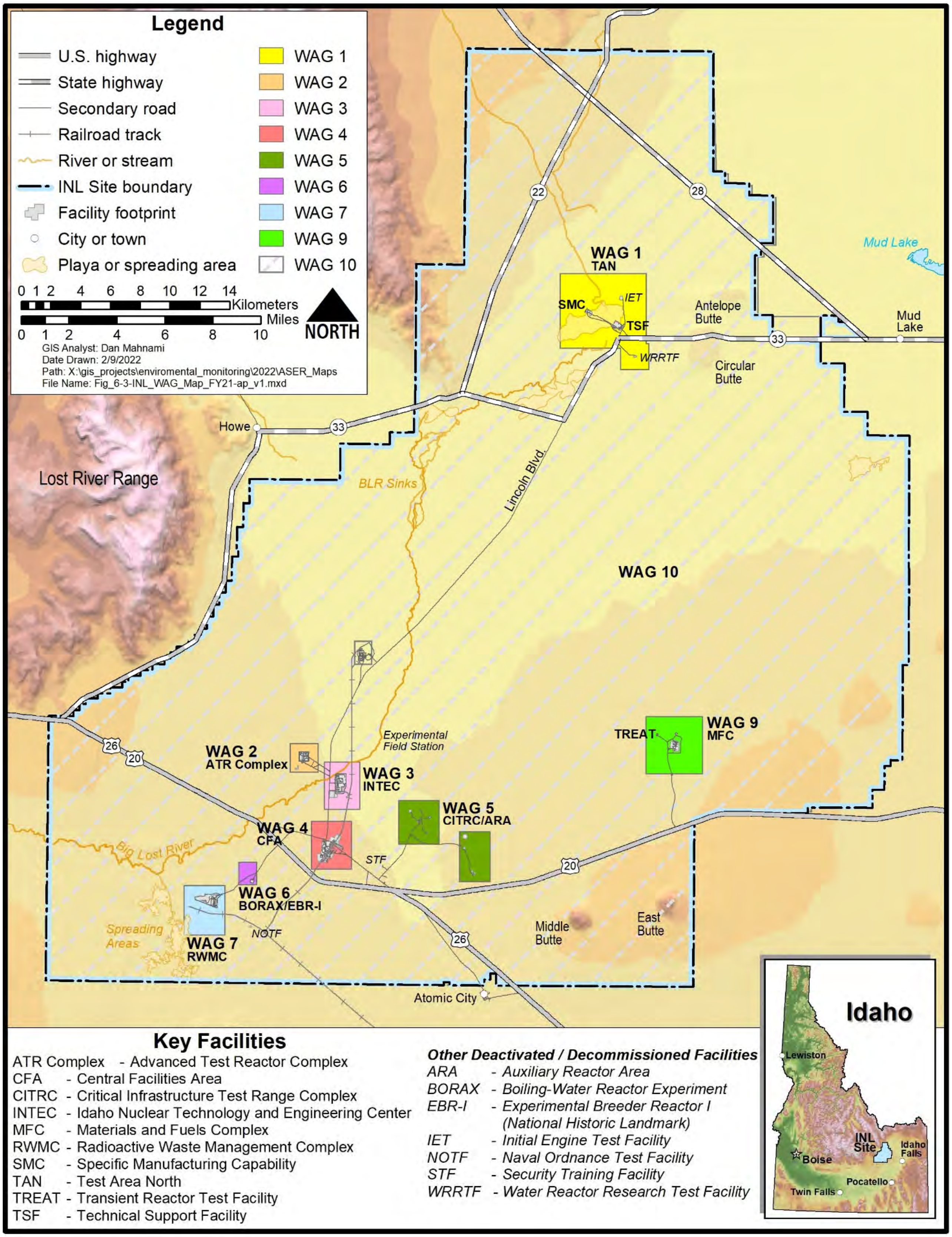


Figure 6-3. Map of the INL Site showing locations of facilities and corresponding WAGs.

Table 6-2. ICP Core contractor drinking water program summary (2021).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha	2 semiannually	15 pCi/L
Gross beta	2 semiannually	50 pCi/L screening level or 4 mrem/yr
Haloacetic acids (HAA5)[a]	2 annually	0.06 mg/L
Total coliform	6 to 8 monthly	See 40 CFR 141.63(d)
E. coli	6 to 8 monthly	See 40 CFR 141.63(c)
Nitrate	2 annually	10 mg/L (as nitrogen)
Radium-226/-228	2 every 9 years	5 pCi/L
Strontium-90	2 annually	8 pCi/L
Total trihalomethanes	2 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium		30 µg/L
VOCs[b]	2 annually	Varies

a. Haloacetic acids = sometimes referred to as HAA5, which includes the most common haloacetic acids found in drinking water. These consist of monochloroacetic acid, dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid, and dibromoacetic acid.

b. VOCs = volatile organic compounds.

- The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9), the ATR Complex, and the Remote Handled Low-Level Waste (RHLLW) Disposal Facility and drinking water at eight INL Site facilities: ATR Complex, CFA, the Critical Infrastructure Test Range Complex (CITRC), the Experimental Breeder Reactor-I (EBR-I), the Gun Range, the Main Gate, the MFC Complex, and TAN/Contained Test Facility (CTF). Table 6-3 summarizes the routine monitoring for the INL contractor drinking water program. In 2021, the INL contractor sampled and analyzed 206 groundwater and 338 drinking water samples, which included 134 surveillance and 36 performance samples for varying constituents including radionuclides, inorganic compounds, and VOCs.
- The Environmental Surveillance, Education and Research (ESER) contractor collects drinking water samples from around the INL Site, as well as samples from natural surface waters on and off the INL Site. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient from the INL Site. A summary of the program may be found in Table 6-4. In 2021, the ESER contractor sampled and analyzed 26 surface and drinking water samples. Samples were not collected from the Big Lost River in 2021 due to water demands upstream inhibiting river flow onto the INL.

Table 6-3. INL contractor drinking water program summary (2021).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha[a]	8 semiannually	15 pCi/L
Gross beta[a]	8 semiannually	4 mrem/yr
Tritium[a]	10 annually, 10 semiannually	20,000 pCi/L
Iodine-129[b]	1 semiannually	1 pCi/L
Parameters required by the state of Idaho under authority of the Safe Drinking Water Act	8 triennially	Varies
Nitrate[c]	10 annually	10 mg/L (as nitrogen)
Microbes (i.e., total coliform and E. coli)	14 monthly	If <40 samples/ month, no more than one positive for total coliform
Total trihalomethanes[d]	1 annual	0.08 mg/L
Haloacetic acids[d]	1 annual	0.06 mg/L
Lead/Copper[d]	35 triennially	0.015/1.3 mg/L

a. Gross alpha, beta, and tritium are sampled at all INL water systems (i.e., TAN/CTF, ATR Complex raw/drinking water, CFA, Gun Range, EBR-1, CITRC, Main Gate, and MFC).

b. Iodine-129 is only sampled at the CFA water system.

c. Nitrate and microbes are sampled at all INL water distribution systems. Nitrites were sampled in 2021.

d. Total trihalomethanes, haloacetic acids (HAA5), and lead/copper are only sampled at ATR Complex, CFA, MFC, and TAN/CTF water systems.

Table 6-4. ESER program surface and drinking water summary (2021).

MEDIUM SAMPLED	TYPE OF ANALYSIS	LOCATIONS AND FREQUENCY		MINIMUM DETECTABLE CONCENTRATION
		ONSITE	OFFSITE	
Drinking Water[a]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	100 pCi/L
Surface Water[b,c]	Gross alpha	6, when available	3-4 semiannually	3 pCi/L
	Gross beta	6, when available	3-4 semiannually	2 pCi/L
	Tritium	6, when available	3-4 semiannually	100 pCi/L

a. Samples are co-located with the state of Idaho Department of Environmental Quality (DEQ) INL Oversight Program at Shoshone and Minidoka water supplies. An upgradient sample is collected at Mud Lake Well #2. The number of samples includes a duplicate sample.

b. Onsite locations are the Big Lost River (when flowing) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, at the Experimental Field Station, and at the Big Lost River Sinks. A duplicate sample is also collected on the Big Lost River. Offsite samples are co-located with the DEQ INL Oversight Program at Alpheus Spring, Clear Springs, and at a fish hatchery at Hagerman. A duplicate sample is also collected at one location.

c. One sample is also collected offsite at Birch Creek as a control for the Big Lost River, when it is flowing.

Details of the aquifer, drinking water, and surface water programs may be found in *the Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2021b) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2021a).

6.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by organizations including USGS, current and past contractors, and other groups. The following data management systems are used:

- The Environmental Data Warehouse is the official long-term environmental data management and storage location for the ICP Core and INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS. It stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.
- The ICP Core Sample and Analysis Management Program consolidates environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.
- The Hydrogeologic Data Repository houses geologic and hydrologic information compiled to support remedial investigation and feasibility study (RI/FS) activities, EIS preparation, site selection and characterization, and modeling of transport in vadose and saturated zones. The information available includes (1) well construction and drill hole information; (2) maps; (3) historical data; (4) aquifer characteristics; (5) soil characterization; and (6) sediment property studies.
- The USGS Data Management Program involves putting all data in the National Water Information System, which is available online at https://waterdata.usgs.gov/id/nwis/nwis.

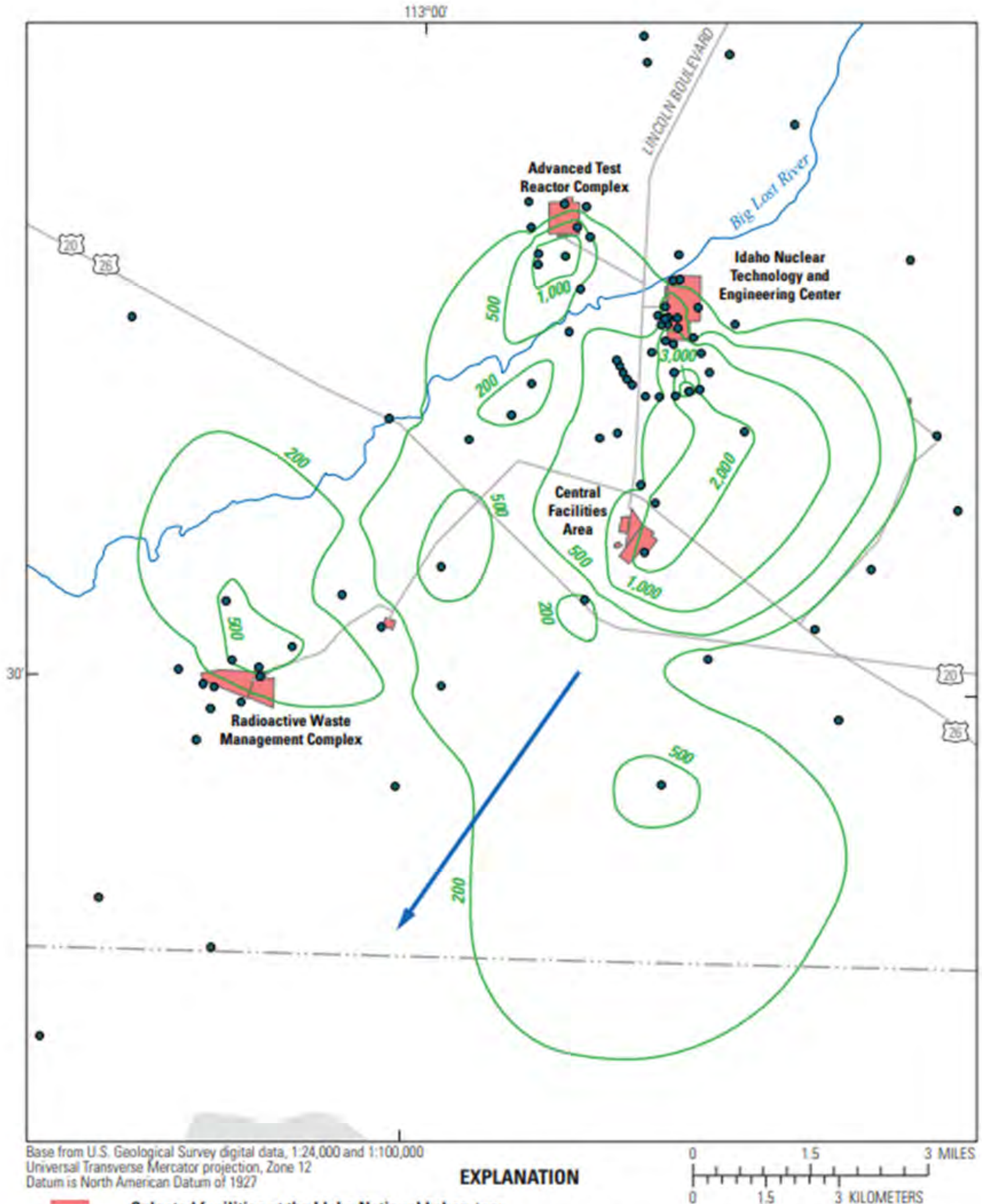
6.3 U.S. Geological Survey Radiological Groundwater Monitoring at the Idaho National Laboratory Site

Historical waste disposal practices have produced localized areas of radiochemical contamination in the eastern Snake River Plain Aquifer beneath the INL Site.

Presently, strontium-90 (^{90}Sr) is the only radionuclide that continues to be detected by the ICP Core contractor and USGS above the primary constituent standard in some surveillance wells between INTEC and CFA, and at TAN. Other radionuclides (e.g., gross alpha) have been detected above the primary constituent standard in wells monitored at individual WAGs.

Tritium – Because tritium is equivalent in chemical behavior to hydrogen—a key component of water—it has formed the largest plume of any of the radiochemical pollutants at the INL Site. The configuration and extent of the tritium contamination area, based on the most recent published USGS data (2018), are shown in Figure 6-4 (Bartholomay et al. 2020). The area of contamination within the 500-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000). The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed. This source is further supported by the fact that there are no known sources of tritium contamination to groundwater at CFA.

Two monitoring wells downgradient of the ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 20 years shown in Figure 6-5. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The concentration of tritium in USGS-065 near the ATR Complex decreased from 1,600 ± 90 pCi/L in 2020 to 1,380 ± 90 pCi/L in 2021; the tritium concentration in USGS-114, south of INTEC, increased slightly from 3,912 ± 173 in 2020 to 4,280 ± 150 pCi/L in 2021.



EXPLANATION

Selected facilities at the Idaho National Laboratory

200 **Line of equal tritium concentration**—April or October 2018. Lines of equal concentration were interpreted from analyses of water samples collected from a three-dimensional flow system. Mapped concentrations represent water samples collected from various depths in boreholes with differing well completions; for example, single- and multiple-screened intervals, and open boreholes. Location is approximate. Interval, in picocuries per liter, is variable.

Idaho National Laboratory boundary

General direction of groundwater flow

Well in the USGS water-level monitoring network—Water samples analyzed for tritium

Figure 6-4. Distribution of tritium (pCi/L) in the eastern Snake River Plain Aquifer on the INL Site in 2018 (from Bartholomay et al. 2020).

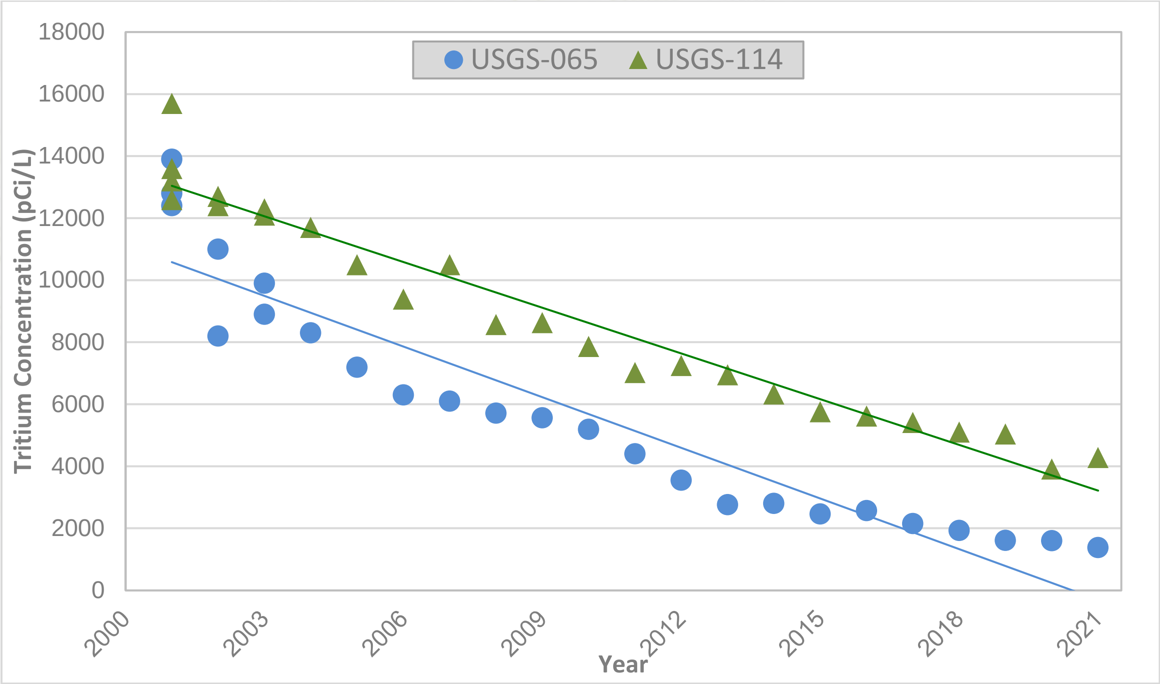


Figure 6-5. Long-term trend of tritium in wells USGS-065 and USGS-114 (2001–2021).

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the EPA MCL for tritium in drinking water. The values in Wells USGS-065 and USGS-114 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.33 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer. A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for tritium in all but one well at the INL Site showed decreasing or no trends, and the well that showed the increasing trend changed to a decreasing trend when data through 2018 were analyzed (Bartholomay et al. 2020, Figure 15).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Bartholomay et al. 2020). The contamination originates at INTEC from historical injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain Aquifer near the ATR Complex during 2021. All ^{90}Sr at the ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At the ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 20 years (e.g., 2001–2021) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased during this period. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons may include increased disposal of other chemicals into the INTEC percolation ponds, which may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000). A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for ^{90}Sr in all but two perched water wells at the INL Site showed decreasing or no trends.

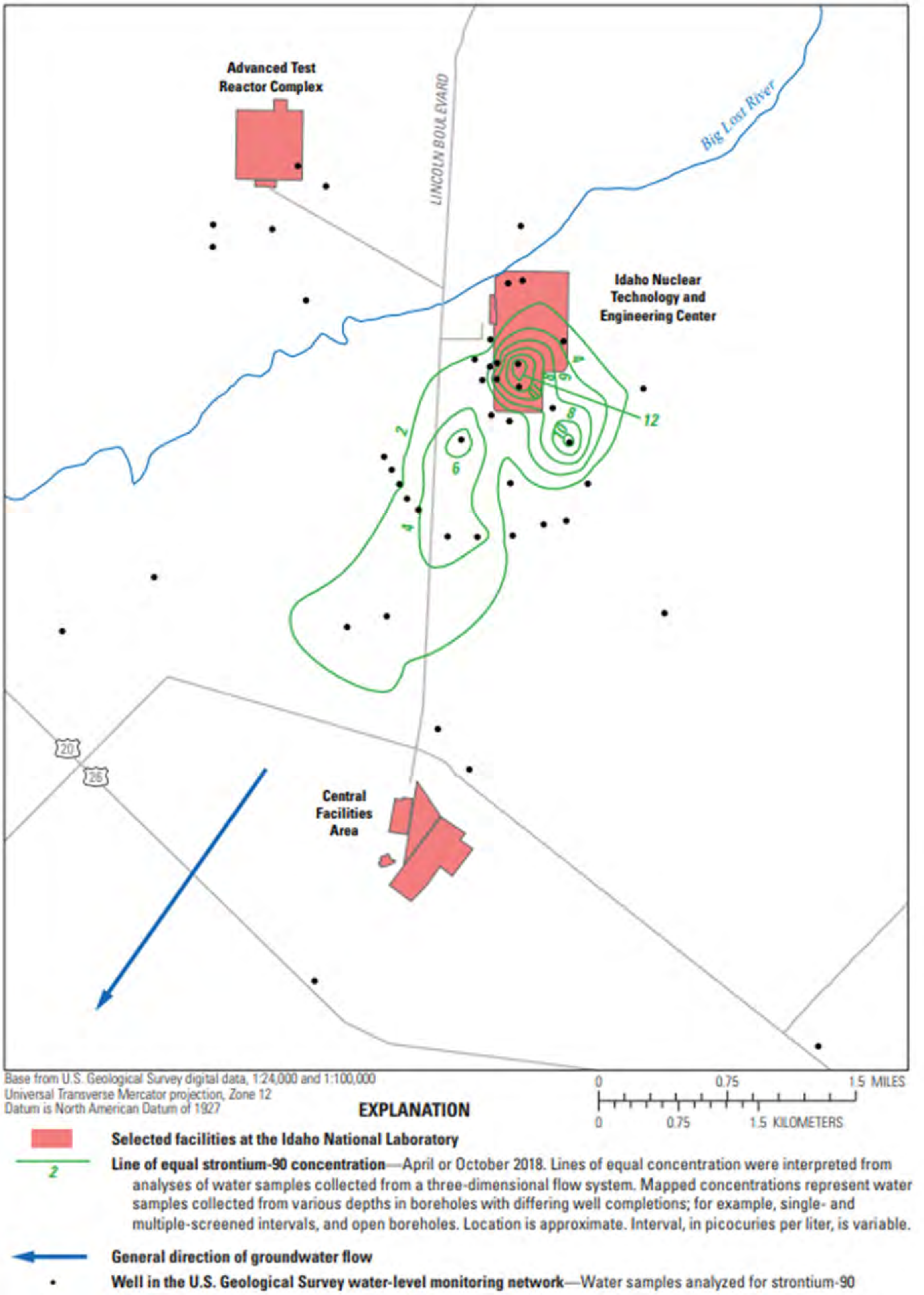


Figure 6-6. Distribution of ^{90}Sr (pCi/L) in the eastern Snake River Plain Aquifer on the INL Site in 2018 (from Bartholomay et al. 2020).

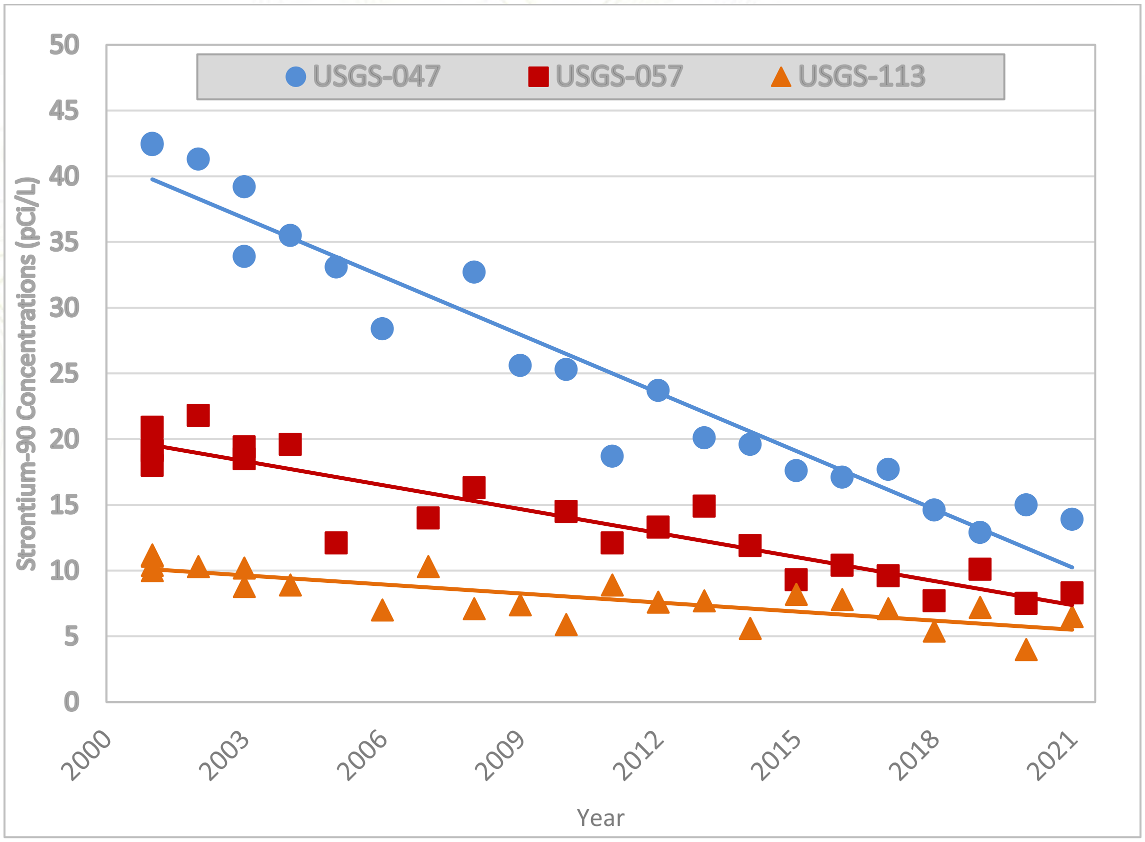


Figure 6-7. Long-term trend of ^{90}Sr in wells USGS-047, USGS-057, and USGS-113 (2000–2021).

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma spectroscopy analyses, and plutonium and americium isotopes. These values are shown in Table 6-1. Results for wells sampled in 2021 are available at https://waterdata.usgs.gov/id/nwis/. Monitoring results for 2016–2018 are summarized in Bartholomay et al. (2020). During 2016–2018, concentrations of cesium-137 (^{137}Cs) were greater than or equal to the reporting level in one well, and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all analyzed samples were less than the reporting level. In 2016–2018, reportable concentrations of gross alpha radioactivity were observed in six of the 55 wells and ranged from 6 ± 2 to 141 ± 29 pCi/L. Beta radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.4 ± 0.8 to 1,390 ± 80 pCi/L (Bartholomay et al. 2020).

Periodically, the USGS has sampled for iodine-129 (^{129}I) in the eastern Snake River Plain Aquifer. Monitoring programs from 1977, 1981, 1986, 1990, 1991, 2003, 2007, 2011, and 2012 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009, 2013). The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2017 and collected additional samples in the spring of 2018. Average concentrations of 15 wells sampled in 1990–1991, 2003, 2007, 2011–2012, and 2017–2018 decreased from 1.15 pCi/L in 1990–1991 to 0.168 pCi/L in 2017–2018. The maximum concentration in 2011 was 1.02 ± 0.04 pCi/L in a monitoring well southeast of INTEC—the drinking water standard for ^{129}I is 1 pCi/L. The concentration in that same well in 2017 decreased to 0.877 ± 0.032 pCi/L. Concentrations around INTEC showed slight decreases from samples collected in previous sample periods, and the decreases are attributed to discontinued disposal, as well as dilution and dispersion in the aquifer. The configuration and extent of ^{129}I in groundwater, based on the 2017–2018 USGS data (most current published date), are shown in Figure 6-8 (Maimer and Bartholomay, 2019). A follow-up sampling campaign for ^{129}I was initiated in 2021 and results will be published in an upcoming report.

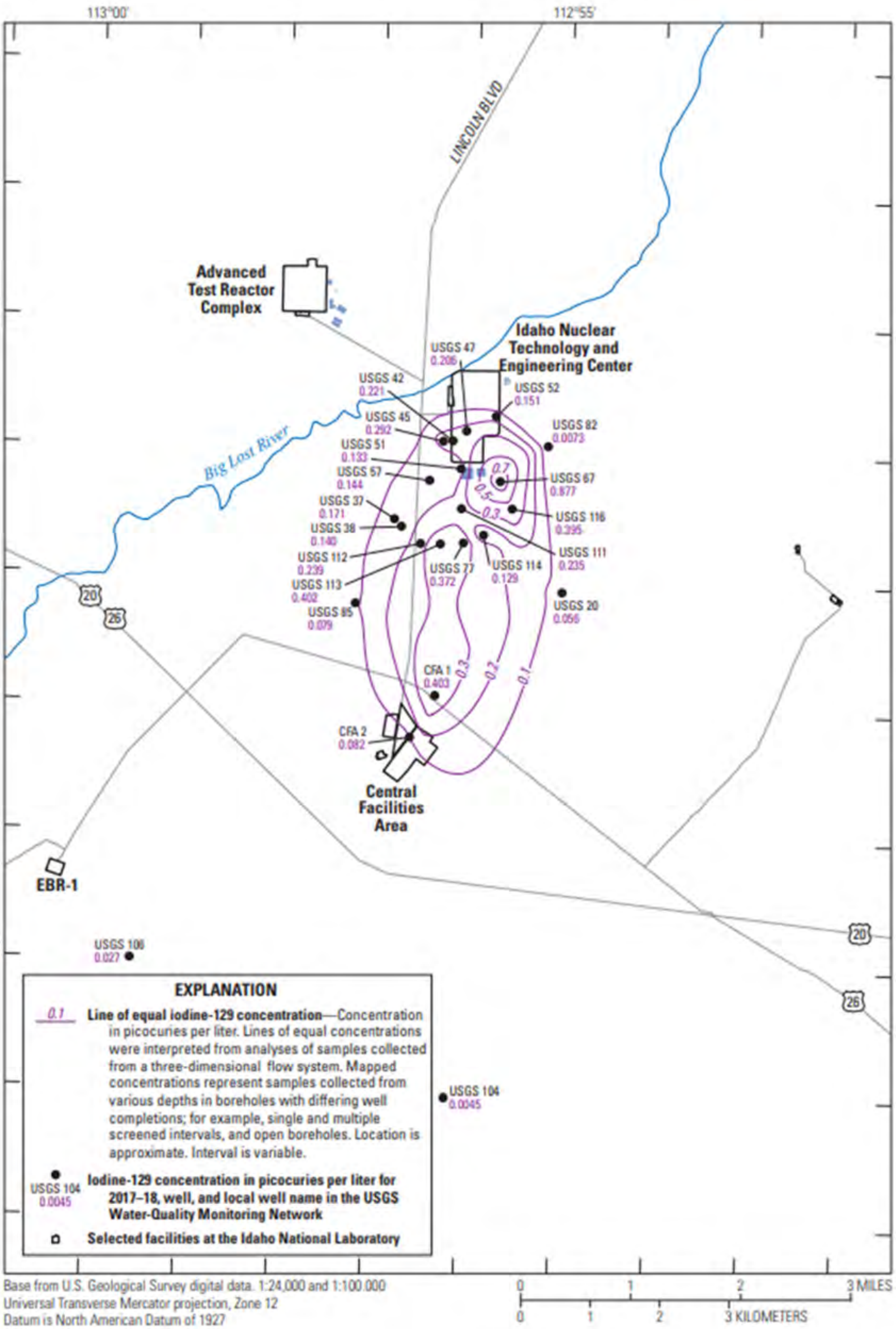


Figure 6-8. Distribution of ¹²⁹I in the eastern Snake River Plain Aquifer on the INL Site in 2017–2018 (from Maimer and Bartholomay 2019).

6.4 U.S. Geological Survey Non-radiological Groundwater Monitoring at the Idaho National Laboratory Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and selected other trace elements and purgeable organic compounds identified in Table 6-1. Bartholomay et al. (2020) provides a detailed discussion of results for samples collected during 2016–2018. Chromium had a concentration at the MCL of 100 µg/L in Well 65 in 2009 (Davis et al. 2013), but its concentration has been below the MCL since then and was 76.4 µg/L in 2021; this well has shown a long-term decreasing trend (Davis et al. 2015, Appendix D).

Concentrations of chloride, nitrate, sodium, and sulfate historically have been above background concentrations in many wells at the INL Site, but concentrations were below established MCLs or secondary MCLs in all wells during 2018 (Bartholomay et al. 2020).

VOCs are present in water from the eastern Snake River Plain Aquifer because of historical waste disposal practices at the INL Site. Products containing VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. The USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2021. Samples from 29 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al., 2003; Knobel et al. 2008; and Bartholomay et al. 2021). Eleven purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site identified in Table 6-5.

Historically, concentrations of VOCs in water samples from several wells at and near the RWMC exceeded the reporting levels (Bartholomay et al. 2020). However, concentrations for all VOCs except tetrachloromethane (also known as carbon tetrachloride) were less than the MCL for drinking water (40 CFR 141, Subpart G). The production well at the RWMC was monitored monthly for tetrachloromethane during 2021, and concentrations exceeded the MCL of 5 µg/L during 7 of the 11 months measured (no data results are available from October 2021) as shown in Table 6-6.

Concentrations have routinely exceeded the MCL for tetrachloromethane in drinking water (5 µg/L) at RWMC since 1998. (Note: VOCs are removed from production well water prior to human consumption—see Section 6.7.1.10.) Trend test results for tetrachloromethane concentrations in water from the RWMC production well indicated a statistically significant increase in concentrations has occurred from 1989 through 2015; however, Bartholomay et al. (2020) indicated that more recent data through 2018 showed no trend for the entire dataset and a decreasing trend for data collected since 2005. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

Concentrations of tetrachloromethane from USGS-87 and USGS-120, south of RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at USGS-88 (Davis et al. 2015; Bartholomay et al. 2020).

Trichloroethylene (trichloroethene) (TCE) exceeded the MCL of 5 µg/L from one sample collected from Well TAN-2336 at TAN identified in Table 6-5. There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1. The sample collected at a perched well at RWMC, USGS 92, also had a detection of TCE above the MCL.

Table 6-5. Purgeable organic compounds in annual USGS groundwater well samples (2021).

CONSTITUENT	TAN-2336	RWMC-M7S	TAN-2271	USGS-87	USGS-88	USGS-120	USGS-132
1,1-Dichloroethane (MCL = 7 µg/L)[a]	<0.5	<0.1	0.15	<0.1	<0.1	<0.1	<0.1
1,1,1-Trichloroethane (MCL = 200 µg/L)[a]	<0.5	0.280	<0.1	0.131	<0.1	0.106	<0.1
cis-1,2-Dichoroethene[b] (MCL = 70 µg/L)[a]	10.49	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ethylbenzene (MCL = 700 µg/L)[a]	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tetrachloroethene[b] (MCL = 5 µg/L)[a]	<0.5	0.330	<0.1	0.187	<0.1	<0.1	<0.1
Tetrachloromethane (PCS = 2 µg/L)[c]	1	4.09	<0.2	3.71	0.67	2.27	0.409
Trichloroethene[b] (MCL = 5 µg/L)[a]	18.74	2.39	<0.1	1.24	0.48	0.725	<0.1
Trichloromethane (MCL = 5 µg/L)[a]	<0.5	0.780	<0.1	0.364	0.45	0.534	<0.1
Toluene (MCL = 1,000 µg/L)[a]	1.32	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
trans-1,2-Dichloroethene[b] (MCL = 100 µg/L)[a]	22.65	<0.1	0.40	<0.1	<0.1	<0.1	<0.1
Vinyl chloride (MCL = 2 µg/L)[a]	2.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1,1-Dichloroethene (MCL = 7 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

a. MCL = maximum contaminant level from the EPA (40 CFR 141)

b. The International Union of Pure and Applied Chemistry (IUPAC) name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11.

Table 6-6. Purgeable organic compounds in monthly production well samples at the RWMC (2021).

CONSTITUENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1,1,1-Trichloroethane (MCL = 200 µg/L) [a]	0.273	0.264	0.272	0.254	0.270	0.248	0.243	0.225	0.24	ND[d]	0.261	0.232
Tetrachloroethene [b] (MCL = 5 µg/L) [a]	0.361	0.349	0.385	0.387	0.311	0.330	0.346	0.291	0.35	ND	0.337	0.296
Tetrachloromethane (MCL = 5 µg/L) [a]	4.99	4.57	5.16	5.02	5.33	5.23	5.27	4.58	5.05	ND	5.30	4.71
Trichloroethene [b] (MCL = 5 µg/L) [a]	3.24	3.49	3.45	3.54	3.37	3.06	2.93	2.97	3.30	ND	2.83	2.99
Trichloromethane (PCS = 2 µg/L) [c]	1.42	1.47	1.57	1.57	1.61	1.5	1.46	1.4	1.55	ND	1.51	1.61

a. MCL = maximum contaminant level values from the EPA (40 CFR 141)

b. The International Union of Pure and Applied Chemistry (IUPAC) name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11.

d. ND = No data are available for the RWMC Production well for October 2021.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2021

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown in Figure 6-3. The following subsections provide an overview of the groundwater sampling results. More detailed discussions of CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at ARIR Home - ARIR (idaho-environmental.com). WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.5.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 (TAN) to evaluate the progress of the remedial action at TAN. The VOC groundwater plume at TAN has been divided into three zones based on the 1997 TCE concentrations with three different remedy components, which work together to remediate the entire VOC plume. The monitoring program and results are summarized by plume zone in the following paragraphs.

Hot Spot Zone (historical TCE concentrations exceeding 20,000 µg/L) – In-situ bioremediation (ISB) was used in the hot spot (near Well TSF-05) to create conditions favorable for naturally occurring anaerobic bacteria in the aquifer to break down chlorinated solvents (principally TCE). The hot spot concentration was defined using TCE data from 1997 identified in Figure 6-9 and is not reflective of current concentrations as shown in Figure 6-10. With regulatory agency concurrence, an ISB rebound test began in July 2012 to determine if the residual TCE source in the aquifer had been sufficiently treated. Currently, the ISB rebound test has been split into two components: (1) an ISB rebound test for the area near the former injection Well TSF-05, and (2) ISB activities to treat the TCE source affecting Well TAN-28.

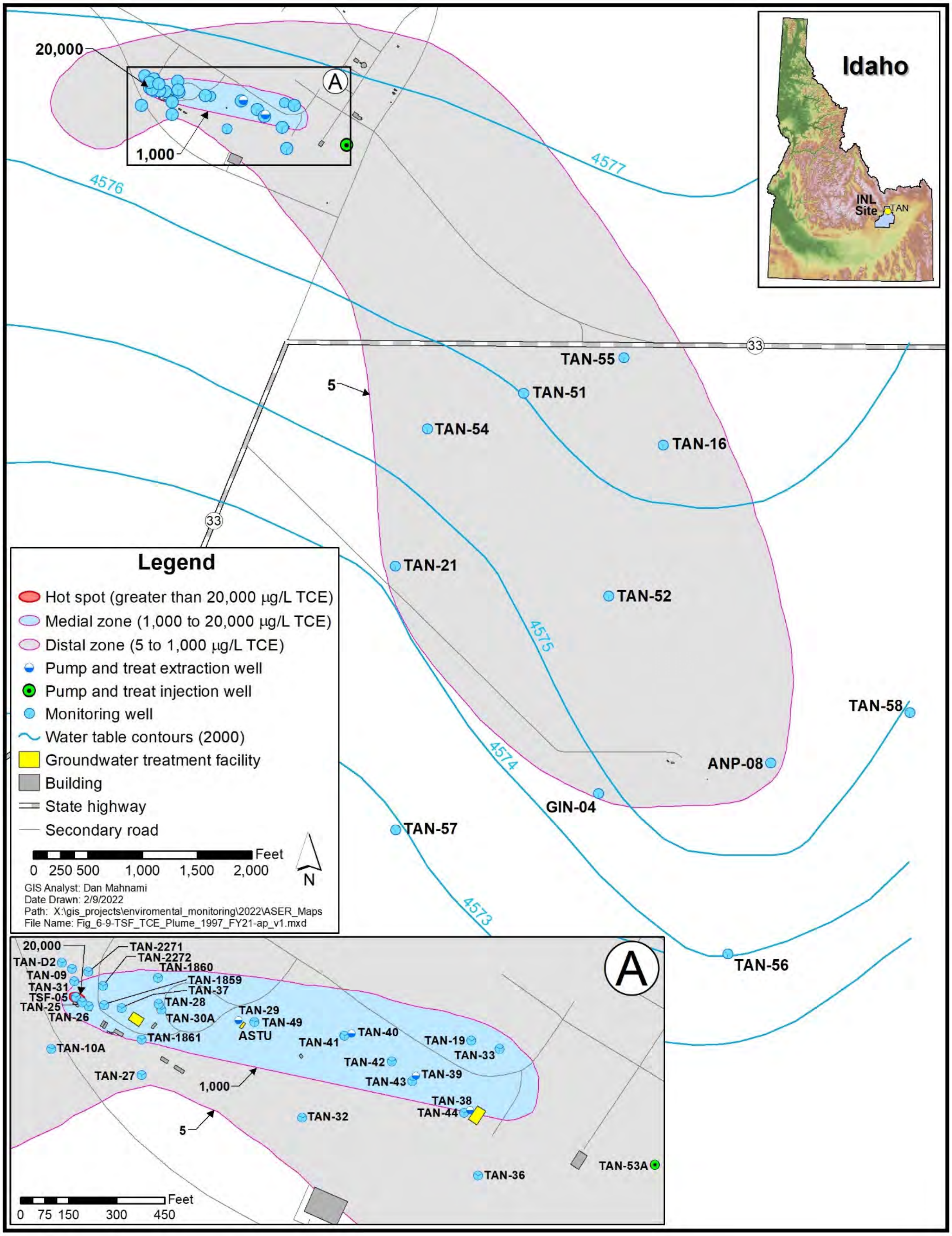


Figure 6-9. TCE plume at TAN in 1997.

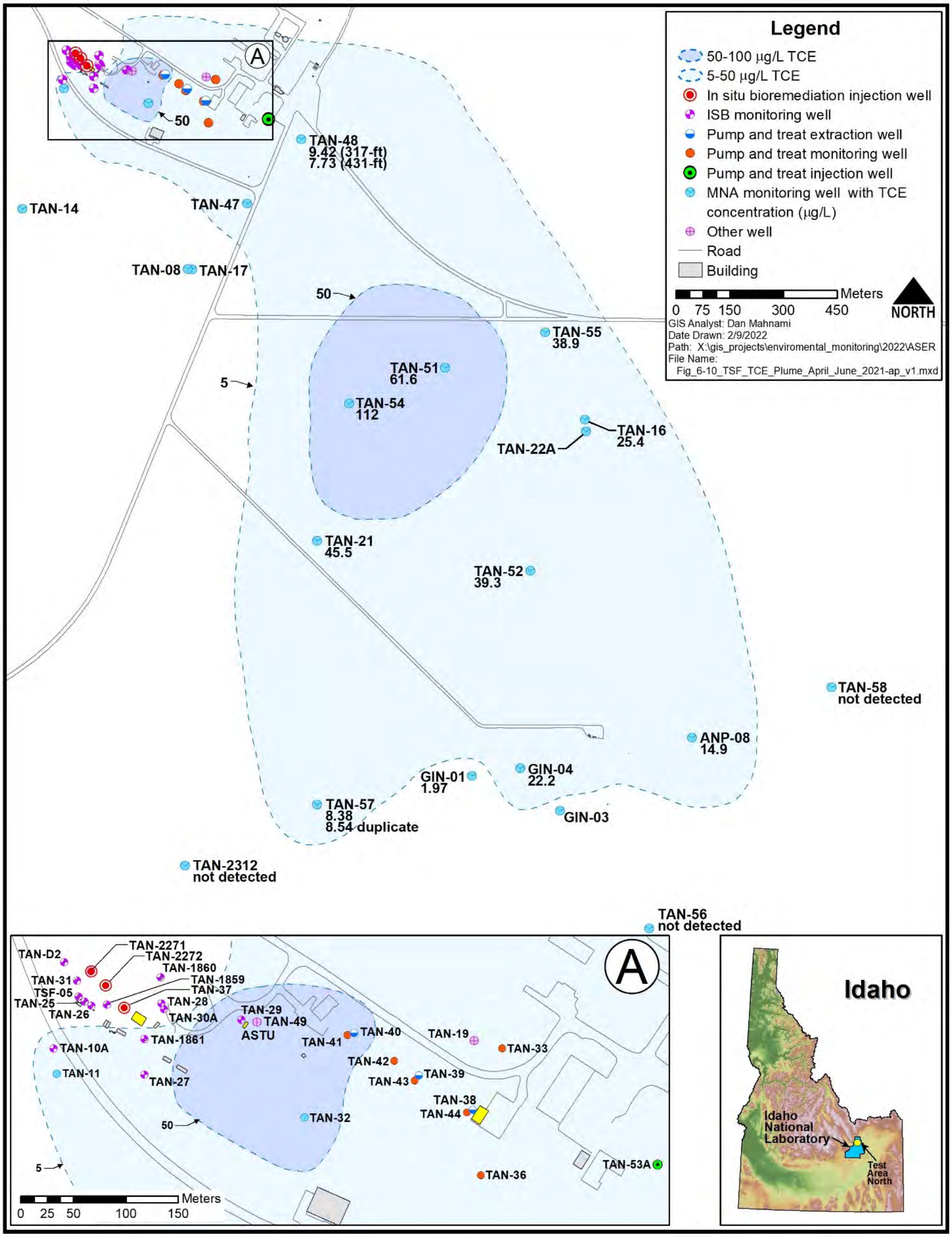


Figure 6-10. Distribution of TCE in the Snake River Plain Aquifer from April–June 2021.

In 2021, data collected during the ISB rebound test for the area near the former injection Well TSF-05 indicated that anaerobic conditions created by ISB were still present in the hot spot area, and that TCE concentrations were near or below MCLs in the wells near the former injection Well TSF-05 as shown in Figure 6-10. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2022a).

To address the source of TCE in well TAN-28, a new well, TAN-2336, was completed in July 2021 near the suspected TAN-28 TCE source. Four ISB injections were made in 2021 with two injections into both TAN-1860A and TAN-2336. TCE concentrations have declined in both TAN-28 and TAN-1860A as a result of the ISB injections to treat the TAN-28 TCE source. ISB injections will continue into the above wells until it can be determined that the TAN-28 TCE source has been successfully treated and a transition to a rebound test for the TAN-28 TCE source can be made.

Medial Zone (historical TCE concentrations between 1,000 and 20,000 µg/L) – A pump and treat system has been used in the medial zone. The pump and treat system extracts contaminated groundwater, circulates the groundwater through air strippers to remove VOCs like TCE, and reinjects treated groundwater into the aquifer. The New Pump and Treat Facility was generally operated Monday–Thursday in 2021, except for shutdowns due to maintenance. All 2021 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone (1,000–20,000 µg/L) are based on data collected in 1997, before remedial actions started shown in Figure 6-9, and do not reflect current concentrations as identified in Figure 6-10. In 2021, no wells were above the concentration 1,000 µg/L used historically to define the medial zone. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 near the New Pump and Treat Facility are used as indicators of TCE concentrations migrating past the New Pump and Treat Facility extraction wells into the distal zone. In 2021, TCE concentrations for Wells TAN-33, TAN-36, and TAN-44 ranged from 14.1 to 45.0 µg/L.

Distal Zone (historical TCE concentrations between 5 and 1,000 µg/L) – Monitored natural attenuation is the remedial action for the distal zone of the plume (Figure 6-9). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Institutional controls are in place to protect current and future users from health risks associated with groundwater contamination until concentrations decline through natural attenuation to below the MCL.

TCE data collected in 2021 from the distal zone wells indicate that all wells are consistent with the model predictions, but additional data are needed to confirm that the monitored natural attenuation part of the remedy will meet the remedial action objective of all wells below the MCL by 2095. The TCE data from the plume expansion wells suggest that plume expansion is currently within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

Radionuclide Monitoring – In addition to the VOC plume, ^{90}Sr, ^{137}Cs, tritium, and uranium-234 (^{234}U) are listed as contaminants of concern in the Record of Decision Amendment (DOE-ID 2001). Strontium-90 and ^{137}Cs are expected to naturally decline below their respective MCLs before 2095. However, wells in the source/ISB area currently show elevated ^{90}Sr and ^{137}Cs concentrations compared to levels prior to starting ISB. The elevated ^{90}Sr and ^{137}Cs concentrations are due to enhanced mobility created by elevated concentrations of competing cations (calcium, magnesium, sodium, and potassium) for adsorption sites in the aquifer. The elevated cation concentrations are due to ISB activities to treat VOCs. As competing cation concentrations decline toward background conditions, ^{90}Sr and ^{137}Cs are trending lower. The radionuclide concentrations are expected to continue to decrease, and concentration trends will continue to be evaluated to determine if the remedial action objective of declining below MCLs by 2095 will be met. All 2021 results for tritium are below the MCL of 20,000 pCi/L with the highest tritium result of 1,570 pCi/L at Well TAN-28. Sampling will be conducted for ^{234}U after ISB conditions dissipate because ISB conditions suppress uranium concentrations.

6.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for monitoring WAG 2, ATR Complex, during 2021 shown in Figure 6-11. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (e.g., the target analyte is cobalt-60), tritium, and chromium (filtered), in accordance with the groundwater monitoring plan (DOE-ID 2016). The data for the October 2021 sampling event will be included in the Fiscal Year 2022 Annual Report for WAG 2 (DOE-ID 2022b). The October 2021 sampling data are summarized in Table 6-7.

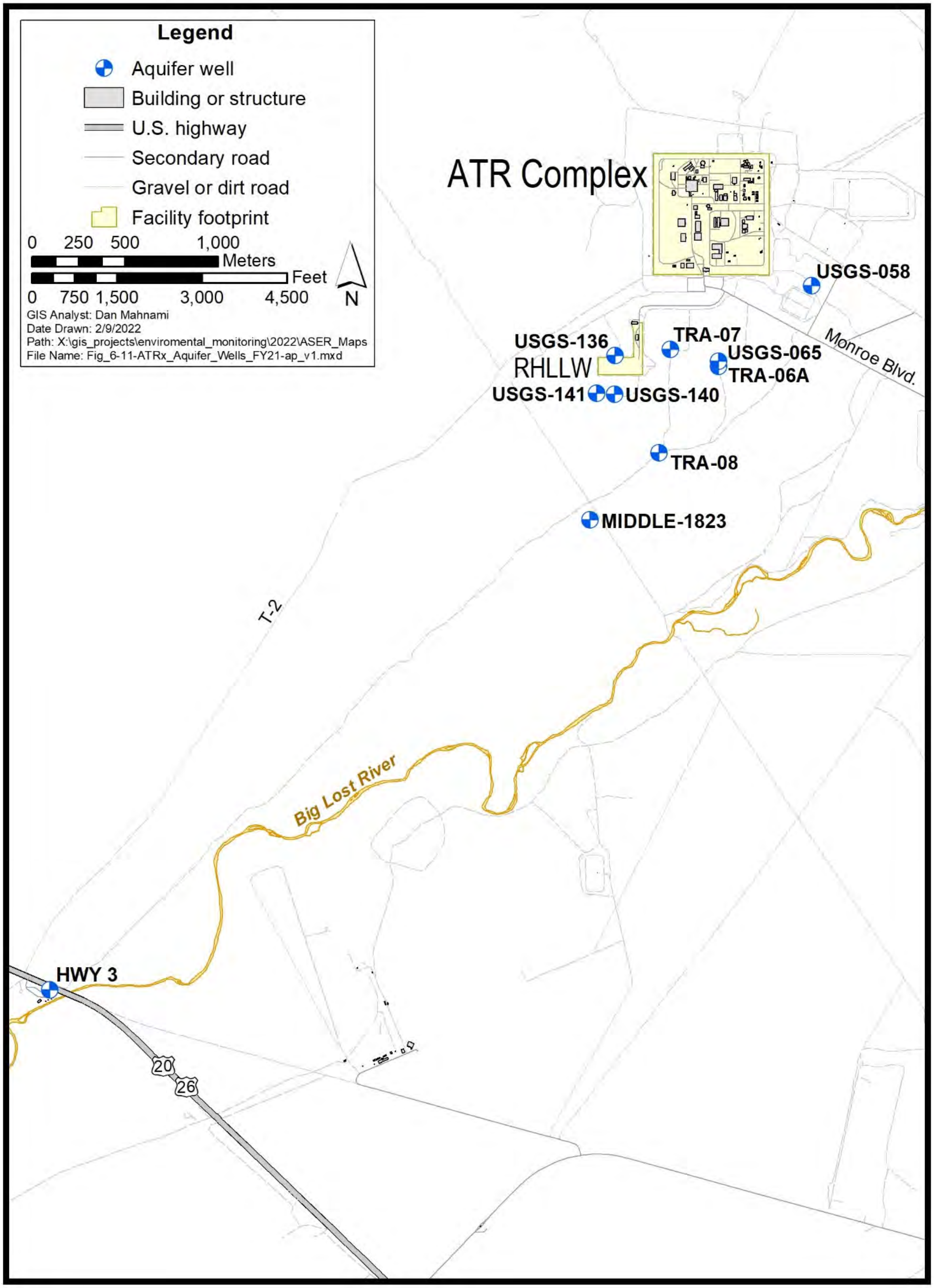


Figure 6-11. Locations of WAG 2 aquifer monitoring wells.

Table 6-7. WAG 2 aquifer groundwater quality summary (October 2021).

ANALYTE	MCL[a]	BACKGROUND[b]	MAXIMUM	MINIMUM	NUMBER OF WELLS ABOVE MCL
Chromium (filtered) (µg/L)	100	4	78.6	2.11	0
Cobalt-60 (pCi/L)	100	0	ND[c]	ND	0
Strontium-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	34	3,460	ND	0

a. MCL = maximum contaminant level.
b. Background concentrations are for western tributary water for the eastern Snake River Plain Aquifer from Bartholomay and Hall (2016).
c. ND = not detected.

No analyte occurred above its MCL in the Snake River Plain Aquifer at WAG 2. The highest chromium concentration occurred in Well TRA-07 at 78.6 µg/L and was below the MCL of 100 µg/L. The second highest chromium concentration was in Well USGS-065 at 77.2 µg/L. Compared to the previous year, the chromium concentrations decreased in both TRA-07 and USGS-065 and both wells are in long-term declining trends.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all sampled wells. The highest tritium concentration was 3,460 pCi/L in Well TRA-07.

Chromium and tritium concentrations in the aquifer have declined faster than predicted by the WAG 2 models used for the Operable Unit 2-12 Record of Decision and the revised modeling performed after the first five-year review (DOE-NE-ID 2005).

The October 2020 eastern Snake River Plain Aquifer water table map prepared for the vicinity of the ATR Complex was consistent with previous maps showing general groundwater flow direction to the southwest. Water levels in the vicinity of the ATR Complex declined by approximately 1.02 ft on average from October 2020 to October 2021.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 17 eastern Snake River Plain Aquifer monitoring wells during 2021 shown in Figure 6-12. Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2021 Annual Report (DOE-ID 2022c). Table 6-8 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, Technetium-99 (^{99}Tc), ^{129}I, and nitrates exceeded their respective drinking water MCLs in one or more of the eastern Snake River Plain Aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remained above the MCL (8 pCi/L) at five of the well locations sampled. During 2021, the highest ^{90}Sr level in eastern Snake River Plain Aquifer groundwater was at monitoring Well USGS-047 (16.4 ± 1.41 pCi/L), located south (down-gradient) of the former INTEC injection well. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events apart from ICPP-2021 (15.3 pCi/L) and USGS-048 (12.9 pCi/L). During the reporting period, both wells reported an elevated range of activity similar to their activity reported in 2013 (i.e., 14.5 pCi/L and 14.3 pCi/L, respectively).

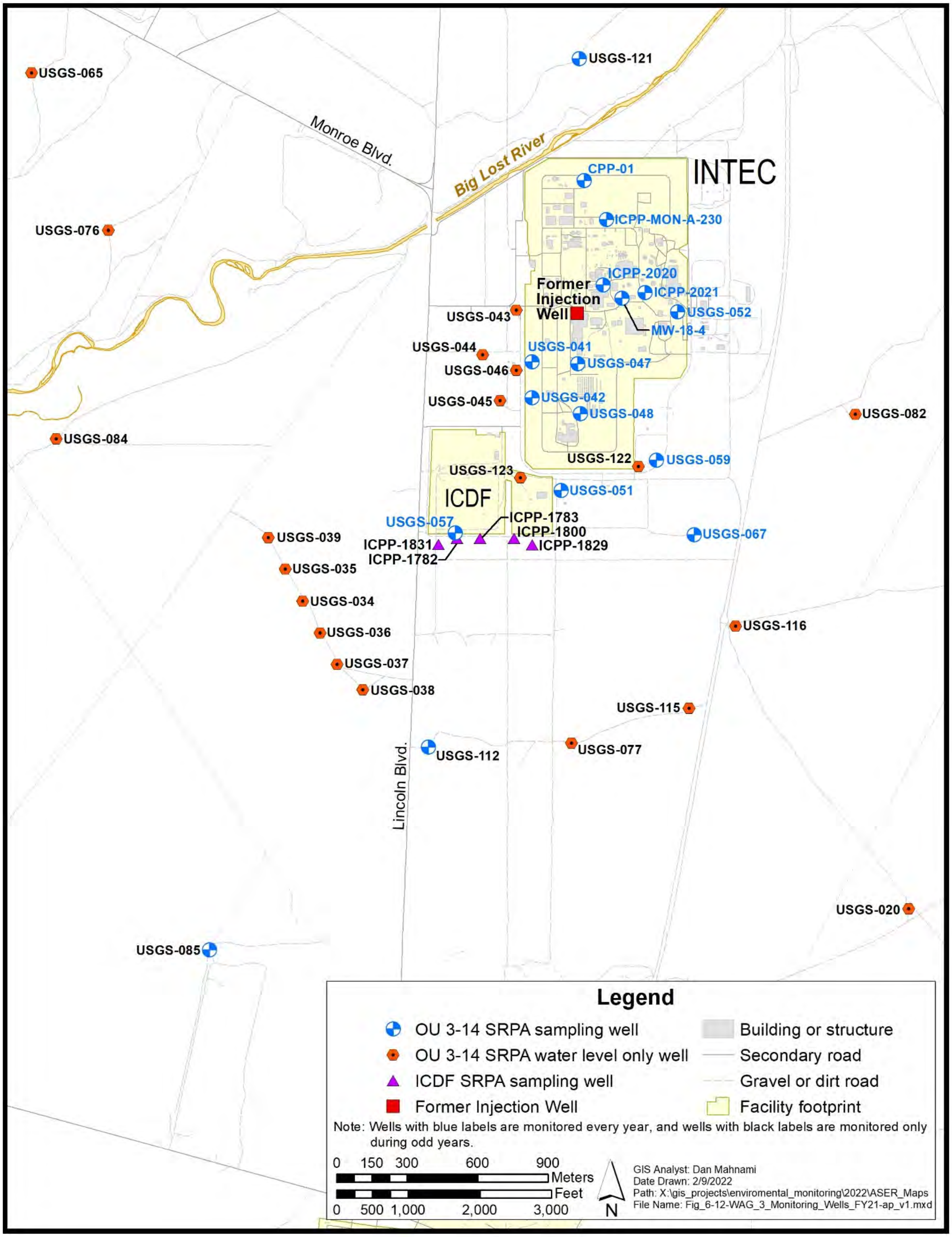


Figure 6-12. Locations of WAG 3 monitoring wells.

Table 6-8. Summary of constituents detected in WAG 3 aquifer monitoring wells (fiscal year [FY] 2021).

CONSTITUENT	EPA MCL[a]	UNITS	SNAKE RIVER PLAIN AQUIFER GROUNDWATER – APRIL 2021		
			MAXIMUM REPORTED VALUE	NUMBER OF RESULTS[b]	RESULTS >MCL[b]
Gross alpha	15	pCi/L	3.8 ± 1.3	19	0
Gross beta	NA[c]	pCi/L	573 ± 11.5	19	NA[c]
Cesium-137	200	pCi/L	ND[d]	19	0
Strontium-90	8	pCi/L	**16.4 ± 1.41[e]**	19	7
Technetium-99	900	pCi/L	**1,750 ± 101**	19	2
Iodine-129	1	pCi/L	**1.03 ± 0.139 J[d]**	19	1
Tritium	20,000	pCi/L	2,030 ± 248	19	0
Plutonium-238	15	pCi/L	–[f]	–[f]	–[f]
Plutonium-239/240	15	pCi/L	–[f]	–[f]	–[f]
Uranium-233/234	NA MCL[g]	pCi/L	2.17 ± 0.343	19	NA
Uranium-235	NA MCL	pCi/L	ND	19	NA
Uranium-238	NA MCL	pCi/L	1.01 ± 0.194	19	NA
Bicarbonate	NA	mg/L	159	19	NA
Calcium	NA	mg/L	68.1	19	NA
Chloride	250	mg/L	130 J	19	0
Magnesium	NA	mg/L	23.6 NJ[d]	19	NA
Nitrate/Nitrite (as N)	10	mg/L	**12.9 J[d,e]**	19	1
Potassium	NA	mg/L	4.83	19	NA
Sodium	NA	mg/L	31.4	19	NA
Sulfate	250	mg/L	41.3	19	0
Total dissolved solids	500	mg/L	443	19	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level.

b. Include field duplicates.

c. NA = not applicable.

d. Data-qualifier flags:
ND = constituent not detected in sample.
J = estimated detection.

e. NJ = matrix spike sample recovery is not within specified control limits; estimated value
Bold values exceed MCL.

f. – = Gross alpha did not exceed 15 pCi/L; constituent not analyzed.

g. NA MCL = Not applicable because values are reported in pCi/L. EPA MCL is reported in mass units (µg/L).

Technetium-99 was detected above the MCL (900 pCi/L) at two monitoring wells. During 2021, the highest ^{99}Tc level in eastern Snake River Plain Aquifer groundwater was at Well ICPP-MON-A-230 (1,750 ± 101 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (12.9 mg/L as N). This was the only location where the nitrate concentration exceeded the MCL (10 mg/L as N). This well is located relatively close to the Tank Farm and shows groundwater quality impacts attributed to past releases of Tank Farm liquid waste. Nitrate concentrations were similar or slightly lower than observed in previous years.

Iodine-129 concentrations were below drinking water MCLs (1 pCi/L) at all Snake River Plain Aquifer monitoring locations, with the exception of Well USGS-067, which is located east of INTEC's former percolation ponds, which received service wastewater until 2002. Iodine-129 was detected at four locations, with the highest detection at Well USGS-067 (1.03 ± 0.139 pCi/L). The detected ^{129}I activities at USGS-067 that have approached and exceeded the MCL have large uncertainties that overlap making all the values near the MCL essentially equivalent and potentially below the MCL.

Tritium was detected at most of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well USGS-051, southeast of INTEC (2,030 ± 248 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotope analyses were performed because the current monitoring plan identifies the contingency for plutonium analysis if gross alpha exceeds 15 pCi/L. Uranium-238 (^{238}U) was detected at all eastern Snake River Plain Aquifer well locations, with the highest concentration at Well USGS-051 (1.01 ± 0.194 pCi/L). Uranium-234 was also detected in all groundwater samples, with the greatest concentrations of 2.17 ± 0.343 pCi/L at Well ICPP-MON-A-230. Uranium-234 is the daughter product (from alpha decay) of the long-lived, naturally occurring ^{238}U. All uranium results for the other wells are consistent with background concentrations reported for Snake River Plain Aquifer groundwater. Ratios of ^{234}U/^{238}U were similar to background ^{234}U/^{238}U activity ratios of 1.5 to 3.1 reported for the eastern Snake River Plain Aquifer.

Uranium-235 (^{235}U) was not detected at any monitoring wells. An evaluation of uranium in groundwater near RWMC indicates that eastern Snake River Plain Aquifer background ^{235}U activities are generally less than 0.15 pCi/L (95% upper tolerance limit).

6.5.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

The WAG 4 groundwater monitoring consists of two different components: (1) CFA landfill monitoring, and (2) monitoring of a nitrate plume south of CFA. The wells at the CFA landfills are monitored to determine potential impacts from the landfills, while the nitrate plume south of CFA is monitored to evaluate nitrate trends. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, and sulfate) and two wells for VOCs only, in accordance with the long-term monitoring plan (DOE-ID 2018). Four wells south of CFA were sampled for nitrate, sulfate, and chloride to monitor the CFA nitrate plume. The CFA landfill and nitrate plume monitoring well locations are shown on Figure 6-13.

Analytes detected in groundwater are compared to regulatory levels identified in Table 6-9. In 2021, iron exceeded an EPA secondary maximum containment level (SMCL) within two CFA landfill wells and three wells exceeded a pH SMCL. The elevated iron concentrations probably result from the interaction of the acid preservative in the sample bottle with particles that passed through the groundwater filter. The elevated pH in the three wells was due to grout placed beneath the well screens during well construction. A complete list of the groundwater sampling results will be included in the Fiscal Year 2021 Annual Report for WAG 4 (DOE-ID 2022d).

In the CFA nitrate plume monitoring wells south of CFA, one well, CFA-MON-A-002, continued to exceed the nitrate groundwater MCL of 10 mg/L-N. The nitrate concentration in Well CFA-MON-A-002 increased from 13.2 mg/L-N in 2020 to 14.5 mg/L-N in 2021, but the concentration is still consistent with a declining trend starting in 2006.

The nitrate concentration of 7.90 mg/L-N in Well CFA-MON-A-003 is below the MCL, and, despite an increase from FY 2020 to FY 2021, shows a declining trend.

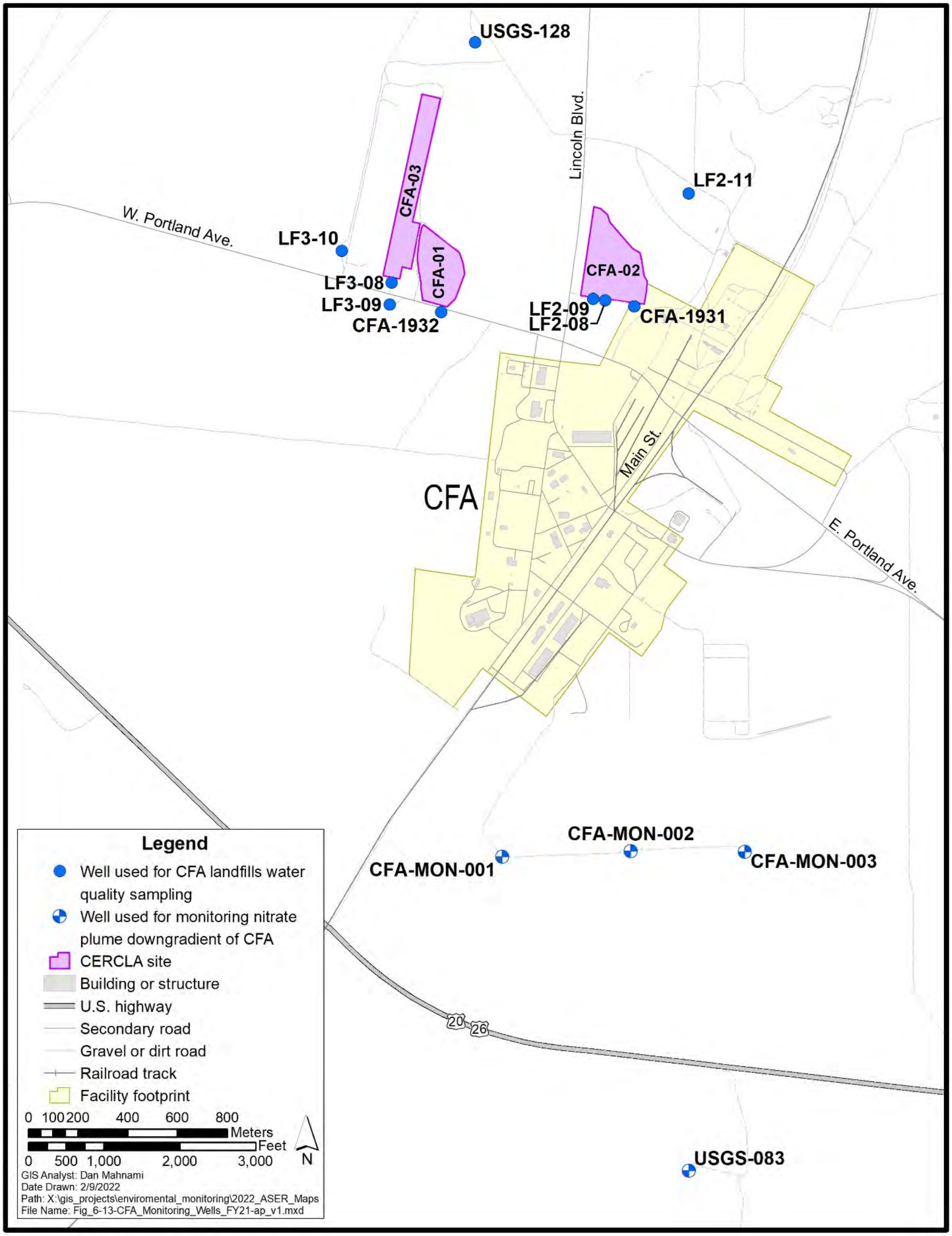


Figure 6-13. Locations of WAG 4/CFA monitoring wells.

Table 6-9. Comparison of WAG 4 groundwater sampling results to regulatory levels (August 2021).

COMPOUND	MCL[a] OR SMCL[b]	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
DOWNGRADIENT CENTRAL FACILITIES AREA WELLS			
Chloride (mg/L)	*250*[c]	73.0	0
Sulfate (mg/L)	*250*	32.9	0
Nitrate/nitrite (mg-N/L)	10	**14.5**[d]	1
CENTRAL FACILITIES AREA LANDFILL WELLS			
ANIONS			
Chloride (mg/L)	*250*	54.5	0
Sulfate (mg/L)	*250*	39.8	0
Nitrate/nitrite (mg-N/L)	10	2.43	0
COMMON CATIONS			
Calcium (µg/L)	None	48,200	NA[e]
Magnesium (µg/L)	None	20,200	NA
Potassium (µg/L)	None	5,510	NA
Sodium (µg/L)	None	28,900	NA
INORGANIC ANALYTES			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	166	0
Arsenic (µg/L)	10	2.64	0
Barium (µg/L)	2,000	96.6	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	67.6	0
Copper (µg/L)	*1,300/1,000*	5.04	0
Iron (µg/L)	*300*	**2,090**	2
Lead (µg/L)	15	3.02	0
Manganese (µg/L)	50	22.5	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	59.5	NA
Selenium (µg/L)	50	ND	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0

Table 6-9. continued.

COMPOUND	MCL[a] OR SMCL[b]	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
Vanadium (µg/L)	None	6.20	NA
Zinc (µg/L)	*5,000*	881	0
DETECTED VOLATILE ORGANIC COMPOUNDS			
Chloroform (µg/L)	80	0.90	0

a. MCL = maximum contaminant level.
b. SMCL = secondary maximum contaminant level.
c. Numbers in *italic* text are for the secondary MCL.
d. **Bold** values exceed an MCL or SMCL.
e. NA = not applicable.
f. ND = not detected.

Water level measurements taken in the CFA area decreased an average of 0.75 ft from August 2020 to August 2021. A water level contour map based on August 2021 water levels showed groundwater gradients and flow directions consistent with previous maps (DOE-ID 2021c).

6.5.5 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from nine monitoring wells near the RWMC in April/May 2021 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 256, 15 met reportable criteria established in the *Field Sampling Plan for Operable Unit 7-13/14 Aquifer Monitoring* (DOE-ID 2021d). Table 6-10 lists maximum concentrations of reportable contaminants of concern in 2021, and a discussion of those results follows. No analytes were detected above their respective MCLs in samples collected from the aquifer in April/May 2021. Figure 6-14 depicts the WAG 7 aquifer well monitoring network.

- ***Carbon tetrachloride*** – Carbon tetrachloride was detected above the quantitation limit (1 µg/L) at seven monitoring locations in April/May 2021. The carbon tetrachloride concentrations decreased or remained stable in most wells near and downgradient of the RWMC, except for Well M7S, which increased slightly from the 2020 concentration, as shown in Figures 6-15 and 6-16.

Table 6-10. Summary of WAG 7 aquifer analyses for April/May 2021 sampling.

ANALYTE	NUMBER OF WELLS SAMPLED	NUMBER OF SAMPLES ANALYZED[a]	NUMBER OF REPORTABLE DETECTIONS[a,b]	CONCENTRATION MAXIMUM[a]	LOCATION OF MAXIMUM CONCENTRATION	NUMBER OF DETECTIONS GREATER THAN MCL[c]	MCL[c]
Carbon tetrachloride	9	11	7	4.27 µg/L	M15S	0	5 µg/L
Trichloroethylene	9	11	4	2.97 µg/L	M15S	0	5 µg/L
Nitrate (as nitrogen)	9	11	4	2.02 mg/L	M6S	0	10 mg/L

a. Includes field duplicate samples collected for quality control purposes and samples collected from wells with multiple ports.
b. Results that exceeded reporting criteria as established in the Operable Unit 7-13/14 Field Sampling Plan (DOE-ID 2021d).
c. MCL = maximum contaminant level. MCLs are from “National Primary Drinking Water Regulations” (40 CFR 141).

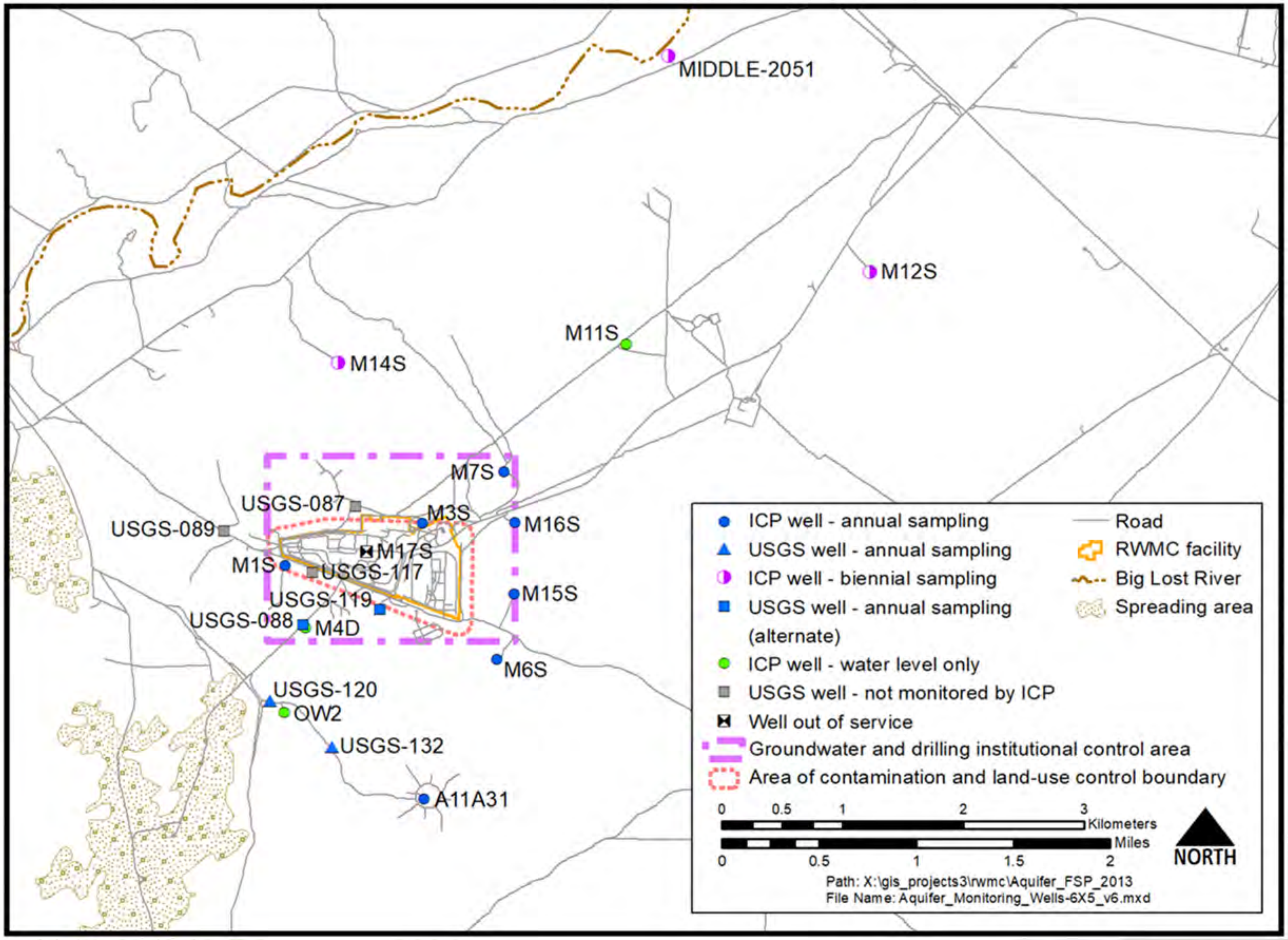


Figure 6-14. The WAG 7 aquifer well monitoring network at the RWMC (DOE-ID 2021d).

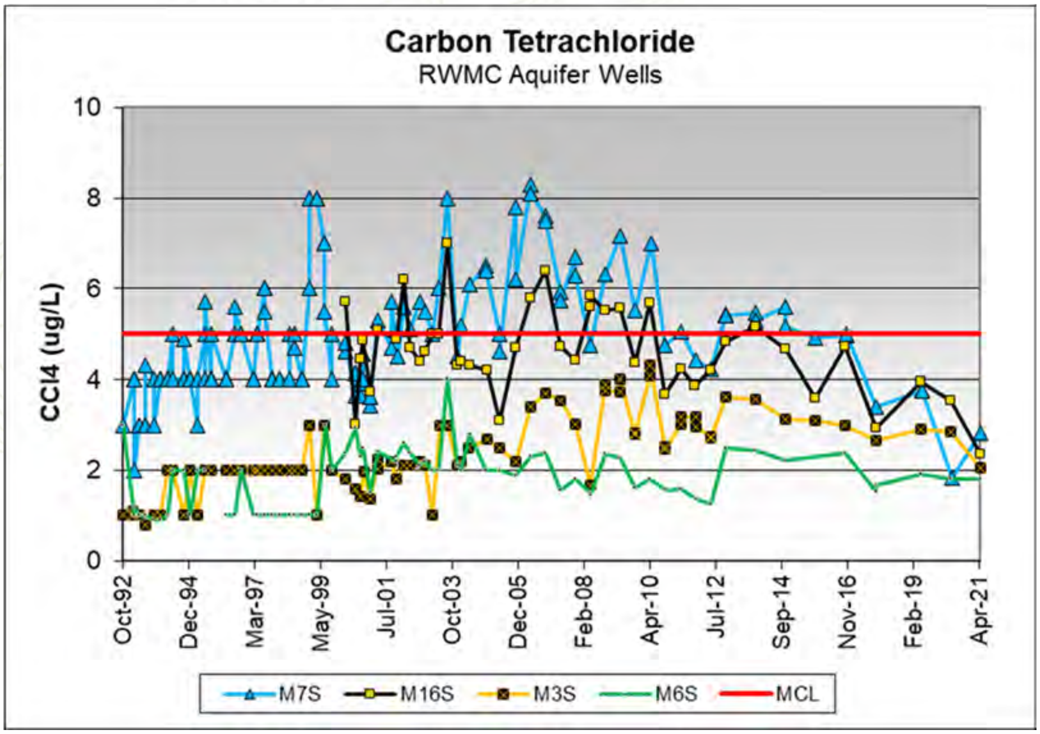


Figure 6-15. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells M7S, M16S, M3S, and M6S.

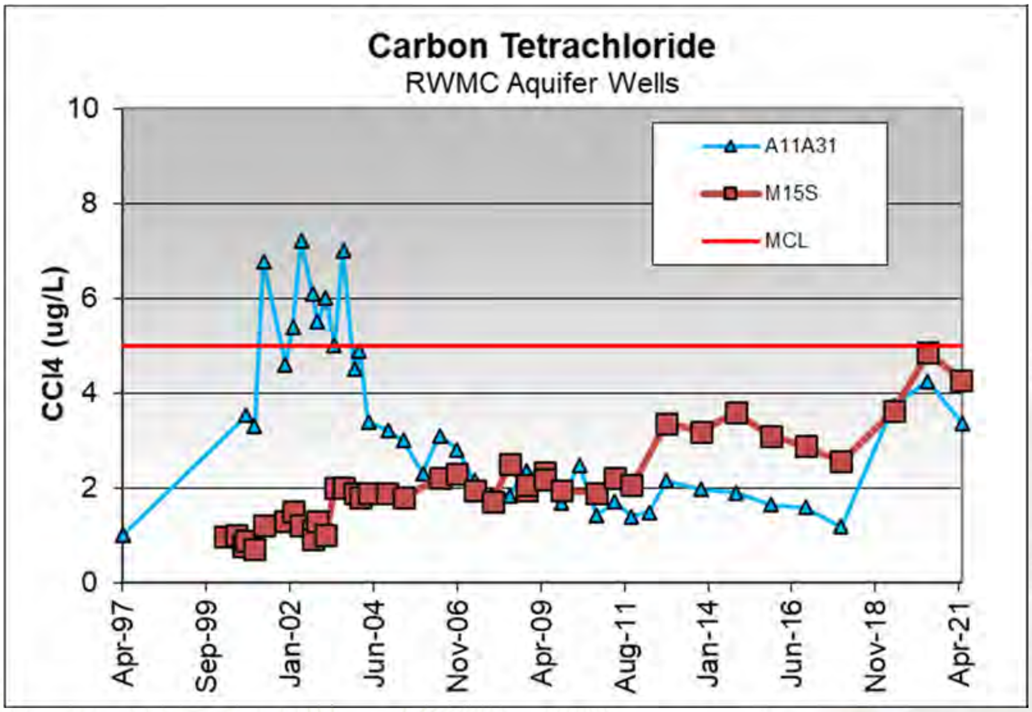


Figure 6-16. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells A11A31 and M15S.

- ***Trichloroethylene*** – In April/May 2021, the concentrations of reportable trichloroethylene (>1 µg/L) either decreased or remained steady in most wells near and downgradient of the RWMC shown in Figure 6-17, except for Well M7S, which exhibited a slight increase from 2020. However, no concentrations were detected above the MCL of 5 µg/L.
- ***Radiological analytes*** – Radiological analytes were not detected above reporting thresholds in groundwater samples collected from the WAG 7 monitoring network in 2021.
- ***Inorganic analytes*** – Nitrate (as nitrogen) was the only inorganic analyte detected above its reporting threshold (background concentration of 1.05 mg/L) in 2021, which was calculated based on maximum concentrations in upgradient background wells (DOE-ID 2021d).

As in previous years, groundwater level measurements in RWMC-area monitoring wells were taken prior to sample collection for the April/May 2021 event. These measurements indicate groundwater flow toward the south beneath RWMC as shown in Figure 6-18.

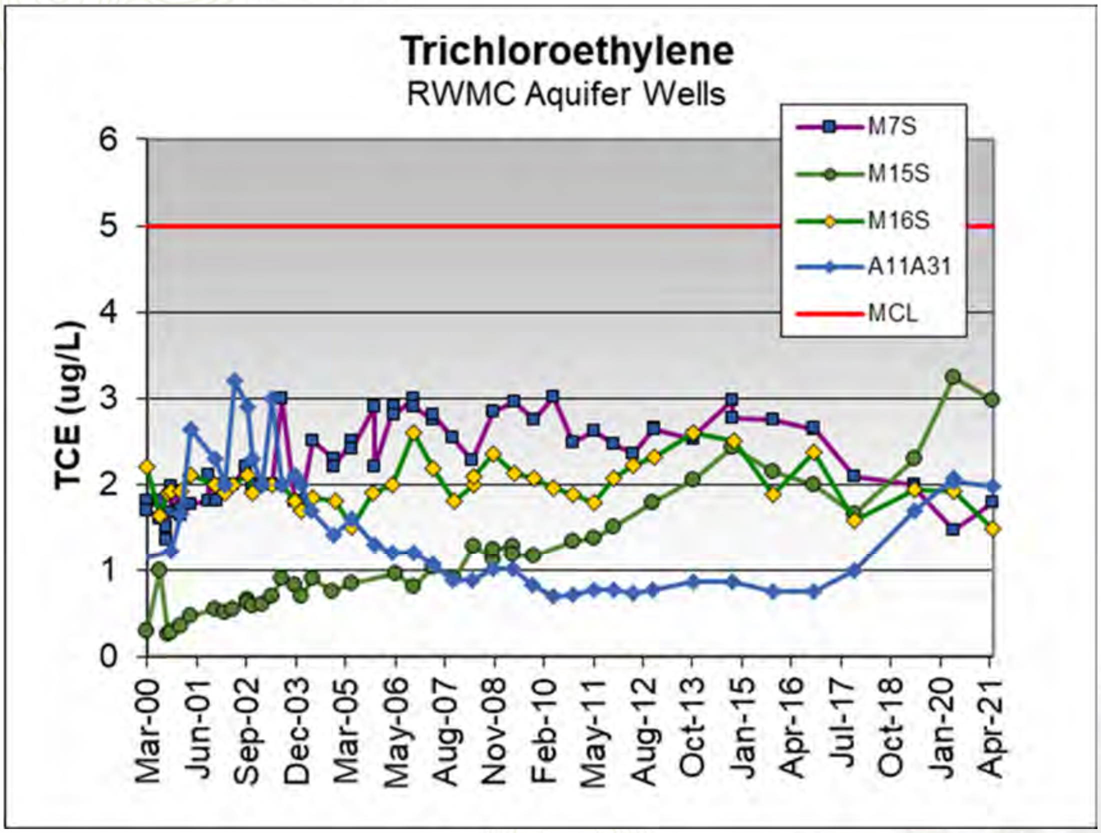


Figure 6-17. Concentration history of TCE in aquifer Wells M7S, M15S, M16S, and A11A31.

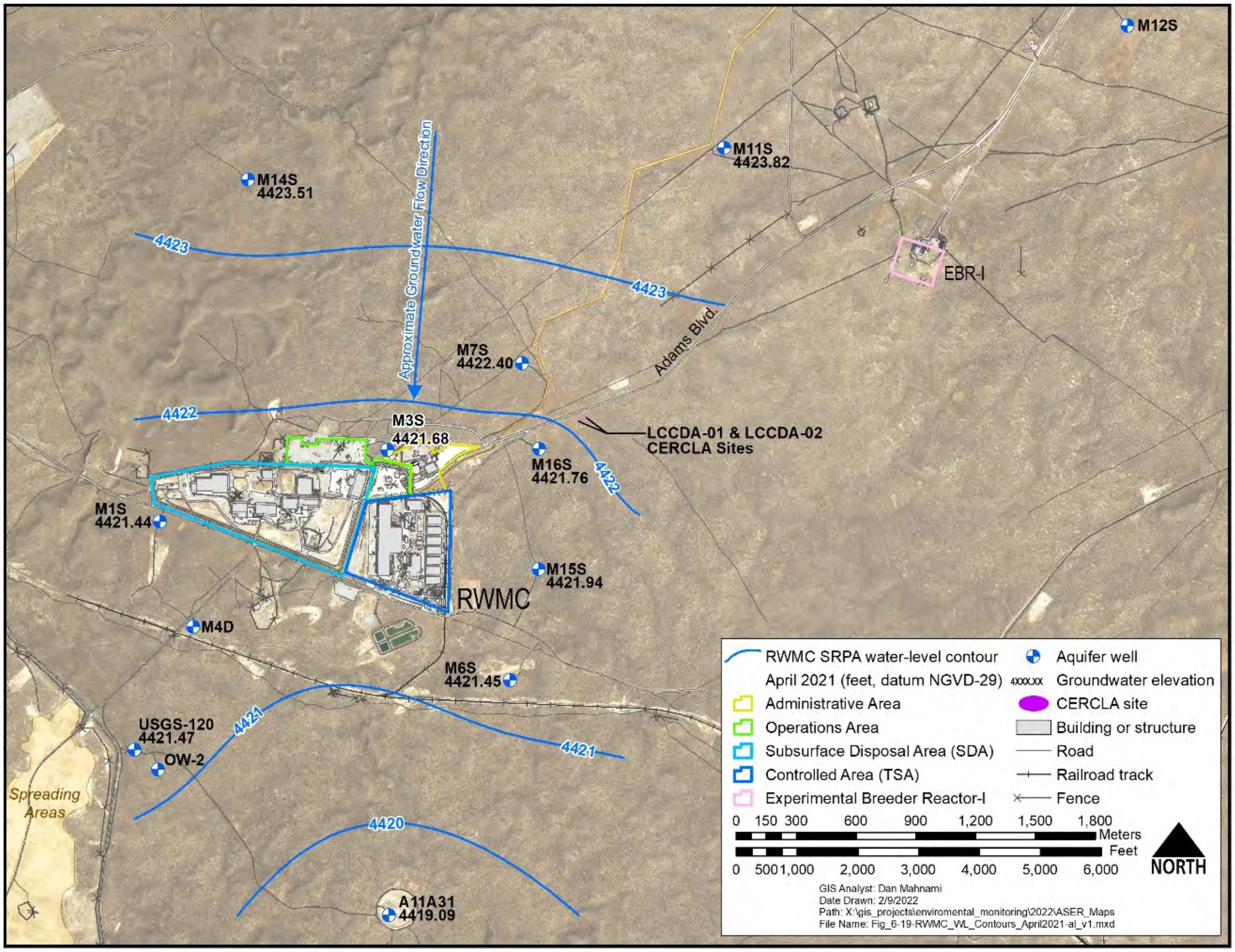


Figure 6-18. Groundwater-level contours in the aquifer near the RWMC, based on 2021 measurements.

6.5.6 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the MFC are sampled twice per year by the INL contractor for selected radionuclides, metals, anions, cations, and other water quality parameters, as surveillance monitoring under the WAG 9 Record of Decision (Figure 6-19; ANL-W 1998). The 2021 results are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

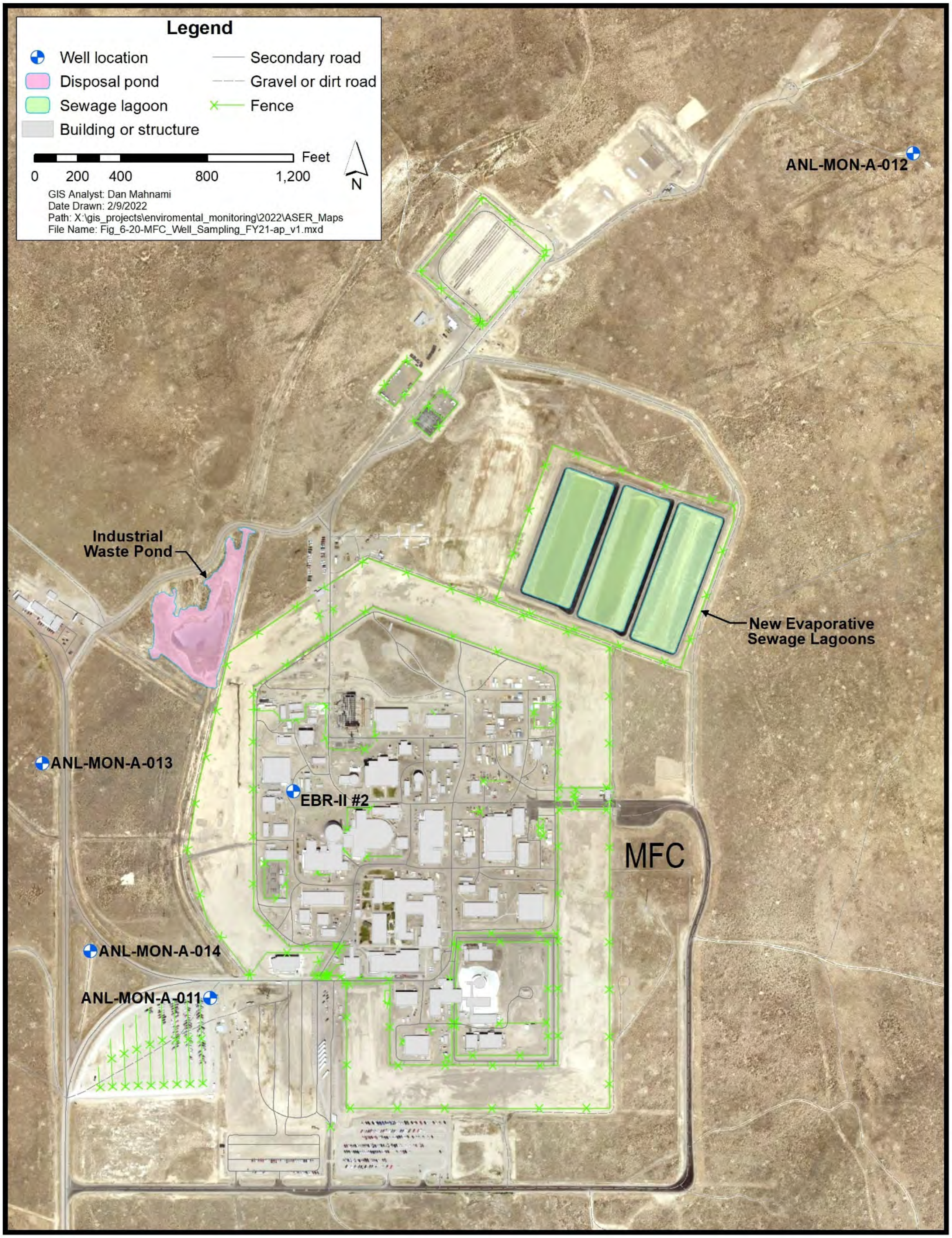


Figure 6-19. Locations of WAG 9 wells sampled in 2021.

Table 6-11. Comparisons of detected analytes to groundwater standards at WAG 9 monitoring wells (2021).

WELL:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] NO. 2		PCS/SCS[b]
SAMPLE DATE:	4/26/2021	9/30/2021	4/20/2021	10/7/2021[c]	4/21/2021	9/29/2021	4/21/2021	9/29/2021	4/26/2021	9/30/2021	
RADIONUCLIDES[d]											
Gross alpha (pCi/L)	1.07 ± 0.297	1.76 ± 0.457	ND[e]	1.58 ± 0.317	ND	ND	ND (ND)	ND	ND	ND	15 pCi/L
Gross beta (pCi/L)	3.67 ± 0.270	2.97 ± 0.402	3.86 ± 0.360	2.78 ± 0.249	2.64 ± 0.236	3.47 ± 0.453	5.02 ± 0.245 (2.18 ± 0.181)[f]	2.09 ± 0.334	2.25 ± 0.183	1.19 ± 0.312	4 mrem/yr[g]
Uranium-233/234 (pCi/L)	1.30 ± 0.138	1.18 ± 0.163	1.44 ± 0.146	1.26 ± 0.164	1.31 ± 0.129	1.48 ± 0.202	1.30 ± 0.134 (1.52 ± 0.141)	1.46 ± 0.190	1.27 ± 0.131	1.24 ± 0.172	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.626 ± 0.085	0.594 ± 0.108	0.727 ± 0.0947	0.570 ± 0.105	0.588 ± 0.0779	0.709 ± 0.129	0.544 ± 0.0796 (0.666 ± 0.0845)	0.787 ± 0.131	0.525 ± 0.0764	0.572 ± 0.108	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	ND	ND	ND	ND	ND	ND (ND)	ND	ND	ND	NA[h]
METALS[i]											
Arsenic (mg/L)	0.00267	0.00210	0.00264	0.002U	0.00276	0.00255	0.00276 (0.00334)	0.00207	0.00317	0.00219	0.05
Barium (mg/L)	0.0360	0.0356	0.0385	0.0391	0.0362	0.0377	0.0379 (0.0383)	0.0363	0.0353	0.0359	2
Calcium (mg/L)	39.9J[e]	38.0	38.9	39.1	39.8	39.2	37.8 (39.5)	38.2	41.2J	37.7	NA
Chromium (mg/L)	0.003U[e]	0.003U	0.003U	0.003U	0.003U	0.00401	0.003U (0.003U)	0.00408	0.003U	0.003U	0.01
Copper (mg/L)	0.0003U	0.000308U	0.000422	0.000520	0.000680	0.000564U	0.000447 (0.000560)	0.000401U	0.00615	0.00337U	1.3
Iron (mg/L)	0.03U	0.03U	0.03U	0.03U	0.03U	0.0484	0.03U (0.03U)	0.03U	0.0752	0.03U	0.3
Lead (mg/L)	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U (0.0005U)	0.0005U	0.00133	0.00101	0.015
Magnesium (mg/L)	13.1J	12.4	11.9	12.2	12.9	12.9	11.9 (12.5)	12.2	13.4J	12.0	NA
Manganese (mg/L)	0.001U	0.001U	0.001U	0.001U	0.00124	0.001U	0.001U (0.001U)	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.0006U	0.0006U	0.0006U	0.0006U	0.000820	0.000609	0.0006U (0.0006U)	0.0006U	0.00371	0.00329	NA
Potassium (mg/L)	3.39	3.48	3.65	3.45	3.42	3.65	3.48 (3.53)	3.47	3.37	3.57	NA
Sodium (mg/L)	18.5	17.4	17.2	17.6	18.9	20.5	17.2 (17.9)	18.2	19.2	17.0	NA

Table 6-11. continued

WELL:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] NO. 2		PCS/SCS[b]
Vanadium (mg/L)	0.00662	0.00544	0.00509	0.00454	0.00633	0.00889	0.00641 (0.00863)	0.00556	0.00817	0.00543	NA
Zinc (mg/L)	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U (0.0033U)	0.0033U	0.0237	0.0183	5
ANIONS											
Chloride (mg/L)	18.4	16.5	15.8J	15.6	17.8	18.6	17.7 (16.6)	15.9	17.4	15.6	250
Nitrate-as nitrogen (mg/L)	2.50	2.43J	2.32J	2.34	2.39	2.28	2.43 (2.43)	2.49	2.50	2.39R[j]	10
Phosphorus (mg/L)	0.0593U	0.0235J	0.0974U	0.0274UJ[e]	0.0876U	0.0207J	0.0461U (0.0866U)	0.0183UJ	0.0794U	0.0282J	NA
Sulfate (mg/L)	19.6J	18.5	18.7J	18.0	19.3	20.7	19.7 (19.8)	18.3	19.3J	18.2	250
WATER QUALITY PARAMETERS											
Alkalinity (mg/L)	140	140	144	140	147	144	138 (143)	141	141	141	NA
Bicarbonate alkalinity (mg/L)	140	140	142	140	147	144	138 (143)	141	141	141	NA
Total dissolved solids (mg/L)	240	216	233	246	240	226	266 (221J)[k]	220	234	213	500

a. EBR-II = Experimental Breeder Reactor II. Also known as well ANL 2.
b. PCS = primary constituent standard; SCS = secondary constituent standard, as specified in the state of Idaho Ground Water Quality Rule, IDAPA 58.01.11.
c. ANL-MON-A-012 was initially sampled on 9/28/2021, but due to an enroute shipping delay the well was re-sampled on 10/7/21.
d. Result ± 1s uncertainty. Only analytes with at least one statistically positive result >3s uncertainty are shown. Samples were analyzed for gross alpha; gross beta; tritium; gamma-emitting radionuclides such as americium-241, antimony-125, cerium-144, cesium-134, cesium-137, cobalt-58, cobalt-60, europium-152, europium-154, europium-155, manganese-54, niobium-95, potassium-40, radium-226, ruthenium-103, ruthenium-106, silver-108m, silver-110m, uranium-235, zinc-65, and zirconium-95; and alpha-emitting radionuclides such as americium-241, uranium-233/234, uranium-235, and uranium-238.
e. ND = not detected; J = associated value is an estimate and may be inaccurate or imprecise; U = the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit, but the value is not more than 5 times the highest positive amount in any laboratory blank; UJ = the sample was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.
f. Results for field duplicate samples shown in parentheses.
g. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a Primary Constituent Standard (PCS) for combined beta/photon emitters of 4 millirems/year effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes, the EPA also specifies a Maximum Contaminant Level (MCL) of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.
h. NA = not applicable. A primary or secondary constituent standard has not been established for this constituent
i. Metals reported as non-filtered unless noted.
j. Due to enroute shipping delays, sample was received by the laboratory beyond the method hold-time. Validator qualified the result as “R” (rejected) due to analysis past 2-times the recommended hold time.
k. Reanalysis of the original TDS field duplicate result is reported. The reanalysis was requested to address quality control issues during data review. The reanalysis occurred beyond the allowable hold-time and the result was qualified J during the data validation process.

6.5.7 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2021e), groundwater samples are collected every two years at the locations shown on Figure 6-20. In 2021, seven wells and three intervals from two Westbay® wells were sampled. Groundwater samples from all wells were analyzed for chloride, nitrate/nitrite as nitrogen, gross alpha, and gross beta. Sulfate and volatile organic compounds were collected from a subset of Operable Unit 10-08 monitoring wells. None of the noted analytes exceeded EPA MCLs or SMCLs (Table 6-12; DOE-ID 2022e).

Table 6-12. WAG 10 aquifer groundwater quality summary (June 2021).

ANALYTE	MCL[a] or SMCL[b]	MAXIMUM	MINIMUM	NUMBER OF WELLS ABOVE MCL
ANIONS				
Chloride (mg/L)	*250*[c]	20.4	11.3	0
Sulfate (mg/L)	*250*	25.3	4.13	0
Nitrate/nitrite (mg-N/L)	10	2.47	0.165	0
RADIONUCLIDES				
Gross alpha (pCi/L)	15	ND[d]	ND	0
Gross beta (pCi/L)	4 mrem/yr[e]	5.19	ND	0
DETECTED VOLATILE ORGANIC COMPOUNDS				
None	–	ND	ND	0

a. MCL = maximum contaminant level.

b. SMCL = secondary maximum contaminant level.

c. Numbers in *italic* text are for the secondary MCL.

d. ND = not detected.

e. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/year effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes, the EPA also specifies a MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

6.6 Remote-Handled Low-Level Waste Disposal Facility

The INL contractor monitors groundwater at the RHLLW Disposal Facility to demonstrate compliance with DOE O 435.1, “Radioactive Waste Management,” and IDAPA 58.01.11, “Ground Water Quality Rule”. Samples were collected from three monitoring wells in 2021 and analyzed for gross alpha, gross beta, carbon-14 (^{14}C), ^{129}I, ^{99}Tc, and tritium in accordance with PLN-5501, “Monitoring Plan for the INL RHLLW Disposal Facility” as shown in Figure 6-21. Results for analytes with positive detections are summarized in Table 6-13. Tritium and gross beta were detected in all three wells, while gross alpha was positively detected in one of the three wells. Carbon-14, ^{129}I, and ^{99}Tc were not detected in any samples. All results are consistent with concentrations in the aquifer established prior to facility completion (INL 2017). The 2021 results show no discernable impacts to the aquifer from RHLLW Disposal Facility operations.

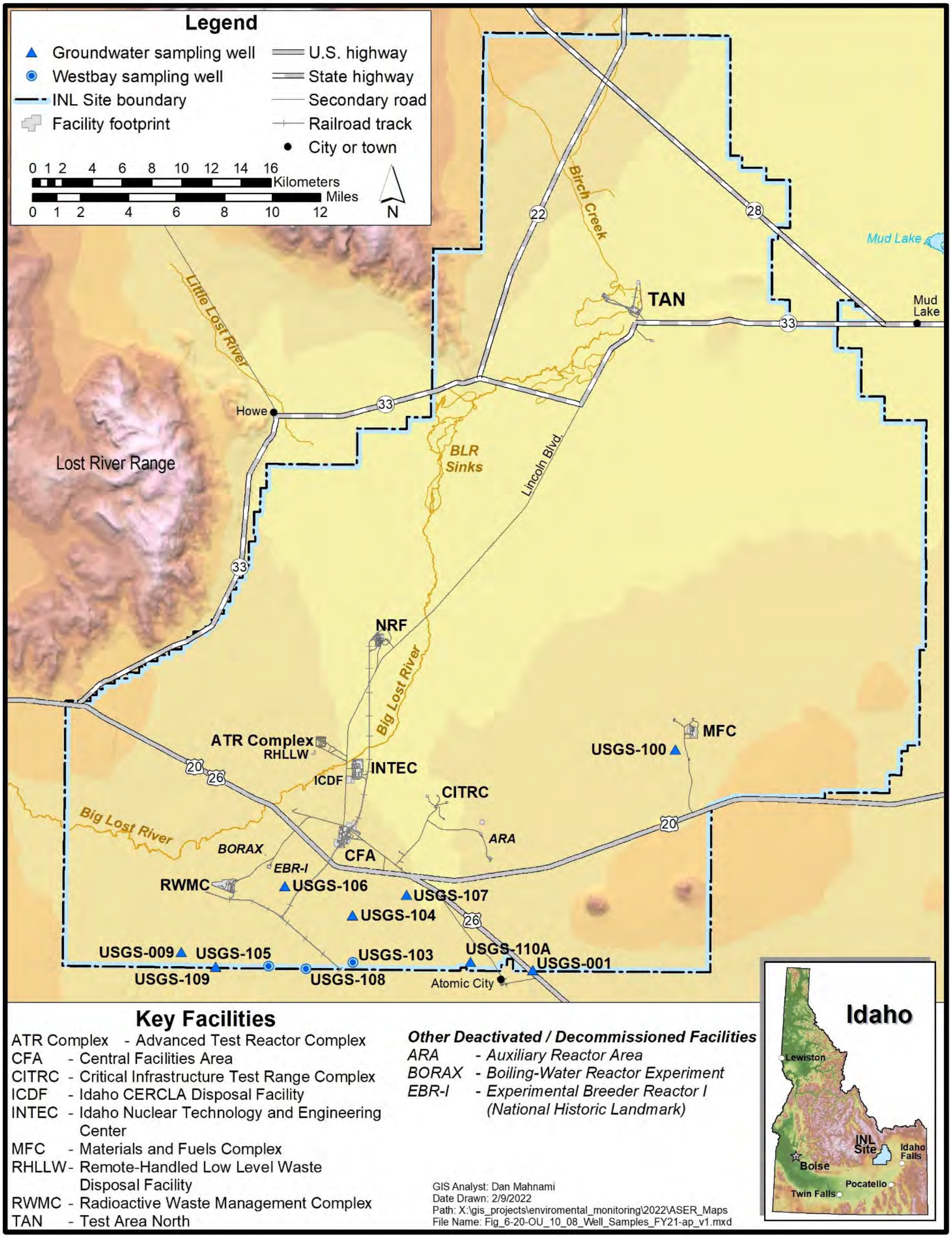


Figure 6-20. Well locations sampled for Operable Unit 10-08.

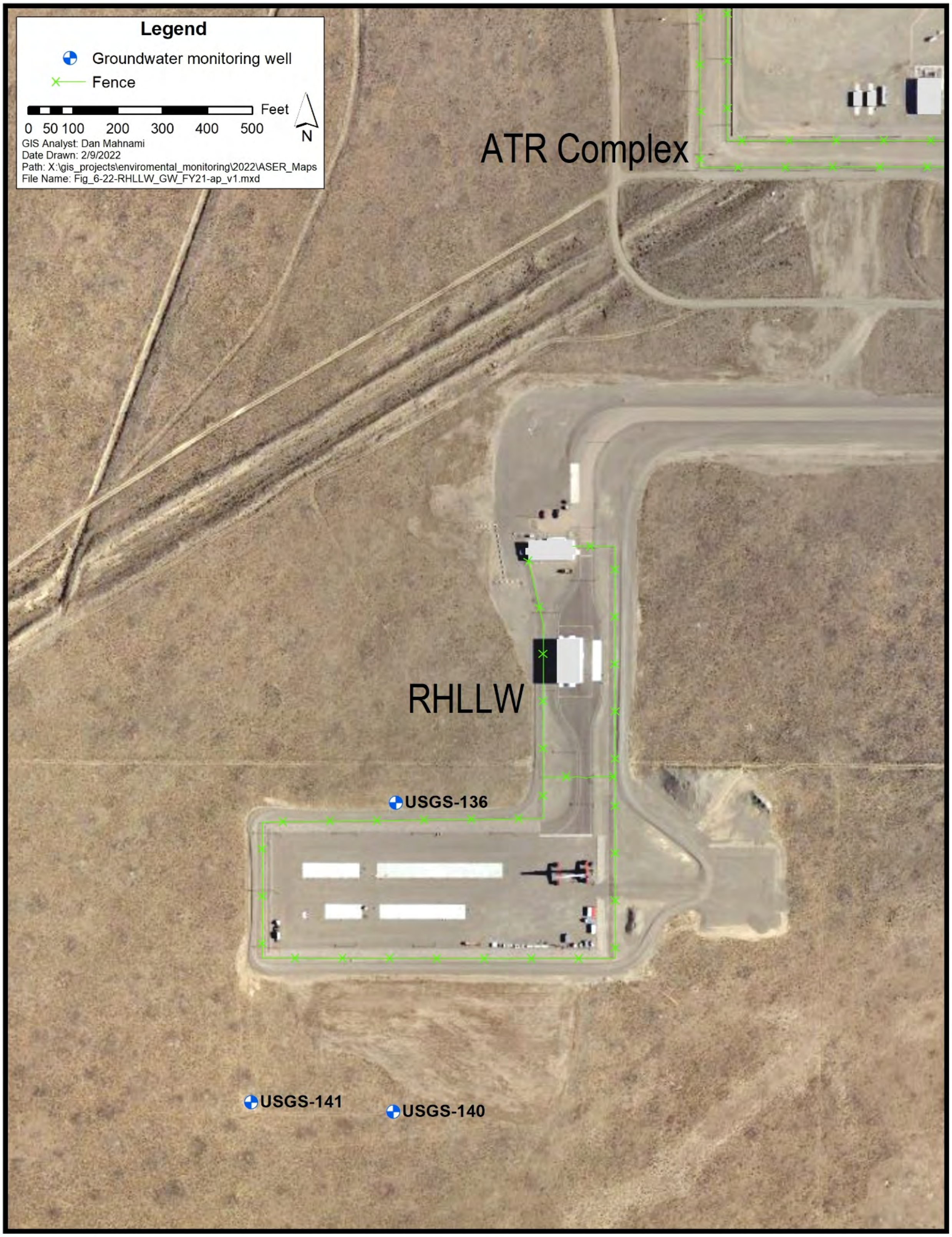


Figure 6-21. Well Locations Sampled for RHLLW Facility.

Table 6-13. Radioactivity detected in surveillance groundwater samples collected at the RHLLW Facility (2021).

WELL:	USGS-136	USGS-140	USGS-141	PCS/SCS[a]
SAMPLE DATE:	4/15/2021	4/19/2021	4/19/2021	
RADIONUCLIDES[b]				
Gross alpha (pCi/L)	ND[c]	ND (ND)[d]	1.06 ± 0.337	15 pCi/L
Gross beta (pCi/L)	2.14 ± 0.260	2.47 ± 0.260 (2.30 ± 0.254)	1.65 ± 0.254	4 mrem/yr[e]
Tritium (pCi/L)	916 ± 149	624 ± 126 (853 ± 143)	608 ± 125	20,000 pCi/L

a. PCS = Primary Constituent Standard, SCS = Secondary Constituent Standard, as specified in the state of Idaho Ground Water Quality Rule, IDAPA 58.01.11.

b. Result ± 1s. Only analytes with at least one statistically positive result >3s uncertainty are shown. Samples were analyzed for gross alpha, gross beta, carbon-14, iodine-129, technecium-99, and tritium.

c. ND = Not Detected.

d. Duplicate sample results are shown in parentheses.

e. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/year effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes only, the EPA also specifies MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

In addition to compliance monitoring of groundwater at the RHLLW Disposal Facility, facility performance is monitored by collecting and analyzing soil-pore water samples, where sufficient water is present, from vadose-zone lysimeters installed in native materials adjacent to and below the base of the vault arrays. The baseline for the soil-pore water samples will be established over the initial three years of operation in 2019, 2020, and 2021. The third year of soil-pore water baseline sampling was collected in 2021. The 2019 - 2021 soil-porewater data will be evaluated in 2022, and the soil-pore water baseline will be established for lysimeter locations with sufficient data. Additional baseline data collection may continue in 2022 and beyond to address data gaps at locations where insufficient soil-pore water for sampling persists. Future soil-pore water sample results will be compared to the baseline measurements, where established, and used as early indicators of facility operations and key assumptions. For establishment of the baseline, soil-pore water samples are analyzed for the same target and indicator analytes as the aquifer compliance samples (e.g., gross alpha, gross beta, tritium, ^{14}C, ^{129}I, and ^{99}Tc).

6.7 Onsite Drinking Water Sampling

The INL and ICP Core contractors monitor drinking water to ensure that it is safe for consumption and to demonstrate that it meets federal and state regulations. Drinking water parameters are regulated by the State of Idaho under authority of the Safe Drinking Water Act (40 CFR 141, 142). Parameters are sampled according to a 9-year monitoring cycle, which identifies the specific classes of contaminates to monitor at each drinking water source, and the frequency (https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=30006644.txt). Parameters with primary MCLs must be monitored at least once every three years. Parameters with SMCLs are monitored every three years based on a recommendation by the EPA (40 CFR 143). Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline results.

The INL Site has 10 drinking water systems that are monitored by the INL and ICP Core contractors. The INL contractor monitors eight of these drinking water systems and the ICP Core contractor monitors two. The Naval Reactors Facility also monitors a drinking water system. The results are not included in this annual report but are addressed in the *Naval Reactors Facility Environmental Monitoring Report for Calendar Year 2021* (FMP 2022). According to the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08), INL Site drinking water systems are classified as either non-transient or transient, non-community water systems. The four INL contractor transient, non-community water systems are located at EBR-I, Gun Range (Live Fire Test Range), CITRC, and the Main Gate. The four remaining INL contractor water systems are classified as non-transient, non-community water systems, and are located at CFA, MFC, the ATR Complex, and TAN/CTF. The two ICP Core contractor non-transient, non-community water systems are INTEC and the RWMC.

As required by the State of Idaho, INL and the ICP Core drinking water programs use EPA-approved (or equivalent) analytical methods to analyze drinking water in compliance with current editions of IDAPA 58.01.08 and 40 CFR Parts 141–143. State regulations also require that analytical laboratories be certified by the state or by another state whose certification is recognized by Idaho. DEQ oversees the certification program and maintains a list of approved laboratories.

The INL and ICP Core contractors monitor certain parameters more frequently than required by regulation because of low volume usage on weekends. For example, bacterial analyses are conducted monthly rather than quarterly at all eight INL contractor drinking water systems and at the two ICP Core contractor drinking water systems during months of operation. Because of known groundwater plumes near one ICP Core contractor drinking water well, additional sampling is conducted for carbon tetrachloride at RWMC.

6.7.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2021, the INL contractor collected 168 routine/compliance samples and 36 quality control samples from eight INL Site drinking water systems. Also, part of the routine drinking water monitoring is our radiological sampling. Semi-annual sampling is done at all eight water systems for gross alpha, beta, and tritium. CFA water system was also sampled for ^{129}I due to being down gradient of the plume from the north. Table 6-14 lists detections in routine/compliance and radiological surveillance monitoring. In addition to routine samples, the INL contractor also collected 120 surveillance samples including: bacteriological, lead and copper, and perfluoroalkyl substances (PFAS).

The ICP Core contractor collected 14 routine/compliance samples and eight quality control samples from two ICP Core drinking water systems. ICP Core also collected 111 surveillance bacteriological, synthetic organic compounds and VOCs samples. Two gross alpha/beta samples were collected semiannually from both ICP Core drinking water systems. One tritium sample was also collected from each drinking water system as shown in Table 6-14.

All INL and ICP Core drinking water systems were well below regulatory limits for drinking water or there were no detections. See Table 6-14 for a summary. Since all the water systems are public water systems (PWS); their data is listed on the DEQ's PWS Switchboard at www.deq.idaho.gov.

In addition, all water systems were sampled for nitrates and all values were less than the MCL of 10 mg/L. The highest nitrate values were 3.57 mg/L at CFA and 2.20/2.26 mg/L at MFC well #1/2 respectively. Samples for the total trihalomethanes (TTHMs), and haloacetic acids (HAA5) were collected at the ATR-Complex, MFC, and TAN/CTF as seen in Table 6-14. The ICP Core contractor sampled for nitrates at both INTEC and RWMC, and all values were less than the MCL of 10 mg/L.

The EPA is actively researching and beginning to establish regulations for a class of very widely used and dispersed man-made-chemicals called PFAS, which are considered to be an 'emerging contaminant' of concern and have been used in industry and consumer products worldwide since the 1950s in non-stick cookware, water-repellent clothing, stain resistant fabrics and carpets, some cosmetics, some firefighting foams, and products that resist grease, water, and oil. Many of the common PFAS have been phased out of production. These chemicals do not degrade in the environment. During production and use, PFAS can migrate into the soil, water, and air. Because of their widespread use and their persistence in the environment, PFAS are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and the environment. Some PFAS can build up in people and animals with repeated exposure over time. Research involving humans suggests that high levels of certain PFAS may lead to

Table 6-14. Summary of INL Site drinking water results (2021).

CONSTITUENT	MCL (units)	ATR COMPLEX 6120020	CFA 6120008	CITRC 6120019	EBR-I 6120009	GUN RANGE 6120025	MAIN GATE 6120015	MFC 6060036	TAN CTF 6120021	RWMC PWS 6120018	INTEC PWS 6120012
RADIOLOGICAL SURVEILLANCE MONITORING											
Gross Alpha[a]	15 pCi/L	ND[b]	ND	ND-3.05	ND	ND	ND	ND-4.68	ND	2.08 – 3.15	ND
Gross Beta[a]	50 pCi/L screening or 4 mrem	ND	4.25-4.28	ND-5.65	ND-2.68	2.43-2.72	ND	1.94-10.5	2.50-2.67	ND - 2.87	1.88 – 2.88
Tritium[a]	20,000 pCi/L	ND	2,310-2,640	ND	ND	ND-284	ND	ND	ND	ND	ND
Iodine-129[c]	1 pCi/L	–	ND	–	–	–	–	–	–	–	–
COMPLIANCE MONITORING											
Nitrate	10 mg/L	ND	3.57	ND	ND	ND	ND	2.20/2.26	ND	ND	ND
Total trihalomethanes	80 ppb	ND	5.0	NA[c]	NA	NA	NA	2.8	1.3	1.5	ND
Total coliform	2 or more present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
E. coli	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
HAA5s	60 ppb	ND	ND	NA	NA	NA	NA	ND	ND	ND	NA
SOCs/VOCs[d]	SOCs varies, 5 ppb for most VOCs	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND

a. Range of results (minimum – maximum) presented.
b. ND = not detected.
c. NA = not applicable based on water system classification.
d. SOCs = synthetic organic compounds and VOCs = volatile organic compounds.

numerous health impacts. A common pathway for humans to be potentially impacted by PFAS is through drinking contaminated water.

In 2021, INL and ICP Core contractors sampled 13 out of 16 wells that supply water to their ten water systems as part of a voluntary Idaho state initiative involving a select group of drinking water systems to explore the potential for the existence of PFAS in Idaho's drinking water sources. The results of this effort will be reported by DOE in the near future.

6.7.1.1 Advanced Test Reactor Complex, PWS 6120020

There are over 500 employees assigned to the ATR Complex. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. A new potable well was completed for the ATR Complex in September 2019. This gives the ATR Complex two drinking water wells. Since both are approximately 600 feet deep and less than 100 feet apart, they are designated as a wellfield. Compliance samples are collected from the wellfield at TRA-696 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2021 all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples. These wells can pump over 200 gpm. Water is also supplied to the RHLLW Facility which is outside the fence of the ATR Complex.

6.7.1.2 Central Facilities Area, PWS 6120008

The CFA water system has two wells that serves a little over 500 people daily. The two wells are 639 and 681 feet deep and they pump over 600 gpm. The water system is continuously disinfected on a voluntary basis as an added protection. Compliance samples are collected from the manifold at CFA-1603 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2021, all constituents sampled were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.3 CITRC Facility, PWS 6120019

At present, there are no permanent employees at CITRC. The water system has a continuous chlorination system to disinfect the water. CITRC #1 well is located at PBF 602 and is 653 feet deep and can pump 400 gpm. CITRC #2 well is located at PBF-614. The well is 1,217 feet deep and can pump 800 gpm. Compliance samples are collected from the manifold, located at PBF-638. In 2021, all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.4 EBR-I, PWS 6120009

EBR-I has a public water system that is open to the public from Memorial Day to Labor Day with scheduled tours throughout the year. There are no personnel stationed at this facility. The well is 1,075 feet deep. EBR-I is one of four water systems at INL that does not automatically disinfect. The water system and well were constructed in 1949. In 2021, all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.5 Gun Range Facility, PWS 6120025

There are seven employees that are permanently stationed at the Gun Range Facility. In 2010 continuous chlorination was discontinued due to an ongoing history of no bacteria (i.e., total coliform and E. coli). The well is located at B21-607 and was completed in January 1990. The well is 626 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B21-607 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2021, all sampled constituents were below the MCL, which includes the monthly bacteriological samples.

6.7.1.6 Main Gate Badging Facility, PWS 6120015

There are three employees permanently stationed at the Main Gate Badging Facility. The well is located at B27-605 and was completed January 1985. The well is 644 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B27-605 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2021 all constituents sampled for were below the MCL; which includes the monthly bacteriological samples.

6.7.1.7 Materials and Fuels Complex, PWS 6060036

There are 1,000 employees located at MFC. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. Well #1 is located at MFC-754 and Well #2 at MFC-756. Well #1 was completed in 1958 and is 747 feet deep. Well #2 was completed in 1959 and is 755 feet deep. Most compliance samples are collected from both wells. Other compliance samples, such as lead/copper, TTHMs/HAA5s, and bacteria (i.e., total coliform and E. coli), are collected from the distribution system as required by the regulations. In 2021, all sampled constituents were below the MCL, which includes the two monthly bacteriological samples.

6.7.1.8 Test Area North/Contained Test Facility (TAN/CTF), 6060021

There are more than 300 employees located at TAN/CTF. The water system has a continuous chlorination system to disinfect the water on a voluntary basis for added protection. TAN/CTF #1 Well is located at TAN 632 and was constructed in November 1957. The well is 339 feet deep. The well can pump 1,000 gpm. TAN/CTF #2 Well is located at TAN 639 and was completed in April 1958. The well is 462 feet deep and can pump 1,000 gpm. Compliance samples are collected from the manifold at TAN 1612 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2021, all sampled constituents were below the MCL; which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.9 Idaho Nuclear Technology and Engineering Center, 6120018

Drinking water for the Idaho Nuclear Technology and Engineering Center (INTEC) is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (e.g., chlorine) is maintained throughout the distribution system. In 2021, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system.

Eleven compliance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for contaminants identified by the state of Idaho per the monitoring frequency. Sample results for these compliance samples are summarized in Table 6-14. All detected contaminants were below the MCL concentrations.

6.7.1.10 Radioactive Waste Management Complex, 6120012

The RWMC production well is located in Building WMF-603 and is the source of drinking water for RWMC. A disinfectant residual (e.g., chlorine) is maintained throughout the distribution system. Historically, carbon tetrachloride, total xylenes, and other VOCs had been detected in samples collected at the WMF-603 production well and at the point of entry to the distribution system (WMF-603). In July 2007, a packed tower air stripping treatment system was placed into operation to remove the VOCs from the groundwater prior to human consumption.

In 2021, drinking water samples were collected from the point of entry to the distribution system (WMF-603) and from various buildings throughout the distribution system.

Twelve compliance samples were collected from various buildings throughout the distribution system at RWMC and analyzed for the contaminants identified by the State of Idaho per the monitoring schedule. Sample results for these compliance samples are summarized in Table 6-14. All detected contaminants were below the MCL concentrations.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program, drinking water samples were collected off the INL Site for radiological analyses in 2021. Two locations, Shoshone and Minidoka, which are downgradient of the INL Site, were co-sampled with the state of Idaho DEQ-INL Oversight Program (DEQ-IOP) in May and November/December 2021. One upgradient location, Mud Lake, was also co-sampled with DEQ-IOP. Samples were also collected at Atomic City, Craters of the Moon, Howe, Idaho Falls, and the public rest area at Highway 20/26. A control sample of bottled water was also obtained. The samples were analyzed for gross alpha and gross beta activities and for tritium. The results are shown in Table 6-15. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Table 6-15. Gross alpha, gross beta, and tritium concentrations in offsite drinking water samples collected by the ESER contractor in 2021.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING	FALL	EPA MCL[b]
Atomic City	0.09 ± 0.19	2.6 ± 0.62	15 pCi/L
Control (bottled water)[c]	0.01 ± 0.19	0.14 ± 0.11	15 pCi/L
Craters of the Moon	0.32 ± 0.25	1.2 ± 0.23	15 pCi/L
Howe	0.19 ± 0.25	0.68 ± 0.21	15 pCi/L
Idaho Falls	0.02 ± 0.33	0.40 ± 0.23	15 pCi/L
Minidoka	0.27 ± 0.19	0.24 ± 0.20	15 pCi/L
Mud Lake (Well #2)	-0.09 ± 0.17	0.23 ± 0.15	15 pCi/L
Rest Area (Highway 20/26)	0.28 ± 0.25	3.3 ± 0.54	15 pCi/L
Shoshone	-0.18 ± 0.22	1.5 ± 0.25	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Atomic City	2.6 ± 0.33	8.8 ± 1.0	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	4.4 ± 0.36	0.76 ± 0.31	4 mrem/yr (50 pCi/L)
Craters of the Moon	3.4 ± 0.39	3.4 ± 0.42	4 mrem/yr (50 pCi/L)
Howe	1.8 ± 0.37	1.7 ± 0.41	4 mrem/yr (50 pCi/L)
Idaho Falls	4.0 ± 0.46	4.7 ± 0.50	4 mrem/yr (50 pCi/L)
Minidoka	1.4 ± 0.32	4.6 ± 0.48	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	3.3 ± 0.33	4.3 ± 0.41	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	3.1 ± 0.38	5.0 ± 0.79	4 mrem/yr (50 pCi/L)
Shoshone	2.8 ± 0.37	4.5 ± 0.45	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	FALL	EPA MCL
Atomic City	24 ± 32	16 ± 23	20,000 pCi/L
Control (bottled water)	-50 ± 23	19 ± 23	20,000 pCi/L
Craters of the Moon	-0.17 ± 31	-6.8 ± 22	20,000 pCi/L
Howe	36 ± 31	-35 ± 23	20,000 pCi/L
Idaho Falls	42 ± 31	-44 ± 23	20,000 pCi/L

Table 6-15. continued.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
Minidoka	80 ± 31	-6.8 ± 23	20,000 pCi/L
Mud Lake (Well #2)	59 ± 31	1.2 ± 23	20,000 pCi/L
Rest Area (Highway 20/26)	116 ± 32	45 ± 24	20,000 pCi/L
Shoshone	58 ± 31	-15 ± 23	20,000 pCi/L

a. Result ± 1σ. Results ≥ 3 σ are considered to be statistically positive.
b. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
c. Water bottled in Ammon, Idaho.
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

Gross alpha activity was detected statistically (above 3σ) in five of nine samples collected in fall 2021 (Atomic City, Craters of the Moon, Howe, Rest Area, and Shoshone). The results are below the screening level of 15 pCi/L for gross alpha activity, with a maximum of 3.3 ± 0.54 pCi/L, as measured at the Rest Area in November.

Gross beta activity was detected statistically in all but one drinking water sample collected during 2021. Gross beta activity was not detected in the bottled water sample (control) collected in December. The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 8.8 ± 1.0 pCi/L, measured at Atomic City in November. If gross beta activity exceeds 50 pCi/L, an analysis of the sample must be performed to identify the major radionuclides present (40 CFR 141). Gross beta activity has been measured at these levels historically in offsite drinking water samples. For example, the maximum level reported since 2011 in past Annual Site Environmental Reports was 7.83 ± 0.61 pCi/L at Atomic City in spring of 2011.

Tritium was statistically detected in one of the drinking water samples collected in 2021. The maximum result measured was 116 ± 32 pCi/L, measured in the sample collected at the Rest Area in May. The result was within historical measurements and well below the EPA MCL of 20,000 pCi/L. The maximum tritium level was lower than the maximum measured since 2011 (209 ± 25 pCi/L) at Minidoka in spring 2018).

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2021 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls; Clear Springs near Buhl; and a trout farm near Hagerman shown in Figure 6-22. Results are summarized in Table 6-16.

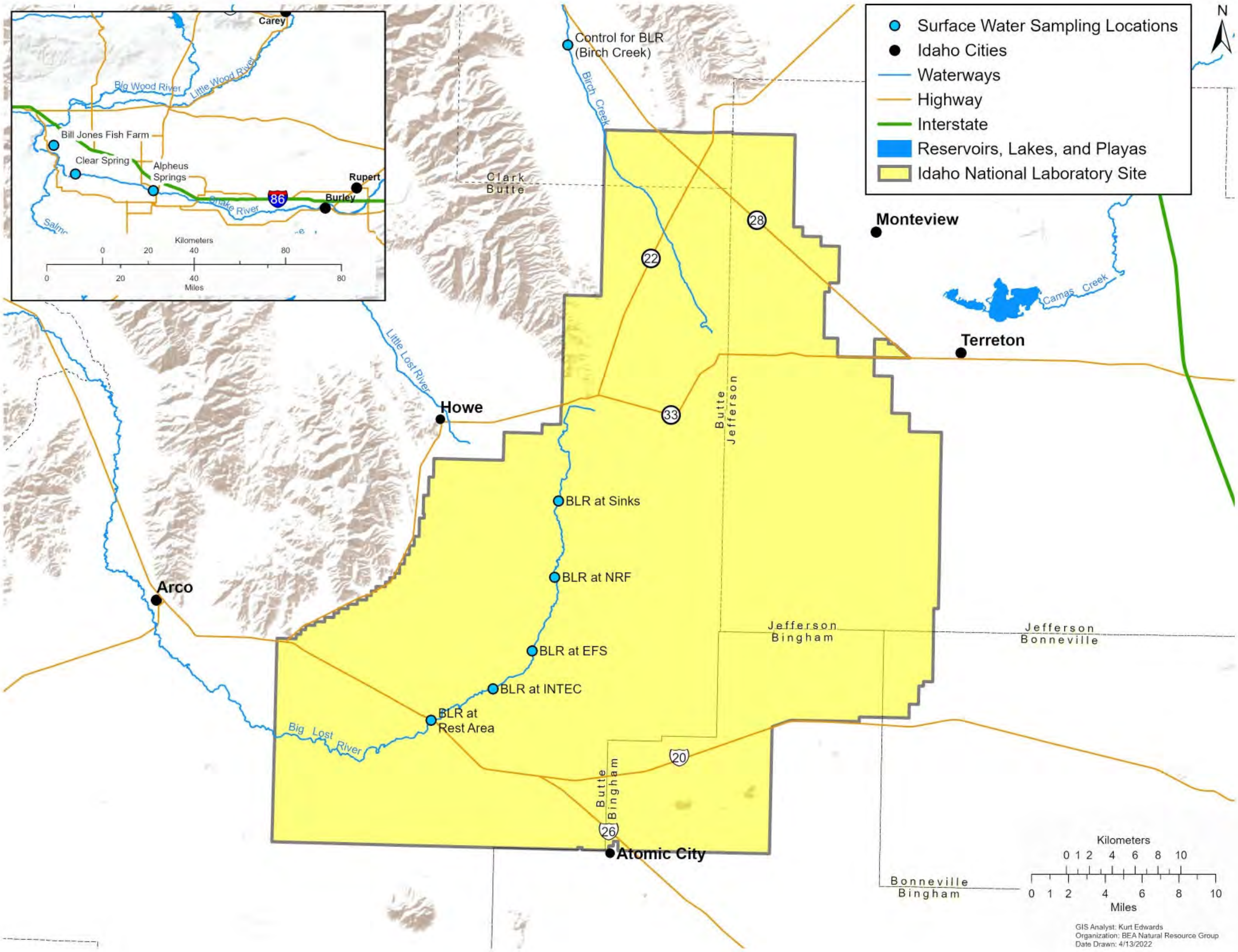


Figure 6-22. Detailed map of ESER program surface water monitoring locations.

Gross alpha activity was detected in one sample collected in November for the sample collected at Alpheus Springs (8.8 ± 0.83 pCi/L). For comparison, the maximum concentration measured since 2011 in all springs was 3.7 ± 0.68 pCi/L at Clear Springs in 2017.

Gross beta activity was detected in all surface water samples. The highest result (14 ± 1.0 pCi/L) was measured in the Alpheus Springs sample collected in the fall. Alpheus Springs has historically shown higher results, and these values are most likely due to natural decay products of thorium and uranium that dissolve into water as it passes through the surrounding basalts of the eastern Snake River Plain Aquifer. The maximum result measured since 2011 was 10.6 ± 0.56 pCi/L at Alpheus Springs in 2014.

Tritium was not detected in any of the surface water samples collected in 2021.

Table 6-16. Gross alpha, gross beta, and tritium concentrations in surface water samples collected along the Big Lost River by the ESER contractor in 2021.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING[b]	FALL[b]	EPA MCL[c]
Alpheus Springs-Twin Falls	-1.2 ± 0.28	8.8 ± 0.83	15 pCi/L
Clear Springs-Buhl	-0.25 ± 0.28	0.10 ± 0.21	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	0.43 ± 0.26	0.58 ± 0.21	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Alpheus Springs-Twin Falls	9.5 ± 0.54	14 ± 1.0	4 mrem/yr (50 pCi/L)[d]
Clear Springs-Buhl	4.9 ± 0.44	5.0 ± 0.50	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	4.6 ± 0.40	4.4 ± 0.45	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	FALL	EPA MCL
Alpheus Springs-Twin Falls	-14 ± 24	-5.9 ± 23	20,000 pCi/L
Clear Springs-Buhl	-39 ± 23	31 ± 23	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	-56 ± 24	23 ± 23	20,000 pCi/L

a. Result ± 1s. Results ≥ 3s are considered to be statistically positive.
b. The springs and trout farm were sampled on May 10, 2021, and on November 8, 2021.
c. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

The Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called the Big Lost River Sinks (see Figure 6-22). The river then mixes with other water in the eastern Snake River Plain Aquifer. Water in the aquifer then emerges about 160 km (100 miles) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls. The ESER contractor did not collect surface water samples from the Big Lost River on the INL Site because water demands upstream at the Mackay Reservoir inhibited river flow onto the INL from March to May 2021 and flow never went as far as the Lincoln Blvd bridge. No river samples were collected during 2021 at INL because of the lack of surface water flow in the Big Lost River.

6.10 U.S. Geological Survey 2021 Publication Abstracts

In 1949, the USGS was asked to characterize water resources prior to the building of nuclear-reactor testing facilities at the INL Site. Since that time, USGS hydrologists and geologists have been studying the hydrology and geology of the eastern Snake River Plain and the eastern Snake River Plain aquifer.

At the INL Site and in the surrounding area, the USGS INL Project Office:

- Monitors and maintains a network of existing wells

- Drills new research and monitoring wells, providing information about subsurface water, rock, and sediment
- Performs geophysical and video logging of new and existing wells
- Maintains the Lithologic Core Storage Library.

Data gathered from these activities are used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer, and to improve understanding of the complex relationships between the rocks, sediments, and water that compose the aquifer. The USGS INL Project Office publishes reports about their studies, available through the USGS Publications Warehouse: https://usgs-r.github.io/inlpubs/articles/inl-bibliography.html. Four reports and two software packages were published by the USGS INL Project Office in 2021. The abstracts of these studies and the publication information associated with each study are presented below.

6.10.1 Multilevel Groundwater Monitoring of Hydraulic Head, Water Temperature, and Chemical Constituents in the Eastern Snake River Plain Aquifer at INL

Radiochemical and chemical wastewater discharged to infiltration ponds and disposal wells since the early 1950s at INL in southeastern Idaho has affected the water quality of the eastern Snake River Plain aquifer. In cooperation with the U.S. Department of Energy in 2005, the USGS added a multilevel well-monitoring network to their ongoing monitoring program to begin describing the vertical movement and distribution of the chemical constituents in the eastern Snake River Plain aquifer (Twining et.al 2021a).

The multilevel monitoring system (MLMS) at INL has been ongoing since 2006. This report summarizes the data that was collected during 2014–2018 from 11 multilevel monitoring wells. Hydraulic head (head) and groundwater temperature data were collected, including 177 measurements from hydraulically isolated depth intervals from 448.0 to 1,377.6 feet below land surface. One port (port 3) within well USGS 134 was not monitored due to the failure of a valve.

Vertical head and temperature changes were quantified for each of the 11 MLMs. Fractured basalt zones generally had relatively small vertical head differences and showed a higher occurrence within volcanic rift zones. Poor connectivity between fractures and higher vertical gradients generally were attributed to sediment layers and (or) layers of dense basalt. Hydraulic head ranged from 4,415.5 to 4,462.6 feet above the North American Vertical Datum of 1988; groundwater temperature ranged from 10.4 to 16.8 degrees Celsius.

Normalized mean head values were analyzed for all 11 multilevel monitoring wells for the period of record (2007–2018). The mean head values suggest a moderately positive correlation among all MLMS wells and generally reflect regional fluctuations in water levels in response to seasonal climatic changes. MLMS wells within volcanic rift zones and near the southern boundary indicate a temporal correlation that is strongly positive. MLMS wells in the Big Lost Trough indicate some variations in temporal correlations that may result from proximity to the mountain front to the northwest and episodic flow in the Big Lost River drainage system.

During 2014–2018, water samples were collected from one to four discrete sampling zones, isolated by packers, in the upper 250–750 feet of the aquifer from 11 multilevel monitoring wells and were analyzed for selected radionuclides, inorganic constituents, organic constituents, and nutrients. Some additional samples were collected for VOCs from wells near the RWMC.

Nine quality-control replicate samples, three field blanks, and two equipment blanks were collected during 2014–2018 as a measure of quality assurance. Concentrations of major ions and chromium in equipment blank samples were near or less than the reporting levels, suggesting no background contamination from field equipment or source water. About 88 percent of the replicate pairs for radionuclide results were statistically comparable and 100 percent of the replicate pairs for inorganic and organic compounds were statistically comparable.

Concentrations in wells USGS 105 and 132 mostly were greater than the reporting levels, and concentrations were mostly consistent. Wells USGS 103, USGS 131, and MIDDLE 2051 had concentrations mostly greater than the two reported 2014–2018 levels and showed decreasing concentrations. The decreasing concentrations are attributed to discontinued disposal, radioactive decay, and dilution and dispersion in the aquifer.

The volatile organic compound tetrachloromethane was found in all zones sampled in well USGS 132 near the RWMC and was found in two zones in well USGS 137A. Concentrations are attributed to waste disposal at the RWMC. Questionable detections of tetrachloroethene were found in well MIDDLE 2051; the source probably was tubing fluid in the well. Tetrachloroethene was found in the tubing fluid at elevated concentrations in three wells (USGS 137A, MIDDLE 2050A, and MIDDLE 2051), and remedial efforts to remove the elevated concentrations of tetrachloroethene from tubing fluid have been successful in each of the three MLMS wells.

6.10.2 Completion Summary for Boreholes USGS 148, USGS 148A, and USGS 149 at the MFC

In cooperation with the DOE in 2019, the USGS drilled and constructed boreholes USGS 148A and USGS 149 for stratigraphic framework analyses and long-term groundwater monitoring of the eastern Idaho Snake River Plain aquifer at INL. Initially, boreholes USGS 148A and USGS 149 were continuously cored to allow the USGS and INL subcontractor to collect select geophysical and seismic data and evaluate properties of recovered core material. The USGS geophysical data and descriptions of core material are described in this report; however, data collected by the INL contractor, including seismic data, are not included as part of the report (Twining et al. 2021b).

The unsaturated zone at both borehole locations is relatively thick, depth to water was measured at approximately 663.6 feet (ft) below land surface (BLS) in USGS 148A, and at approximately 654.1 ft BLS at USGS 149. On completion of coring and data collection, both boreholes (USGS 148A and USGS 149) were repurposed as monitoring wells. Well USGS 148A was constructed to a depth of 759 ft BLS and instrumented with a dedicated submersible pump and measurement line; well USGS 149 was constructed to a depth of 974 ft BLS and instrumented with a multilevel monitoring system (Westbay^{TM}).

As collected by the USGS, geophysical data were used to characterize the subsurface geology and aquifer conditions. Natural gamma log measurements were used to assess sediment-layer thickness and location. Neutron and gamma-gamma source logs were used to confirm fractured and vesicular basalt identified for aquifer testing and multilevel monitoring well zone testing. Acoustic televiewer logs, collected for well USGS 149, were used to identify fractures and assess groundwater movement when compared with neutron measurements. Furthermore, gyroscopic deviation measurements were used to measure horizontal and vertical displacement for the USGS 148A and USGS 149 constructed boreholes.

A single-well aquifer test was done in well USGS 148A during November 6–7, 2019, to provide estimates of transmissivity and hydraulic conductivity. Estimates for transmissivity and hydraulic conductivity were 6.34×103 feet squared per day and 3.17 feet per day, respectively. The aquifer test was run overnight (21.3 hours) and measured drawdown was relatively small (0.09 ft) at sustained pumping rates ranging from 15.7 to 16.1 gallons per minute. The transmissivity estimates for well USGS 148A were slightly lower than those determined from previous aquifer tests for wells near the Materials and Fuels Complex, but well within range of other aquifer tests done at the INL Site.

Water-quality samples, collected from well USGS 148A and from four zones in well USGS 149, were analyzed for cations, anions, metals, nutrients, VOCs, stable isotopes, and radionuclides. Water samples for most of the inorganic constituents showed a similar chemistry in USGS 148A and all four zones in USGS 149. Water samples for stable isotopes of oxygen and hydrogen indicated some possible influence of irrigation on water quality. Nitrate plus nitrite concentrations indicated influence from anthropogenic sources. The VOC and radiochemical data indicated that wastewater disposal practices at the MFC or from drilling had no detectable influence on these wells.

6.10.3 Optimization of the INL Water-Quality Aquifer Monitoring Network

Long-term monitoring of water-quality data collected from wells at the INL have provided essential information for delineating the movement of radiochemical and chemical wastes in the eastern Idaho Snake River Plain aquifer. In cooperation with DOE, the USGS has maintained as many as 200 wells in the INL water-quality monitoring network since 1949. A network design tool, distributed as an R package, was developed to evaluate and optimize groundwater monitoring in the existing network based on water-quality data collected at 153 sampling sites since January 1, 1989. The objective of the optimization design tool is to reduce well monitoring redundancy while retaining sufficient data to reliably characterize water-quality conditions in the aquifer. A spatial optimization was used to identify a set of wells whose removal leads to the smallest increase in the deviation between interpolated concentration maps using the existing and reduced monitoring networks while preserving significant long-term trends and seasonal components in the data. Additionally, a temporal optimization was used to identify reductions in sampling frequencies by minimizing the redundancy in sampling events (Fisher et al. 2021).

Spatial optimization uses an islands genetic algorithm to identify near-optimal network designs removing 10, 20, 30, 40, and 50 wells from the existing monitoring network. With this method, choosing a greater number of wells to remove results in greater cost savings and decreased accuracy of the average relative difference between interpolated maps of the reduced-dataset and the full-dataset. The genetic search algorithm identified reduced networks that best capture the spatial patterns of the average concentration plume while preserving long-term temporal trends at individual wells. Concentration data for 10 analyte types are integrated in a single optimization so that all datasets may be evaluated simultaneously. A constituent was selected for inclusion in the spatial optimization problem when the observations were sufficient to: (1) establish a two-range variability model; (2) classify at least one concentration time series as a continuous record block; and (3) make a prediction using the quantile-kriging interpolation method. The selected constituents include sodium, chloride, sulfate, nitrate, carbon tetrachloride, 1,1-dichloroethylene, 1,1,1-trichloroethane, trichloroethylene, tritium, strontium-90, and plutonium-238.

In temporal optimization, an iterative-thinning method was used to find an optimal sampling frequency for each analyte-well pair. Optimal frequencies indicate that for many of the wells, samples may be collected less frequently and still be able to characterize the concentration over time. The optimization results indicated that the sample-collection interval may be increased by an average of 273 days owing to temporal redundancy.

6.10.4 Field Methods, Quality-Assurance, and Data Management Plan for Water-Quality Activities and Water-Level Measurements, INL

Water-quality activities and water-level measurements conducted by the USGS INL Project Office coincide with the USGS mission of appraising the quantity and quality of the Nation’s water resources. The activities are conducted in cooperation with the DOE–Idaho Operations Office. Results of water-quality and hydraulic head investigations are presented in various USGS publications or in refereed scientific journals. The data are stored in the National Water Information System (NWIS) database. The results of the studies are used by researchers, regulatory and managerial agencies, and civic groups (Bartholomay e al. 2021).

In its broadest sense, ‘quality assurance’ refers to doing the job right the first time. It includes the functions of planning for products, review and acceptance of the products, and an audit designed to evaluate the system that produces the products. Quality control and quality assurance differ in that quality control ensures that things are done correctly given the ‘state-of-the-art’ technology, and quality assurance ensures that quality control is maintained within specified limits.

6.10.5 ObsNetQW, Assessment of a Water-Quality Aquifer Monitoring Network

The establishment of an efficient aquifer water-quality aquifer monitoring network is a critical component in the assessment and protection of groundwater quality. A periodic evaluation of the monitoring network is mandatory to ensure effective data collection and possible redesigning of existing network. This R package assesses the efficacy and appropriateness of an existing water-quality aquifer monitoring network in the eastern Idaho Snake River Plain aquifer (Fisher 2021a). This software is the companion to two USGS publications:

- Fisher, J. C., R. C. Bartholomay, G. W. Rattray, and N. V. Maimer, 2021, Optimization of the Idaho National Laboratory water-quality aquifer monitoring network, southeastern Idaho: U.S. Geological Survey Scientific Investigations Report 2021-5031 (DOE/ID-22252), 63 p., https://doi.org/10.3133/sir20215031.
- Fisher, J. C., 2020, INLDATA—Collection of datasets for the U.S. Geological Survey-Idaho National Laboratory Aquifer Monitoring Networks: U.S. Geological Survey software release, R package, Reston, Va., https://doi.org/10.5066/P9PP9UXZ.

6.10.6 INLPUBS, Bibliographic Information for the USGS INL Project Office

The R package, inlpubs, may be used to search and analyze 366 publications that cover the 74-year history of the USGS, Idaho Water Science Center, Idaho National Laboratory Project Office (INLPO). The INLPO publications were authored by 253 researchers trying to better understand the effects of waste disposal on water contained in the eastern Idaho Snake River Plain aquifer and the availability of water for long-term consumptive and industrial use. Information contained within these publications is crucial to the management and use of the aquifer by INL and the State of Idaho. USGS geohydrologic studies and monitoring, which began in 1949, were done in cooperation with the DOE–Idaho Operations Office (Fisher 2021b).

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