

# **DEQ-INL Oversight Program Annual Report 2019**



**DEPARTMENT OF ENVIRONMENTAL QUALITY  
IDAHO NATIONAL LABORATORY OVERSIGHT PROGRAM**

## **INL Oversight Office**

Idaho Falls Office  
900 N. Skyline, Suite B  
Idaho Falls, Idaho 83402  
Phone: (208) 528-2600  
Fax: (208) 528-2605

# Table of Contents

Idaho's INL Oversight Mission .....	1
Environmental Surveillance Program .....	1
Monitoring Results.....	2
Trends .....	3
Comparison with DOE Data .....	3
Air Monitoring.....	3
Air Monitoring Equipment and Procedures .....	6
Air Monitoring Results and Trends.....	7
Particulate Matter in Air.....	7
Atmospheric Tritium .....	8
Gaseous Radioiodine.....	8
Precipitation .....	8
Air Monitoring Verification Results .....	8
Air Monitoring Impacts and Conclusions .....	9
Radiation Monitoring.....	10
Radiation Monitoring Equipment and Procedures .....	10
Radiation Monitoring Results and Trends .....	11
Radiation Monitoring Verification Results .....	12
Radiation Monitoring Impacts and Conclusions .....	12
Groundwater Monitoring .....	12
Sample Locations .....	13
Groundwater Monitoring Equipment and Procedures.....	14
Analyses .....	15
Water Monitoring Results and Trends .....	19
Gross Alpha and Gross Beta Radioactivity.....	22
Tritium ( <sup>3</sup> H).....	22
Strontium-90 ( <sup>90</sup> Sr).....	25
Technetium-99 ( <sup>99</sup> Tc).....	29
Cesium - 137 .....	31
Uranium Isotopes .....	32
Plutonium Isotopes and Americium-241.....	32
Chloride, Sulfate, and Nitrate.....	33
Chromium.....	34
Arsenic, Iron, Manganese and Selenium.....	36
Volatile Organic Compounds.....	37
Verification of Co-sampler Results.....	39
Groundwater Monitoring Impacts and Conclusions .....	41
Terrestrial Monitoring.....	41
Terrestrial Monitoring Equipment and Procedures .....	41
Terrestrial Monitoring Results and Trends .....	42
Terrestrial Monitoring Verification Results .....	43
Terrestrial Monitoring Impacts and Conclusions.....	43
Quality Assurance for the ESP .....	43
Data Assessment Summary.....	43
Issues and Problems .....	44
Comparing Data .....	44

Radiological Emergency Response Planning and Preparedness .....	45
Non-INL Radiological Activities.....	46
Drills and Exercises .....	46
Waste Isolation Pilot Plant Shipment Safety .....	46
Emergency Response .....	46
Planning and Preparedness Meetings .....	47
Classes and Presentations .....	47
Public Outreach.....	47
Publications .....	47
Presentations and Events.....	47
Community Monitoring Network .....	50



## List of Figures

Figure 1. Locations of selected DEQ monitoring sites. ....	4
Figure 2. Off-site DEQ continuous air monitoring station. ....	4
Figure 3. On-site DEQ continuous air monitoring station. ....	5
Figure 4. DEQ air monitoring station with a radioiodine sampler, an atmospheric moisture sampler, a precipitation sampler, and two total suspended particulate (TSP) matter samplers. ....	6
Figure 5. Collecting an electret ionization chamber (EIC) and deploying a new one. ....	10
Figure 6. Locations of HPIC/EcoGamma and EIC monitoring sites. ....	11
Figure 7. Water quality monitoring sites distant from the INL sampled in 2019. ....	16
Figure 8. Water quality monitoring sites on and near the INL sampled in 2019. ....	17
Figure 9. Collecting water samples at a distant well. ....	18
Figure 10. Water sampling in Magic Valley. ....	18
Figure 11. Tritium concentrations (pCi/L) over time for selected facility wells. ....	24
Figure 12. Tritium concentrations for DEQ sample locations in 2019 in and around the INL. ....	25
Figure 13. Strontium-90 concentrations over time for selected wells at TAN. ....	27
Figure 14. Strontium-90 concentrations over time for selected wells at INTEC and ATR. ....	28
Figure 15. Aquifer strontium-90 concentrations for DEQ sample locations in 2019 in and around the INL. ....	29
Figure 16. Technetium-99 concentrations over time for selected wells at INTEC. ....	30
Figure 17. Technetium-99 concentrations over time for selected wells at or downgradient of INTEC. ....	30
Figure 18. Technetium-99 concentrations for DEQ sample locations in 2019. ....	31
Figure 19. Chromium concentrations (µg/L) over time for selected aquifer wells at ATR and INTEC. ....	35
Figure 20. Chromium concentrations for DEQ sample locations in 2019 in and around the INL. ....	36
Figure 21. TCE concentrations (µg/L) over time for selected wells located in the medial zone at TAN. ....	38
Figure 22. Carbon Tetrachloride concentrations (µg/L) over time for selected wells at RWMC. ....	39
Figure 23. <i>In-situ</i> soil monitoring sites for 2019. ....	42
Figure 24. Water Awareness Poetry Contest 2019 on display at the Idaho Falls Library. ....	48
Figure 25. DEQ teaching Macroinvertebrate Mayhem at Mackay Water Festival 2019. ....	48
Figure 26. Children participating in the Edible Aquifer activity at the 2019 Earth Day event. ....	49
Figure 27. DEQ staff handing out give-away items at the 2019 Earth Day event. ....	49
Figure 28. Idaho Falls Community monitoring station at the Greenbelt. ....	50

## List of Tables

Table 1. Gross alpha and beta screening ranges, means, and medians observed by DEQ-INL Oversight Program for 2019. ....	7
Table 2. Comparison of DEQ suspended particulate matter analysis results for paired samples with ESER and BEA results in 2019. ....	9
Table 3. Comparison of DEQ with ESER, and DEQ with BEA radiation measurements at co-located sites in 2019. (Units in micro-Roentgen per hour or $\mu\text{R/hr}$ ) .....	12
Table 4. Maximum reported concentration for each analyte in each water sample location group in 2019. ....	20
Table 5. Comparison of DEQ-INL OP's sample results with those of co-sampling organizations in 2019.. ....	40

## Table of Acronyms and Abbreviations

aCi/m <sup>3</sup>	attocuries per cubic meter	ESP	Environmental Surveillance Program
AMWTP	Advanced Mixed Waste Treatment Project	ESRPA	Eastern Snake River Plain Aquifer
ATR	Advanced Test Reactor	fCi/m <sup>3</sup>	femtocuries per cubic meter
BEA	Battelle Energy Alliance, LLC	FDA	Food and Drug Administration
BHS	Bureau of Homeland Security	ft bgs	feet below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	HEPA	High Efficiency Particulate Air Filter
CFA	Central Facilities Area	HAD	Hazard Assessment Document
CFR	Code of Federal Regulations	HPIC	High-Pressure Ion Chamber
DEQ	Idaho Department of Environmental Quality	IBHS	Idaho Bureau of Homeland Security
DEQ-INL OP	Idaho Department of Environmental Quality, Idaho National Laboratory Oversight Program	IBS	Idaho Bureau of Laboratories
DOE	U.S. Department of Energy	ICP	Idaho Cleanup Project
EA	Environmental Assessment	INL	Idaho National Laboratory
EBR II	Experimental Breeder Reactor II	INTEC	Idaho Nuclear Technology and Engineering Center
EM	Environmental Management	IOEM	Idaho Office of Emergency Management
EIC	Electret Ionization Chamber	ISFF	Idaho Spent Fuel Facility
EIS	Environmental Impact Statement	ISP	Idaho State Police
EML	Environmental Monitoring Laboratory	ISU	Idaho State University
EOC	Emergency Operations Center	LEPC	Local Emergency Planning Committee
EOMA	Environmental Oversight and Monitoring Agreement	LLD	Lower Limit of Detection
EPA	Environmental Protection Agency	MCL	Maximum Contaminant Level
ESER	Environmental Surveillance, Education and Research Program	MFC	Materials and Fuels Complex
		µg/L	micrograms per liter
		µR/hr	microRoentgen per hour
		mg/L	milligrams per liter
		mrem	millirem or 1/1000 <sup>th</sup> of a rem

mR/hr	milliRoentgen per hour	RASCAL	Radiological Assessment System for Consequence Analysis
MDA	Minimum Detectable Activity	RPD	Relative Percent Difference
MDC	Minimum Detectable Concentration	RCRA	Resource Conservation and Recovery Act
MV	Magic Valley	RTC	Reactor Technology Complex
NCRP	National Council on Radiation Protection and Measurements	RWMC	Radioactive Waste Management Complex
NIST	National Institute of Standards and Technology	SD	Standard Deviation
nCi/L	nanocuries per liter	SDA	Subsurface Disposal Area
NOAA	National Oceanic and Atmospheric Administration	SI	International System of Units
NRC	Nuclear Regulatory Commission	SMCL	Secondary Maximum Contaminant Level
NRF	Naval Reactors Facility	TAG	Technical Advisory Group (WIPP)
ORPS	Occurrence Reporting and Processing System	TAN	Test Area North
OSLD	Optically Stimulated Luminescent Dosimeter	TCE	Trichloroethylene
pCi/g	picocuries per gram	TDS	Total Dissolved Solids
pCi/L	picocuries per liter	TRU	Transuranic
pCi/m <sup>3</sup>	picocuries per cubic meter	TSA	Transuranic Storage Area
PCE	Tetrachloroethylene	TSP	Total Suspended Particulate
QAPP	Quality Assurance Program Plan	TSS	Total Suspended Solids
QA/QC	Quality Assurance/Quality Control	USGS	U.S. Geological Survey
RAP	Radiological Assistance Program	VOC	Volatile Organic Compound
RAPTER	Radiological Assistance Program Training for Emergency Response	WGA	Western Governors Association
		WIPP	Waste Isolation Pilot Plant
		WMD	Weapon(s) of Mass Destruction

SI Prefixes				
Prefix	Symbol	Meaning	Multiplier (Numerical)	Multiplier (Exponential)
tera	T	trillion	1 000 000 000 000	$10^{12}$
giga	G	billion	1 000 000 000	$10^9$
mega	M	million	1 000 000	$10^6$
kilo	k	thousand	1 000	$10^3$
hecto	h	hundred	100	$10^2$
deka	da	ten	10	$10^1$
deci	d	tenth	0.1	$10^{-1}$
centi	c	hundredth	0.01	$10^{-2}$
milli	m	thousandth	0.001	$10^{-3}$
micro	$\mu$	millionth	0.000 001	$10^{-6}$
nano	n	billionth	0.000 000 001	$10^{-9}$
pico	p	trillionth	0.000 000 000 001	$10^{-12}$
femto	f	quadrillionth	0.000 000 000 000 001	$10^{-15}$
atto	a	quintillionth	0.000 000 000 000 000 001	$10^{-18}$

# Idaho's INL Oversight Mission

For more than half a century, the Idaho National Laboratory (INL) Site, operated by the Department of Energy (DOE) and its contractors, has been home to research and development of nuclear technology. The work performed at INL addressed the nation's interests in establishing nuclear reactors as a viable source of energy for civilian and military applications. Beginning in the 1950s, numerous facilities were constructed at INL to study all aspects of the nuclear fuel cycle, including fuel testing, reprocessing, and reactor prototype safety testing. The INL consequently became a site for management of spent reactor fuel (primarily from naval reactors), and radioactive and mixed wastes. Covering almost 900 square miles of the Snake River Plain and located 40 miles west of Idaho Falls, Idaho, the INL was well-suited for these activities. In the late 1980s, environmental management became a major part of the INL's mission. DOE initiated projects to decontaminate and decommission aging facilities, remove waste, and perform environmental cleanup and restoration.

In 1989, the Idaho Legislature established an INL oversight program to provide citizens with independent information and analysis related to the INL Site. In 2007, legislation was enacted to confirm DEQ as the agency responsible for the INL Oversight Program (DEQ-INL OP), which verifies that INL Site activities are protective of public health and the environment. Our staff has expertise in radiation protection, hydrogeology, engineering, ecology, biology, computer science, education, and communications. We serve our fellow Idahoans by:

- Monitoring the environment on and around the INL Site.
- Preparing for emergencies involving radioactive materials.
- Keeping the public informed about INL Site activities.

The purpose of this report is to provide a summary of the activities performed by DEQ during 2019. The report is divided into sections covering the Environmental Surveillance Program (ESP), Radiological Emergency Response Planning and Preparedness, and Public Outreach.

## Environmental Surveillance Program

DEQ provides independent environmental monitoring of the INL site for the citizens of Idaho through a multifaceted program of environmental media measurements. Measurements are made at locations on and near the INL Site, including population centers close to the INL Site boundary, and at relatively distant locations in southeast and south central Idaho. DEQ scientists use their data to evaluate public and environmental safety, and to verify monitoring of ambient environmental radiation and radioactivity in air, water, soil, and milk performed by DOE contractors. Currently, DOE funds environmental surveillance through contracts with Veolia, the United States Geological Survey (USGS), Idaho Cleanup Project Core (ICP) contractor (Fluor LLC), and the prime INL contractor, Battelle Energy Alliance, LLC (BEA). Veolia conducts the Environmental Surveillance, Education and Research (ESER) program, which performs environmental surveillance outside the INL site boundary – BEA performs surveillance within the INL site.

In order to present sampling results to the public and interested agencies, DEQ publishes quarterly and annual reports. Each quarterly report contains detailed data and results of the DEQ

environmental monitoring program. Annual reports summarize the quarterly data, identify general trends in the concentrations of major contaminants found in and around the INL Site, assess the impacts of DOE operations on the environment, and evaluate the reliability of DOE-contracted monitoring programs.

## Monitoring Results

In 2019, DEQ conducted monitoring to measure environmental radiation levels and radioactivity in air, water, milk, and soil on and around the INL Site. Radioactivity levels found in air, soil, and milk samples were typical of background values. Tritium in groundwater was detected at a concentration above background in the vicinity of the southern INL boundary. No sites monitored by DEQ exceed federal drinking water standards for tritium.

Concentrations of tritium at the INL continue to decline site-wide. No other contaminants attributable to INL Site operations were identified in groundwater samples collected outside of the INL Site.

Environmental measurements made by DEQ within the INL Site in 2019 were consistent with past results. Water samples collected from on-site locations near INL Site facilities identified concentrations of  $^{90}\text{Sr}$  (strontium-90),  $^{99}\text{Tc}$  (technetium-99), chloride, manganese, iron, total nitrate/nitrite (as nitrogen), and some volatile organic compounds (VOCs) greater than drinking water standards. These contaminants were found in known INL contaminant plumes and at levels consistent with historic trends for the sampling locations. These water sources are not used by the public or INL Site workers.

Other contaminants from historic INL Site operations were identified in water, but at concentrations less than drinking water standards and within expected levels.

Tritium was occasionally detected in atmospheric moisture samples collected from both on-site and off-site monitoring locations. When detected these levels were less than one percent of EPA regulatory limits. Environmental screening measurements of gross alpha and beta radioactivity in air and direct radiation were typical of background levels at all sites. Several of the specific radionuclide analyses of composite air samples resulted in statistical detections of man-made

### Did You Know?

The amount of radioactivity in the environment is measured using terms that describe how often the material undergoes radioactive decay.

A **curie** is a unit of radioactivity, symbolized as Ci, equal to  $3.7 \times 10^{10}$  disintegrations or nuclear transformations per second. This is approximately the amount of radioactivity emitted by one gram (1g) of radium-226. The unit is named after Pierre Curie, a French physicist.

Fractions of curie are typically used to define small amounts of radioactivity. For example:

**milli** - millicurie is one one-thousandth of a curie

**micro** - microcurie is one one-millionth of a curie

**nano** - nanocurie is one one-billionth of a curie

**pico** - picocurie is one one-trillionth of a curie

**femto** - femtocurie is one-quadrillionth of a curie

**atto** - attocurie is one-quintillionth of a curie

Multiplication Factor	Prefix	Symbol
$0.001 = 10^{-3}$	milli	m
$0.000001 = 10^{-6}$	micro	$\mu$
$0.000000001 = 10^{-9}$	nano	n
$0.000000000001 = 10^{-12}$	pico	p
$0.000000000000001 = 10^{-15}$	femto	f
$0.000000000000000001 = 10^{-18}$	atto	a

radionuclides at concentrations much less than one percent of the federal standards for members of the public. Radioactivity in the terrestrial environment and food chain remained at background levels, based on soil and milk sampling results.

## ***Trends***

Results for 2019 monitoring in terrestrial media and air were generally consistent with historic trends. Radiation levels were consistent with historic background measurements. Concentrations of <sup>90</sup>Sr, <sup>99</sup>Tc, chloride, manganese, iron, nitrate plus nitrite, and some VOCs exceeded federal drinking water standards at locations on the INL in 2019. Tritium concentration in groundwater continues to decline. Gross beta radioactivity in groundwater at all locations followed trends for <sup>90</sup>Sr and <sup>99</sup>Tc. The concentrations of some contaminants in groundwater (such as <sup>99</sup>Tc and VOCs) showed trends that were not as clearly understood, possibly resulting from changes in INL operations and cleanup efforts. Tritium concentrations in atmospheric moisture remained consistent over time.

## ***Comparison with DOE Data***

In general, there is satisfactory agreement between the environmental monitoring data reported by DEQ and the DOE. This level of comparability between DEQ and DOE confirms that both programs present reasonable representations of the state of the environment surrounding the INL. This helps to foster public confidence in both the State's and DOE's monitoring programs and in the conclusions drawn from their monitoring.

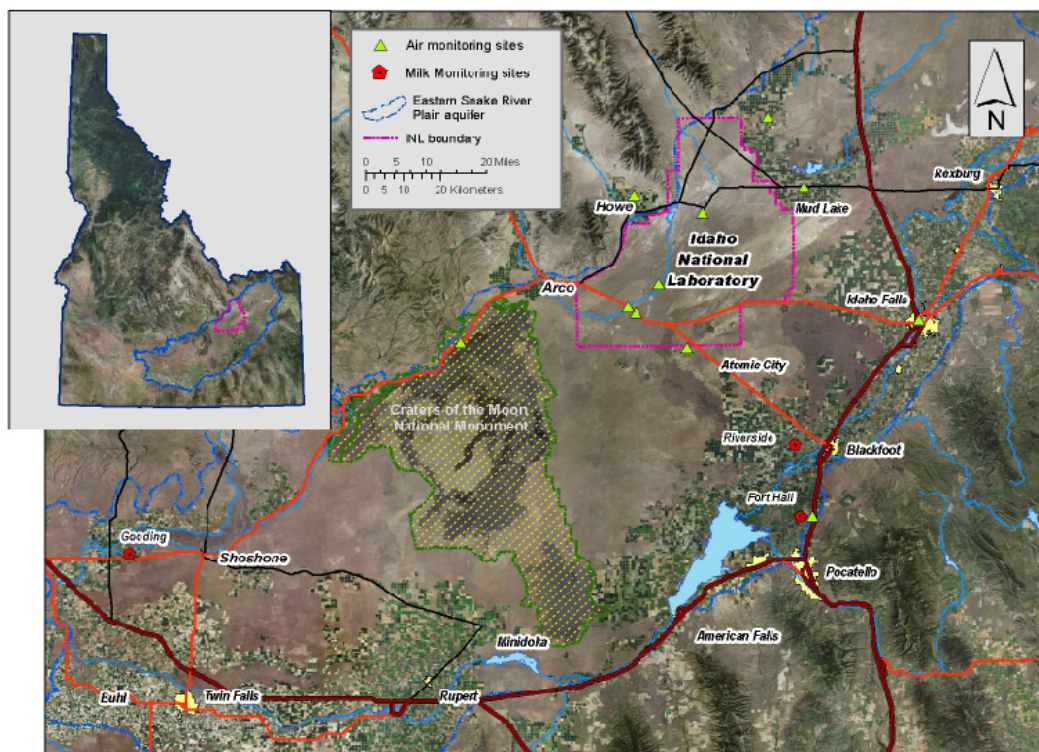
In the pages that follow, the results of DEQ's monitoring for each type of media (air, radiation, water, soil, and milk) are discussed in greater detail.

## ***Air Monitoring***

Continuous air monitoring is conducted at 11 locations to monitor concentrations of radionuclides in the atmosphere. These 11 locations include one air monitoring station operated by the Shoshone-Bannock Tribes at Fort Hall, Idaho.

Air monitoring locations (and other selected DEQ monitoring sites) are shown in **Figure 1** and continuous air monitoring stations are pictured in **Figures 2 and 3**.





**Figure 1. Locations of selected DEQ monitoring sites.**



**Figure 2. Off-site DEQ continuous air monitoring station.**



Air monitoring stations are segregated into three categories by location:

- On-site stations are located within the INL boundary and include Experimental Field Station, Van Buren Avenue, Highway 20 (Big Lost River) Rest Area, and Sand Dunes/INL Gate 4.
- Off-site stations are located near the INL boundary and include Mud Lake, Montevideo, Howe, and Atomic City.
- Distant background stations are located at the Craters of the Moon visitor center, Idaho Falls, and Fort Hall. Measurements at distant locations characterize the regional background conditions for comparison with conditions at on- and off-site stations.



**Figure 3. On-site DEQ continuous air monitoring station.**

Particulate air samples (filters) and radioactive iodine gas samples (charcoal cartridges) are collected weekly to monitor short-term radiological conditions in the environment. Atmospheric moisture is also collected continuously to measure tritium concentrations present in the air. Finally, precipitation samples are collected at six locations to monitor for tritium and gamma-emitting radionuclides that may be present in the environment. A DEQ air monitoring station with all four types of sampling equipment is pictured in **Figure 4**.



**Figure 4. DEQ air monitoring station with a radioiodine sampler, an atmospheric moisture sampler, a precipitation sampler, and two total suspended particulate (TSP) matter samplers.**

In order to verify results, data collected by DEQ at some air monitoring stations are directly compared to the air monitoring results obtained by the DOE and its contractors at co-located sample sites.

### **Air Monitoring Equipment and Procedures**

Particulate matter is collected on filters using high-volume total suspended particulate (TSP) matter air samplers. The filters are collected weekly and are analyzed for gross alpha and gross beta radioactivity. Air concentrations are calculated based upon the amount of radioactivity on the filter divided by the volume of air that has passed through the filter. Quarterly composite samples of all TSP filters collected from each location are analyzed for gamma-emitting radionuclides. Yearly composite samples of all TSP filters collected from each location are analyzed via radiochemical separation for  $^{90}\text{Sr}$  (strontium-90),  $^{241}\text{Am}$  (americium-241),  $^{238}\text{Pu}$  (plutonium-238), and  $^{239/240}\text{Pu}$  (plutonium-239/plutonium-240).

Radioactive iodine (radioiodine) samples are collected weekly. Samples are collected by drawing air through a canister filled with activated charcoal, using a low-volume air pump. The activated charcoal contained in the canister traps the radioiodine by adsorption onto its porous surface. Each week, canisters are collected from all 11 air monitoring stations and analyzed together as a group. If radioiodine is detected in this grouping, the canisters are individually analyzed.

Atmospheric moisture is collected by drawing air through a column filled with molecular sieve beads (a desiccant or water-absorbing material). Upon saturation with moisture, the column is removed and the beads are heated, causing them to release their stored moisture. This moisture is then condensed and collected as water, and subsequently analyzed for tritium.

Precipitation samples are obtained at each location using a collection tray that is heated during the winter months. The sample flows from the tray into a 5-gallon container that is collected at the end of each calendar quarter or whenever it is full. The precipitation samples are analyzed for tritium and for gamma-emitting nuclides.

All samples collected from DEQ's air monitoring program are analyzed by the Idaho State University Environmental Monitoring Laboratory (ISU-EML) or its subcontractor(s). Analysis methods used are consistent with industry standards.

## Air Monitoring Results and Trends

The following sections include monitoring results and trends for air monitoring.

### Particulate Matter in Air

A total of 594 filters from TSP samplers were collected during 2019. The results from the analyses of off-site location samples were indistinguishable from those of on-site locations. All gross alpha and beta screening results during 2019 were less than the DEQ action levels for prompt response to elevated air screening measurements. Gross alpha/beta results are summarized in **Table 1**.

**Table 1. Gross alpha and beta screening ranges, means, and medians observed by DEQ-INL Oversight Program for 2019.**

DEQ-INL Oversight Program	Gross Alpha Range (fCi/m <sup>3</sup> ) <sup>a</sup>	Gross Alpha Mean $\pm 2SD$ and Median (fCi/m <sup>3</sup> )	Gross Beta Range (fCi/m <sup>3</sup> )	Gross Beta Mean $\pm 2SD$ and Median (fCi/m <sup>3</sup> )
2019	0.1 to 3.3	0.9 $\pm$ 0.1 (Median = 0.8)	6.9 to 167.8	30.3 $\pm$ 1.3 (Median = 27.4)

a. fCi/m<sup>3</sup> – femto ( $10^{-15}$ ) curies per cubic meter.

Radiochemical analysis of the annual TSP filter composite samples resulted in detection of <sup>90</sup>Sr at all eleven station locations. Values ranged from  $9.0 \pm 3.8$  attocuries<sup>1</sup> per cubic meter (aCi/m<sup>3</sup>) at the Sand Dunes station to  $148.4 \pm 36.6$  aCi/m<sup>3</sup> at the Experimental Field Station.

Four results exceeded the <sup>238</sup>Pu MDC, with values ranging from  $0.2 \pm 0.2$  aCi/m<sup>3</sup> at Craters of the Moon to  $0.3 \pm 0.2$  aCi/m<sup>3</sup> at Montevue, Mud Lake, and Van Buren stations. Eight results exceeded the <sup>239/240</sup>Pu MDC at Atomic City, Craters of the Moon, Experimental Field Station, Fort Hall, Idaho Falls, Mud Lake, Big Lost River Rest Area, and Van Buren stations. Values

---

<sup>1</sup> An attocurie is  $10^{-18}$  curies, or 1/1000<sup>th</sup> of a femtocurie.



ranged from  $0.3 \pm 0.2$  aCi/m<sup>3</sup> at Big Lost River Rest Area to  $0.7 \pm 0.5$  aCi/m<sup>3</sup> at the Experimental Field Station. One result exceeded the <sup>241</sup>Am MDC at the Fort Hall station with a value of  $0.4 \pm 0.2$  aCi/m<sup>3</sup>.

These values are within the expected range due to global fallout from historic above-ground nuclear weapons testing. The reported concentrations are well under DEQ-INL OP's action levels and less than one percent of the federal regulatory limit for <sup>90</sup>Sr of 19000 aCi/m<sup>3</sup>, <sup>239/240</sup>Pu of 2000 aCi/m<sup>3</sup>, <sup>238</sup>Pu of 2100 aCi/m<sup>3</sup>, and 1900 for <sup>241</sup>Am (40 CFR 61).

Composites of filters collected using TSP samplers during the course of a calendar quarter are analyzed using gamma spectroscopy. The only detected manmade gamma-emitting radionuclide was <sup>137</sup>Cs, detected in the third quarter composite at the Experimental Field Station, with a value of  $0.13 \pm 0.05$  fCi/m<sup>3</sup> (MDC = 0.07 fCi/m<sup>3</sup>.) This result is well below the federal regulatory limit and the DEQ-INL OP action level.

### **Atmospheric Tritium**

A total of 110 atmospheric moisture samples were collected in 2019 from 11 monitoring locations and analyzed for tritium. Detectable airborne tritium concentrations are occasionally observed in the environment. The highest airborne tritium concentrations observed by DEQ on the INL in 2019 were  $1.39 \pm 0.46$  pCi/m<sup>3</sup> (MDC = 0.67 pCi/m<sup>3</sup>) at the Experimental Field Station for the time period of March 26 through April 25,  $1.04 \pm 0.47$  pCi/m<sup>3</sup> (MDC = 0.71 pCi/m<sup>3</sup>) at Van Buren Avenue for the time period of April 25 through June 4,  $0.82 \pm 0.53$  pCi/m<sup>3</sup> (MDC = 0.84 pCi/m<sup>3</sup>) at the Big Lost River Rest Area station for the time period of May 23 through June 24, and  $0.39 \pm 0.36$  pCi/m<sup>3</sup> (MDC = 0.58 pCi/m<sup>3</sup>) at the Sand Dunes station for the time period of May 16 through June 13.

All atmospheric tritium measurements for 2019 were significantly lower than one percent of the concentration for compliance with federal regulations (40 CFR 61), 1500 pCi/m<sup>3</sup>. Tritium levels were at or near background levels at all locations.

### **Gaseous Radioiodine**

No gaseous radioiodine was detected by DEQ in 2019.

### **Precipitation**

No tritium or manmade gamma-emitting radionuclides were detected by DEQ in precipitation samples at any location throughout the year.

### **Air Monitoring Verification Results**

Gross alpha and beta particle results for suspended particulate matter samples from monitoring stations used by DEQ are compared with results from co-located stations operated by the Environmental Surveillance, Education and Research Program (ESER) and by Battelle Energy Alliance (BEA). As a convention, paired sample results are taken to agree if they differ from each other by no more than 20 percent of their average value, or to within 3 times the combined

uncertainty of the two measurements. Agreement between 80% of the paired samples is considered to indicate overall statistical agreement between the data sets of the programs being compared. Another test of agreement is to determine if the conclusions relevant to public health drawn from the results of one program differ from those drawn from the results of another program.

For 2019, 100% of BEA's gross alpha results and 72% of their gross beta results were in agreement with DEQ's results, indicating overall statistical agreement between DEQ's and BEA's gross alpha data sets. However the BEA and DEQ gross beta data sets were not in overall statistical agreement (**Table 2**). Gross alpha and gross beta data sets of ESER and DEQ were not in overall statistical agreement. Variations in sampling schedule, equipment configuration and random uncertainty may contribute to observed differences. It is important to recognize that gross alpha and beta particle measurements are a screening method and do not represent quantitative measurement of specific radionuclides.

The results do agree in the important sense that all measurements from the three monitoring organizations are several orders of magnitude below the most restrictive regulatory limit for radionuclides of concern from the INL. The results from all three monitoring agencies indicate that there is no public health risk.

**Table 2. Comparison of DEQ suspended particulate matter analysis results for paired samples with ESER and BEA results in 2019.**

(Results are presented as percentage of samples that agree within 20 percent or 3 times the combined uncertainty.)

Sampling Agency	ESER Veolia <sup>a</sup>	BEA <sup>b</sup>
DEQ - Gross Alpha Analysis	69 %	100%
DEQ - Gross Beta Analysis	46 %	72%

a. ESER – Environmental Surveillance, Education and Research [Program], conducted by INL contractor Veolia.

b. BEA – Battelle Energy Alliance, INL prime contractor during 2019.

Comparing tritium sample results among DEQ, ESER, and BEA is problematic because although sampling sites are co-located, samples are not paired or split samples. Each monitoring agency collects its tritium sample when the desiccant material becomes saturated with moisture; therefore the sampling frequency is dependent on the volume of desiccant used and the sampler flow rate resulting in differences and overlaps in sampling schedules throughout the year. Also, most of the results are near or below the MDC, where statistical uncertainties are relatively high. These factors make a direct one-to-one comparison of results not possible. However, all the results agree in that the maximum measured concentrations are about 3 orders of magnitude below the regulatory limit. Results from all three monitoring agencies indicate no public health risk.

## Air Monitoring Impacts and Conclusions

Based upon 2019 air quality measurements, DEQ concludes that there are no discernable impacts to off-site locations as a result of INL operations. The results of screening analyses performed on particulate filters collected at boundary locations are consistent with the results obtained from background locations. Several of the specific radionuclide analyses of composite air samples resulted in statistical detections of human-made radionuclides at concentration much less than

1% of the federal standard for members of the public (40CFR61).

Atmospheric moisture and precipitation sampling by all three agencies has occasionally shown detectable quantities of tritium in the environment; however, all detected quantities are well below federal regulatory limits and indicate no risk to public health.

Overall, DEQ and DOE contractor air monitoring results are considered to be in agreement based on (1) direct statistical comparison or, (2) because each organization's results support the conclusion that environmental concentrations are well below regulatory limits and pose no health concerns for the citizens of Idaho.

## ***Radiation Monitoring***

Penetrating radiation is naturally present in the environment due to cosmic sources, and naturally occurring radioactive materials in rock and soil. Human-made sources include nuclear reactor operations and the residual radioactivity present in soil from historic above-ground testing of nuclear weapons. Radiological conditions on the INL and throughout the eastern Snake River Plain are continuously monitored by DEQ. Penetrating radiation is measured at each of DEQ's air monitoring stations, at meteorological towers maintained by the National Oceanic and Atmospheric Administration (NOAA), along roadways that bound or cross the INL, and at background locations far from the INL (**Figure 6**). Co-located radiation monitoring is conducted by DEQ and DOE contractors at a number of locations. DEQ measurements at these locations are compared with the DOE contractors' results to determine whether the data are in agreement.

### **Radiation Monitoring Equipment and Procedures**

DEQ operates real-time radiation exposure rate measurement systems in a network of 11 monitoring stations in the region. One of these monitoring stations is owned by the Shoshone-Bannock Tribes at Fort Hall, Idaho. Real-time radiation exposure measurements are available to the public on the World Wide Web at:

<http://www.deq.idaho.gov/inl-oversight/monitoring/gamma-radiation-measurements.aspx>

Currently, DEQ uses measurement systems incorporating high-pressure ion chamber (HPIC) or EcoGamma dual Geiger-Mueller (GM) detectors, each with associated data recording and remote data reporting equipment. Several years of operational history indicate that the overall reliability and maintainability of the EcoGammas (detector and supporting equipment) is significantly better than the HPIC-based systems, and measurement performance for DEQ's environmental surveillance program is comparable. DEQ plans to place EcoGamma systems at all stations to take advantage of greatly simplified calibration procedures which can be performed by the EML, and improved remote data reporting via cell modems. The use of cell modems provides DEQ with an



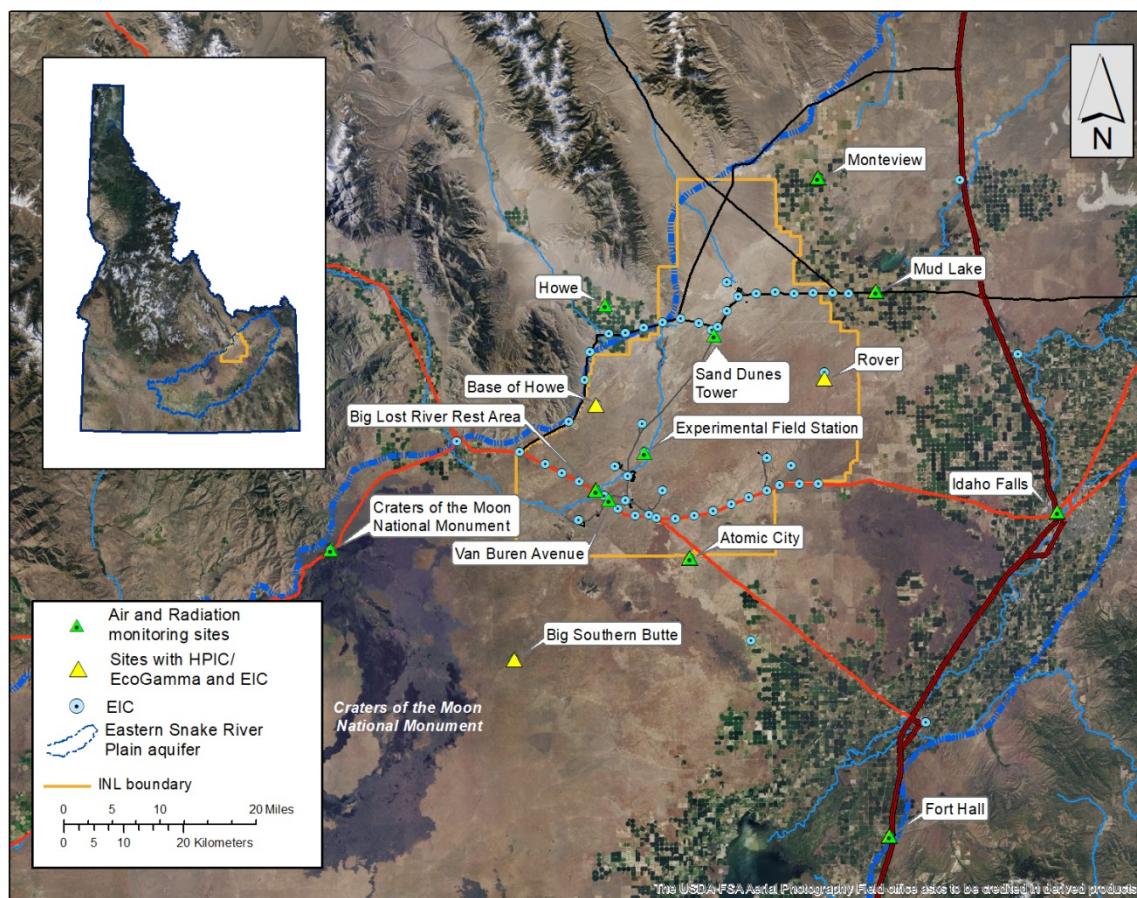
**Figure 5. Collecting an electret ionization chamber (EIC) and deploying a new one.**

independent communication path for remote data acquisition and the capability for remote siting of the systems at locations outside the routine network, if required.

DEQ also uses a network of passive electret ionization chambers (EICs) on and around the INL to measure cumulative radiation exposure over quarterly monitoring periods. The objectives of the DEQ EIC network are to identify baseline (background radiation) levels to use for comparison in the event of an upset condition (accidental release of radioactive material), assess potential dose in the ambient environment, validate dose assessment models, and to verify contractor environmental radiation data. **Figure 5** shows a DEQ staff member collecting an EIC for analysis and deploying a new one.

## Radiation Monitoring Results and Trends

During the course of 2019, EIC and HPIC/EcoGamma measurements performed at locations on the INL were similar to those at off-site monitoring locations and were consistent with expected background radiation exposure associated with cosmic, naturally occurring terrestrial and human-made sources.



**Figure 6. Locations of HPIC/EcoGamma and EIC monitoring sites.**



## Radiation Monitoring Verification Results

DEQ uses EICs at several locations where DOE contractors monitor radiation using optically stimulated luminescent dosimeters (OSLD). Results of the contractors' and DEQ's measurements are used to determine the comparability of the organizations' ambient penetrating radiation measurement programs. During 2019, 82% of BEA's annual average OSLD measurements and 90% of ESER's annual average OSLD measurements were in statistical agreement with DEQ's measurements at co-located EIC sites (**Table 3**), meeting the program's objectives.

**Table 3. Comparison of DEQ with ESER, and DEQ with BEA radiation measurements at co-located sites in 2019. (Units in micro-Roentgen per hour or  $\mu\text{R/hr}$ )**

Statistical Measure	DEQ ( $\mu\text{R/hr}$ )	ESER <sup>a</sup> ( $\mu\text{R/hr}$ )	DEQ ( $\mu\text{R/hr}$ )	BEA <sup>b</sup> ( $\mu\text{R/hr}$ )
Mean	12.1	14.9	12.6	14.6
Median	11.9	14.7	12.2	14.5
Standard Deviation	1.2	1.3	1.5	1.0
Minimum	10.1	13.3	10.1	12.5
Maximum	13.9	17.8	15.4	15.9
Average Relative % Difference		-21%		-15%
Percent of results in agreement <sup>c</sup>		90%		82%

a. ESER – Environmental Surveillance, Education and Research [Program], conducted by INL contractor Veolia.

b. BEA – Battelle Energy Alliance, INL prime contractor during 2019.

c. Each organization's dataset is reviewed to ensure that it supports a valid test of comparability of measurements.

## Radiation Monitoring Impacts and Conclusions

Based upon radiation measurements made by DEQ, there were no discernable impacts from INL operations in 2019. Measurements on the INL are comparable to those at background locations. Quarterly averaged HPIC/EcoGamma and EIC exposure measurements during 2019 met DEQ's criterion for agreement. The results from all three monitoring agencies indicate no public health risk from environmental ambient penetrating radiation from both natural and human-made sources.

## Groundwater Monitoring

DEQ-INL OP samples groundwater, wastewater, and surface water from locations within, upgradient of, and downgradient of the INL Site to monitor the effects of past and present INL activities on water quality in the eastern Snake River Plain aquifer (ESRPA).

The ESRPA is a sole-source aquifer that underlies much of eastern Idaho and provides water to over 300,000 Idahoans. Since the 1950s, the INL has released millions of gallons of wastewater to the aquifer via injection wells, infiltration ponds, and accidental spills and leaks from facilities. The resulting radioactive and chemical contamination of the aquifer is characterized by plumes of tritium, strontium-90, technetium-99, iodine-129, chloride, chromium, nitrate, and

volatile organic compounds that extend south or southwestward from facility complexes toward the southern INL boundary. Above-background concentrations of other radionuclides, trace metals, and volatile organic compounds are commonly detected at isolated locations in the aquifer, as well. Most contaminant detections are at concentrations below federal drinking water standards.

The migration of radioactive and chemical contaminants in the groundwater underlying and downgradient of the INL Site is comprehensively monitored by the United States Geological Survey (USGS) and by DOE contractors for the INL, the Idaho Cleanup Project (ICP), and the Environmental Surveillance, Education, and Research (ESER) program. The goals of DEQ-INL OP's groundwater monitoring activities are to verify and supplement the results and conclusions of other organizations' monitoring programs and provide to the citizens of Idaho a broad and independent assessment of the state of contamination in the ESRPA.

### Sample Locations

DEQ-INL OP selects groundwater monitoring locations based on where other organizations collect samples, where elevated concentrations of INL-sourced contaminants have been found, where INL-sourced contaminants might be expected to appear based on past or present INL operations and waste disposal practices, and where public interest warrants additional monitoring. Most locations—approximately 75-85 per year—are sampled concurrently with another organization (“co-sampled”). Co-sampled locations are mostly on or near the INL Site. The organizations with which DEQ-INL OP co-samples water are:

- USGS
- ICP contractor – currently Fluor Idaho, LLC (Fluor)
- INL contractor – currently Battelle Energy Alliance, LLC (BEA)
- ESER contractor – currently Veolia Nuclear Solutions-Federal Services (Veolia)

DEQ-INL OP samples another 10-15 locations per year independently. Independently sampled locations are primarily in the Magic Valley of south-central Idaho.

Most water samples are collected from aquifer wells or springs where the aquifer water table meets the surface (**Figures 7 and 8**). These wells and springs are categorized into four groups based on their position along a generalized groundwater flow path through the aquifer:

- **Upgradient** sites are wells located upgradient of INL facilities. They are used to monitor background concentrations in the aquifer.
- **Facility** sites are wells located near facility complexes within the INL, including the Advanced Test Reactor complex (ATR), the Central Facilities Area (CFA), the Idaho Nuclear Technology and Engineering Center (INTEC), the Materials and Fuels Complex (MFC), the Naval Reactors Facility (NRF), the Radioactive Waste Management Complex (RWMC), and Test Area North (TAN). Facility sites are located within or immediately downgradient of known areas of contamination and are selected to monitor the concentration and migration of specific contaminants.
- **Boundary** sites are wells situated near the southern boundary of the INL, downgradient of potential sources of INL contamination.

- **Distant** sites are wells and springs located farther downgradient of the INL, primarily in the Magic Valley, and include wells and springs used for agricultural, municipal, domestic, and industrial purposes.

A smaller number of samples are collected from water sources that recharge the aquifer. These locations fall into three groups:

- **Perched groundwater** sites are wells drilled into pockets of perched groundwater underlying INL facilities and overlying the aquifer. Perched groundwater beneath facilities contains water from past or present infiltration ponds or from breaches in disposal wells that were once in use. DEQ-INL OP monitors perched groundwater at ATR.
- **Surface water** sites are sample locations along streams that recharge the ESRPA upstream from the INL Site. Streams sampled include the Big Lost River and Birch Creek.
- **Wastewater** sites are locations at which wastewater effluent flowing to wastewater infiltration ponds and ditches is sampled. DEQ-INL OP samples wastewater sites at ATR.

In 2019, DEQ-INL OP sampled 95 groundwater monitoring sites: 5 upgradient, 43 facility, 19 boundary, 18 distant, 6 perched groundwater, 3 surface water, and 1 wastewater. See **Figures 7 and 8** for specific locations.

## Groundwater Monitoring Equipment and Procedures

Most groundwater samples are collected from wells equipped with submersible pumps or vertical turbine pumps. A few wells are sampled using portable pumps or plastic bailers that are maintained, deployed, and decontaminated by the co-sampler. Seven boundary wells<sup>2</sup> sampled by DEQ are fitted with Westbay<sup>TM</sup> multilevel sampling systems (“Westbay wells”). Westbay wells use artificial barriers placed at specific depths to isolate different permeable layers in the aquifer, allowing samples to be collected from multiple depths in the same well.

At locations that DEQ-INL OP co-samples with the USGS, Fluor, or BEA, including all facility sites and most boundary and upgradient sites, samples are collected in accordance with the co-samplers’ procedures and protocols using equipment provided and operated by the co-sampler. The co-sampler directs all sampling activities, including well purging, and determines the sample time. DEQ-INL OP copies well purging data directly from the co-sampler’s field data sheet and collects samples immediately following the co-sampler.

At locations that DEQ-INL OP samples independently or with Veolia, including all distant sites and one upgradient site, DEQ-INL OP conducts sampling activities in accordance with its own procedures and protocols (**Figures 9 and 10**). Samples collected from private domestic wells, irrigation wells, stock wells, or public supply wells use the existing pump and distribution system. Water samples are collected from a faucet or sample port nearest the well and before any

---

<sup>2</sup> Middle-2051, USGS-103, USGS-105, USGS-108, USGS-131A, USGS-132, USGS-137A.

treatment system. Wells are purged for a minimum of fifteen minutes, and temperature, pH, specific conductance, and dissolved oxygen are measured every three to five minutes during the purge. The well is sampled once the difference between consecutive readings is within 0.5°C for temperature, 0.1 unit for pH, and 5% for specific conductance for three readings.

## Analyses

Monitoring sites are sampled for both radiological and non-radiological constituents of interest. Radiological samples are analyzed at Idaho State University's Environmental Monitoring Lab (ISU-EML) in Pocatello, ID or by a vendor lab chosen by ISU-EML. Non-radiological samples are analyzed by the Idaho Bureau of Laboratories (IBL) in Boise, ID.

All locations are sampled for gross alpha and gross beta radioactivity, gamma-emitting radionuclides<sup>3</sup>, tritium, chloride, nitrate<sup>4</sup>, and chromium. Selected sites are also sampled for specific radionuclides— strontium-90 (<sup>90</sup>Sr), technetium-99 (<sup>99</sup>Tc), iodine-129 (<sup>129</sup>I), uranium isotopes (<sup>234</sup>U, <sup>235</sup>U, and <sup>238</sup>U), plutonium isotopes (<sup>238</sup>Pu, <sup>239/240</sup>Pu), and americium-241 (<sup>241</sup>Am)—other major ions<sup>5</sup>, other trace metals<sup>6</sup>, total phosphorus, and volatile organic compounds (VOCs) based on potential sources of groundwater contamination in the area and the results of past observations. If unexpected levels of radioactivity are detected in gross radioactivity measurements, additional samples will be collected and analyzed for specific radionuclides.

Water samples are preserved in accordance with laboratory requirements. Samples for gross alpha, gross beta, gamma-emitting nuclides, <sup>90</sup>Sr, <sup>234</sup>U, <sup>235</sup>U, <sup>238</sup>U, <sup>238</sup>Pu, <sup>239/240</sup>Pu, <sup>241</sup>Am, trace metals, nitrate-plus-nitrite, and total phosphorus are preserved with acid (HNO<sub>3</sub> or H<sub>2</sub>SO<sub>4</sub>) immediately after sample collection. VOCs are collected in vials already containing acid (HCl).

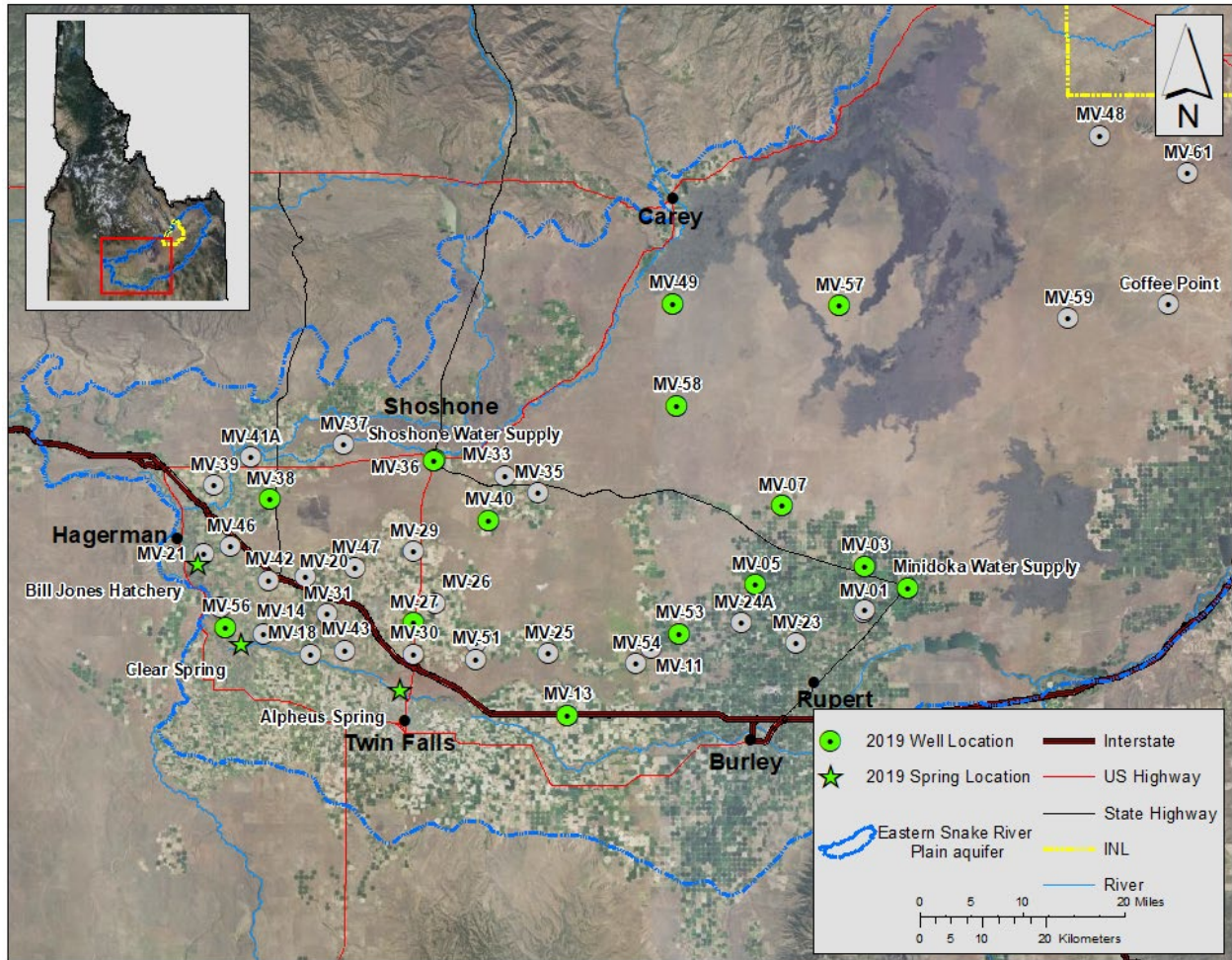
---

<sup>3</sup> All man-made gamma emitting radionuclides detected are reported. At most locations none are detected and only the cesium-137 (<sup>137</sup>Cs) MDA is reported.

<sup>4</sup> DEQ-INL OP samples for nitrate plus nitrite. Since the samples typically contain dissolved oxygen, all nitrogen is assumed to be in the form of nitrate.

<sup>5</sup> Calcium, magnesium, potassium, sodium, fluoride, sulfate, and bicarbonate (reported as alkalinity).

<sup>6</sup> Arsenic, chromium (sampled at all locations), iron, manganese, and selenium.



**Figure 7. Water quality monitoring sites distant from the INL sampled in 2019.**



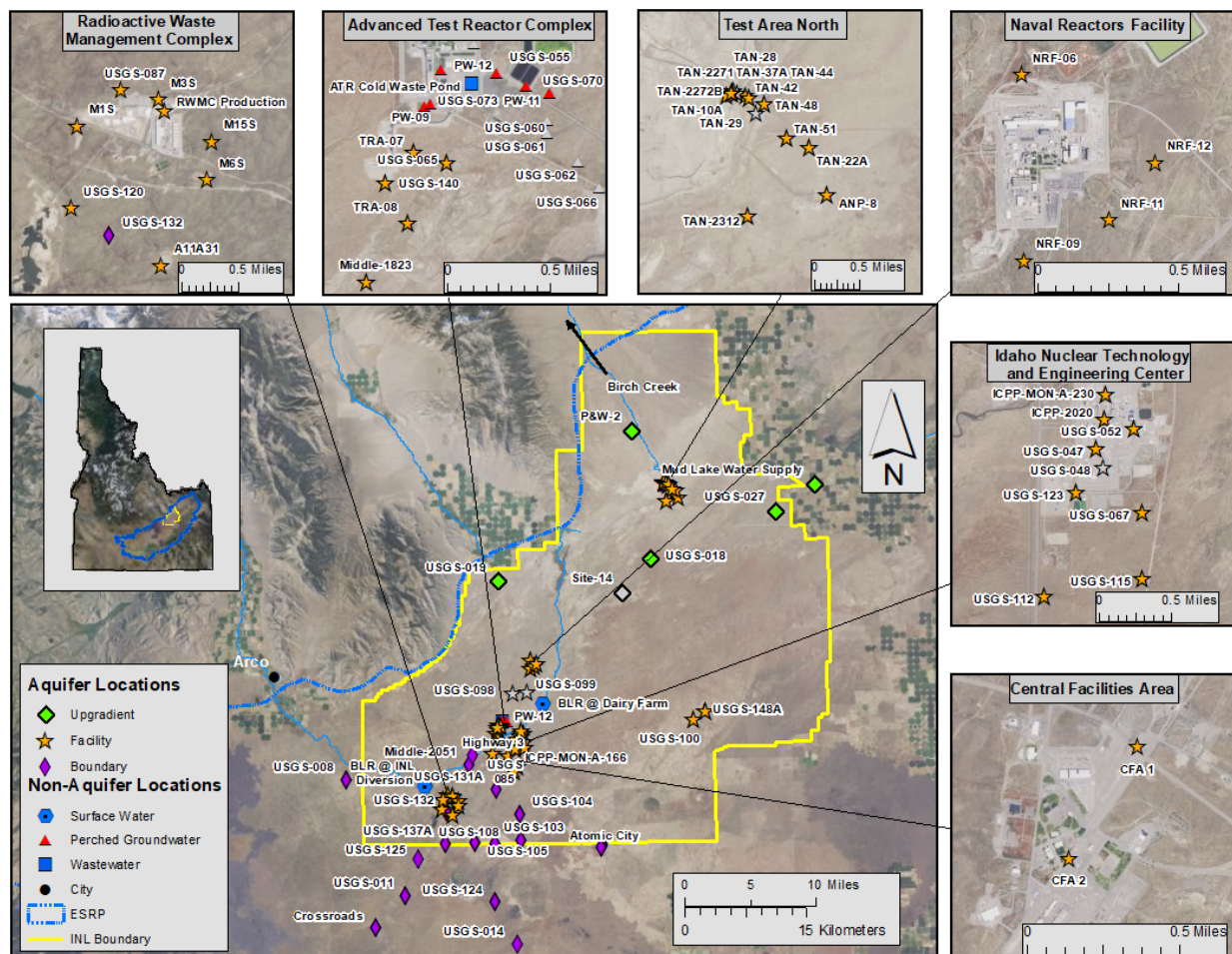


Figure 8. Water quality monitoring sites on and near the INL sampled in 2019.





**Figure 9. Collecting water samples at a distant well.**



**Figure 10. Water sampling in Magic Valley.**

## Water Monitoring Results and Trends

A summary of groundwater constituent concentrations measured in 2019 is presented below. EPA maximum contaminant limits (MCLs) for drinking water are used for comparison throughout this summary. None of the facility or perched groundwater wells and only one of the boundary wells (Atomic City) sampled by DEQ-INL OP are used for drinking water.

**Table 4** shows the maximum concentration for major constituents of concern in each sample location group in 2019. Results for all environmental surveillance samples collected by DEQ-INL OP are available in quarterly data reports on the [DEQ-INL OP website](#).



**Table 4. Maximum reported concentration for each analyte in each water sample location group in 2019.**

Analyte	Samples Collected	Aquifer Locations				Non-aquifer Locations			Background <sup>1</sup>	MCL <sup>2</sup>
		Upgradient	Facility	Boundary	Distant	Surface	Perched GW	Waste		
Radionuclides (pCi/L)										
Gross Alpha	107	5.6 ± 1.3	5.5 ± 1.9	3.9 ± 1.0	2.5 ± 1.2	2.9 ± 1.0	15.0 ± 2.7	<MDC	0-5.6 <sup>a</sup>	15
Gross Beta <sup>3</sup>	107	8.3 ± 1.1	976.1 ± 11.0	4.3 ± 0.9	9.6 ± 1.2	2.8 ± 0.9	126.7 ± 2.9	7.0 ± 2.1	0-8.6 <sup>a</sup>	4 mrem/yr <sup>†</sup>
Tritium <sup>4</sup>	107	<MDC	3900 ± 220	1100 ± 140	<MDC	<MDC	13390 ± 380	<MDC	0-33 <sup>b</sup>	20,000
<sup>90</sup> Sr	33	---	620 ± 150	<MDC	---	---	32.9 ± 7.9	---	0	8
<sup>99</sup> Tc	21	<MDC	1040 ± 170	<MDC	---	---	---	---	0	900
<sup>129</sup> I	0	---	---	---	---	---	---	---	0	1
<sup>137</sup> Cs	107	<MDC	<MDC	<MDC	<MDC	<MDC	<MDC	<MDC	0	200
<sup>234</sup> U	20	---	8.8 ± 1.5	---	---	---	---	---	0.043-1.36 <sup>c</sup>	30 □g/L (total U)
<sup>235</sup> U	20	---	0.41 ± 0.15	---	---	---	---	---	0-0.025 <sup>c</sup>	
<sup>238</sup> U	20	---	1.27 ± 0.29	---	---	---	---	---	0.021-0.541 <sup>c</sup>	
<sup>238</sup> Pu	12	---	<MDC	---	---	---	---	---	0	NA
<sup>239/240</sup> Pu	12	---	<MDC	---	---	---	---	---	0	NA
<sup>241</sup> Am	7	---	<MDC	---	---	---	---	---	0	NA
Anions (mg/L)										
Cl	93	45.9	398	23.9	72.7	5.12	172	38	4.9-11.8 <sup>c</sup>	250*
SO <sub>4</sub>	93	39.6	144	27.8	85.3	25.8	150	444	9.6-21.4 <sup>c</sup>	250*
NO <sub>3</sub> +NO <sub>2</sub>	88	2.5	5.4	1.6	5.9	0.28	21	2.7	<0.04-0.655 <sup>c</sup>	10
Total P	17	0.036	0.83	---	0.044	---	0.3	---	<0.01 – 0.02 <sup>d</sup>	NA
Metals (µg/L)										
As	17	---	2.1	---	2.6	---	8.8	4.8	2 – 3 <sup>e</sup>	10
Cr	85	5.3	79	11	3.5	---	36	12	<1.0 – 5.2 <sup>a</sup>	100
Fe	8	---	3100	---	---	---	---	96	4 – 16 <sup>d</sup>	300*
Mn	8	---	1800	---	---	---	---	3.0	<1 – 4 <sup>d</sup>	50*
Se	3	---	---	---	---	---	---	3.6	<1 <sup>e</sup>	50
Volatile Organic Compounds (µg/L)										
Chloroform	20	---	1.65	---	---	---	---	---	0	70
Carbon tetrachloride	20	---	5.78	---	---	---	---	---	0	5
1,1-DCA <sup>5</sup>	20	---	0.63	---	---	---	---	---	0	NA

1,1-DCE <sup>5</sup>	20	---	0.69	---	---	---	---	---	0	7
cis-1,2-DCE <sup>5</sup>	20	---	50.8	---	---	---	---	---	0	70
trans-1,2-DCE <sup>5</sup>	20	---	126	---	---	---	---	---	0	100
PCE <sup>5</sup>	20	---	28	---	---	---	---	---	0	5
TCE <sup>5</sup>	20	---	209	---	---	---	---	---	0	5
Vinyl chloride	20	---	---	---	---	---	---	---	0	2
Methylene chloride	20	---	1.67	---	---	---	---	---	0	5
Methyl Ethyl Ketone	20	---	1030	---	---	---	---	---	0	NA

Uncertainties are reported at 2σ. Abbreviations: pCi/L, picocuries per liter; MDC, minimum detectable concentration; MCL, maximum contaminant limit.

<sup>1</sup> Background concentrations depend on local geology and proximity to surface water recharge locations. Analyte concentrations at sites not influenced by INL-sourced contamination may still be higher than the given background concentration. <sup>a</sup> Background range determined from DEQ data for distant, upgradient, and surface water sites from previous years. <sup>b</sup> Background levels for tritium are taken from a five-year average plus two standard deviations of DEQ data from distant and upgradient locations.

<sup>c</sup> Bartholomay and Hall, 2016 (DOE/ID-22237); <sup>d</sup> Knobel and others, 1999 (DOE/ID-22164); <sup>e</sup> Knobel and others, 1992.

<sup>2</sup> Maximum Contaminant Levels (MCLs) are the highest level of a contaminant that is allowed in drinking water by the EPA. They are legally enforceable in public water systems. Secondary MCLs, designated with \*, are non-enforceable recommended limits for contaminants that may cause aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends but does not require that water systems comply with SMCLs.

<sup>3</sup> Gross beta as <sup>137</sup>Cs.

<sup>4</sup> Due to a backlog of samples waiting to be analyzed for tritium by the low-level analysis method, results for tritium here are from the standard analysis method, with an MDC of approximately 130 pCi/L.

<sup>5</sup> Abbreviations: PCE = tetrachloroethene; TCE = trichloroethene; 1,1-DCE = 1,1-dichloroethene; cis-1,2-DCE = cis-1,2-dichloroethene; trans-1,2-DCE = trans-1,2-dichloroethene; 1,1-DCA = 1,1-dichloroethane.

<sup>†</sup> The federal drinking water standard for beta- and gamma-emitting radionuclides is expressed as a cumulative annual dose of 4 millirem/year. This value equates to a different specific concentration (pCi/L) for each nuclide.

--- Not sampled or analyzed.

NA-Not available; no MCL established.

## Gross Alpha and Gross Beta Radioactivity

Gross alpha and gross beta analyses measure radioactivity contributed by all alpha- and beta-emitting radionuclides in a water sample, excluding radon and tritium. Radionuclide contributors of alpha and beta activity are present in the aquifer both naturally and as a result of past INL operations. Analyses of gross radioactivity are used for screening purposes only and do not yield quantitative measurements of specific radionuclides.

Background concentrations of gross alpha and gross beta radioactivity in the aquifer, derived from over 20 years of DEQ-INL OP data collected from ESRPA locations not affected by INL activities, are given as ranges in **Table 4**. Because a small amount of sediment in a sample can have a large effect on measurements of gross radioactivity, it is not unusual for a sample from an uncontaminated area of the aquifer to slightly exceed these typical background ranges.

In 2019, most above-background detections of gross alpha and gross beta radioactivity were from areas of known radionuclide contamination. No unexpectedly high concentrations were found, and no evidence of radionuclide contamination, excluding tritium (see below), was found beyond the INL Site boundary.

The highest gross alpha concentrations measured were in perched groundwater near ATR in well PW-9, where the maximum concentration was  $15.0 \pm 2.7$  pCi/L. Elevated gross alpha in perched groundwater is well known and due to previous wastewater disposal methods. Fluctuations in contaminant levels occurring in perched groundwater are most likely due to yearly precipitation fluctuations which transport contaminants from the vadose zone (unsaturated ground between the land surface and the top of the aquifer) to perched groundwater zones.

The highest gross beta concentrations were at TAN, where the maximum concentration was  $976.1 \pm 11.0$  pCi/L at TAN-2271, and at INTEC, where the highest concentration was  $638.6 \pm 6.2$  pCi/L at ICPP-MON-A-230. These high levels are caused by known  $^{90}\text{Sr}$  contamination at TAN and  $^{90}\text{Sr}$  and  $^{99}\text{Tc}$  contamination at INTEC (discussed below). The MCL for beta activity is 4 mrem/year, which is equivalent to 8 pCi/L if the source is  $^{90}\text{Sr}$ , 900 pCi/L if  $^{99}\text{Tc}$ , and 20,000 pCi/L if tritium.

Gross alpha and gross beta concentrations in all distant wells were at or near background levels and consistent with past results.

### Tritium ( $^3\text{H}$ )

Tritium is a beta-emitting radionuclide with a half-life of 12.3 years and an MCL of 20,000 pCi/L. Tritium in ESRPA groundwater comes from natural sources, twentieth-century nuclear weapons tests, and past INL waste disposal practices. Naturally occurring tritium and tritium from weapons tests are incorporated in groundwater through surface recharge, resulting in a low background concentration of tritium in young groundwater that decreases as the groundwater ages and tritium decays. The range of background concentrations of tritium observed in the ESRPA is given in **Table 4**.

Tritium was introduced to the aquifer at concentrations well above the background range by past INL waste disposal practices, including the use of wastewater injection wells and percolation ponds at ATR, INTEC, and TAN. The largest area of tritium contamination in the ESRPA is a plume extending south-southwestward from sources at INTEC and ATR to the southern INL boundary. Smaller plumes exist near sources at TAN and RWMC. The highest concentrations of tritium in the aquifer are found near the sources of these plumes. Tritium concentrations once exceeded the MCL in some source-area wells. Over the past two decades, concentrations have decreased significantly due to radioactive decay and dilution.

In 2019, tritium concentrations in the aquifer continue to decrease or remain steady at most locations. **Figure 11** shows tritium trends for selected wells at ATR, INTEC, and RWMC, and **Figure 12** shows a concentration map of tritium measurements in and around the INL. The highest concentration measured in the aquifer at each facility complex with elevated tritium was:

- ATR →  $3900 \pm 220$  pCi/L at TRA-07
- CFA →  $3000 \pm 190$  pCi/L at CFA-2
- INTEC →  $1720 \pm 150$  pCi/L at USGS-123
- TAN →  $770 \pm 120$  pCi/L at TAN-28
- RWMC →  $500 \pm 110$  pCi/L at M3S

Tritium continues to be detected near the southern INL boundary. The highest concentration for a boundary-area well was  $1100 \pm 140$  pCi/L at the 812-ft depth of Westbay well USGS-131A, which is approximately 4.25 miles north of the boundary. Along the Site boundary line, the highest concentration was  $300 \pm 110$  pCi/L at the 1,072-ft depth of Westbay well USGS-105. The 950-ft-deep zone in USGS-105 did not detect tritium at this time. Outside of the boundary, the above-background tritium concentrations were measured in USGS-125 ( $44 \pm 9$  pCi/L), approximately 1 mile south of the boundary, and USGS-124 ( $40 \pm 7$  pCi/L), approximately 4.5 miles south of the boundary. Concentrations in both wells continue a long-term decreasing trend, though in both cases the concentration measured in 2019 was slightly higher than in 2018 and 2017.

In perched groundwater at ATR, tritium concentrations continue to remain elevated and are not trending upward or downward. A maximum concentration of  $13,390 \pm 380$  pCi/L was measured at PW-12, a new DEQ well that agrees with the ICP contractor result of  $13,000 \pm 1,310$  pCi/L and is under investigation by the ICP contractor<sup>7</sup>. Other concentrations are consistent with previous years.

At distant sites, tritium concentrations at all locations were at or below background levels. Distant sites continue to show no evidence of tritium contamination from the INL.

---

<sup>7</sup> Annual Groundwater Monitoring Status Report for Waste Area Group 2 for Fiscal Year 2019. DOE/ID-12016.

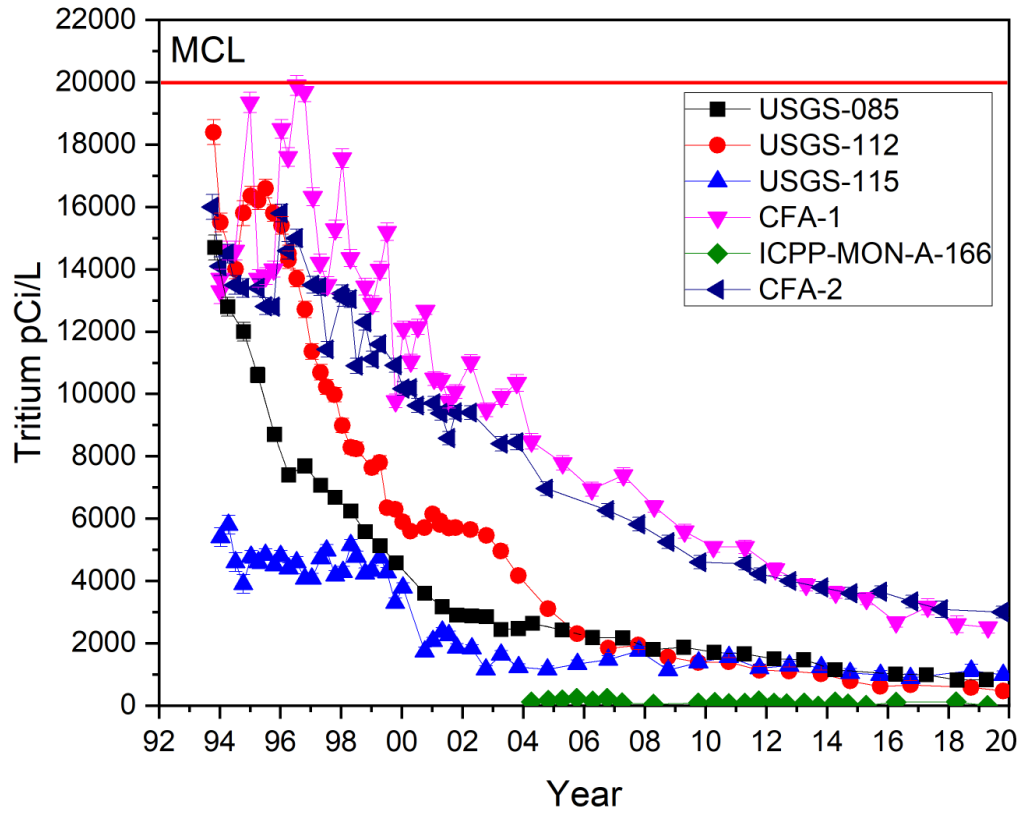
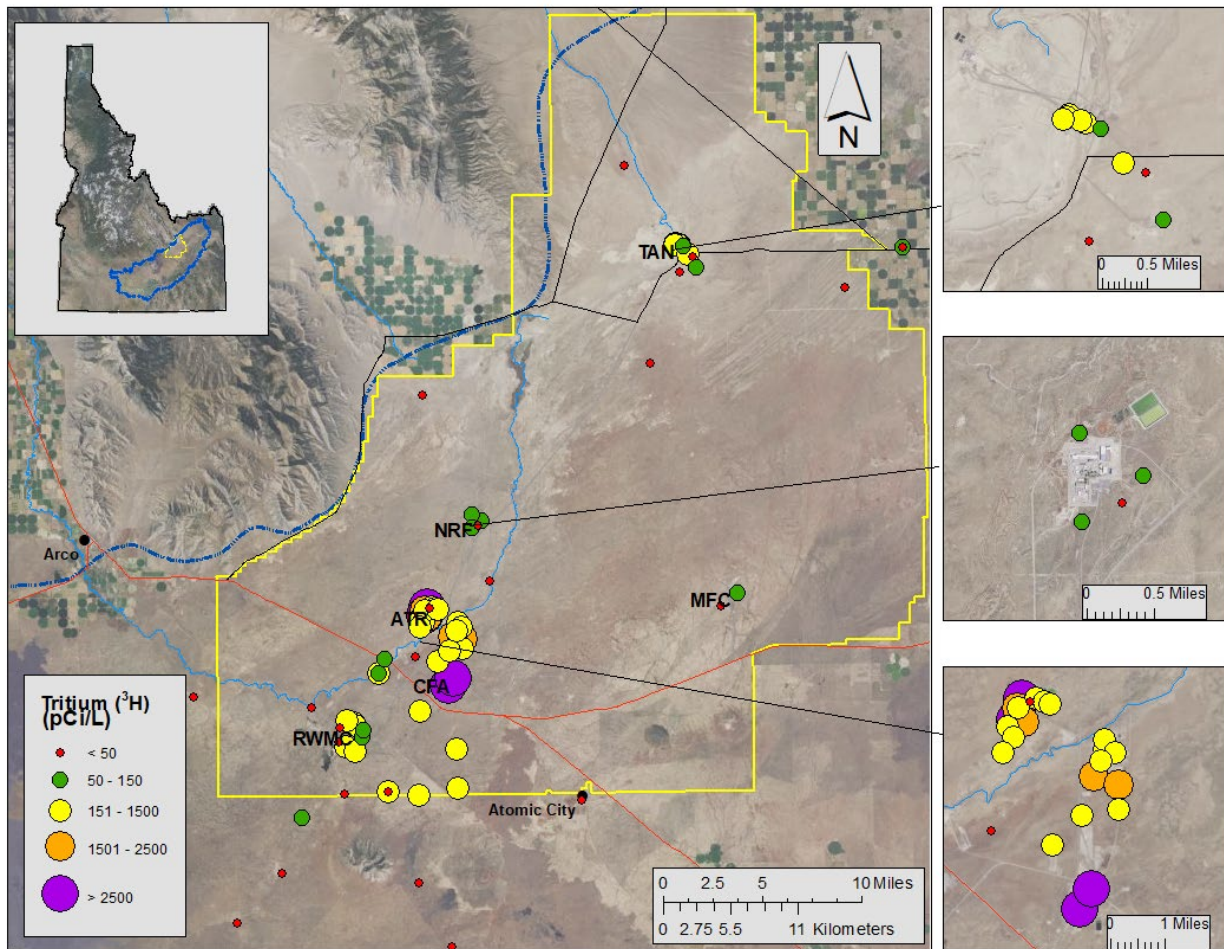


Figure 11. Tritium concentrations (pCi/L) over time for selected facility wells.



**Figure 12. Tritium concentrations for DEQ sample locations in 2019 in and around the INL. Locations with tritium concentrations reported as below the minimum detectable concentration (MDC) are plotted based on the value of the MDC (e.g., a location whose tritium concentration is reported as <130 pCi/L will be plotted as a green circle).**

### Strontium-90 ( $^{90}\text{Sr}$ )

Strontium-90 is a manmade beta-emitting radionuclide with a half-life of 29.1 years and an MCL of 8 pCi/L. Strontium-90 is present in the ESRPA as a result of past waste disposal practices at INTEC, TAN, and ATR and past leaks and spills from the INTEC Tank Farm. The highest concentrations in the aquifer are found at TAN. A more extensive but lower-concentration plume extends from INTEC to just north of CFA. Strontium-90 has not been found in the aquifer near or outside the boundary of the INL and is not at risk of exiting the boundary of the Site in the near future.

In 2019, the highest  $^{90}\text{Sr}$  concentrations in the aquifer continue to be measured at TAN, with a maximum of  $620 \pm 150$  pCi/L at TAN-37A. (Fluor frequently measures concentrations near 1000 pCi/L at TAN well TSF-05, approximately 150 ft northwest of TAN-37A; however, DEQ-INL OP does not sample this location due to radiological sample handling concerns.) Strontium-90 concentrations in some TAN wells have increased in recent years due to resumed amendment injections for treatment of volatile organic compounds. Injected amendments increase competition for cation exchange sites in the aquifer substrate, resulting in the displacement of

adsorbed strontium cations into the groundwater. Once injections have been stopped, it is anticipated that  $^{90}\text{Sr}$  concentrations will stabilize and eventually decrease as  $^{90}\text{Sr}$  decays and dilution occurs. **Figure 13** shows  $^{90}\text{Sr}$  trends for wells at TAN. Vertical error bars through data points represent an uncertainty of two sample standard deviations.

Strontium-90 contamination in the aquifer beneath and south of INTEC is lower in concentration than the highest concentration wells at TAN but more widespread. In 2019, the highest concentration measured in the aquifer at INTEC was  $14.6 \pm 3.5$  pCi/L at USGS-047. Concentrations in all  $^{90}\text{Sr}$ -bearing wells at INTEC and to the south continue to decrease or remain stable. The location of the farthest downgradient detection in this plume continues to be USGS-085 ( $1.85 \pm 0.58$  pCi/L).

Strontium-90 is also present in perched groundwater. The highest known  $^{90}\text{Sr}$  concentrations in perched groundwater at the INL are at INTEC, where Fluor reports concentrations of  $>100,000$  pCi/L. DEQ-INL OP does not sample these wells due to radiological sample handling concerns.<sup>8</sup> Perched groundwater at ATR, which DEQ-INL OP does sample, has lower concentrations. In 2019, the highest perched groundwater concentration at ATR was  $32.9 \pm 7.9$  pCi/L at PW-12, a new DEQ INL OP monitoring well.

DEQ-INL OP also samples for  $^{90}\text{Sr}$  at locations in which it is not typically detected but is a constituent of concern, including aquifer wells at ATR, CFA, NRF, and RWMC. In 2019,  $^{90}\text{Sr}$  was not detected at any of these locations.

**Figure 14** shows  $^{90}\text{Sr}$  concentrations over time for aquifer wells at INTEC (USGS-047, USGS-067, ICPP-2020, USGS-085, and USGS-112) and a perched groundwater well at ATR (USGS-055). A concentration map of all INL locations sampled for  $^{90}\text{Sr}$  in 2019 is shown in **Figure 15**.

---

<sup>8</sup> DEQ-INL OP does monitor the aquifer beneath and in the vicinity of INTEC perched groundwater to detect the appearance of  $^{90}\text{Sr}$  from the vadose zone in the aquifer.

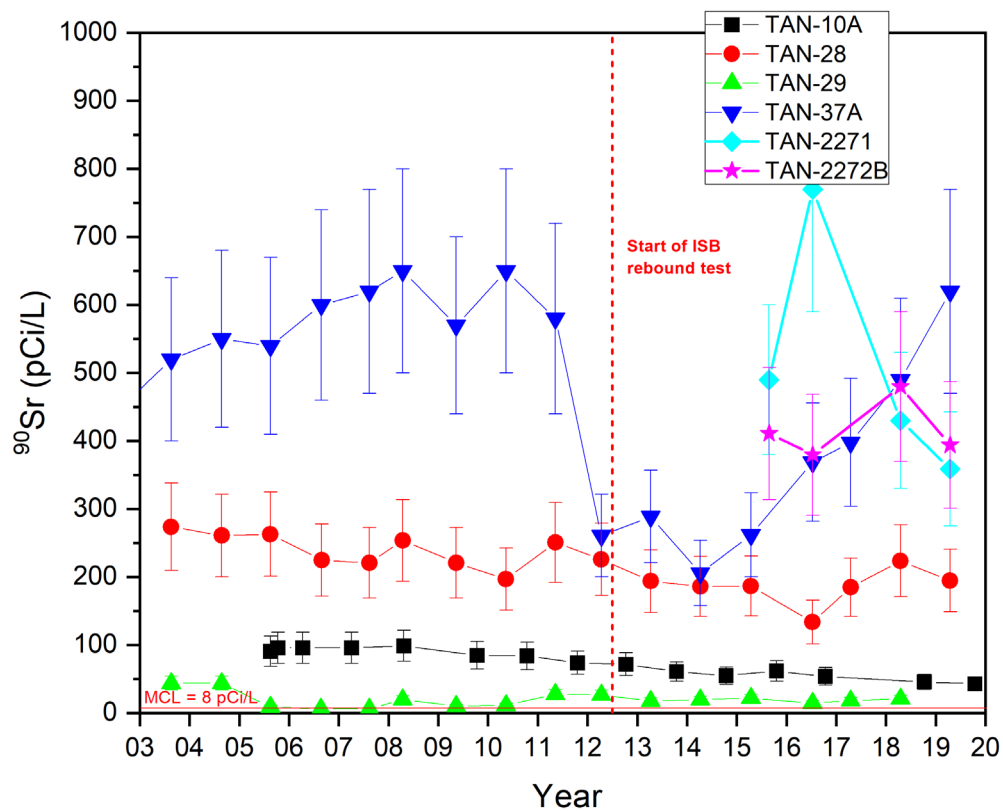


Figure 13. Strontium-90 concentrations over time for selected wells at TAN.



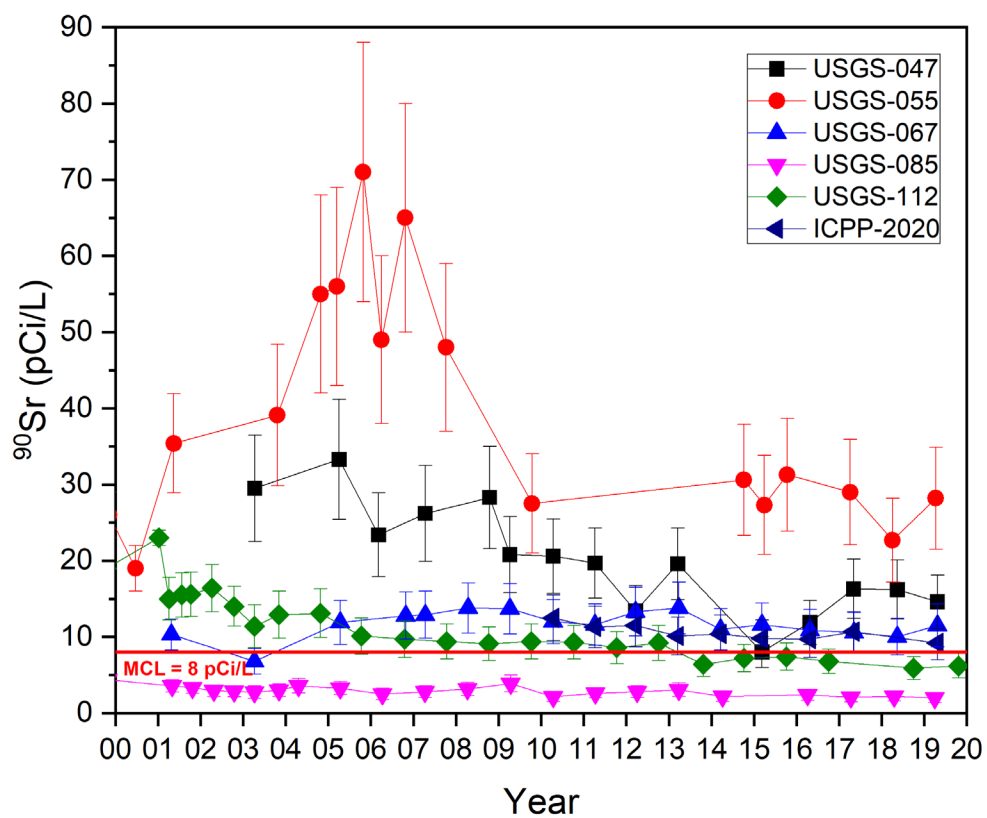
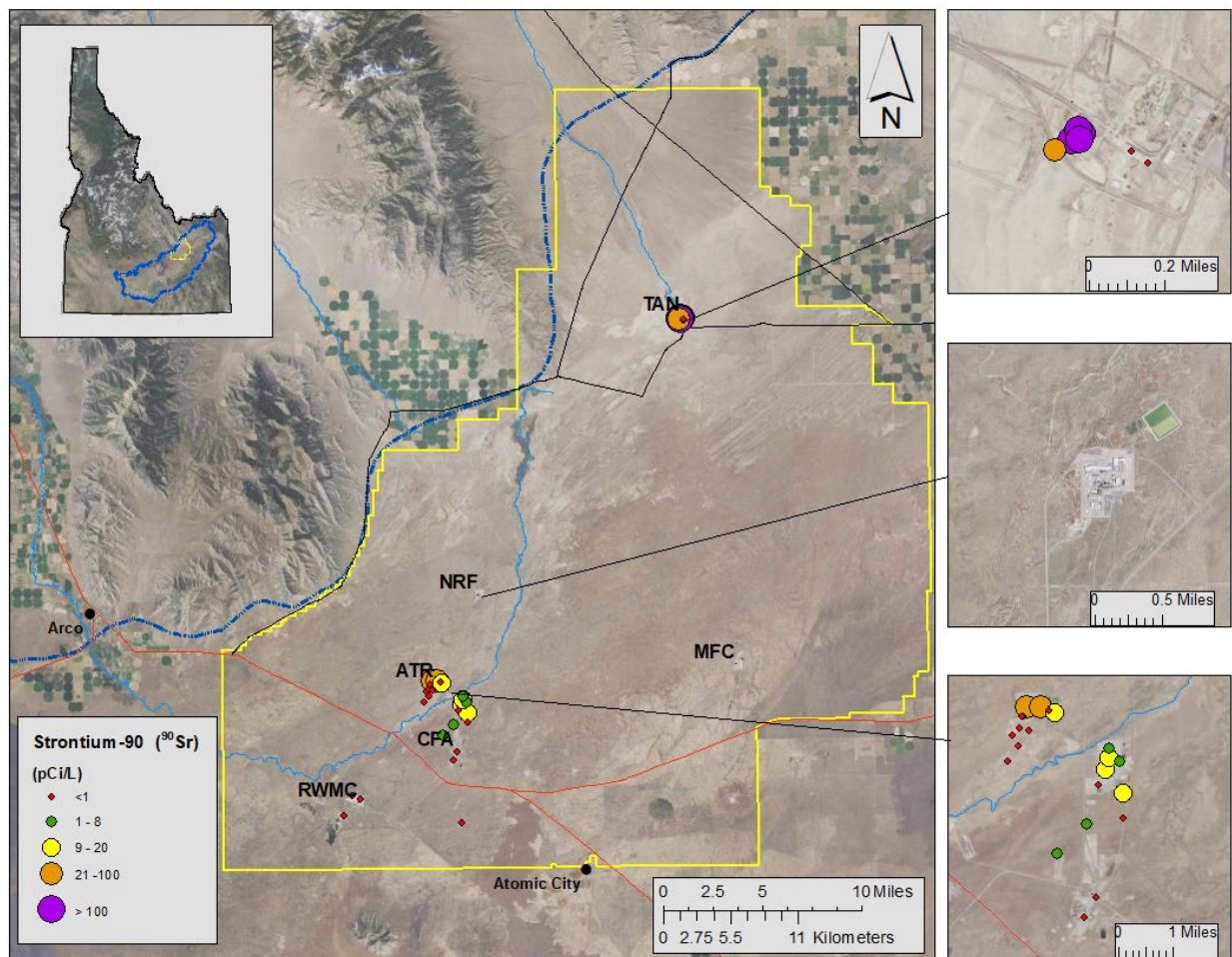


Figure 14. Strontium-90 concentrations over time for selected wells at INTEC and ATR.



**Figure 15. Aquifer strontium-90 concentrations for DEQ sample locations in 2019 in and around the INL.**

### **Technetium-99 ( $^{99}\text{Tc}$ )**

Technetium-99 is a manmade beta-emitting radionuclide with a half-life of 211,100 years and an MCL of 900 pCi/L. Technetium-99 is present in the ESRPA primarily as a result of leaks and spills at the INTEC Tank Farm, including the inadvertent release of 18,600 gallons of sodium-bearing waste during a transfer between underground storage tanks at INTEC in 1972. Detectable concentrations define a plume extending from INTEC to CFA. Technetium-99 is highly mobile in groundwater and migrates more easily than  $^{90}\text{Sr}$ . DEQ-INL OP has not detected  $^{99}\text{Tc}$  near or beyond the boundary of the INL Site.

In 2019, the highest concentrations of  $^{99}\text{Tc}$  continue to be at INTEC, with a maximum of  $1040 \pm 170$  pCi/L at ICPP-MON-A-230. This well was recently added to the program after a hiatus since 2003 when the concentration was  $2419 \pm 4$  pCi/L showing a 67% reduction in the 16 year hiatus. It will continue to be sampled annually. All other detections were well below the MCL. Concentrations at most locations continue to decrease or remain steady, with the exception of USGS-115, where the concentration has been increasing since the mid-2000s. The highest downgradient detection was  $8.6 \pm 4.0$  pCi/L at USGS-115. **Figures 16 and 17** show  $^{99}\text{Tc}$  concentrations over time for selected INL wells located at or downgradient of INTEC. **Figure 18** shows a concentration map of all INL  $^{99}\text{Tc}$  sample locations in 2019.

DEQ-INL OP also samples for  $^{99}\text{Tc}$  at locations in which it is not typically detected but is a constituent of concern, including aquifer and perched groundwater wells at RWMC and boundary aquifer wells Highway 3, USGS-131A, and USGS-104. In 2019,  $^{99}\text{Tc}$  was not detected at any of these locations.

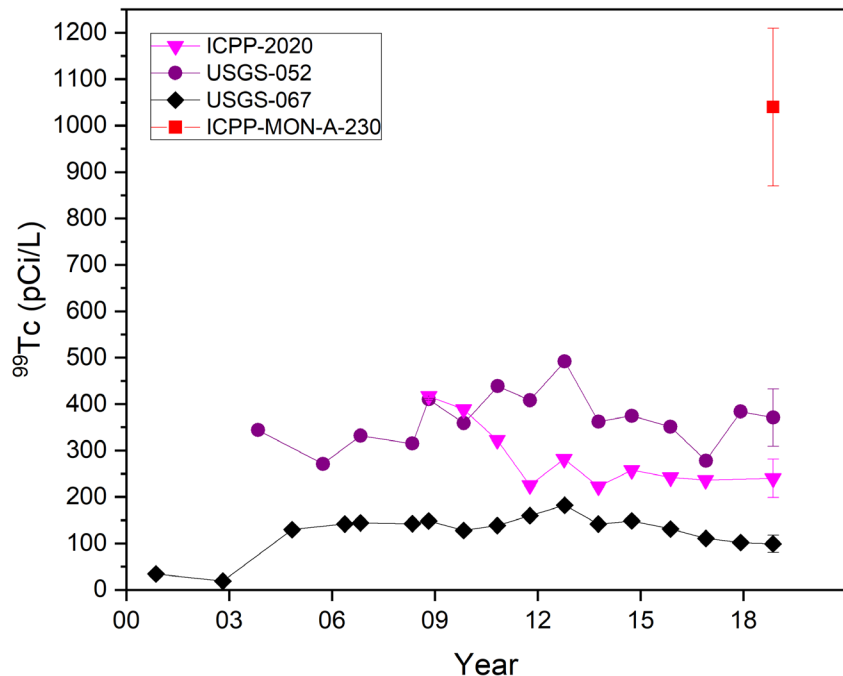


Figure 16. Technetium-99 concentrations over time for selected wells at INTEC.

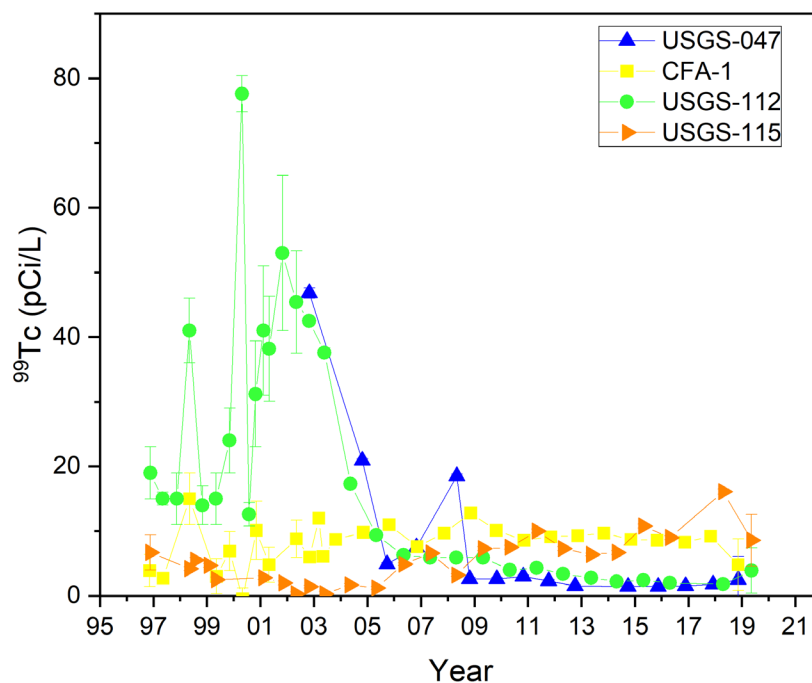
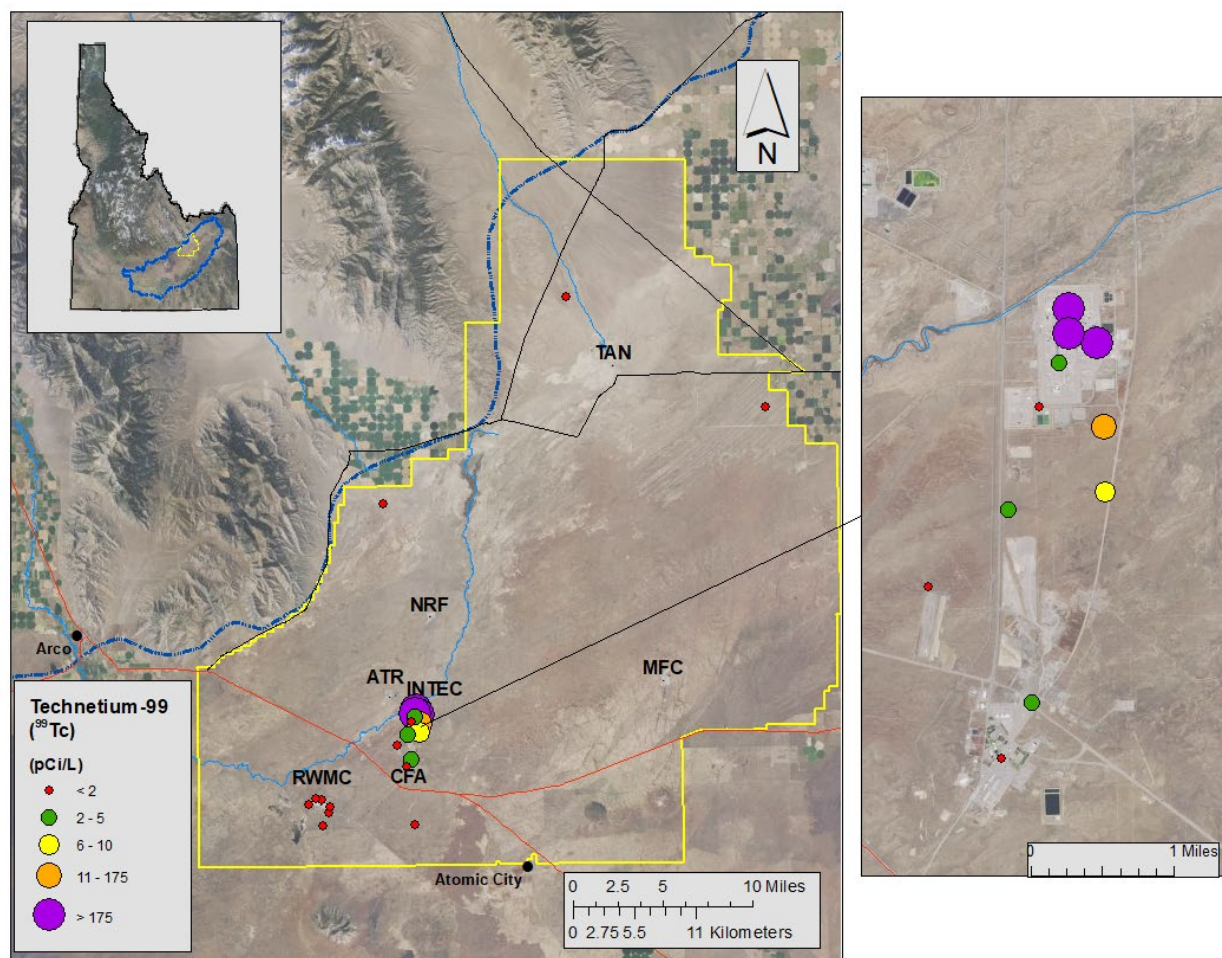


Figure 17. Technetium-99 concentrations over time for selected wells at or downgradient of INTEC.



**Figure 18. Technetium-99 concentrations for DEQ sample locations in 2019.**

## Cesium - 137

Cesium-137 is a gamma-emitting radionuclide with a half-life of 30.17 years and an MCL of 200 pCi/L. Past releases of  $^{137}\text{Cs}$  to the environment include direct discharge to the aquifer through disposal wells at TAN and INTEC, discharge to infiltration ponds at ATR and INTEC, and a large accidental discharge to the subsurface from the INTEC Tank Farm in 1972. Despite these releases, the only wells in which  $^{137}\text{Cs}$  is regularly detected are in a small area at TAN. The lack of  $^{137}\text{Cs}$  in groundwater at INTEC, where  $^{99}\text{Tc}$  from the same Tank Farm release has formed a plume in the aquifer, suggests that the mobility of  $^{137}\text{Cs}$  in the aquifer and vadose zone at the INL is limited.

The highest known  $^{137}\text{Cs}$  concentrations in the ESRPA are typically reported at TAN well TSF-05 by Fluor and are on the order of 6000 pCi/L. DEQ-INL OP does not sample this location due to sample handling concerns related to the high activity. Of the wells DEQ-INL OP samples, the only location at which  $^{137}\text{Cs}$  is commonly detected is TAN-37A. Nearby TAN-2271 and TAN-2272B have had recent detections, as well. In 2019,  $^{137}\text{Cs}$  was not detected by DEQ-INL OP at any location sampled.



## Uranium Isotopes

DEQ-INL OP samples some locations for uranium isotopes  $^{234}\text{U}$ ,  $^{235}\text{U}$ , and  $^{238}\text{U}$ . Uranium isotopes are alpha-emitting radionuclides with half-lives of 250,000 years for  $^{234}\text{U}$ , 703.8 million years for  $^{235}\text{U}$ , and 4.5 billion years for  $^{238}\text{U}$ . Total uranium—the sum of all uranium isotopes—has an MCL of 30  $\mu\text{g/L}$ . Uranium occurs naturally in the ESRPA. Typical background concentrations for each isotope are given in **Table 4**. Because clay particles can be rich in uranium, a small amount of sediment in a sample may result in uranium isotope concentrations above background. To discern manmade contamination of the aquifer from sediment contamination of a sample, the ratio of uranium isotopes may be used: ESRPA samples containing only naturally occurring uranium should have a  $^{234}\text{U}/^{238}\text{U}$  activity ratio of about 1.5 to 3.1.

Uranium has been discharged to the aquifer through now-abandoned disposal wells and infiltration ponds at INTEC and TAN. Concentrations of uranium isotopes above background are typically found at TAN, where changing redox conditions due to amendment injections for VOC treatment have led to a recent mobilization of uranium ions in groundwater, and occasionally at INTEC. To date, above-background uranium detections have been well below the MCL and are not widespread enough to define a plume.

In 2019, the highest uranium isotope concentrations were at TAN-28 ( $^{234}\text{U} = 8.8 \pm 1.5$  pCi/L,  $^{235}\text{U} = 0.41 \pm 0.15$  pCi/L,  $^{238}\text{U} = 1.27 \pm 0.29$  pCi/L), where the total uranium concentration calculated from the activities of each isotope was 3.97  $\mu\text{g/L}$ . The  $^{234}\text{U}/^{238}\text{U}$  ratio of 6.93 confirms the anthropogenic source. Other TAN wells with elevated uranium concentrations had similarly high  $^{234}\text{U}/^{238}\text{U}$  ratios, consistent with previous years.

In 2019, INTEC wells USGS-052 and ICPP-2020 and ATR wells USGS-065 and TRA-07 had slightly elevated concentrations of all three uranium isotopes but  $^{234}\text{U}/^{238}\text{U}$  ratios within the background range. DEQ-INL OP also monitors for uranium isotopes at RWMC, where they are not known to occur above background levels but are constituents of concern. In 2019, wells M3S and A11A31 had slightly elevated levels of  $^{235}\text{U}$  (0.084 and 0.068 pCi/L, respectively).

## Plutonium Isotopes and Americium-241

DEQ-INL OP samples some locations for plutonium isotopes  $^{238}\text{Pu}$  and  $^{239/240}\text{Pu}$  and americium isotope  $^{241}\text{Am}$ , none of which occur naturally in the environment.<sup>9</sup> Plutonium and americium isotopes are alpha-emitting radionuclides with half-lives of 87.7 years for  $^{238}\text{Pu}$ , 24,110 years for  $^{239}\text{Pu}$ , 6,560 years for  $^{240}\text{Pu}$ , and 432.2 years for  $^{241}\text{Am}$ .

In the past, plutonium and americium were in wastewater discharged to the aquifer at INTEC, and americium was in wastewater discharged to the aquifer at ATR. Large quantities of plutonium and americium have been buried in the Subsurface Disposal Area (SDA) at RWMC. DEQ-INL OP has detected plutonium isotopes and  $^{241}\text{Am}$  at low concentrations at INTEC and RWMC very sporadically in the past. Such detections have not been consistent at any location and may be statistical anomalies.

---

<sup>9</sup>  $^{239/240}\text{Pu} = ^{239}\text{Pu} + ^{240}\text{Pu}$ .

DEQ-INL OP samples for plutonium isotopes at RWMC and INTEC and <sup>241</sup>Am at RWMC and ATR. No plutonium isotopes or <sup>241</sup>Am were detected at any location in 2019.

### **Chloride, Sulfate, and Nitrate**

Large quantities of chloride, sulfate, and nitrate have been discharged in wastewater to percolation ponds, disposal wells, and infiltration ditches at the INL. All three anions are mobile in groundwater and are good indicators of wastewater in the aquifer at the INL. Chloride and sulfate each have a secondary MCL of 250 mg/L, and nitrate has an MCL of 10 mg/L. The USGS has documented a chloride plume extending southward from sources at INTEC and CFA.

DEQ-INL OP samples for chloride and nitrate<sup>10</sup> at all locations and sulfate at all except distant locations. Within the INL Site, the highest chloride concentrations in groundwater are in the aquifer at NRF, TAN, and CFA and in perched groundwater at ATR, the highest sulfate concentrations are in the aquifer and perched groundwater at ATR and in the aquifer at NRF, and the highest nitrate concentrations are in perched groundwater at ATR and in the aquifer at INTEC and NRF. Outside of the INL boundary, concentrations of all three anions are elevated and increasing in many wells and springs due to agricultural impacts.<sup>11</sup>

In 2019, concentrations and distribution of chloride, sulfate, and nitrate measured in the aquifer did not change significantly from previous years.

The highest chloride concentration in the aquifer beneath the INL was 398 mg/L at NRF-06. NRF-06 is located near the NRF industrial waste ditch, an infiltration ditch in which wastewater from water softeners is discharged. Chloride concentrations at NRF-06 have been above the secondary MCL at NRF-06 since 2002. Other aquifer locations with high chloride concentrations at the INL include TAN, with a maximum of 115 mg/L at TAN-2271, and CFA, with a maximum of 148 mg/L at CFA-2. The highest concentration measured in non-aquifer water was 172 mg/L in ATR perched-groundwater well USGS-073, a significant increase from previous years. Wells near the southern INL boundary had generally low chloride concentrations.

The highest sulfate concentration in the aquifer beneath the INL was 144 mg/L at USGS-065 and TRA-07, both immediately downgradient of ATR. Concentrations between 17 mg/L and 77 mg/L were measured in wells from every facility complex. The highest sulfate concentrations in non-aquifer locations were in ATR perched groundwater well PW-11 (150 mg/L) and in wastewater from the ATR cold waste pond (444 mg/L). The ATR cold waste pond result was well above the secondary MCL. Wells near the southern INL boundary had generally low sulfate concentrations.

---

<sup>10</sup> Nitrate here refers to the analysis for nitrate plus nitrite. Since the water DEQ samples typically contain dissolved oxygen, all of the nitrite has likely been oxidized to nitrate.

<sup>11</sup> Chloride and sulfate increase as irrigation water, which has elevated salt concentrations due to evaporation, recharges the aquifer. Nitrate increases as residue from nitrate plant fertilizers and dairy farms reaches the water table.

The highest nitrate concentration in the aquifer beneath the INL was 5.4 mg/L at well ICPP-MON-A-230 at INTEC. Other facility sites with concentrations above 1 mg/L include wells at RWMC, CFA, MFC, NRF, and ATR but most were within the background range of 0.04-3.59 mg/L. Nitrate concentrations at boundary wells Atomic City and Highway 3 had concentrations of 1.6 and 0.49 mg/L, respectively. While neither concentration is near the MCL, nitrate at both locations has increased steadily since the 1990s. The source of this increase is unknown but is unlikely to be related to INL wastewater, as no other wastewater indicator has shown a similar trend at these locations. The highest nitrate concentration measured in non-aquifer water at the INL was 21 mg/L in ATR perched-groundwater well USGS-073.

Chloride, sulfate, and nitrate concentrations in many distant wells and springs and some upgradient wells are well above background and continue to increase. Outside of the INL boundary, the highest chloride concentration in 2019 was 72.7 mg/L, the highest sulfate concentration was 85.3 mg/L, and the highest nitrate concentration was 5.9 mg/L. All three of these maximums were in distant well MV-53. The high anion concentrations of many distant and upgradient wells and springs, particularly in the Magic Valley, reflect the intensive agricultural use of these areas. As agricultural impacts increase the concentrations of anions in the aquifer downgradient of the INL, chloride, sulfate, and nitrate become less useful as potential indicators of INL wastewater.

## **Chromium**

Chromium occurs naturally in the ESRPA at a concentration of around <1.0-5.2 µg/L. Thousands of pounds of chromium were discharged to the aquifer at INL facility complexes (primarily ATR) during the twentieth century, making it an indicator of the presence of INL wastewater in the aquifer. Chromium concentrations are typically highest in the wells immediately downgradient of ATR and in perched groundwater at ATR, but they are above background in nearly all INL wells showing evidence of INL-sourced contamination. The MCL for chromium is 100 µg/L.

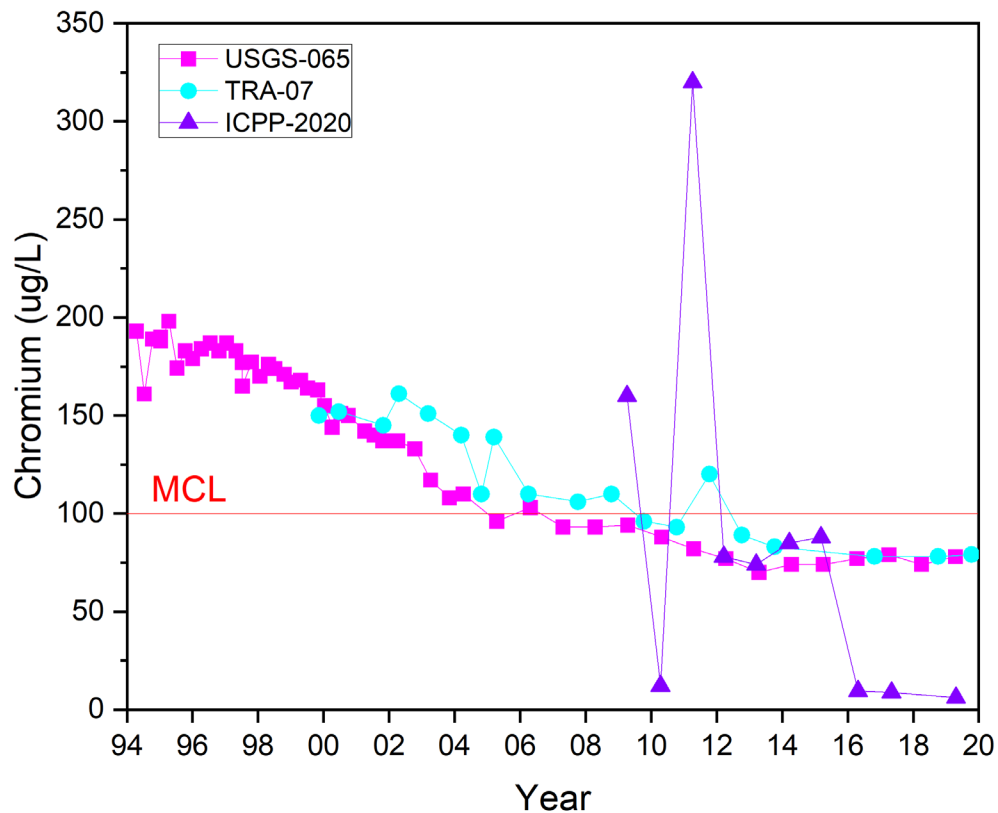
In 2019, chromium concentrations were above background in most facility and some boundary wells. The maximum concentrations were 79 and 78 µg/L at TRA-07 and USGS-065, respectively, immediately downgradient of ATR. A concentration of 49 µg/L at NRF-06, near the NRF industrial waste ditch, suggests that infiltrate from the vadose zone has a chromium concentration well above background.

Concentrations above 5 µg/L were measured in 12 boundary wells with a maximum of 11 µg/L at USGS-131A at a depth of 616 ft bgs. The distribution of above-background chromium detections in the vicinity of the downgradient INL boundary remains similar to previous years, and no unexpected increases or decreases have been observed. With the exception of USGS-104, which has had an average increase of 0.46% per year since sampling began in the 1990s, no boundary well currently has a statistically significant long-term increasing trend.

Chromium concentrations in all distant wells remain at background levels. No INL-sourced chromium has been detected in the Magic Valley or at any other distant site.

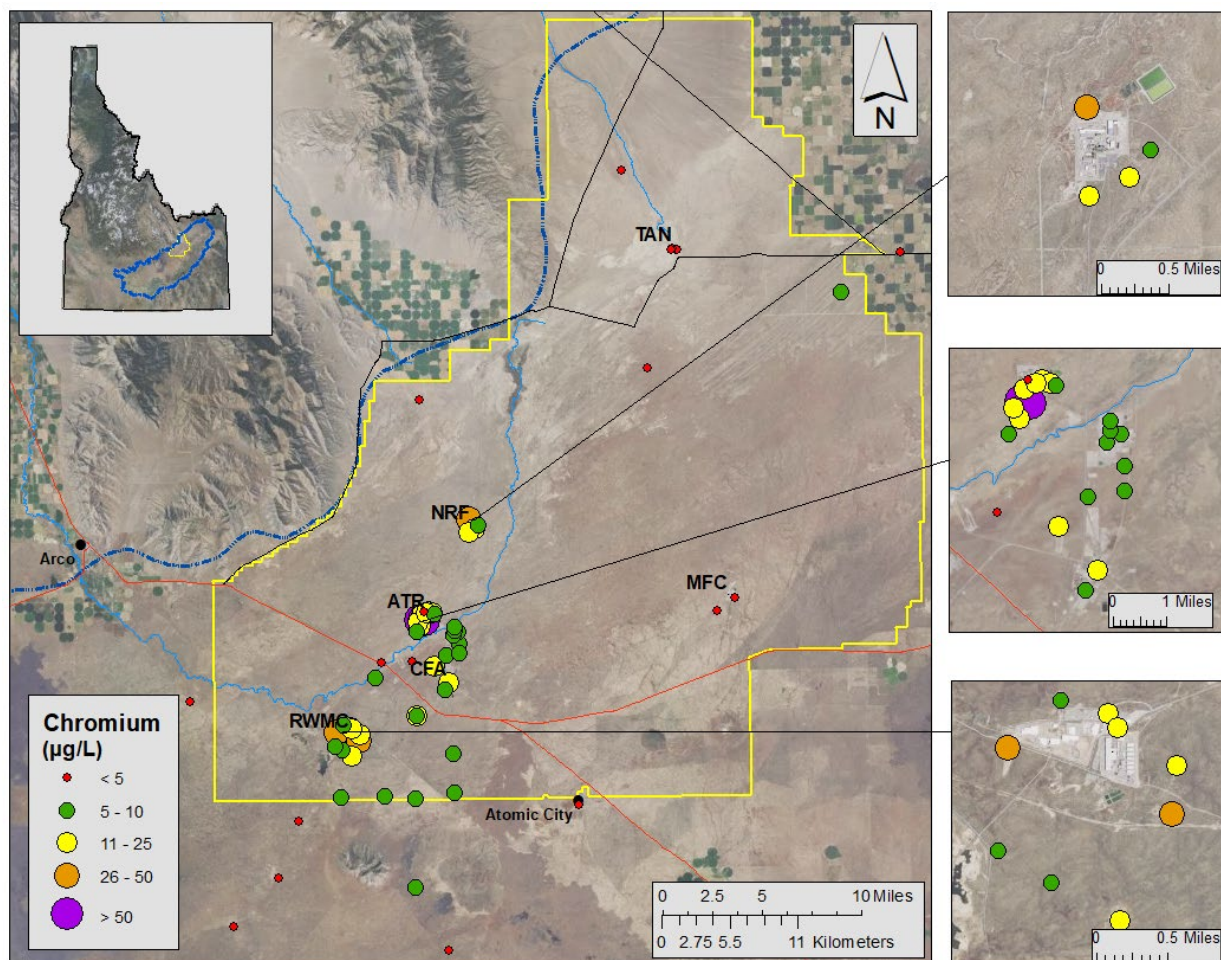
Results for wells that have historically had of high levels of chromium are shown in **Figure 19**.

A concentration map for all INL locations sampled in 2019 is shown in **Figure 20**.



**Figure 19. Chromium concentrations ( $\mu\text{g/L}$ ) over time for selected aquifer wells at ATR and INTEC.**





**Figure 20. Chromium concentrations for DEQ sample locations in 2019 in and around the INL.**

### **Arsenic, Iron, Manganese and Selenium**

DEQ-INL OP samples for other trace metals, including arsenic, iron, manganese, and selenium, at a small number of locations. Iron and manganese samples are collected at TAN, where the reducing conditions created by amendment injections for the remediation of VOCs in groundwater have caused the concentrations of both metals to increase dramatically over the past decade. Arsenic samples are collected at a small number of wells in which arsenic has been elevated in the past. It is unknown whether elevated arsenic concentrations are caused by INL contamination or local geology. All four metals are also collected at wastewater sites.

In 2019, iron and manganese concentrations in the aquifer at TAN remain extremely high. The maximum manganese concentration was 1800 µg/L at TAN-28, an increase from 1400 µg/L in 2018. The maximum iron concentration was 3100 µg/L at TAN-2271, a decrease from 4000 µg/L from 2018. Iron and manganese have secondary MCLs of 300 µg/L and 50 µg/L, respectively.

Arsenic was detected at six groundwater and one wastewater sites. All arsenic results were consistent with previous years. The maximum concentration was 8.8 µg/L in ATR perched-groundwater well USGS-070. The MCL for arsenic is 10 µg/L.

Selenium was detected at one wastewater site. The maximum concentration was 3.6 µg/L at ATR Cold Waste Pond. The MCL for selenium is 50 µg/L.

## **Volatile Organic Compounds**

VOCs contaminate the groundwater at TAN and RWMC. At TAN, a plume originating at a former wastewater injection well extends to the east and south of the facility complex, with its downgradient edge approximately 1.7 miles from its source. The plume is characterized by high concentrations of trichloroethene (TCE) and its degradation products (cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride) and lower concentrations of tetrachloroethene (PCE). In the 1990s, groundwater near the source of the plume had a TCE concentration of over 20,000 µg/L. Over the past two decades, different remedial strategies have been employed in different areas of the plume depending on the pre-remediation concentration of TCE:

- The areas of highest plume concentrations are at TAN in the vicinity of TAN-37A. The remediation strategy here has been enhanced in situ bioremediation (ISB), in which a carbon source is injected into the groundwater to promote the microbial anaerobic reduction of chlorinated ethenes.
- The medial zone extends about 1500 feet east-southeast from the hot spot (area of highest concentration). The remediation strategy here is pump-and-treat—groundwater is pumped into a facility, treated, and reinjected into the aquifer.
- The distal zone surrounds the medial zone as a much larger lobe that extends about 900 feet west and 1.7 miles southeast of the hot spot. The remediation strategy here is monitored natural attenuation.

DEQ-INL OP samples wells in all three zones of the plume. VOC concentrations today are much lower than when remediation began approximately two decades ago.

In 2019, TCE (MCL = 5 µg/L) and PCE (MCL = 5 µg/L) were detected above their MCLs at TAN. The maximum TCE concentration was 209 µg/L at TAN-28 and the maximum PCE concentration was 28.0 µg/L at TAN-51. **Figure 21** shows TCE trends for TAN-28, TAN-29, and TAN-37A. TCE concentrations in TAN-28 have varied widely over time, probably as a result of intermittent changes in groundwater chemistry due to ISB injections as well as seasonal changes in groundwater flow (DOE/ID-11444). In 2019, TCE concentrations in TAN-28 (209 µg/L) were increased from 2018 (154 µg/L) but significantly lower than in 2017 (308 µg/L) and still within the range measured at these locations over the past 15 years. VOCs were not detected in TAN-2312, a well in which detection in future years would indicate a downgradient migration of the contaminant plume.

At RWMC, carbon tetrachloride, TCE, and chloroform from buried waste at the SDA have reached the water table. VOC concentrations at RWMC are much lower than in the hottest areas of TAN but have been climbing in some wells. No ESRP aquifer remediation has been undertaken or planned to date, aside from the vacuum extraction of organic vapors from the vadose zone to prevent further migration to the aquifer. TCE, carbon tetrachloride (MCL = 5 µg/L), and/or chloroform (MCL = 70 µg/L) were detected in six wells. Only one of these detections—carbon tetrachloride in well RWMC Production (5.78 µg/L) was above the MCL. **Figure 22** shows the carbon tetrachloride trends in wells near RWMC. The VOC detections at RWMC are consistent with historical observations.

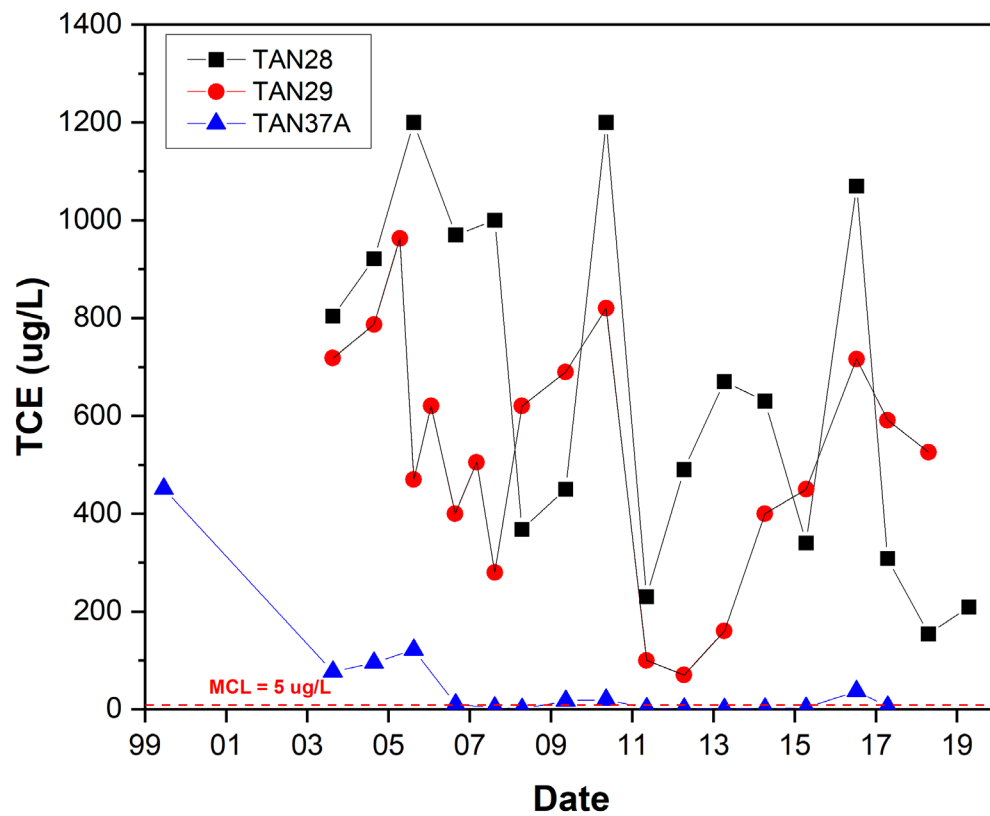
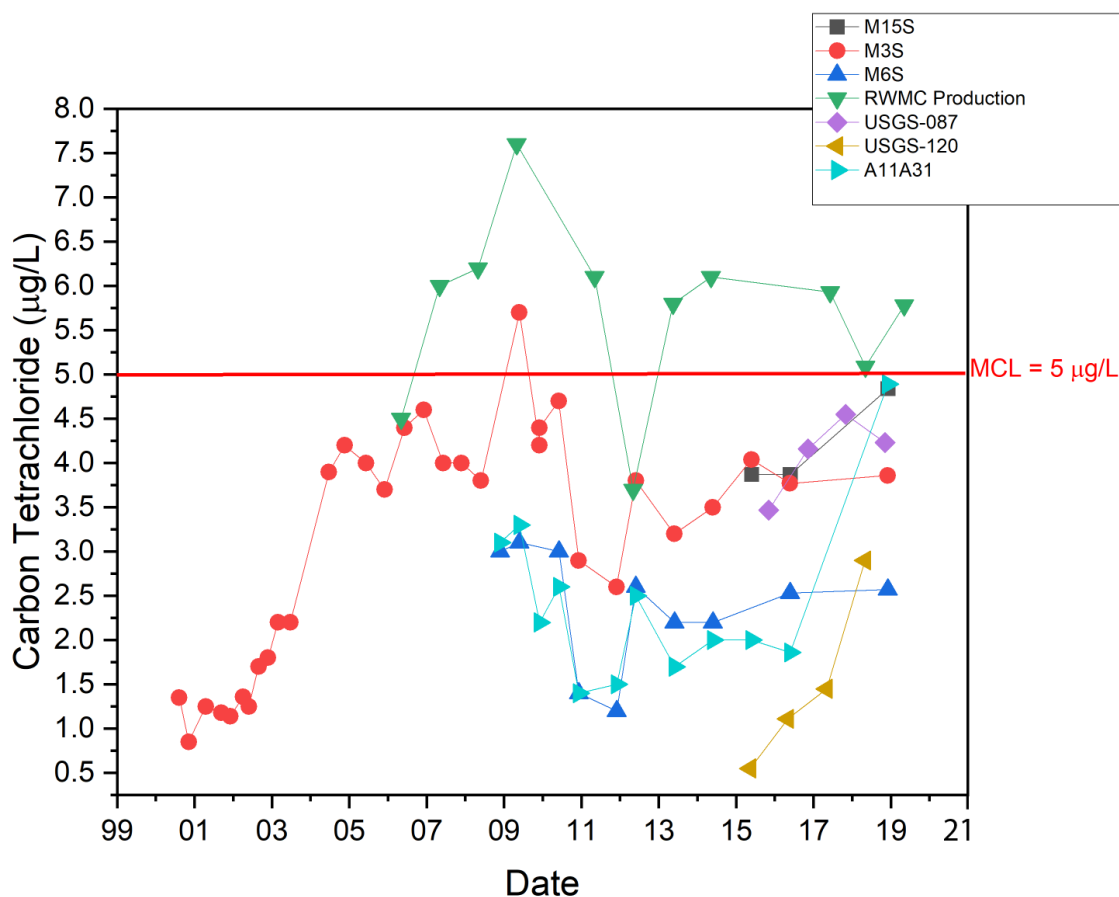


Figure 21. TCE concentrations (µg/L) over time for selected wells located in the medial zone at TAN.



**Figure 22. Carbon Tetrachloride concentrations (µg/L) over time for selected wells at RWMC.**

### Verification of Co-sampler Results

As a part of its mission to verify the results and conclusions of other organizations conducting environmental monitoring at the INL, DEQ-INL OP compares its analytical results for co-sampled groundwater monitoring locations with those of the co-sampler and reports the percentage that are in agreement. DEQ-INL OP sets an annual goal of co-sampling for at least 200 water analyses with USGS, 100 analyses with Fluor, 25 analyses with Veolia, and 10 analyses with BEA. These numbers are approximately proportional to the total number of locations co-sampled with each organization.

The criteria used to decide whether a pair of samples is in agreement are the same as those described in the Quality Assurance section for assessing duplicate agreement. Some differences between samples are to be expected due to natural variation in the flow of water from the well, differences in laboratory equipment calibration, and the non-zero probability that a small number of samples from the same population will have significantly different concentrations. DEQ-INL OP considers agreement of at least 80% of a co-sampling organization's results with its own to be acceptable.

**Table 6** presents the percentages of co-sampled analyses that were in agreement for each co-sampling organization and each analyte. Of 604 analyses that were compared, 93 percent were in agreement. Greater than 80% of co-sampled analyses agreed for each organization. When broken down by analyte, greater than 80% of co-sampled analyses were in agreement for each analyte except for the following:

- Only 75% of the VOC pairs agreed. There does not appear to be a clear pattern or reason as to why certain results were high or low in this case. Methods of preservation, laboratory analytical methods, or sample handling could all be sources of error in this case. More investigation is needed to determine the causes of this disagreement.

On the basis of this verification, DEQ-INL OP considers the water-monitoring results of other organizations at the INL to be of good quality overall.

**Table 5. Comparison of DEQ-INL OP's sample results with those of co-sampling organizations in 2019. Under each organization, number indicates the number of analyses for which results have been compared, and % Pass indicates the percent of those pairs of compared results that meet the criteria described for duplicate sample agreement in the Quality Assurance section of this report.**

Analyte	USGS		Fluor		Veolia		BEA		Total	
	Number	% Pass	Number	% Pass	Number	% Pass	Number	% Pass	Number	% Pass
<b>Radionuclides</b>										
Gross alpha	25	100	10	100	12	100	1	100	48	100
Gross beta	25	92	10	70	12	75	1	0	48	81
Tritium	46	100	20	100	12	100	1	100	79	100
<sup>90</sup> Sr	14	100	12	100	---	---	---	---	26	100
<sup>99</sup> Tc	---	---	10	100	---	---	---	---	10	100
<sup>129</sup> I	---	---	---	---	---	---	---	---	---	---
<sup>137</sup> Cs	14	100	11	100	---	---	1	100	26	100
<sup>234</sup> U	---	---	11	100	---	---	---	---	11	100
<sup>235</sup> U	---	---	13	100	---	---	---	---	13	100
<sup>238</sup> U	---	---	11	100	---	---	---	---	11	100
<sup>238</sup> Pu	4	100	---	---	---	---	---	---	4	100
<sup>239/240</sup> Pu	4	100	---	---	---	---	---	---	4	100
<sup>241</sup> Am	2	100	---	---	---	---	---	---	2	100
<b>Anions</b>										
Cl	46	100	10	100	---	---	1	100	57	100
SO4	40	100	14	100	---	---	1	100	55	100
NO3+NO2	39	85	12	100	---	---	1	100	52	88
Total P	1	100	---	---	---	---	---	---	1	100
<b>Metals</b>										
As	2	100	1	100	---	---	---	---	3	100
Cr	32	97	5	100	---	---	1	100	38	97
Fe	1	100	2	100	---	---	1	100	4	100
Mn	2	100	1	100	---	---	1	100	4	100
Se	2	100	0	---	---	---	---	---	2	100
<b>Volatile Organic Compounds</b>										
Multiple analytes	26	96	80	69	0	---	---	---	106	75
<b>Total</b>	<b>325</b>	<b>97</b>	<b>233</b>	<b>88</b>	<b>36</b>	<b>92</b>	<b>10</b>	<b>90</b>	<b>604</b>	<b>93</b>

## Groundwater Monitoring Impacts and Conclusions

DEQ-INL OP continues to monitor groundwater contamination in the Eastern Snake River Plain Aquifer caused by the discharge of INL wastewater to the aquifer and vadose zone during the twentieth century. Specifically:

- Concentrations of  $^{90}\text{Sr}$  and  $^{99}\text{Tc}$  exceeded federal drinking water standards (MCLs) at some DEQ monitoring sites on the INL in 2019. The elevated  $^{90}\text{Sr}$  and  $^{99}\text{Tc}$  concentrations also contribute to elevated gross beta values found at the same locations. These sites are not used for drinking water.
- Chloride, iron, manganese, and some VOCs exceeded federal drinking water standards (MCLs or secondary MCLs) at some DEQ monitoring sites on the INL in 2019. These sites are not used for drinking water.
- Tritium continues to be detected at a concentration above background in the vicinity of the southern INL boundary. No sites monitored by DEQ exceed federal drinking water standards for tritium. Concentrations of tritium at the INL continue to decline site-wide.
- Carbon tetrachloride continues to increase in some of the wells around and downgradient of RWMC.
- Concentrations of other INL contaminants in water remain constant or continue to decrease at most locations as a result of changes in waste disposal practices.
- INL impacts to the aquifer are not identifiable in water samples collected at sites distantly downgradient of the INL, including in the Magic Valley.
- Of 604 analytical results compared with the results of a co-sampling organization, 93 percent were in agreement, indicating that water monitoring results from other INL organizations are of good quality overall.

## Terrestrial Monitoring

Terrestrial monitoring is performed by measuring radionuclide accumulations in soil to help assess long-term trends of radiological conditions in the environment on and around the INL. Monitoring of milk samples is performed to indirectly verify the presence or absence of atmospheric radioiodine deposited in the terrestrial environment on and near the INL. Some of these data are also used to determine whether the monitoring results obtained by the DOE and its contractors were consistent with the soil and milk sampling results obtained by DEQ for these same locations.

### Terrestrial Monitoring Equipment and Procedures

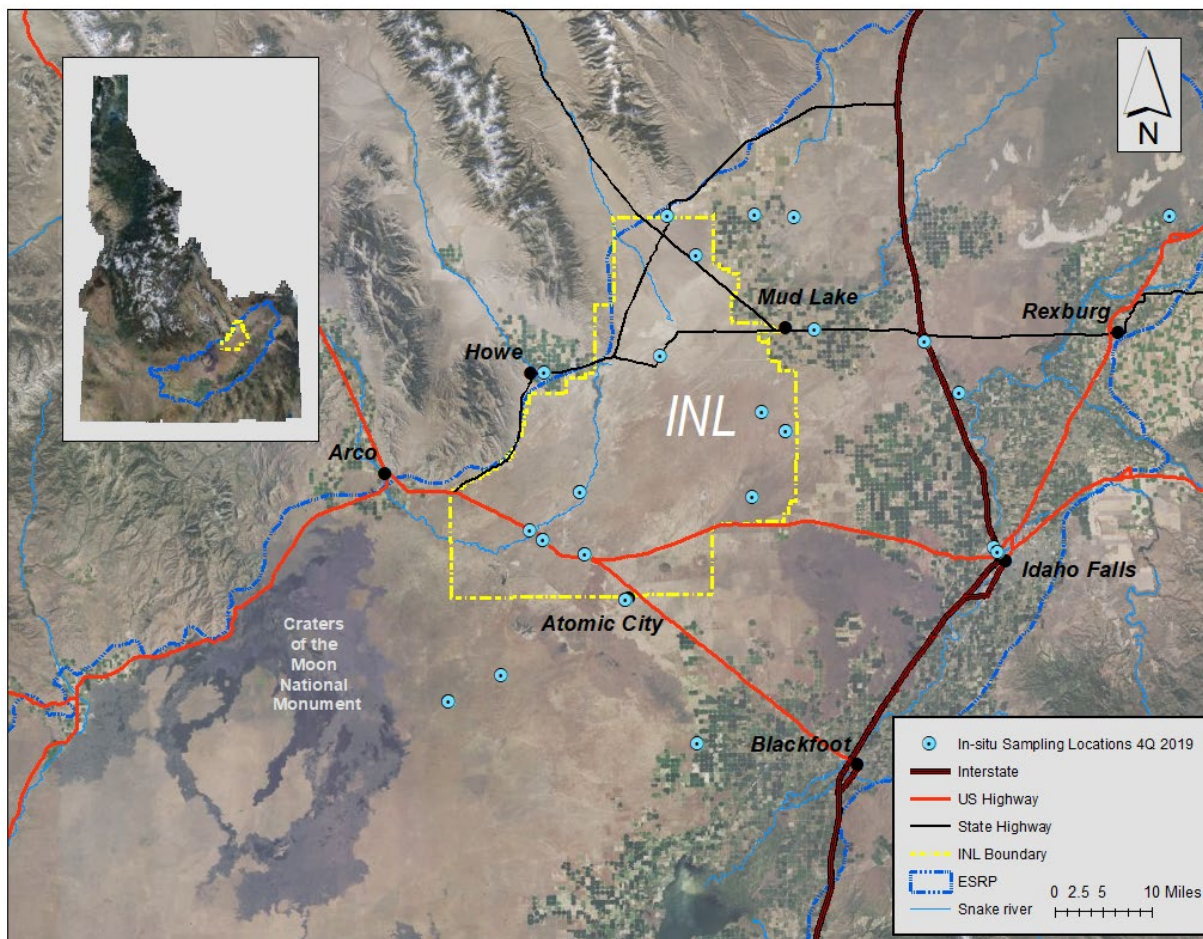
DEQ uses a combination of *in-situ* gamma spectrometry and physical soil samples to monitor concentrations of gamma-emitting radionuclides in soil at DEQ air monitoring stations and selected soil sampling sites on and around the INL (2019 soil sampling sites are shown in **Figure 23**). A portable gamma radiation detector was used in the field to collect surface gamma radiation measurements. These *in-situ* sampling measurements were then used to identify radionuclides present and to estimate soil radioactivity concentrations. Physical soil samples are collected during even numbered years, and were not collected during 2019.

DEQ collected milk samples from distribution centers where milk was received and from individual dairies in southern and southeastern Idaho. Milk sampling locations are shown in



**Figure 1.** Raw milk samples were collected from trucks arriving at the distribution centers from each region of interest. For the independent cow and goat dairies, DEQ personnel drop off empty sample containers that are filled by the owner/operator of the dairy. The samples are picked up within 1-2 days of collection.

Two DEQ milk samples were collected and split by a DOE contractor each month. One half of the split samples were analyzed by the DOE contractor and the other half were submitted to DEQ for analysis. DEQ used the analysis results from these split samples to verify the DOE contractor's milk sampling results and conclusions.



**Figure 23.** *In-situ* soil monitoring sites for 2019.

## Terrestrial Monitoring Results and Trends

Monitoring concentrations of gamma-emitting radionuclides in surface soil provides insight to the transport, deposition, and accumulation of radioactive material in the environment as a result of INL operations and historic atmospheric testing of nuclear weapons. During 2019, DEQ made *in-situ* gamma spectrometry measurements to estimate accumulations of gamma-emitting radionuclides in surface soil at 24 locations. Of the 24 measurements, Cesium-137 ( $^{137}\text{Cs}$ ) was the only man-made radionuclide that was detected. The average  $^{137}\text{Cs}$  value for *in-situ* measurements was 0.15 picocuries per gram (pCi/g) with a minimum value of 0.03 pCi/g and a

maximum of 0.32 pCi/g. All results were well below the recommended federal screening limit for surface soil of 6.8 pCi/g of Cesium-137 (NCRP Report 129).

Milk sampling is conducted by DEQ to determine whether radioiodine is present or absent in the food supply. Radioiodine is produced in relatively large quantities during fission reactions (e.g., in nuclear reactors). The chemical nature of iodine makes it mobile under normal conditions. Gaseous radioiodine can be dispersed through the atmosphere and carried along with the wind until it is deposited on plants. Dairy cows and goats that graze on radioiodine-contaminated pasture or feed will accumulate iodine in the milk they produce. Drinking this milk could lead to an accumulation of radioiodine in the thyroid gland and a greater risk of thyroid cancer.

During 2019, DEQ analyzed 41 milk samples. Radioiodine ( $^{131}\text{I}$ ) was not detected in any milk sample. The DEQ action level of 4.4 pCi/L is based upon the radioiodine concentration in milk necessary for an infant to receive an annual thyroid radiation dose of 5 millirem. The Food and Drug Administration (FDA) recommended maximum concentration of  $^{131}\text{I}$  for food, including milk, is 4600 pCi/kg.

### **Terrestrial Monitoring Verification Results**

Naturally occurring Potassium-40 ( $^{40}\text{K}$ ) is present in milk and soil and is ideal as a quality control measurement and indicator of measurement sensitivity. Therefore, many of the comparisons conducted between DEQ and DOE sample results include this isotope, especially since the target radionuclide (such as Iodine-131) is seldom detected in milk samples.

Gamma spectroscopic analysis results of the 24 milk split samples collected by the DOE contractor and submitted to DEQ for analysis were compared with DOE results.  $^{40}\text{K}$  results obtained by DEQ showed 100% agreement with DOE contractor results. All  $^{131}\text{I}$  results were below the minimum detectable activity for both agencies.

The DOE contractor did not conduct any in-situ soil sampling in 2019, so no comparisons between DEQ and DOE contractor's results could be made.

### **Terrestrial Monitoring Impacts and Conclusions**

Based upon terrestrial radiological measurements of soil and milk, there were no discernable impacts to the environment from INL operations. Long-term accumulation of radionuclides observed by soil monitoring was consistent with historical measurements and was in the range of concentrations expected as a result of historic above-ground testing of nuclear weapons.

## ***Quality Assurance for the ESP***

### **Data Assessment Summary**

This section summarizes the results of the quality assurance (QA) assessment of the data collected during calendar year 2019 by the DEQ's Environmental Surveillance Program. All analyses and quality control (QC) measures at the analytical laboratories used by the DEQ were performed in accordance with approved written procedures maintained by each laboratory. Sample collection and those analyses performed by DEQ were in accordance with written procedures maintained by the DEQ.



During calendar year 2019 the DEQ submitted QC samples for 302 radiological and non-radiological analyses, representing 11.0 percent of the 2739 field sample analyses completed. Analytical results for these QC samples (202 blank results, 54 duplicate results, and 46 spiked sample results) were used to assess the precision, accuracy, and representativeness of results from analyzing laboratories. All analytical results for QC samples and field samples are found in the DEQ quarterly reports for 2019.

During 2019, nine gross alpha and nine gross beta results for weekly TSP air samples were qualified as rejected, all due to insufficient air sample volume. Also, a total of seven expected weekly TSP samples were not obtained from various locations during the year. Equipment issues, winter weather, and excessive filter loadings due to wildfires were the primary causes of these events. During the fourth quarter of 2019, the Van Buren Avenue TSP sampler was calibrated and its flowmeter was found to be incorrect. All Van Buren gross alpha and gross beta results for the quarter were re-calculated based on the calibration data and qualified as estimates.

Also during 2019, four QC blank results, one QC duplicate result, and two QC spiked sample results failed DEQ acceptance criteria for groundwater. These failures resulted in five associated groundwater field sample results being qualified as estimates (two VOCs and three gross betas.)

The overall 2019 data usability (non-rejected results divided by total field sample results obtained) was acceptable at 99.3%. In addition to the 2739 field sample analysis results completed, another 27 expected results were not obtained for 2019, due primarily to TSP sampler issues and environmental radiation detector electronic issues. The overall 2019 data completeness (usable results divided by total field sample results expected) was acceptable at 98.4%. The field data were validated, assigned qualifiers to designate restrictions on their use, and deemed usable and complete, meeting the program's data quality objectives.

## **Issues and Problems**

No major issues or problems affecting data quality were identified during 2019.

## **Comparing Data**

DEQ compares its data with DOE's to determine whether the programs' data sets are statistically equivalent, or if each program's data support the same conclusions relative to environmental impacts and public health. To evaluate statistically the degree of agreement between organizations' split sampling and co-sampling measurements, DEQ evaluates the Relative Percent Difference (RPD) between paired sample results using the following equation:

$$RPD = ((DOE \text{ result} - DEQ \text{ result}) / ((DEQ \text{ result} + DOE \text{ result})/2)) \times 100$$

An RPD in the range of  $\pm 20\%$  is considered to indicate acceptable agreement between measurements. For non-radiological analysis, the RPD is used to compare paired samples in which both of the results exceed five times the detection level. If one or both of the sample results are less than five times the detection level, the absolute difference between the two results is acceptable if it is less than or equal to the larger method detection limit.

For radiological analysis, the RPD is calculated (using the above equation) to compare paired samples if both results are greater than the sample-specific minimum detectable concentration

(MDC). DEQ also considers paired sample results with an absolute difference of no more than three times the pooled error to be in acceptable agreement. This is accomplished using the following equation:

$$| R_1 - R_2 | \leq 3(S_1^2 + S_2^2)^{1/2}$$

Where:

$R_1$  = First sample value.

$R_2$  = Second sample value.

$S_1$  = Uncertainty (one standard deviation) associated with the laboratory measurement of the first sample.

$S_2$  = Uncertainty (one standard deviation) associated with the laboratory measurement of the second sample.

Individual pairs of radiological measurements having an absolute difference of no more than three times their pooled error, or with an RPD in the range of  $\pm 20\%$ , are considered to be statistically in agreement.

Paired data sets are considered to be in satisfactory statistical agreement if at least 80% of the individual paired results are in agreement.

## Radiological Emergency Response Planning and Preparedness

DEQ-INL OP's role in emergency response planning and preparedness is defined in detail in the Environmental Oversight and Monitoring Agreement (EOMA) with the DOE. DEQ works with DOE and INL contractors to evaluate and participate in response planning, and to respond to incidents. DEQ works with state, federal and local agencies to respond to incidents, as described in the Idaho Hazardous Materials/WMD Incident Command and Response Support Plan. The Idaho Office of Emergency Management (IOEM) coordinates state emergency response actions in Idaho. Most of DEQ's emergency response activities are directed towards planning and response to INL incidents. DEQ also responds to non-INL radiological incidents to help maintain lines of communication with the State's emergency response organization, and as opportunities to test organizational readiness under real-world conditions. As a part of public outreach, DEQ can provide technical information, assistance, and training to local and state authorities for incidents involving radioactive materials at the INL or elsewhere in Idaho.

By agreement with DOE, INL radiological incident response planning is based on hazard assessment documents (HADs) developed by DOE contractors. These documents describe potential incidents at INL facilities that could release radionuclides to the environment. Review of current INL HADs is a key element of preparing for INL radiological emergencies. This information allows DEQ to identify scenarios that could potentially result in off-site radiological impacts, and plan appropriate responses. DEQ uses the source inventory and accident scenarios from the HADs to develop input for atmospheric dispersion and dose modeling using the Radiological Assessment System for Consequence Analysis (RASCAL) code. RASCAL uses real time National Oceanic and Atmospheric Administration (NOAA) weather data for regional-scale dispersion modeling. This allows DEQ to make independent radiological dose assessments

for planning purposes, and would support development of timely technical and protective action recommendations for state authorities during actual emergencies. DEQ also receives text messages from the INL Warning Communication Center anytime their emergency resources are deployed; primarily the INL Fire Department.

### ***Non-INL Radiological Activities***

1. The manager and/or staff members participated in 20 regional and county emergency planning meetings.
2. The manager and staff members participated in the Northwest Emergency Managers Workshop Meetings.
3. One staff member attended the Western Interstate Energy Board, High Level Waste Committee meeting in San Diego. The DEQ-INL OP manager attended via teleconference.
4. Some staff members participated in the Region V Local Emergency Planning Committee (LEPC) and National Weather Service meeting.

### ***Drills and Exercises***

1. Various staff participated in multiple INL drills and exercises. When the INL Emergency Operations Center (EOC) was activated DEQ-INL OP staff members were in the EOC running plume/dose projections and interfacing with EOC personnel.
2. Staff members helped plan and participated in the INL full scale exercise.
3. Some staff participated in an exercise with the Naval Reactors Facility (NRF) and Butte County at EBR I and Lost River Medical Center in Arco.

### ***Waste Isolation Pilot Plant Shipment Safety***

DOE contracts with the Western Governors Association (WGA) to coordinate activities related to the safe shipment of transuranic waste to the Waste Isolation Pilot Plant (WIPP) through western states. DEQ-INL OP works with the Idaho State Police (ISP) and the Idaho Office of Emergency Management to manage WIPP shipment safety activities on the US Route 20/26, Interstate 15, and Interstate 84 / 86 corridors in Idaho.

During 2019, DEQ-INL OP:

1. Provided oversight for radiological equipment repairs and calibrations for ISP, all seven Idaho regional response teams, the Shoshone-Bannock Tribes, and three area hospitals.
2. Staff members attended the National Transportation Stakeholders Forum and two meetings of the WIPP Technical Advisory Group (TAG). DEQ-INL OP staff also participated in monthly conference calls with the WIPP TAG.

### ***Emergency Response***

- DEQ INL-OP staff responded to the Sheep Fire and an MFC containment event.

## **Planning and Preparedness Meetings**

1. Staff members attended 20 Local Emergency Planning Committee (LEPC) meetings, and the five regional emergency planning meetings. DEQ-INL OP Manager and/or staff attended multiple Northwest Emergency Managers Workshops.
2. The manager and a few staff attended multiple INL Citizens Advisory Board Meetings.

## **Classes and Presentations**

1. All staff received training in INL Web Emergency Operations Center access and database and Wildland Fire Safety Brief.
2. A staff member provided radiological emergency response training to first responders in Twin Falls, Fort Hall and Idaho Falls.
3. One staff member attended the Nuclear Regulatory Commission (NRC) R800 Reactor Safety Course in Washington DC.

## **Public Outreach**

A fundamental aspect of DEQ-INL OP's work is sharing our findings with the public and factoring public input into our activities and policy recommendations. Several tools are used to provide Idahoans with independent, accurate, and timely information about activities relating to the INL and other DOE activities in Idaho – publications, events, our Web site, and our community monitoring network.

### ***Publications***

Technical and non-technical publications are issued to communicate the findings and activities of our program. In 2019, the following were issued:

- The DEQ-INL OP Annual Report for 2018.
- Four quarterly environmental surveillance data reports.

DEQ-INL OP publications are available at  
<http://www.deq.idaho.gov/inl-oversight/monitoring/reports.aspx>.

### ***Presentations and Events***

DEQ-INL OP also communicates with the public about INL-related issues through schools, fairs, special interest groups, and public events. In 2019, we gave public presentations on the aquifer, and INL Site information to a range of schools, civic groups, and special interest groups.

The Water Festival begins with a distribution of water education materials to approximately 3100 eastern Idaho students from 44 schools. Each year, some of the students from the Water Festival participate in the Poetry Contest. The poems and winners are displayed in the Idaho Falls Library three weeks prior to the event (**Figure 24**). The Idaho Falls Water Festival is held 2 days to accommodate a total of over 1,600 students. Water Festival events were also held at Mackay and Shelley elementary schools. (**Figures 25**).



Figure 24. Water Awareness Poetry Contest 2019 on display at the Idaho Falls Library.



Figure 25. DEQ teaching Macroinvertebrate Mayhem at Mackay Water Festival 2019.



Idaho Falls Earth Day continues to offer several activities for the youth and adults to enjoy. DEQ provides an Edible Aquifer activity to teach about the importance of water in our aquifer (Figure 26). DEQ-INL OP provides carry-all bags with Earth Day giveaways at the booth (Figure 27).



Figure 26. Children participating in the Edible Aquifer activity at the 2019 Earth Day event.



Figure 27. DEQ staff handing out give-away items at the 2019 Earth Day event.



## ***Community Monitoring Network***

DEQ also participates in a community monitoring network in Eastern Idaho in cooperation with the Shoshone-Bannock Tribes, the U.S. Department of Energy, and NOAA. Strategically located community monitoring stations provide real-time atmospheric and radiological data to the public at each station location and also transmit data to the World Wide Web at <http://www.idahoop.org/>. (Figure 28).



**Figure 28. Idaho Falls Community monitoring station at the Greenbelt.**