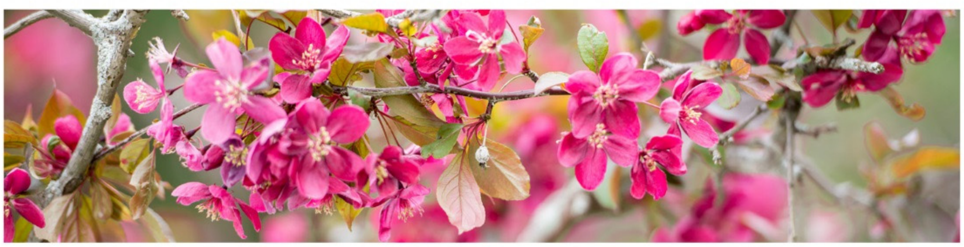
ANL-17/02

SITE ENVIRONMENTAL REPORT

for Calendar Year 2016



Health, Safety, and Environment Division

ANL-17/02

Argonne National Laboratory Site Environmental Report for Calendar Year 2016

Preceding Report in This Series: ANL-16/02

prepared by
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This Site Environmental Report (SER) was prepared by the Health, Safety, and Environment (HSE) Division at Argonne National Laboratory (Argonne) for the U.S. Department of Energy (DOE). The main authors are pictured to the right. The results of the environmental monitoring program and an assessment of the impact of site operations on the environment and the public are presented in this publication. This SER is available on the Internet at http://www.anl.gov/community/environmental-protection.

Many of the figures and tables were prepared by Jennifer Tucker (HSE). Some figures, however, were prepared by the authors and various staff members of Argonne's Environmental Science Division (EVS). Many members of the Environmental Protection and the Environmental Sustainability programs contributed to this report. Pictures of the contributors are found at the beginning of each chapter. Names are listed below.

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ACHP	Advisory Council for Historic Preservation
ACM	Asbestos-Containing Material
AEA	Atomic Energy Act of 1954
AGHCF	Alpha Gamma Hot Cell Facility
ALARA	As Low As Reasonably Achievable
APES	Argonne Property Excess System
APS	Advanced Photon Source
Argonne	Argonne National Laboratory
ASO	Argonne Site Office
ATLAS	Argonne Tandem Linac Accelerator System
BAT	Best Available Technology
BCG	Biota Concentration Guide
BOD	Biochemical Oxygen Demand
BMPs	Best Management Practices
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CAP-88	Clean Air Act Assessment Package-1988
CAS	Chemical Abstracts Service
CEDE	Committed Effective Dose Equivalent
CEM	Continuous Emission Monitor
CEPA	Communications, Education & Public Affairs
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CHP	Combined Heat and Power
CNM	Center for Nanoscale Materials
CoC	Contaminants of Concern
COE	U.S. Army Corps of Engineers
CP-5	Chicago Pile-Five
CWA	Clean Water Act
CY	Calendar Year
DCA	1,1-Dichloroethane
DCS	Derived Concentration Standard
DMR	Discharge Monitoring Report
DMR-QA	Discharge Monitoring Report–Quality Assurance Program
DOE	U.S. Department of Energy
DOE-ASO	DOE Argonne Site Office
DOE-HQ	DOE Headquarters
EA	Environmental Assessment
EHS	Extremely Hazardous Substance
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENE	East-Northeast
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESA	Endangered Species Act of 1973

ESPC	Energy Savings Performance Contract
EVS	Environmental Science Division
FFCA	Federal Facility Compliance Act of 1992
FMS	Facilities Management and Services
FY	Fiscal Year
GHG	Greenhouse Gas
GMZ	Groundwater Management Zone
GQS	Groundwater Quality Standard
GRO	Groundwater Remediation Objective
HAP	Hazardous Air Pollutant
HPSB	High Performance and Sustainable Buildings
HSE	Health, Safety, and Environment Division
HSWA	Hazardous and Solid Waste Amendments of 1984
HTRL	Howard T. Ricketts Laboratory
IAC	*Illinois Administrative Code*
ICRP	International Commission on Radiological Protection
IEPA	Illinois Environmental Protection Agency
IPNS	Intense Pulsed Neutron Source
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
LEPC	Local Emergency Planning Committee
LINAC	Linear Accelerator
LLRW	Low-Level Radioactive Waste
LTS	Long-Term Stewardship
LUCMOA	Land Use Control Memorandum of Agreement
LWTP	Laboratory Wastewater Treatment Plant
MAPEP	Mixed Analyte Performance Evaluation Program
MW	Mixed Waste
MY	Model Year
NBL	New Brunswick Laboratory
NCRP	National Council on Radiation Protection & Measurements
NEPA	National Environmental Policy Act of 1969
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFA	No Further Action
NHPA	National Historic Preservation Act of 1966
NIST	National Institute of Standards and Technology
NNSS	Nevada National Security Site
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	National Response Center
NRHP	*National Register of Historic Places*
ORPS	Occurrence Reporting Processing System
OSHA	Occupational Safety and Health Administration
OSL	Optically Stimulated Luminescence Dosimeter
P2	Pollution Prevention/Waste Miniminzation
PCB	Polychlorinated Biphenyl

PCE	Tetrachloroethene
PSTP	Proposed Site Treatment Plan
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RACT	Reasonably Available Control Technology
RCRA	Resource Conservation and Recovery Act of 1976
RESL	Radiological and Environmental Sciences Laboratory
RFI	RCRA Facility Investigation
RICE	Reciprocating Internal Combustion Engines
RQ	Reportable Quantity
SARA	Superfund Amendments and Reauthorization Act
SDS	Safety Data Sheet
SDWA	Safe Drinking Water Act of 1974
SER	Site Environmental Report
SERC	State Emergency Response Commission
SME	Subject Matter Expert
SPCC	Spill Prevention Control and Countermeasures
SSP	Site Sustainability Plan
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
SWPPP	Stormwater Pollution Prevention Plan
SWTP	Sanitary Wastewater Treatment Plant
TACO	Tiered Approach to Corrective Action Objectives
TCS	Theory and Computing Sciences
TDS	Total Dissolved Solids
THMs	Trihalomethanes
TOC	Total Organic Carbon
TRC	Total Residual Chlorine
TRI	Toxic Release Inventory
TRU	Transuranic Waste
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WIPP	Waste Isolation Pilot Plant
WMO	Waste Management Operations
WP&C	Work Planning and Control
WQS	Water Quality Standard
WTP	Wastewater Treatment Plant

This report discusses the status and the accomplishments of the environmental protection program at Argonne National Laboratory for calendar year 2016. The status of Argonne environmental protection activities with respect to compliance with the various laws and regulations is discussed, along with environmental management, sustainability efforts, environmental corrective actions, and habitat restoration. To evaluate the effects of Argonne operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the Argonne site were analyzed and compared with applicable guidelines and standards. A variety of radionuclides were measured in air, surface water, on-site groundwater, and bottom sediment samples. In addition, chemical constituents in surface water, groundwater, and wastewater were analyzed. External penetrating radiation doses were measured, and the potential for radiation exposure to off-site population groups was estimated. Results are interpreted with respect to the origin of the radioactive and chemical substances (i.e., natural, Argonne, and other) and are compared with applicable standards intended to protect human health and the environment. A U.S. Department of Energy (DOE) dose calculation methodology, based on International Commission on Radiological Protection (ICRP) recommendations and the U.S. Environmental Protection Agency's (EPA) CAP-88 Version 3 computer code, was used in preparing this report.

1. INTRODUCTION

1.1. General Background Information

This annual report for calendar year 2016 of the Argonne National Laboratory (Argonne) environmental protection program was prepared to inform the U.S. Department of Energy (DOE), environmental agencies, and the public about the levels of radioactive and chemical pollutants in the vicinity of Argonne, as well as the amounts, if any, added to the environment by Argonne operations. It also summarizes the compliance of Argonne operations with applicable environmental laws and regulations and highlights significant accomplishments and issues related to environmental protection, sustainability, and remediation. The report was prepared in accordance with the guidelines of DOE Orders 436.1[1] and 231.1B[2] and supplemental DOE guidance.

Argonne is managed by UChicago Argonne, LLC, for the U.S. Department of Energy's Office of Science. Argonne is a DOE research and development (R&D) laboratory. Research at Argonne centers around three principal areas: sustainable energy, a healthy environment, and a secure nation. Argonne conducts an environmental surveillance program on and near the site to determine the identity, magnitude, and origin of radioactive and chemical substances in the environment. Monitoring of releases of such materials to the environment from Argonne operations is performed to verify the adequacy of the site's pollution control systems.

The principal radiological facilities at Argonne are the Advanced Photon Source (APS), a superconducting heavy-ion linear accelerator (Argonne Tandem Linac Accelerator System [ATLAS]), a 22-MeV pulsed electron linac, and several other charged-particle accelerators. The principal remaining nuclear facilities at Argonne are the Alpha Gamma Hot Cell Facility (AGHCF), the Waste Management Operations (WMO) Facility, and the Radioactive Waste Storage Facility. These nuclear facilities are non-reactor facilities and they involve material handling, management, storage, and disposition. The principal non-nuclear activities at Argonne that could potentially have measurable impacts on the environment include the five steam boilers at the central heating plant and the discharge of wastewater from various sources.

The DOE New Brunswick Laboratory (NBL), a plutonium and uranium measurements and analytical chemistry laboratory, and the University of Chicago's Howard T. Ricketts Regional Biocontainment Laboratory, a state-of-the-art biocontainment facility intended to study infectious diseases, are also located on the Argonne site.

1.2. Description of Site

Argonne occupies the central 607 ha (1,500 acres) of a 1,514-ha (3,740-acre) tract in DuPage County, Illinois. The site is 43 km (27 mi) southwest of downtown Chicago and 39 km (24 mi) west of Lake Michigan. It is north of the Des Plaines River Valley, south of Interstate Highway 55, and west of Illinois Highway 83. Figures 1.1 and 1.2 are maps of the site and the surrounding areas that show some of the sampling locations associated with the monitoring program. Much of the 907-ha (2,240-acre) Waterfall Glen Forest Preserve surrounding the site was part of the Argonne site before it was deeded to the DuPage County Forest Preserve District

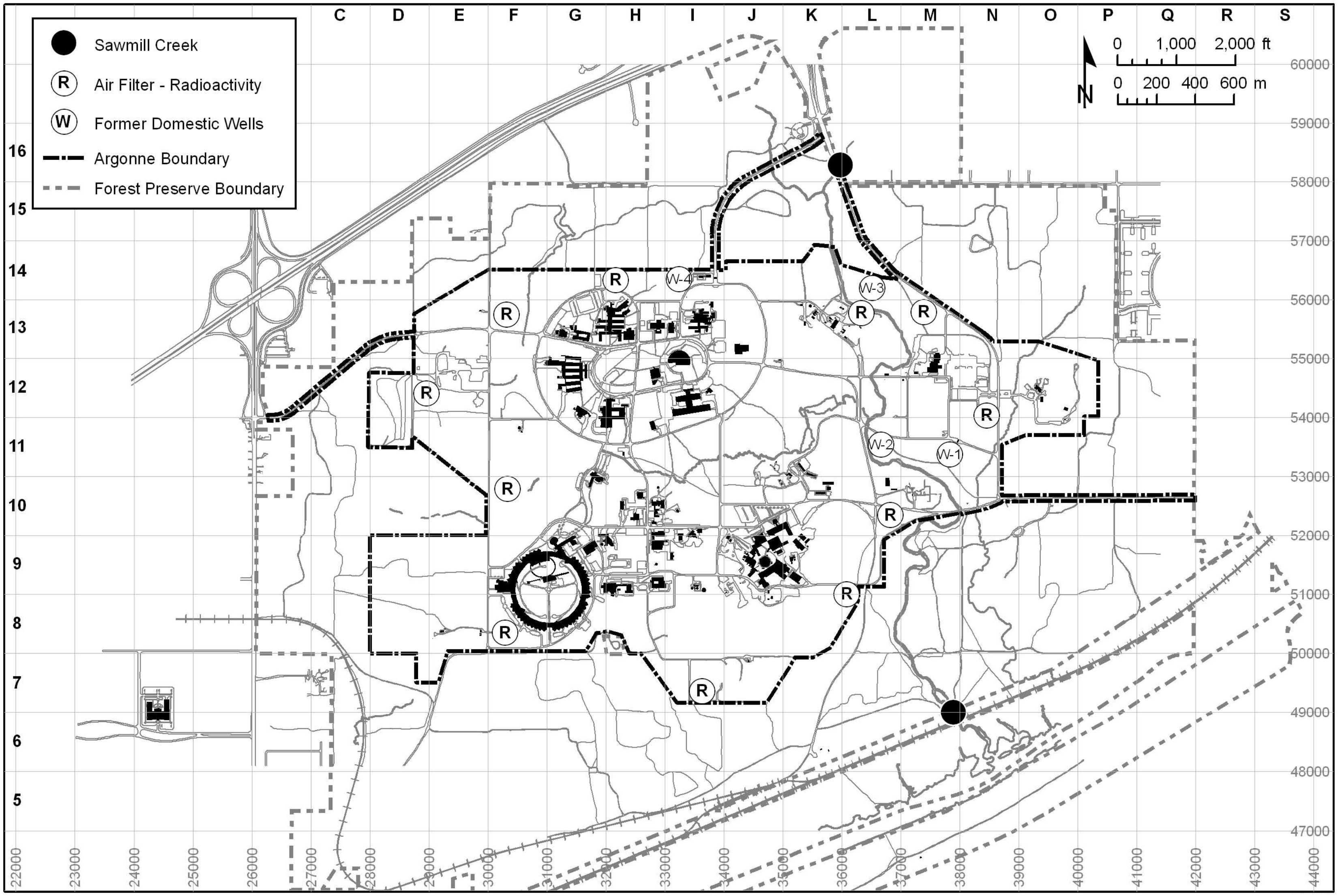

FIGURE 1.1 Sampling Locations at Argonne National Laboratory

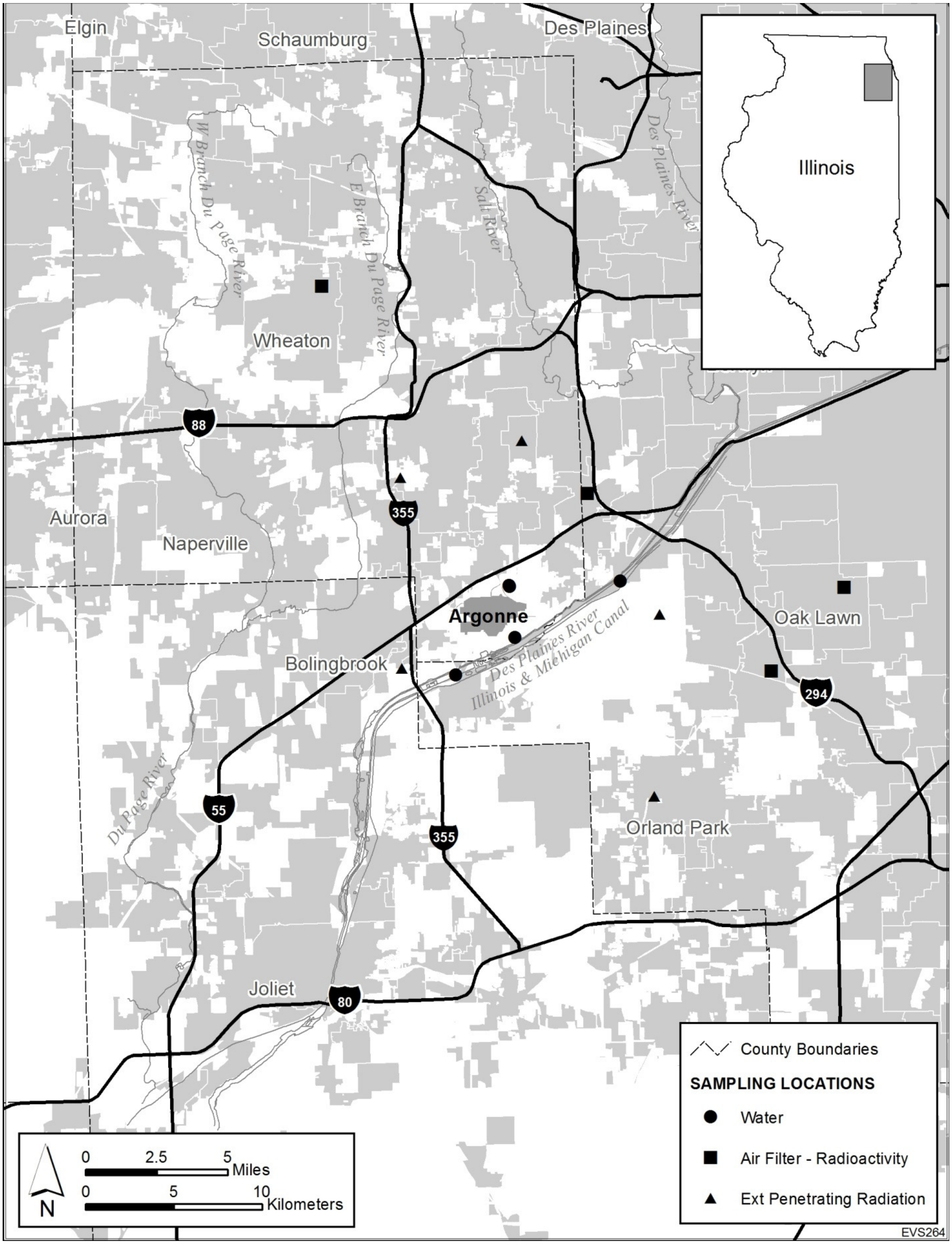

FIGURE 1.2 Sampling Locations Near Argonne National Laboratory

in 1973 for use as a public recreational area, nature preserve, and demonstration forest. In this report, facilities and some sampling locations are identified by the alpha-numeric row and column designations in Figure 1.1, to facilitate identification of their locations.

The terrain of Argonne is gently rolling, partially wooded, former prairie and farmland. The grounds contain a number of small ponds and streams. The principal stream is Sawmill Creek, which runs through the site in a southerly direction and enters the Des Plaines River about 2.1 km (1.3 mi) southeast of the center of the site. The land is drained primarily by Sawmill Creek, although the extreme southern portion drains directly into the Des Plaines River, which flows along the southern boundary of the forest preserve. This river flows southwest until it joins the Kankakee River about 48 km (30 mi) southwest of Argonne to form the Illinois River.

The largest topographical feature of the area is the Des Plaines River Valley, which is about 1.6 km (1 mi) wide. This valley contains the river, the Chicago Sanitary and Ship Canal, and the Illinois and Michigan Canal. The elevation of the channel surface of these waterways is 180 m (578 ft) above sea level. The bluffs that form the southern border of the site rise from the river channel at slope angles of 15 to 60° and reach an average elevation of 200 m (650 ft) above sea level at the top. The land then slopes gradually upward and reaches the average site elevation of 220 m (725 ft) above sea level at 915 m (3,000 ft) from the bluffs. Several large ravines, oriented in a north-south direction, are located in the southern portion of the site. The bluffs and ravines generally are forested with mature deciduous trees. The remaining portion of the site changes in elevation by no more than 7.6 m (25 ft) in a horizontal distance of 150 m (500 ft).

1.3. Population

The area around Argonne has experienced significant population growth in the past 40 years as large areas of farmland have been converted into housing. Table 1.1 gives the directional and annular 80-km (50-mi) population distribution for the area, which is used to derive the population dose calculations presented later in this report. The population distribution, centered on the former Intense Pulsed Neutron Source (IPNS) (Location 9J in Figure 1.1), was prepared by the Risk Assessment and Safety Evaluation Group of the Environmental Science Division at Argonne and represents projections based on 2010 census data, projected to 2013.

1.4. Climatology

The climate of the area is representative of the upper Mississippi Valley, as moderated by Lake Michigan. The most important meteorological parameters for the purposes of this report are wind direction, wind speed, temperature, and precipitation. Historic wind data were used to select air sampling locations. Data from the current year were used to calculate radiation doses from air emissions. Temperature and precipitation data are useful in interpreting some of the monitoring results. The 2016 data were obtained from the on-site Argonne meteorological station. The average wind direction usually varies from the west to the south, but with a significant northeast component.

TABLE 1.1

Population Distribution in the Vicinity of Argonne, 2015

Direction	Miles[a]									
	0–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
N	0	896	2,610	5,901	8,828	47,592	184,834	351,618	241,141	345,563
NNW	0	1,141	2,692	5,349	8,321	35,679	212,567	282,263	201,525	148,111
NW	0	1,187	2,645	5,707	9,129	46,573	84,518	149,233	46,155	28,562
WNW	0	871	2,768	5,851	6,064	45,012	193,450	59,691	11,876	66,453
W	0	421	2,052	7,286	9,650	51,065	143,553	55,519	23,453	5,256
WSW	0	419	517	696	2,390	26,613	50,896	12,637	12,382	14,676
SW	0	520	1,238	1,008	707	21,728	116,623	27,385	18,868	6,826
SSW	0	459	2,018	1,996	1,721	22,052	91,904	13,063	19,133	9,882
S	0	443	2,950	2,136	1,497	12,608	43,378	7,061	41,557	33,616
SSE	0	441	883	1,130	1,784	21,673	61,017	11,875	22,998	15,241
SE	0	436	571	839	1,098	25,954	142,625	117,141	44,393	22,208
ESE	0	427	570	749	576	19,542	184,248	287,238	215,712	106,129
E	0	420	774	657	542	42,902	413,299	194,284	10,986	29,584
ENE	0	419	1,130	1,796	2,233	34,832	585,379	220,070	0	0
NE	0	625	1,911	1,884	1,976	39,454	660,490	998,751	0	0
NNE	0	788	2,682	6,265	5,821	45,872	297,859	511,676	102,520	1,973
Totals	0	9,913	28,011	49,250	62,337	539,151	3,466,640	3,299,505	1,012,699	834,080
Cumulative totals[b]	0	9,913	37,924	87,174	149,511	688,662	4,155,302	7,454,807	8,467,506	9,301,586

[a] To convert from miles to kilometers, multiply by 1.6.

[b] Cumulative totals = the total of this sector plus the totals of all previous sectors.

Table 1.2 gives 2016 precipitation and temperature data. The monthly precipitation data for 2016 was below the Argonne historical average for seven months out of the year. The 2016 monthly average temperature exceeded the long-term monthly average for nine months out of the year. Both the 2016 average precipitation and the 2016 average temperature were higher than the long-term annual totals. The climatology information was provided by the Climate and Atmospheric Science Department of the Environmental Science (EVS) Division.

TABLE 1.2

Argonne Weather Summary, 2016

	Precipitation (cm)			Temperature (°C)	
Month	Argonne 2016	Argonne Historical[a]		Argonne 2016	Argonne Historical[a]
January	2.12	4.65		–3.9	–4.6
February	3.29	4.44		–0.9	–2.6
March	9.91	6.27		6.6	3.4
April	7.27	8.85		9.2	9.5
May	15.92	10.57		15.6	15.4
June	5.00	9.52		22.1	20.8
July	23.10	10.91		22.9	23.2
August	15.90	10.76		23.7	22.3
September	4.08	8.37		19.9	18.2
October	9.62	8.51		14.3	11.6
November	5.97	8.01		8.2	4.7
December	3.94	5.49		-3.8	–2.5
Total	106.12	96.62	Average	11.2	9.9

[a] Averages were obtained from the Argonne meteorological tower by using data from the last 34 years (1983–2016).

1.5. Geology

The geology of the Argonne area consists of about 30 m (100 ft) of glacial drift on top of nearly horizontal bedrock consisting of Niagara and Alexandrian dolomite underlain by shale and older dolomites and sandstones of Ordovician and Cambrian age. The glacial drift sequence is composed of the Wadsworth and Lemont formations. Both are dominated by fine-grained drift units but also contain sandy, gravelly, or silty interbeds. Niagara and Alexandrian dolomite is approximately 60 m (200 ft) thick but has an irregular, eroded upper surface.

The southern boundary of Argonne follows the bluff of a broad valley, which is now occupied by the Des Plaines River, the Chicago Sanitary and Ship Canal, and the Illinois and Michigan Canal. This valley was carved by waters flowing out of the glacial Lake Michigan about 11,000 to 14,000 years ago. The soils on the site were derived from glacial drift over the past 12,000 years and are primarily of the Morley series, that is, moderately well-drained upland soils with a slope ranging from 2 to 20%. The surface layer is a dark grayish-brown silt loam, the subsoil is a brown silty clay, and the underlying material is a silty clay loam glacial drift. Morley soils have a relatively low organic content in the surface layer, moderately slow subsoil permeability, and a large water capacity. The remaining soils along creeks, intermittent streams, bottomlands, and a few small upland areas are of the Sawmill, Ashkum, Peotone, and Beecher series, which are generally poorly drained. They have a black to dark gray or brown silty clay loam surface layer, high organic matter content, and a large water capacity.

1.6. Seismicity

No tectonic features within 100 km (62 mi) of Argonne are known to be seismically active. Although a few minor earthquakes have occurred in northern Illinois, none has been positively associated with particular tectonic features. Most of the recent local seismic activity is believed to be caused by isostatic adjustments of the earth's crust in response to glacial loading and unloading, rather than by motion along crustal plate boundaries.

Several areas of considerable seismic activity are located at some distance from Argonne. These areas include the New Madrid Seismic Zone (NMSZ), in the St. Louis area of southeast Missouri; the Wabash Valley Seismic Zone, along the southern Illinois-Indiana border; and the Anna Seismogenic Region of western Ohio.

According to United States Geological Survey's (USGS) Earthquake Hazards Program, ground motion induced by seismic sources in northern Illinois is expected to be minimal. The probability that peak ground acceleration in the Argonne area will exceed 10% of gravity (the approximate threshold of major damage) is approximately 2% within a 50-year period.

1.7. Groundwater Hydrology

Two principal aquifers are used as water supplies in the vicinity of Argonne. The upper aquifer resides in the Niagaran and Alexandrian dolomite, which is approximately 60 m (200 ft) thick in the Argonne area and has a piezometric surface between 15 and 30 m (50 and 100 ft) below the ground surface for much of the site. The lower aquifer is in the Galesville sandstone, which lies between 150 and 450 m (500 and 1,500 ft) below the surface. Maquoketa shale separates the upper dolomite aquifer from the underlying sandstone aquifer. This shale retards the movement of groundwater between the two aquifers.

Until 1997, most groundwater supplies in the Argonne area were derived from the Niagaran, and to some extent, the Alexandrian dolomite bedrock. Delivery of Lake Michigan water to the nearby suburban areas began in 1992. Argonne currently obtains all of its domestic water from the DuPage Water Commission, which obtains Lake Michigan water from the City of Chicago water system.

1.8. Water and Land Use

Sawmill Creek flows through the eastern portion of the site. This stream originates north of the site, flows through the property in a southerly direction, and discharges into the Des Plaines River. Two small streams, one originating on-site and the other just off-site, combine to form Freund Brook, which discharges into Sawmill Creek. In addition to the streams, various ponds and marshes are present on the site. A network of ditches and culverts transports surface runoff toward these water bodies. Along the southern margin of the property, the terrain slopes abruptly downward, forming forested bluffs. These bluffs are incised by ravines containing intermittent streams that discharge some site drainage into the Des Plaines River.

The majority of the Argonne site is drained by Freund Brook. Two branches of Freund Brook flow from west to east discharging into Sawmill Creek. The larger south branch originates in a marsh adjacent to the western boundary line of the site. It traverses wooded terrain for a distance of about 2 km (1.5 mi) before discharging into the Lower Freund Pond. The Upper Freund Brook branch originates within the central part of the site and also discharges into the Lower Freund Pond.

Treated sanitary and laboratory wastewater from Argonne are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. In 2016, this effluent averaged 2.73 million L/day (0.72 million gal/day). The combined Argonne effluent consisted of 65% laboratory wastewater and 35% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 45.8 million L/day (12.1 million gal/day) during 2016.

Sawmill Creek and the Des Plaines River upstream of Joliet, Illinois, about 21 km (13 mi) southwest of Argonne, receive very little recreational or industrial use. Water from the Chicago Sanitary and Ship Canal is used by Argonne for cooling tower makeup water and by others for industrial purposes, such as hydroelectric generators and condensers. Argonne usage is approximately 1.90 million L/day (0.50 million gal/day). The canal, which receives Chicago Metropolitan Sanitary District effluent water, is used for industrial transportation and some recreational boating. Near Joliet, the river and canal combine into one waterway, which continues until it joins the Kankakee River to form the Illinois River about 48 km (30 mi) southwest of Argonne. The Dresden Nuclear Power Station is located at the confluence of the Kankakee, Des Plaines, and Illinois Rivers. This station uses water from the Kankakee River for cooling and discharges the water into the Illinois River. The first downstream location where river water is used as a community water supply is at Peoria, Illinois, which is on the Illinois River about 240 km (150 mi) downstream of Argonne. In the vicinity of Argonne, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

The principal recreational area near Argonne is the Waterfall Glen Forest Preserve, which surrounds the site (see Section 1.2 and Figure 1.1). The area is used for hiking, skiing, biking, and horseback riding. Sawmill Creek flows south through the eastern portion of the preserve on its way to the Des Plaines River. Several large forest preserves of the Forest Preserve District of Cook County are located southeast of Argonne and the Des Plaines River. The preserves include the McGinnis and Saganashkee Sloughs, as well as other smaller lakes. These areas are used for picnicking, boating, fishing, and hiking. A small park located in the eastern portion of the Argonne site (Location 12O in Figure 1.1) is for use by Argonne and DOE employees. A local municipality also has use of the park for athletic events. The park contains a day-care center for children of Argonne and DOE employees.

1.9. Vegetation

Argonne lies within the Prairie Peninsula of the Oak-Hickory Forest Region. The Prairie Peninsula is a mosaic of oak forest, oak openings, and tall-grass prairie occurring in glaciated portions of Illinois, northwestern Indiana, southern Wisconsin, and sections of other states. Much of the natural vegetation of this area has been modified by clearing and tillage. Forests in the Argonne region, which are predominantly oak and hickory, are somewhat limited to slopes of shallow, ill-defined ravines or low moraine like ridges. Gently rolling to flat intervening areas between ridges and ravines were predominantly occupied by prairie before their use for agriculture. The prevailing successional trend in these areas, in the absence of cultivation, is toward oak-hickory forest. Forest dominated by red oak and basswood may occupy more pronounced slopes. Poorly drained areas, streamside communities, and floodplains may support forests dominated by silver maple, elm, and cottonwood. Figure 1.3 shows the vegetation communities on the Argonne site.

Early photographs of the site indicate that most of the land that Argonne now occupies was actively farmed. About 75% was plowed field and 25% was pasture, open oak woodlots, and oak forests. Starting in 1953 and continuing for three seasons, some of the formerly cultivated fields were planted with jack, white, and red pine trees. Other fields are dominated by bluegrass.

The deciduous forests on the remainder of the site are dominated by various species of oak, generally as large, old, widely spaced trees, which often do not form a complete canopy. Their large low branches indicate that they probably matured in the open, rather than in a dense forest. Other upland tree species include hickory, hawthorn, cherry, and ash.

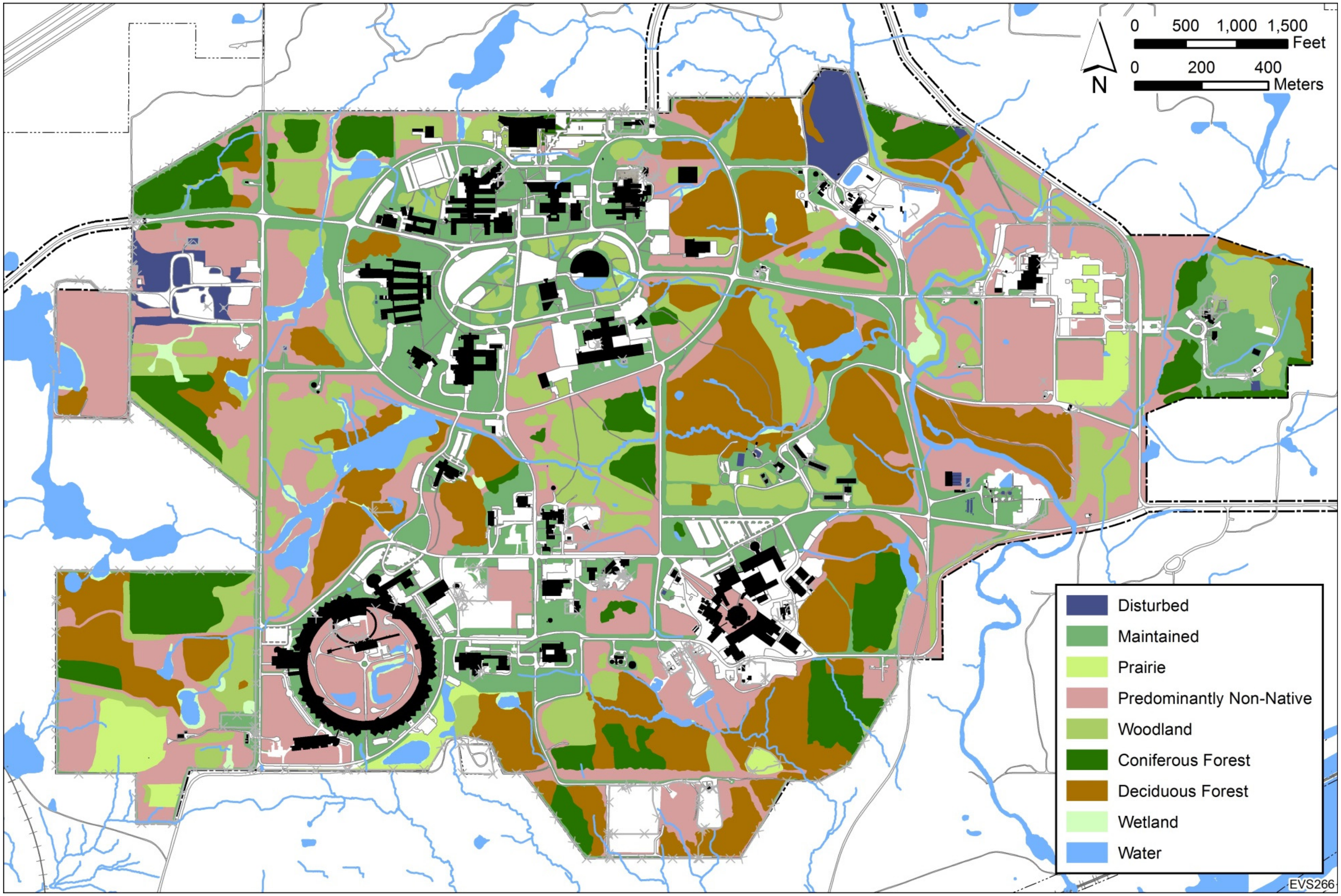

FIGURE 1.3 Argonne Vegetation Communities

1.10. Fauna

Terrestrial vertebrates that are commonly observed or likely to occur on the site include about 5 species of amphibians, 7 species of reptiles, 40 species of summer resident birds, and 25 species of mammals. More than 100 other bird species can be found in the area during migration or in winter; however, they do not nest on the site or in the surrounding region. An unusual species on the Argonne site is the fallow deer, a European species that was introduced to the area by a private landowner prior to government acquisition of the property in 1947. However, over the past few years, the fallow deer population has decreased significantly. At most, only a few fallow deer are still present on the site. A population of native white-tailed deer also inhabits the Argonne site. The deer population is maintained at a target density of 15 deer/mi^2 under an ongoing deer management program.

Freund Brook crosses the center of the site. The gradient of the stream is relatively steep, and riffle habitat predominates. The substrate is coarse rock and gravel on a firm mud base. Primary production in the stream is limited by shading, but diatoms and some filamentous algae are common. Aquatic macrophytes include common arrowhead, pondweed, duckweed, and bulrush. Invertebrate fauna consist primarily of dipteran larvae, crayfish, caddisfly larvae, and midge larvae. Few fish are present because of low summer flows and high temperatures. Other aquatic habitats on the Argonne site include beaver ponds, artificial ponds, ditches, and Sawmill Creek.

The biotic community of Sawmill Creek is relatively impoverished, which reflects the creek's high silt load, steep gradient, and historic release of sewage effluent from the Marion Brook sewage treatment plant north of the site. The fauna consists primarily of blackflies, midges, isopods, flatworms, segmented worms, and creek chubs. A few species of minnows, sunfish, and catfish are also present. Clean-water invertebrates, such as mayflies and stoneflies, are rare or absent. Fish species that have been recorded in Argonne aquatic habitats include black bullhead, bluegill, creek chub, golden shiner, goldfish, green sunfish, largemouth bass, stoneroller, and orange spotted sunfish.

2. COMPLIANCE SUMMARY

Argonne is a U.S. government-owned, contractor-operated research and development (R&D) facility that is subject to environmental statutes and regulations administered by the U.S. Environmental Protection Agency (EPA), the Illinois Environmental Protection Agency (IEPA), the U.S. Army Corps of Engineers (COE), and the State Fire Marshal, as well as numerous DOE Orders and Executive Orders (EOs). The status of Argonne during 2016 with regard to these authorities is discussed in this chapter.

The Atomic Energy Act of 1954 (AEA) was enacted to assure the proper management of radioactive materials. Under the act, DOE regulates the control of radioactive materials under its authority. Sections of the act authorize DOE to set radiation protection standards for itself and its contractors. Accordingly, DOE promulgated a series of regulations (e.g., Title 10 of the *Code of Federal Regulations*, Parts 820, 830, and 835 [10 CFR Parts 820, 830, and 835], and DOE Orders 435.1, 436.1, and 458.1) to protect public health and the environment from potential risks associated with radioactive materials. This Site Environmental Report (SER) is also used to document compliance with these regulations and orders.

2.1. Clean Air Act

The Clean Air Act (CAA) is a federal statute that addresses the emission of regulated air pollutants, which include criteria pollutants (carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, particulate matter, and ozone), hazardous air pollutants (HAPs), and ozone-depleting substances. The CAA also regulates greenhouse gases (GHG): CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. The program for compliance with the requirements of the CAA is implemented by the individual states through a State Implementation Plan that describes how that particular state will ensure compliance with the air quality standards for stationary sources.

Under Title V of the Clean Air Act Amendments of 1990, on April 3, 2001, Argonne was issued a Clean Air Act Permit Program (CAAPP) operating permit to cover emissions of all regulated air pollutants at the facility. This permit supersedes the prior individual state air pollution control permits, with two exceptions for prior open-burning permits. The open-burning permits are renewed each year. Argonne meets the definition of a major source because of potential emissions of oxides of nitrogen in excess of 100 tons/yr, carbon monoxide in excess of 100 tons/yr, or sulfur dioxide in excess of 100 tons/yr at the Building 108 central heating plant.

The CAAPP permit was renewed October 17, 2006. The renewal application for this permit, which expired in 2011, was submitted to IEPA on August 2, 2010, and received a Determination of Completeness on August 3, 2010. Argonne's CAAPP permit was renewed again effective May 29, 2015.

Facilities that are subject to Title V must characterize emissions of all regulated air pollutants, not only those that qualify as major sources. In addition to oxides of nitrogen and sulfur dioxide, Argonne also must evaluate emissions of carbon monoxide, particulates, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs)—in all, a list of over 180 chemicals, including radionuclides, and ozone-depleting substances. In addition, since GHGs are also regulated air pollutants, carbon dioxide, methane, and nitrous oxide emissions must also be evaluated and included. The air pollution control permit program requires that facilities pay annual fees on the basis of the total amount of regulated air pollutants (except carbon monoxide [CO] and GHGs) they are allowed to emit.

The Argonne site contains a large number of air emission point sources. The vast majority are laboratory ventilation systems used for bench-scale research activities. For purposes of the Title V permit, these activities are categorized as insignificant, except in cases involving the emission of radionuclides. In the summer of 2014, low NOx burners were installed in Boiler No. 5 to comply with the new NOx emission limit taking effect January 1, 2015. A NOx continuous emission monitor (CEM), which was also required by the new state NOx Reasonably Available Control Technology (RACT) rule, was installed on the boiler in December 2014.

In May 2016, the combined heat and power (CHP) gas-fired turbine and heat recovery steam generator (HRSG) installed by the Energy Savings Performance Contract (ESPC) contractor (Noresco) began preliminary operation. Concurrent with startup of the CHP unit, Boiler #3 was permanently decommissioned to provide the emissions offsets as required by permit.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) constitute a body of federal regulations that set forth emission limits and other requirements, such as monitoring, recordkeeping, and operational and reporting requirements, for activities generating emissions of HAPs. Significant NESHAPs affecting Argonne operations include those for radionuclides, asbestos, and emissions from reciprocating internal combustion engines (RICE) and gasoline dispensing facilities. On May 3, 2013, changes to the RICE NESHAP regulation, which affects Argonne's emergency generators, took effect. As a result, the Argonne generators that participate in an emergency demand response program are required to have annual reports filed with the USEPA. In 2016, the DC Circuit Court, acting upon a lawsuit filed against the RICE NESHAP regulation, vacated certain provisions regarding emergency generators and invited EPA to propose revisions. EPA chose not to do so and as of May 1, 2016 the Argonne emergency generators registered for the emergency demand response program no longer qualify to be used in this program.

2.1.1.1. Asbestos Emissions

Many buildings on the Argonne site contain large amounts of asbestos-containing material (ACM), such as insulation around pipes and tanks, spray-applied surfacing material for fireproofing, floor tile, and asbestos-cement (Transite) panels. This material is removed as necessary during renovations or maintenance of equipment and facilities. The removal and disposal of this material are governed by the asbestos NESHAP.

Argonne maintains an asbestos abatement program designed to ensure compliance with this and other regulatory requirements. ACM is removed from buildings either by Argonne personnel or by outside contractors who are licensed by the Illinois Department of Public Health. All removal work is performed in accordance with both NESHAP and Occupational Safety and Health Administration (OSHA) requirements governing worker safety at ACM removal sites. A separate portion of the asbestos removal standards contains requirements for disposing of ACM. Off-site shipments are to be accompanied by completed shipping manifests.

Approximately 111.5 m^3 (3936 ft^3) of ACM was generated from Argonne asbestos removal projects during 2016. The 119 small removal projects that were completed generated 29.0 m^3 (1023 ft^3) of ACM waste. Eight large removal projects generated the remaining 82.5 m^3 (2913 ft^3) of ACM waste. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2016 that no more than 34.0 m^3 (1,200 ft^3) of ACM waste is expected to be generated from small-scale projects during 2017.

TABLE 2.1

Asbestos Abatement Projects
DOE/IEPA Notifications 2016

Completion Date	Asbestos Abatement Contractor	Notification Quantity ft	Notification Quantity ft^2	Notification Quantity ft^3	Material	Building	Disposal Quantity (ft^3)	Landfill
2/3/2016	Brock Industrial Services	0	590	0	Ceiling Tile	362	96	Environtech Morris, IL
3/25/2016	Argonne Nuclear and Waste Management	0	0	8	Sealant inside Pipe Flange	264	80	Environtech Morris, IL
4/11/2016	Argonne Nuclear and Waste Management	0	1,460	0	Floor Tile Mastic[a]	203	49	Environtech Morris, IL
5/16/2016	Brock Industrial Services	0	12,000	0	Transite Panels	377A	810	Environtech Morris, IL
8/31/2016	Brock Industrial Services	0	3,000	0	Ceiling Tiles, Spray-On Fireproofing, Floor Tiles	362	927	Livingston Pontiac, IL
9/27/2016	Argonne Nuclear and Waste Management	0	800	0	Floor Tile and Mastic	208	67	Livingston Pontiac, IL
12/5/2016	Brock Industrial Services	0	3,000	0	Ceiling Tiles, Spray-On Fireproofing, Floor Tiles	362	688	Livingston Pontiac, IL
12/21/2016	Argonne Nuclear and Waste Management	75	4,220	0	Floor Tile and Mastic, Thermal System Insulation, Concrete Firestop	200 and 212	196	Livingston Pontiac, IL

[a] Courtesy notification, material removed intact.

2.1.1.2. Radionuclide Emissions

The NESHAP standard for radionuclide emissions from DOE facilities (40 CFR Part 61, Subpart H) establishes the emission limits for the release of radionuclides other than radon to the air and the corresponding requirements for monitoring, reporting, and recordkeeping. A number of emission points at Argonne are subject to these requirements and are operated in compliance with them.

The amount of radioactive material released to the atmosphere from Argonne emission sources is extremely small, contributing little to the off-site dose. The maximum potential NESHAP-reported off-site dose to a member of the general public for 2016 was 0.0028 mrem/yr, which is approximately 0.028% of the 10 mrem/yr EPA standard. The 2016 NESHAP report contains more detailed discussions of these emission points and about compliance with the standard.

2.1.2. Conventional Air Pollutants

The Argonne site contains a number of sources of conventional air pollutants, including a steam plant, gasoline and ethanol/gasoline blend fuel-dispensing facilities, waste handling facilities, an engine test facility, a surface treatment facility for etching research equipment, a number of diesel generators, and a wastewater treatment plant (WTP). These facilities are operated, and their associated activities are conducted, in compliance with applicable regulations and permit conditions.

The Title V permit requires continuous emission monitoring for NOx at Boiler No. 5 when firing on gas. Boiler No. 5 has not burned coal since 2011. Any future use of coal will require significant upgrades to this boiler to meet the Boiler NESHAP and state NOx RACT rule requirements.

An annual compliance certification must be submitted to the IEPA and EPA each May 1 for the previous calendar year, detailing any deviation from the Title V permit and subsequent corrective actions. For calendar year 2016, two deviations from the Title V permit were identified. During the Combined Heat and Power (CHP) emission testing of September 15/16, 2016 the unit when operating in fresh air firing mode (Heat Recovery Steam Generator (HRSG) operation only) failed to meet the NOx emission limit specified in 40 CFR 60 Subpart KKKK. A notification as required by permit was sent to the IEPA. Following burner adjustments and tuning, the fresh air firing mode was retested on November 9, 2016. The unit complied with the 40 CFR 60 Subpart KKKK NOx emission limit, but failed to comply with the additional permit limit of 0.150 lb/mmbtu when running at maximum level (100,000 lb steam/hour). The test was terminated and the IEPA was notified. The energy savings performance contractor and the equipment vendor were evaluating options to bring the CHP into compliance in this mode of operation, which will not be utilized until a solution has been identified and implemented.

Landfill gas monitoring is conducted quarterly at the 800 Area Landfill via 4 gas wells placed into the waste area and 10 gas wells at the perimeter of the landfill. Figure 2.1 shows their locations. In addition to the wells, ambient air is sampled in one nearby building and at three open-air locations to assess the presence of methane. The gas monitoring near the landfill provides information on whether methane is migrating from the landfill. In 2016, no methane was detected above the action level of 2.5% methane in the landfill perimeter gas sampling wells.

A fuel-dispensing facility is located at Building 46, Grounds and Transportation. This facility has volatile organic compound (VOC) emissions typical of any commercial service station that dispenses gasoline and E85 (ethanol/gasoline 85%/15%).

Pursuant to *Illinois Administrative Code (IAC)*, Title 35, Part 254 (35 IAC Part 254), Argonne submits an emissions report to the IEPA each May 1, for the previous year. The summary for 2016 is presented in Table 2.2.

2.1.3. Clean Fuel Fleet Program

Although reporting requirements for the Clean Fuel Fleet Program are still in effect under the CAA and 35 IAC Part 241, the IEPA indicated that it no longer wanted reports to be filed for model year (MY) 2016 (September 1, 2015−August 31, 2016) vehicles because all current MY vehicles meet the clean fuel fleet standards. Nevertheless, because the requirements are still in effect, in lieu of a report, DOE/Argonne Site Office (ASO) submitted a letter to the IEPA prior to November 1, 2016, certifying that all vehicles acquired in MY 2016 meet federal emission standards.

2.1.4. Greenhouse Gas Reporting

There are three annual reporting requirements for GHG, with reports filed with DOE, IEPA, and USEPA. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) are reported to DOE in accordance with Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*. In November 2016, Argonne reported to DOE Headquarters (HQ) on its Scope 1 GHG emissions (direct emissions including fugitive emissions), Scope 2 GHG emissions (indirect emissions from electrical purchases), and Scope 3 GHG emissions (indirect emissions primarily from employee activities) for FY2016.

Since 2011, as part of the Annual Emission Report to IEPA required under 35 IAC Part 254, Argonne also reports on CO_2, CH_4, N_2O, and carbon dioxide equivalents (CO_2e).

Argonne is required to report under 40 CFR Part 98 Subpart C on GHG emissions from combustion sources. The GHG report for calendar year (CY) 2015 required by EPA under 40 CFR Part 98 was submitted on March 1, 2016 on the EPA Electronic Greenhouse Gas Reporting Tool (e-GGRT) system.

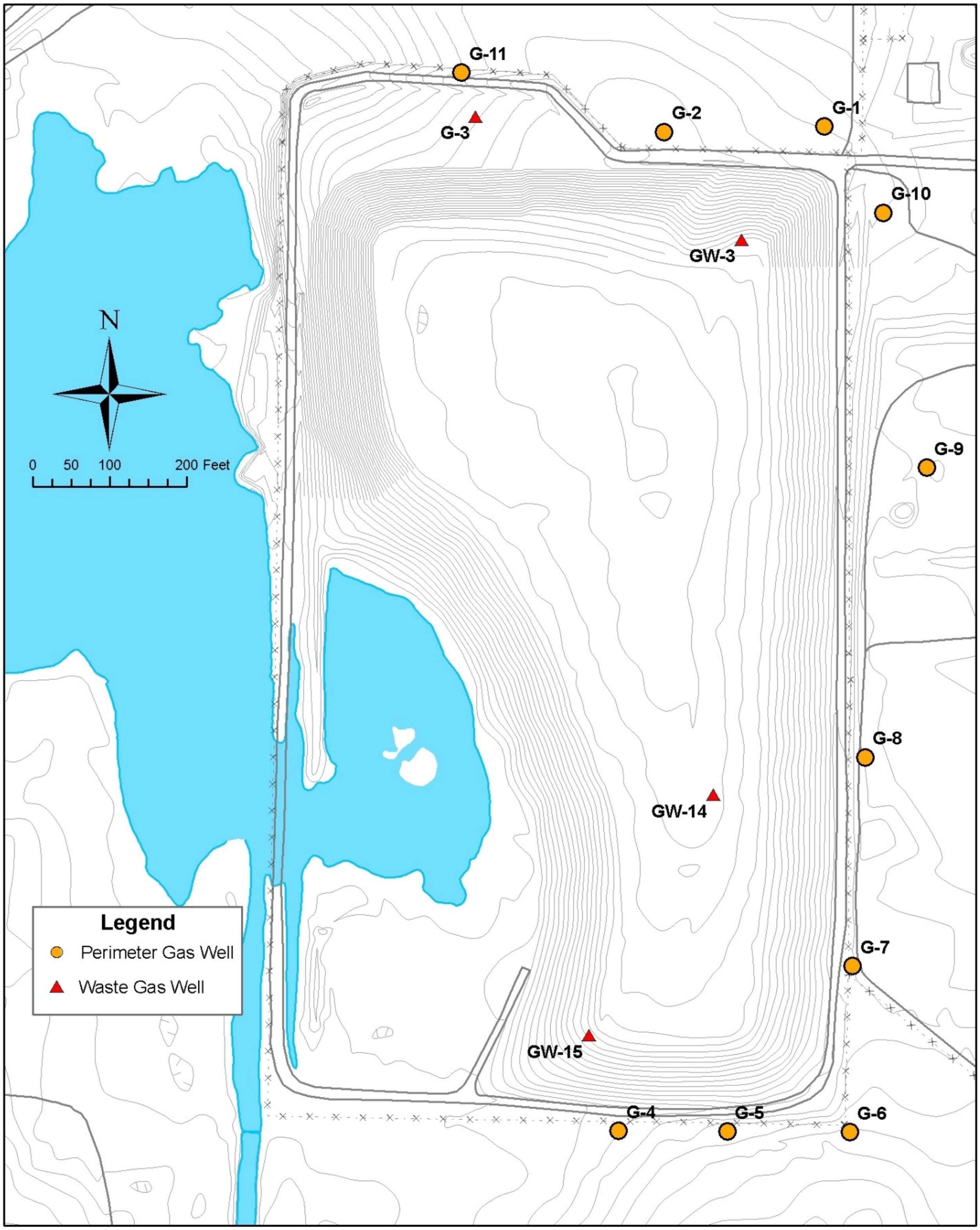

FIGURE 2.1 800 Area Landfill Gas Monitoring Wells

TABLE 2.2

Annual Emission Summary Report
(emissions in lbs/yr)

Source	CO[a]	NO_x	PM/PM_{10}	$PM_{2.5}$[e]	SO_2	VOM	HAP[b]	NH_3[e]	CO_2[f]	CH_4[f,g]	N_2O[f,g]	CO_2e[f,g]
108 Boiler 1 (gas-fired)	14,385	17,125	1,302	325	103	942		84	20,577,920	388	39	20,599,189
108 Boiler 2 (gas-fired)	3,891	4,633	352	88	28	255		23	5,566,497	105	10	5,572,251
108 Boiler 3 (gas-fired)[i]	5,234	6,230	474	118	37	343		31	7,486,624	141	14	7,494,362
108 Boiler 4 (gas-fired)	20,448	24,343	1,850	463	146	1,339		119	29,251,298	552	55	29,281,531
108 Boiler 5 (gas-fired)	11,694	7,742	1,058	264	84	766		68	16,727,658	315	32	16,744,947
108 Boiler 5 (coal-fired)	0	0	0	0	0	0	0	0.0	0	0	0	0
109 Combined Heat & Power (CHP)	478	3,890	2,491	2,491	220	92		3,698	24,583,151	695	214	24,664,188
400 APS Generator (Caterpillar)	180	900	40	40	80	20		0.9	24,707	1.0	0.2	24,876
400 APS Generators - Kohler (2)	740	3,880	120	120	320	120		1.7	48,378	2.0	0.4	48,378
200 Peak Shaving Generator	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
202 Peak Shaving Generator	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0
Transportation Research Facility	649	2,918	164	162	199	567		8	121,479	4.4	0.8	121,827
PCB Tank Cleanout						0						
208 Surface Preparation Facility		15.3					2.0					
46 EtOH/gasoline Storage						1.9						
46 10K Gal Gasoline Storage						3.0						
308 Alkali Reaction Booth			0	0								
370 Alkali Reaction Booth[c]			-									
363 Central Shop Dust Collector[c]			-									
212 Building Exhausts[c]			-									
368 Woodshop Dust Collector[c]			-									
108 Sulfuric Acid Storage[c]			-									
Torch Cut Pb-Based Paint[c]			-									
206 Alkali Reaction Booth (R)[h]												
306 Building Vents (R)												
306 Chemical Photo-oxidation Unit (R)												
306 Waste Bulking Sheds (R)						0	0.0					
211 Linac (R)												
366 Wakefield Accelerator (R)												
203 ATLAS (CARIBU) (R)												
375 Intense Pulsed Neutron Source (R)												
200 M-Wing Hot Cells (R)												
400 APS Facility (R)		71										
212 Alpha Gamma Hot Cell (R)												
350 NBL P/U Hoods (R)												
Lab Rad Hoods (R)												
WM Portable HEPA - (6) (R)												
303 Mixed Waste Storage (R)												
331 Rad Waste Facility (R)												
595 Lab Wastewater Plant (R)												
315 MACE Project (R)	160											
Total (lb/yr)	**57,860**	**71,748**	**7,850**	**4,072**	**1,217**	**9,108**	**2**	**4033**	**104,387,711**	**2,204**	**366**	**104,551,548**
Total (ton/yr)	**28.9298**	**35.8738**	**3.9250**	**2.0361**	**0.6083**	**4.5540**	**0.0010**	**2.0166**	**52,193.8557**	**1.1019**	**0.1829**	**52,275.7741**
CAAPP Permit Limit (ton/yr)	(233.50)[d]	373.80	60.93	-----	284.70	28.03	10.00	-----	-----	-----	-----	

[a] Abbreviations: APS = Advanced Photon Source; ATLAS = Argonne Tandem Linac Accelerator System; CAAPP = Clean Air Act Permit Program; CARIBU = Californium Rare Isotope Breeder Upgrade; CH4 = methane; CO = carbon monoxide; CO_2 = carbon dioxide; CO_2e = carbon dioxide equivalents; EtOH = Ethanol; HAP = hazardous air pollutant; HEPA = high-efficiency particulate air; MACE = melt attack and coolability experiment; Linac = linear accelerator; N_2O = nitrous oxide; NBL = New Brunswick Laboratory; NH_3 = ammonia; NO_x = oxides of nitrogen; Pb = lead; PCB = polychlorinated biphenyl; PM = particulate matter; PM_{10} = particulate matter less than 10 microns; $PM_{2.5}$ = particulate matter less than 2.5 microns; P/U = plutonium/uranium; SO_2 = sulfur dioxide; VOM = volatile organic matter; WM = Waste Management

[b] Hazardous air pollutants (HAP) not included in VOM or Particulates (hydrochloric acid, hydrofluoric acid, methyl chloroform, methylene chloride).

[c] These sources designated as insignificant in the CAAPP permit.

[d] Not a permit limit, but is the maximum potential emission level for carbon monoxide.

[e] As of 2003 emissions of PM2.5 and a precursor, ammonia (NH3), must be included on the Annual Emission Report.

[f] As of 2011, greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, carbon dioxide equivalents) must be included on the Annual Emission Report.

[g] As of 2013 revised global warming factors pursuant to 40 CFR 98 Subpart A were used for methane and nitrous oxide.

[h] (R) = Radionuclide source - radionuclides except radon regulated by NESHAP (40 CFR 61, Subpart H).

[i] With the commencement of operation of the CHP unit, Boiler #3 was permanently decommissioned in May, 2016.

2.2. Clean Water Act

The Clean Water Act (CWA) was established in 1977 as an amendment to the Federal Water Pollution Control Act of 1972 and was modified substantially by the Water Quality Act of 1987. Section 101 of the CWA provides for the restoration and maintenance of water quality in all waters throughout the country, with the ultimate goal of "fishable and swimmable" water quality. The act established the National Pollutant Discharge Elimination System (NPDES) permitting system as the regulatory mechanism designed to achieve this goal. The authority to implement the NPDES program has been delegated to those states, including Illinois, which have developed a program substantially the same and at least as stringent as the federal NPDES program.

2.2.1. Wastewater Discharge Permitting

The NPDES permitting process administered by the IEPA is the primary tool for enforcing the requirements of the NPDES program. Before wastewater can be discharged to any receiving stream, each wastewater discharge point (outfall) must be characterized and described in a permit application. The IEPA then issues a permit that, for each outfall, contains numeric limits and monitoring frequencies on certain pollutants likely to be present, and sets forth a number of additional specific and general requirements, including sampling and analysis schedules and reporting and recordkeeping requirements. NPDES permits are effective for five years and must be renewed by the submission of a permit application at least 180 days prior to the expiration of the existing permit.

Wastewater at Argonne is generated by a number of activities and consists of sanitary wastewater (from restrooms, cafeteria sinks, and sinks in certain buildings and laboratories), laboratory wastewater (from laboratory sinks and other industrial wastewater sources), and stormwater. Water from boiler house activities can be discharged into the DuPage County sewer system or the Argonne laboratory sewer system. Cooling water and cooling tower blowdown are generally sent to the laboratory wastewater sewer, although a very small volume is still discharged—on an emergency only basis—into stormwater ditches that are monitored as part of the NPDES permit. The permit authorizes the release of wastewater or stormwater from 42 separate outfalls, most of which discharge directly or indirectly into Sawmill Creek. Two of the outfalls are internal sampling points that combine to form the main wastewater outfall, Outfall 001. Table 2.3 lists these outfalls, and Figure 2.2 shows the outfall locations.

2.2.1.1. NPDES Permit Activities

Wastewater discharge at Argonne is permitted by NPDES Permit No. IL 0034592. The IEPA issued a renewed permit effective September 1, 2011. That permit had an expiration date of August 31, 2016. During 2016, Argonne applied for a new permit.

The permit reflects Argonne's continuing efforts to reduce its NPDES "footprint" with fewer outfalls requiring monthly sampling, removal of select parameters from several outfalls

TABLE 2.3

Characterization of National Pollutant Discharge Elimination System Outfalls at Argonne, 2016[a]

Outfall Number	Description	Average 2016 Flow[b]
A01	Sanitary Treatment Plant	0.252
B01	Laboratory Treatment Plant	0.471
001	Combined Outfall	0.723
B03	Stormwater and groundwater discharge from the 300 Area	Stormwater only
C03	South discharge from Building 205, fire protection test discharge (FPTD) water	Stormwater only
D03	Steam trench discharge and stormwater	0.009
F03	South reach of Building 201, Building 201 fire pond overflow stormwater	Stormwater only
G03	North Building 201 storm sewer (condensate), FPTD water	<0.001
H03	Stormwater, FPTD water	Stormwater only
I03	South stormwater discharge from Buildings 200 and 211, FPTD water	Stormwater only
J03	Building 213 and Building 213 parking lot stormwater, FPTD water	Stormwater only
K03	Stormwater, APS, FPTD water	Stormwater only
L03	Stormwater, APS, FPTD water	Stormwater only
M03	Stormwater, APS, FPTD water	Stormwater only
N03	Stormwater, 212 East, FPTD water	Stormwater only
004	Stormwater, emergency chiller water, FPTD water	No flow[c]
A05	Westgate Road stormwater	Stormwater only
B05	800 Area East stormwater	Stormwater only
C05	Stormwater (Building 200 West), air compressor condensate, FPTD water	0.009
D05	Stormwater	Stormwater only
E05	Building 203 West footing drainage, FPTD water	Stormwater only
006	Stormwater, emergency compressor cooling water, FPTD water	No flow[c]
007	Stormwater, FPTD water	Stormwater only
008	Transportation and grounds stormwater	Stormwater only
011	North fence line marsh storm discharge	Stormwater only
012	100 Area stormwater discharge, FPTD water	Stormwater only
013	Southeast 100 Area stormwater	Stormwater only
014	Northern East Area stormwater discharge	Stormwater only
A15, B15	Building 40 stormwater discharge	Stormwater only
A16, B16	Southern East Area stormwater discharge	Stormwater only
018	Eastern 300 Area stormwater, compressor condensate, FPTD water	Stormwater only
020	Shooting range stormwater discharge	Stormwater only
021	319 Landfill and Northeast 317 Area	Stormwater only
A22	Southern 317 Area	Stormwater only
B22	Western 317 Area	Stormwater only
023	Southern and Eastern 800 Area Landfill stormwater runoff	Stormwater only
025	Buildings 314, 315, 316, southern APS stormwater, FPTD water	Stormwater only
026	Water Treatment Plant area stormwater	Stormwater only
027	CNM building stormwater, FPTD water	Stormwater only
028	Stormwater from HTRL building area, FPTD water	Stormwater only

[a] Abbreviations: APS = Advanced Photon Source; CNM = Center for Nanoscale Materials; HTRL = Howard T. Ricketts Laboratory.

[b] Flow is measured in million gallons per day.

[c] All process wastewater discharged to these outfalls was redirected to the Laboratory sewer. There was no recordable wastewater flow in 2016.

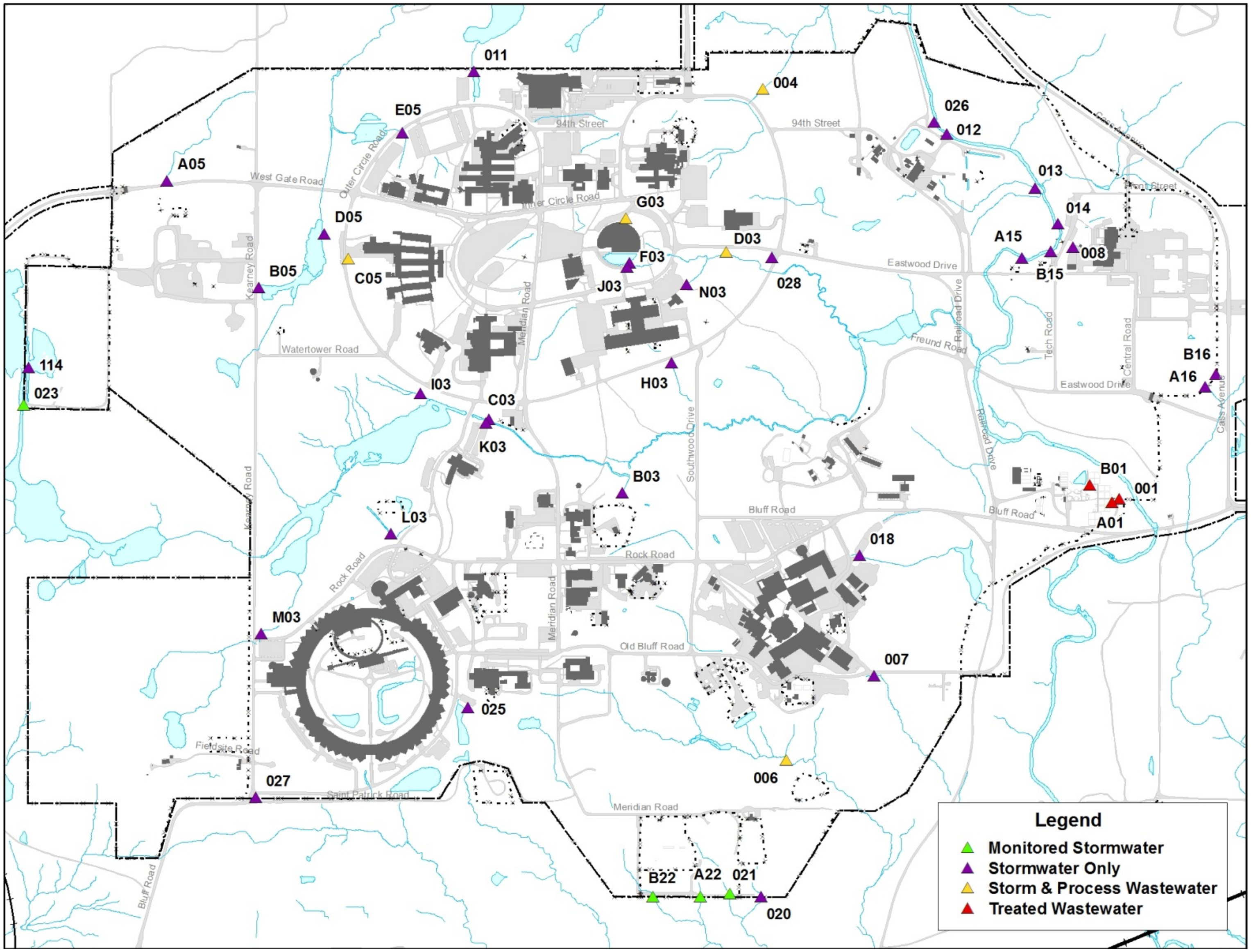

FIGURE 2.2 National Pollutant Discharge Elimination System Outfall Locations

due to their repeated absence or very low concentrations in discharges, and removal of the Total Dissolved Solids (TDS) monitoring requirement (although chloride and sulfate, two components of TDS, remain included in the permit as limited parameters). Other permit features include the addition to the Laboratory Wastewater Treatment Plant (LWTP) of process wastewater streams originating from new programmatic buildings and chiller plants, the discharge without IEPA approval of domestic fire protection water to storm sewers during required testing activities, and the addition of dissolved oxygen as a limited parameter at the combined treatment plant outfall.

2.2.1.2. Compliance with NPDES Permit

Wastewater is treated at Argonne in two independent treatment systems, the sanitary system and the laboratory system. The sanitary wastewater collection and treatment system collects wastewater from sanitation facilities, the cafeteria, office buildings, some of the small industrial discharges that cannot be routed to the laboratory sewer, and other portions of the site that do not contain radioactive or hazardous materials. This wastewater is treated in the sanitary wastewater treatment plant (SWTP), consisting of primary clarifiers, trickling filters, secondary clarifiers, and slow sand filters. Wastewater generated during research-related activities, including those that utilize radioactive materials, generally flows to a series of retention tanks located in each building and is pumped to the laboratory wastewater sewer after radiological analysis and release certification. Treatment in the LWTP consists of aeration, solids-contactor clarification, and pH adjustment. Additional steps can be added, including powdered-activated carbon addition for organic removal, alum addition, and polymer addition, if analysis demonstrates that any of these is required.

Figure 2.3 shows the two wastewater treatment systems. The volume of wastewater discharged from these facilities in 2016 averaged 0.95 million L/day (0.252 million gal/day) for the sanitary wastewater and 1.78 million L/day (0.471 million gal/day) for the laboratory process wastewater.

Results of the routine monitoring required by the NPDES permit are submitted monthly to the IEPA in a Discharge Monitoring Report (DMR). As required by the permit, any exceedance of permit limits or conditions is reported by telephone to the IEPA within 24 hours, and a written explanation of the exceedance is submitted with each DMR. During 2016, there were two exceedances of NPDES permit limits out of approximately 1,500 measurements. Outfalls B01 and 001 had one exceedance each. Biological oxygen demand (BOD), 5-Day, exceeded its daily limit once at Outfall B01 and chloride exceeded its daily limit once at Outfall 001. NPDES Permit exceedances reported in 2016 are summarized in Table 2.4. All of the monitoring results are discussed in Chapter 5.

The elevated BOD, 5-Day concentration, which was just over the permit limit for this parameter, was likely the result of a discharge of organic-rich wastewater to the laboratory sewer system. The source was not identified and the exceedance probably represents an isolated occurrence. Less snowfall during 2016 winter months, and consequently less salt usage on site roadways and parking lots (compared to recent winters), resulted in just one chloride exceedance during 2016. The elevated chloride concentration occurred in the winter and was associated with

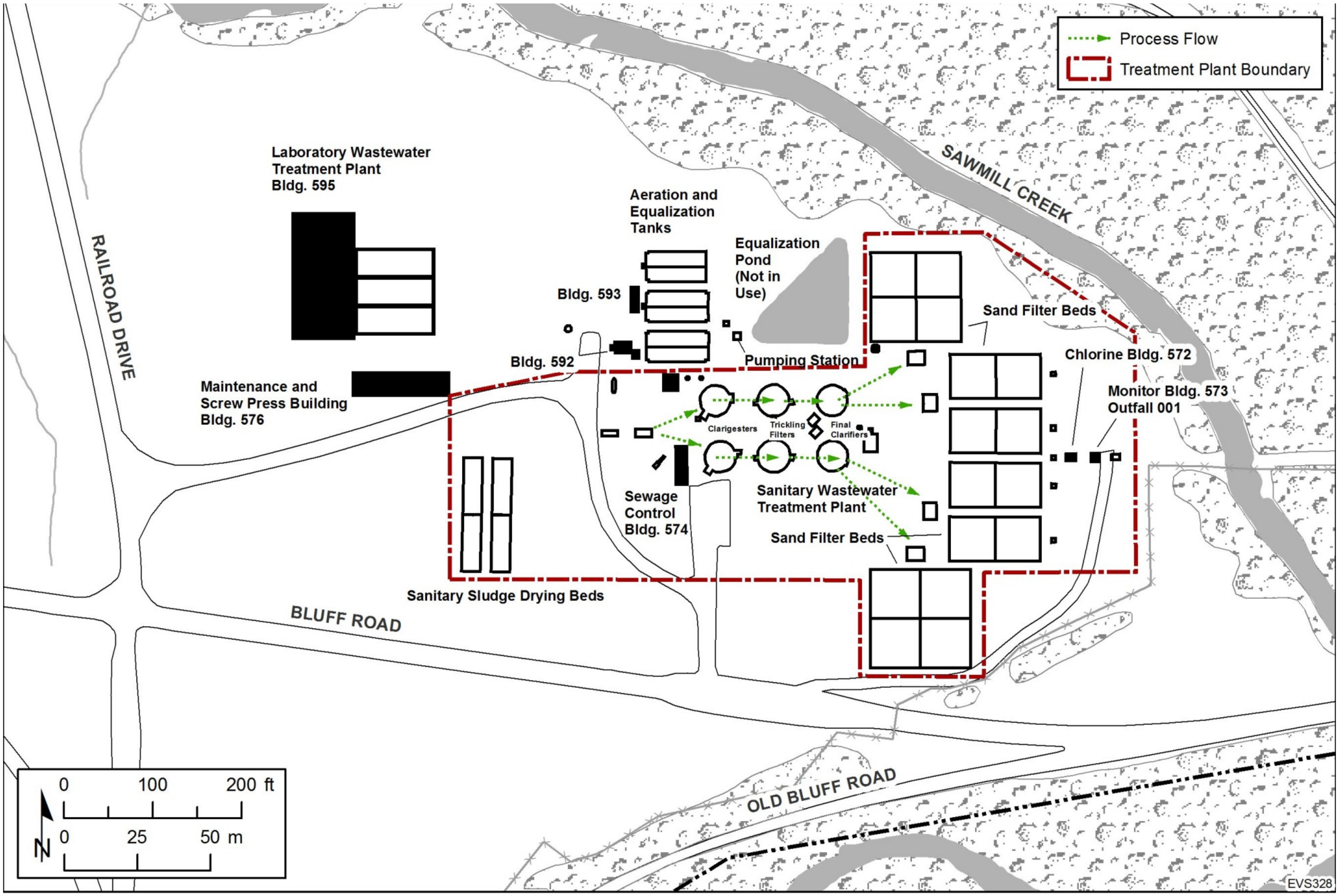

FIGURE 2.3 Argonne Wastewater Treatment Plant

TABLE 2.4

Summary of 2016 Water Effluent Exceedances

Date Reported	Outfall	Parameter	Cause
March 3	B01	BOD, 5-Day	Most likely cause is isolated discharge of organic-rich wastewater to laboratory sewer system.
March 14	001	Chloride	Road deicing chemicals entering stormwater and site sewers

increased boiler activity, the associated high-TDS blowdown, road salt application and wastewater generated from use of Canal water for cooling. To reduce impacts to the LWTP, boiler blowdown (up to 142,555 L/day) is periodically diverted to DuPage County during the heating season and Argonne has implemented a Snow Management Plan, focusing on using alternative deicing compounds and reducing deicing compound application through not plowing and not deicing lightly-used roadways. Argonne believes that continued implementation of the Snow Management Plan through road and parking lot closures and increased use of organic additives will significantly reduce chloride loading to site waterways.

Figure 2.4 presents the total number of permit limit exceedances each year over time. Overall, the decrease in the number of exceedances since 2007 reflects the site-wide rerouting of TDS/chloride-contaminated wastewater from stormwater outfalls into the laboratory wastewater

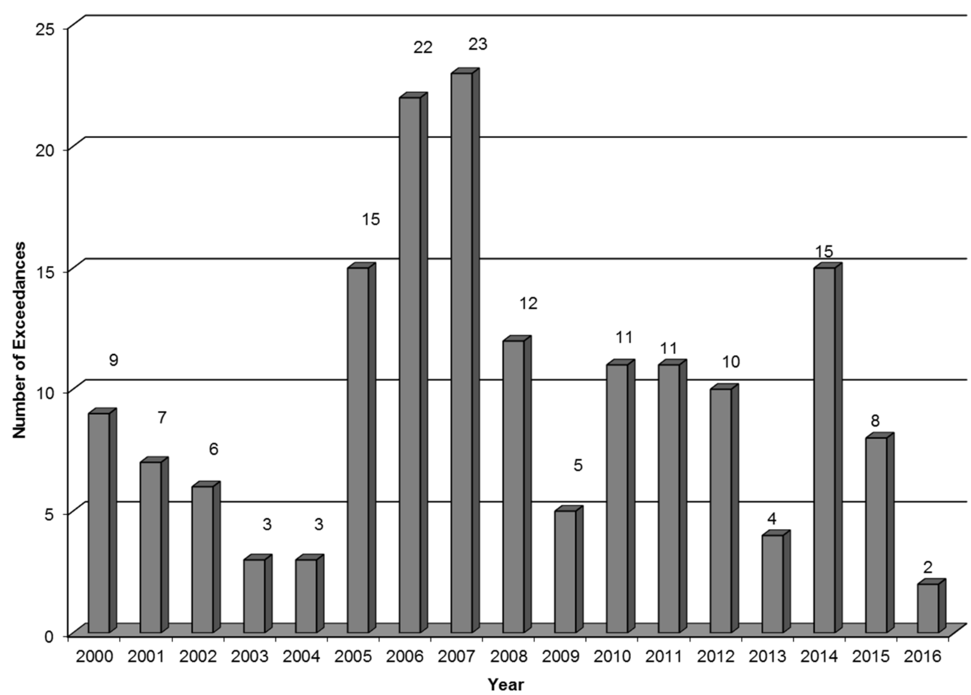

FIGURE 2.4 Total Number of NPDES Exceedances, 2000 to 2016

sewer system, reclassification of outfalls to stormwater-only, removal of TDS as a limited parameter by the IEPA, and continued implementation of the Snow Management Plan. Chloride continues to be a challenging issue for Argonne, as it is also a component (from regional road runoff) of the industrial water source (the nearby Chicago Sanitary and Ship Canal) used at the Laboratory for site cooling.

2.2.1.3. Priority Pollutant Analysis and Biological Toxicity Testing

The NPDES permit requires semiannual testing of Outfall B01 (the LWTP outfall) and annual testing of Outfall 021 (downstream of the 317 and 319 areas) for all the priority pollutants, 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2016, the Outfall B01 samplings were conducted in June and December and the Outfall 021 sampling was conducted in June. Results are summarized in Table 2.5 and in Chapter 5.

In addition to the priority pollutant analysis, the permit requires annual biological toxicity testing of the combined effluent stream, Outfall 001. This testing was conducted on June 7 and 8, 2016. The data indicate that the effluent was not acutely toxic to either the fathead minnow or the water flea.

TABLE 2.5

Summary of 2016 Priority Pollutant Results

Outfall	Results	Comments
B01	June: Dichlorobromomethane (0.0006 mg/L)[a] Bromoform (0.001 mg/L) Chloroform (0.0008 mg/L) Chlorodibromomethane (0.008 mg/L)[a] 1,1-dichloroethane (0.0003 mg/L)[a]	Dichlorobromomethane and chlorodibromomethane were present at estimated concentrations. Bromoform and chloroform were detected very near their detection limits. All of these compounds are trihalomethane-type compounds resulting from chlorination of drinking water. The origin of 1,1-dichloroethane, present at an estimated concentration, is unknown but could be from the 317 Area groundwater collection system, which discharges to the laboratory sewer.
	December: Dichlorobromomethane (0.0008 mg/L)[a] Chloroform (0.0009 mg/L)[a] Bromoform (0.001 mg/L) Chlorodibromomethane (0.001 mg/L)	Dichlorobromomethane and chloroform were present at estimate concentrations. These compounds are trihalomethane-type compounds resulting from chlorination of drinking water.
021	June:	No compounds detected.

[a] Result is an estimation since it is less than the reporting limit.

2.2.1.4. Stormwater Regulations

In November 1990, the EPA promulgated regulations governing the permitting and discharging of stormwater from industrial sites. The Argonne site contains a large number of small-scale operations that are considered to be industrial activities under these regulations, and therefore, subject to these requirements. An extensive stormwater characterization and permitting program was initiated in 1991 and continues as required by the present NPDES permit. Argonne's NPDES permit includes both stormwater with some industrial wastewater component and stormwater-only discharges to surface water.

Special Condition 9 of Argonne's permit requires the Laboratory to maintain its Stormwater Pollution Prevention Plan (SWPPP), as well as to modify it as necessary to ensure compliance with all provisions of the stormwater regulations. Special Condition 9 also requires Argonne to inspect and report annually on the effectiveness of the site-wide SWPPP. The annual SWPPP assessment consists of tours of building exteriors residing in Argonne outfall watersheds to identify any potential pollutant sources and/or conditions that may lead to industrial discharges into the outfalls. Outfall watersheds are also inspected to verify that no changes have occurred that may affect the permitted discharges at the outfalls. Finally, SWPPP "best management practices" are evaluated to ensure that potential surface water pollution sources remain under good institutional control.

The 2016 annual inspection was completed and a report was submitted to the IEPA in October. The 2016 SWPPP assessment identified several instances where best management practices (BMPs) were not being implemented. Unlabeled or poorly labeled drums stored outdoors at three locations, an uncovered debris pile, and inadequate stormwater control at a construction site were identified as areas where BMPs were not fully implemented. These issues were brought to the attention of the responsible persons, documented in Argonne's issues tracking system, and were quickly resolved.

In 2016 Argonne's Facilities Management and Services (FMS)-Sustainability and Environmental Programs (SEP) department implemented a quarterly outfall inspection program to more frequently document water quality and general environmental conditions at Argonne's stormwater outfalls. In addition, FMS-SEP continued to conduct monthly SWPPP inspections to document BMP implementation at designated buildings.

At Argonne, spills are reported to emergency responder personnel primarily via the on-site 911 alert system. During 2016 there were 13 spills, both indoors and outdoors, across the Argonne site, as summarized below:

- Three spills involved oil materials, all of which were minor in nature, quickly contained, and remediated without any impact to surface water. These included releases of hydraulic oil from hydraulic line breaks on fleet equipment and transmission fluid from a personal vehicle.

- Ten releases of water (seven domestic water releases and three canal water), resulted from a mixture of failing hardware and breaches in piping. Four of these releases flowed into site storm sewers or entered directly into site waterways. Therefore, they were reported to the IEPA, in accordance with the NPDES permit.

2.2.2. Spill Prevention Control and Countermeasures Plan

The Spill Prevention Control and Countermeasures (SPCC) plan regulations were finalized in 2002, and then amended in 2006, 2008, and 2009. The most recent requirements became effective in December 2015. Argonne maintains a SPCC Plan as required by the Clean Water Act (CWA) and EPA regulations at 40 CFR Part 112. This plan describes the planning, design features, and response measures that are in place to prevent oil or oil products from being released into navigable waters of the United States. Persons with specific duties and responsibilities in such situations are identified, as are reporting and recordkeeping requirements mandated by the regulations. Annual training is conducted on implementation of this plan and SPCC requirements are regularly communicated to Argonne research and operations divisions as needed. In 2016, there no spills that required external notification as described in the SPCC Plan.

2.2.3. General Effluent and Stream Quality Standards

In addition to specific NPDES permit-required monitoring, Argonne's discharges are monitored to determine if they conform to the general effluent limits contained in 35 IAC Part 304. During 2016, the wastewater was found to be in conformance with these standards. Samples are also collected to determine if Sawmill Creek meets IEPA General Use Water Quality Standards (WQSs) found in 35 IAC Part 302, Subpart B. None of the Sawmill Creek samples collected in 2016 exceeded the water quality standards. Chapter 5 of this report, which presents the results of the nonradiological environmental monitoring program, describes the general effluent limits and WQSs and discusses conformance with these limits.

2.3. Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act of 1976 (RCRA) and its implementing regulations are intended to ensure that facilities that generate, treat, store, or dispose of hazardous waste do so in a way that protects human health and the environment. The Hazardous and Solid Waste Amendments of 1984 (HSWA) created a set of restrictions on land disposal of hazardous waste. In addition, the HSWA also requires that releases of hazardous waste or hazardous constituents from any Solid Waste Management Unit (SWMU) at a RCRA-permitted facility be remediated, regardless of when the waste was placed in the unit or whether the unit originally was intended as a waste disposal unit.

The RCRA program also includes regulations governing the management of underground storage tanks (USTs) containing hazardous materials or petroleum products. The IEPA has been authorized to administer most aspects of the RCRA program in Illinois. The IEPA issued a RCRA Part B permit to Argonne and DOE on September 30, 1997. The permit was renewed in April 2010, and it is effective for 10 years.

The corrective action portion of the RCRA Part B permit provided the primary regulatory vehicle for cleaning up contamination from former waste management areas. The Argonne remediation program achieved compliance with all applicable corrective action requirements related to assessing and cleaning up releases of hazardous materials from inactive waste sites in 2003. However, seven SWMUs could not be remediated to No Further Action (NFA) status. The long-term maintenance and monitoring of these inactive waste sites is carried out by the Argonne Long-Term Stewardship (LTS) Program. Quarterly reports are transmitted to the IEPA describing ongoing monitoring of these inactive sites. The LTS Program is described in greater detail in Chapter 6. During 2014, one new SWMU was identified by Argonne (SWMU No. 747 [Building 310]) and the IEPA added it to the Argonne corrective action program. Argonne submitted a soil investigation work plan to IEPA for this SWMU in Fiscal Year (FY) 2015. The work plan was approved in May 2015 and the field work completed in August 2015.

The final report for the SWMU No. 747 investigation was submitted to IEPA in April 2016. The results of the SWMU investigation indicated that contaminants north and west of the buildings (selected metals in soils under a grass lawn) were present at concentrations below IEPA soil remediation objectives. In December 2016, IEPA granted a determination of no further action for these soils, and requested that an institutional control be developed for soils south of the former building (which were not sampled because the asphalt serves as an effective engineered barrier) to ensure the engineered barrier is maintained and soils remain undisturbed. To accomplish this, SWMU No. 747 will be incorporated into an already existing Land Use Control Memorandum of Agreement (LUCMOA) between IEPA and DOE. The land use control document for SWMU No. 747 is due in July 2017.

2.3.1. Hazardous Waste Generation, Storage, Treatment, and Disposal

The nature of the research activities conducted at Argonne results in the generation of small quantities of a large number of waste chemicals. Many of these materials are classified as hazardous waste under RCRA. Argonne has 15 Hazardous Waste Management Units: 9 container storage units, 1 tank storage unit, 3 miscellaneous treatment units, and 2 tank chemical treatment units. Table 2.6 provides descriptions of these units. Figure 2.5 shows the locations of the major active hazardous waste treatment, storage, and disposal areas at Argonne.

TABLE 2.6

Permitted Hazardous Waste Treatment and Storage Facilities, 2016

Description	Location	Purpose
Container Storage (9)		
Concrete Storage Pad	Building 331	Storage of solid radioactive waste and solid mixed waste (MW) in the form of steel-encased lead shielding containers and containerized solid MW.
Container Storage Area	Building 303 MW Storage Facility	Storage of containers of ignitable, corrosive, oxidizing, reactive, solid hazardous, radiological, or MW.
	Building 331 Radioactive Waste Storage Facility	Storage of containers of flammable, toxic, corrosive, oxidizing hazardous, radiological, or MW.
Portable Storage Units[a]	Building 306	Storage of hazardous, radiological, or MW (3 of 4 units).
		Bulking operations to consolidate and reduce the volume of lab-packed waste in containers (1 of 4 units).
MW Storage	Building 306 – Storage Room A-142	Storage of ignitable MW.
	Building 306 – Storage Room A-150	Storage of solid and liquid MW.
	Building 306 – Storage Room C-131	Storage of ignitable, corrosive, and reactive hazardous waste.
	Building 306 – Storage Room C-157	Storage of corrosive and oxidizing MW.
	Building 306 – Storage Room D-001	Storage of solid MW containing toxic metal constituents.
Tank Storage (1)		
Waste Storage Tank[a]	Building 306	Storage of corrosive and toxic MW and radiological liquid wastes (4,000 gal).
Treatment (5)		
Alkali Metal Passivation Booth	Building 206	Destruction of water reactive alkali metals possibly contaminated with radionuclides.
Alkali Metal Passivation Booth	Building 308	Destruction of water reactive alkali metals.
Chemical/Photooxidation Unit[a]	Building 306	Treatment of ignitable liquid MW containing organic contaminants.
Metal Precipitation System	Building 306	Treatment of aqueous, corrosive LLW, some of which is contaminated with heavy metals.
MW Immobilization/ Macroencapsulation Unit[a]	Building 306	Treatment of solid, semisolid, and organic liquid MW containing RCRA metals.

[a] Not in use.

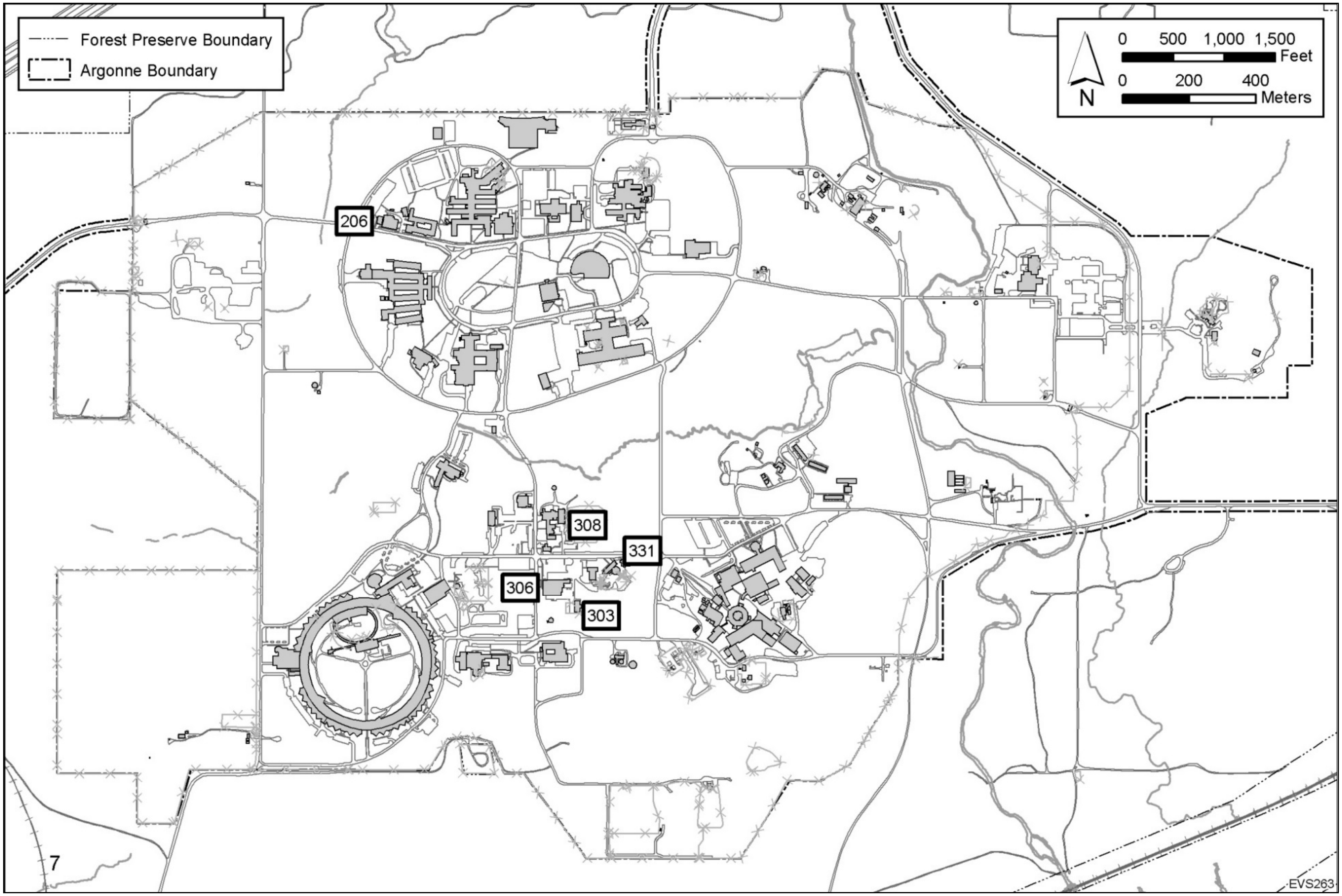

FIGURE 2.5 Permitted Treatment and Storage Areas at Argonne

Argonne prepares an annual Hazardous Waste Report. The report is submitted to the IEPA by March 1 of each year and it describes the activities of the previous year. It is a summation of all RCRA waste activities, including on-site storage and off-site disposal. The report describing such activities during 2016 was submitted to the IEPA. The RCRA-permitted storage facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and storage of waste pending off-site disposal. The wastes consist mostly of labpacks, with a small amount of bulk toxic liquids and solids, bulk flammable solids, bulk corrosive liquids, and bulk aerosols. Off-site treatment and disposal take place at approved hazardous waste treatment and disposal facilities. Hazardous and nonhazardous waste totals that were shipped during 2016 are included in Table 2.7.

TABLE 2.7

Non-Rad Hazardous and Nonhazardous Waste Shipped Off-Site, 2016

Waste Category	Quantity (lbs)
Non-Rad Hazardous	175,994
Nonhazardous	177,536
Recycle/Reuse	66,892
Total	420,422

TABLE 2.8

Radioactive Low-Level and Mixed Waste, 2016

Waste Category	Volume (ft^3)
Generated	
Low-Level	5,627
Mixed Low-Level	1,797
TRU	327
Total	7,751
Shipped	
Low-Level	5,312
Mixed Low-Level	1,463
TRU	0
Total	6,775

2.3.2. Hazardous Waste Treatability Studies

The IEPA requires that Argonne submit a report by March 15 of each year that estimates the number of hazardous waste treatability studies and the amount of waste expected to be used in the studies during the current year. No treatability studies were conducted in 2016.

2.3.3. Mixed Waste Generation, Storage, Treatment, and Disposal

The hazardous component of mixed waste (MW) is governed by RCRA regulations, while the radioactive component is subject to regulation under the AEA as implemented by DOE. Accordingly, facilities storing or disposing of MW must comply with both DOE requirements and RCRA permitting and facility standards. Argonne generates several types of MW, including acids, solvents, and lead-containing debris contaminated with radionuclides. The RCRA Part B permit provides for on-site treatment in five mixed-waste treatment systems. These systems include neutralization of low-level radioactive waste (LLRW) and stabilization of sludge and soil. During 2016, the majority of the MW was sent off-site to Energy Solutions, an out-of-state commercial treatment and disposal facility. MW that were generated and disposed of during 2016 are included in Table 2.8.

DOE Order 435.1 and its implementing manual also require that radioactive wastes be characterized and certified to meet the requirements for the facility within which they will be managed. Argonne maintains waste certification programs for the types of radioactive waste generated at the site (see Table 2.8). The waste certification program for LLRW meets the requirements of the DOE Nevada National Security Site (NNSS), where much of Argonne's radioactive waste is disposed, but also meets the requirements for commercial waste treatment and disposal facilities that Argonne also uses. The waste certification program for TRU meets the requirements of the DOE Waste Isolation Pilot Plant (WIPP), the deep geologic repository facility used for TRU disposal. Both of these waste certification programs have been reviewed and authorized by the DOE receiving sites to meet their requirements. LLRW and TRU Waste that were generated and disposed of during 2016 are described in Table 2.8. MW generated in 2016 but not shipped off-site for disposal is stored on-site pending future off-site shipment.

2.3.4. Federal Facility Compliance Act Activities

The Federal Facility Compliance Act of 1992 (FFCA) amended RCRA to clarify the application of its requirements and sanctions to federal facilities. The FFCA also requires that DOE prepare mixed-waste treatment plans for DOE facilities that store or generate MW. The Proposed Site Treatment Plan (PSTP) for MW generated at Argonne was submitted to the IEPA and the Illinois Department of Nuclear Safety in March 1995. Argonne's RCRA Part B permit provides for on-site treatment of certain MW as required by the PSTP. An update to the PSTP was provided to DOE showing that MW at Argonne have been stored less than one year.

2.3.5. Underground Storage Tanks

The Argonne site currently has 11 underground storage tanks (USTs). The UST at Building 300 that had contained fuel oil was removed in 2015. Six of the remaining tanks are being used to store fuel oil. The on-site vehicle maintenance facility (Building 46) uses the other five underground tanks to store diesel, gasoline, used oil, antifreeze, and an ethanol/gasoline blend. The Office of the State Fire Marshal conducts UST inspections every two years. On November 5, 2015 the Illinois State Fire Marshal along with a representative from US EPA Region 5 conducted an UST inspection. There were no citations for noncompliance, but the EPA inspector indicated that the newly revised federal EPA UST regulations issued in October 2015 now required that information be kept by UST owners demonstrating that the tank and associated equipment are compatible with the tank contents. The EPA inspector provided a checklist for the E85 (85% ethanol/15% gasoline) UST to be completed and returned to him along with supplemental information from the tank and equipment vendors. This information was sent to the EPA on February 22, 2016. On April 27, 2016, EPA requested additional information, some of which was not available. On August 11, 2016, EPA issued a Notice of Violation (NOV) for failing to provide adequate documentation of the compatibility of the E85 components. Following a conference call and subsequent visit by EPA, it was agreed that Argonne would replace or otherwise address all of the components for which documentation of compatibility was not available. Most of these components were replaced in December 2016, with the balance of the work to be completed in 2017.

2.3.6. Solid Waste Disposal

Argonne generates a large volume and variety of wastes. Table 2.7 lists the non-rad hazardous and nonhazardous waste shipped during 2016. All non-recycled nonhazardous special wastes generated at Argonne in 2016 were disposed of at permitted off-site landfills.

2.4. National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) established a national environmental policy that promotes consideration of environmental impacts in federal or federally-sponsored projects. NEPA requires that the environmental impacts of proposed actions with potentially significant effects be considered in an Environmental Assessment (EA) or in an Environmental Impact Statement (EIS). DOE has promulgated regulations at 10 CFR Part 1021 that list classes of actions that ordinarily require those levels of documentation or that are categorically excluded from further NEPA review. No EAs or EISs were prepared during 2016. Argonne utilizes an Environmental Review Form (ERF) to document the NEPA review of all proposed projects.

2.5. Safe Drinking Water Act

The Safe Drinking Water Act of 1974 (SDWA) established a program to ensure that public drinking water supplies are free of potentially harmful materials. This mandate is carried out through the institution of national drinking water quality standards, including maximum contaminant levels and maximum contaminant level goals, as well as through the imposition of wellhead protection requirements, monitoring requirements, treatment standards, and regulation of underground injection activities. The regulations implementing the SDWA set forth requirements to protect human health (primary standards) and provide aesthetically acceptable water (secondary standards).

In January 1997, Argonne incorporated Lake Michigan water as its only source of domestic water, thereby replacing the dolomite groundwater that formerly constituted its source of drinking water. Because the Lake Michigan water is purchased from the DuPage Water Commission, Argonne is now a customer, rather than a supplier of water. Consequently, on January 23, 1997, the DuPage County Health Department notified DOE that the federal and state monitoring requirements previously applicable to Argonne as a “non-transient, non-community” public water supply were no longer applicable. The 2016 DuPage Water Commission’s Consumer Confidence Report on drinking water quality indicates the drinking water at Argonne meets the drinking water standard for all tested contaminants.

In late 2015, all former potable groundwater wells at Argonne were formally taken out of service and sealed in accordance with Illinois Department of Public Health and DuPage County Health Department requirements. Accordingly, in 2016 Argonne discontinued the informational monitoring program of site potable groundwater.

2.6. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the use of pesticides. Applications of general-use pesticides to control nuisance insects were applied by a contractor with a license from the Illinois Department of Public Health. Argonne coordinates the contractor's activities and ensures that the chemicals are EPA-approved, that they are used properly, and that any unused chemicals are removed from the site by the contractor. Also, general-use herbicides were applied to various landscape, utility, and habitat areas by both contractors and in-house staff with licenses from the Illinois Department of Agriculture. No mixed application products are stored on-site; however, manufactured concentrates such as Round Up®, a glyphosate formulation, are stored on-site and used by FMS Grounds.

2.7. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) addresses the cleanup of hazardous waste disposal sites and the response to hazardous substance spills. Under CERCLA, the EPA collects site data regarding sites subject to CERCLA action through generation of a Preliminary Assessment report, followed by a Site Screening Investigation. Sites then are ranked, on the basis of the data collected, according to their potential for affecting human health or causing environmental damage. The sites with the highest rankings are placed on the National Priority List (NPL) and are subject to mandatory cleanup actions. No Argonne sites are included in the NPL. All Argonne cleanup actions were performed under the RCRA corrective action program rather than CERCLA.

2.7.1. Emergency Planning and Community Right to Know Act (Superfund Amendments and Reauthorization Act, Title III)

Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA) amendments to CERCLA is the Emergency Planning and Community Right to Know Act (EPCRA), a freestanding provision. EPCRA requires providing federal, state, and local emergency planning authorities with information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including plans for responding to emergency situations involving hazardous materials. Under EPCRA, Argonne submitted reports pursuant to Sections 302, 304, 311, 312, and 313, which are discussed in the following paragraphs. Table 2.9 gives Argonne's status in regard to EPCRA.

TABLE 2.9

Status of EPCRA Reporting, 2016

EPCRA Section	Description of Reporting	Status
Section 302	Planning notification	Not Required
Section 304	Extremely hazardous substance release notification	Not Required
Section 311–312	Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Release Inventory reporting	Required

Section 302 of SARA Title III, Planning Notification, addresses notifying and updating the Local Emergency Planning Committee (LEPC) and the State Emergency Response Commission (SERC) as to the presence of extremely hazardous substances (EHSs) at Argonne, including laboratory usage, that exceed any EHS threshold planning quantity. Reporting under Section 302 is necessary when the EHS is initially brought on-site, and when the EHS storage information changes. No EHS storage information changed in 2016.

Section 304 of SARA Title III, Extremely Hazardous Substances Release Notification, requires that the LEPC and state emergency management agencies be notified of accidental or unplanned releases of Section 302 hazardous substances to the environment. Also, the National Response Center (NRC) is notified if a release exceeds the CERCLA Reportable Quantity (RQ) for that particular hazardous substance. No such releases occurred in 2016, thus no notifications were made.

Under SARA Title III, Section 311, Safety Data Sheet (SDS)/Chemical Inventory, Argonne is required to provide applicable emergency response agencies with SDSs, or a list of SDSs, for each hazardous chemical stored on-site. The 2016 information was uploaded and certified on the Illinois Emergency Management Agency (Illinois' SERC) database, with a hard copy submitted to DOE for transmittal to the LEPC in March 2016 with a subsequent SDS update submitted in July 2016..

Pursuant to EPCRA Section 312, Argonne is required to report certain information regarding inventories and the locations of hazardous chemicals to state and local emergency authorities upon request. Chemicals used in research laboratories under the direct supervision of a technically qualified individual are exempt from reporting. The report on Section 312 (Tier 2) information for 2016 was to be provided to the SERC, LEPC, and Argonne Fire Department during February 2017. Table 2.10 lists the hazardous chemicals to be reported.

Section 313 of SARA Title III, Toxic Release Inventory (TRI) Reporting, requires certain facilities to prepare an annual report entitled "Toxic Chemical Release Inventory, Form R," if annual usage of listed toxic chemicals exceeds certain thresholds. Argonne filed one report under Section 313 for activities in 2016, for lead. Use of lead included machining of various types of lead articles in excess of the 100-lb reporting threshold.

TABLE 2.10

SARA, Title III, Section 312, Chemical List, 2016

CAS No.	Name	Hazard[a]
10043-01-3	Aluminum sulfate	A
10043-52-4	Calcium chloride solution	A
75-45-6	Chlorodifluoromethane	P
306-83-2	Dichlorotrifluoroethane	P,A,C
68476-30-2	Diesel Fuel #2	F,A,C
64-17-5	E85 Fuel	F,A,C
8006-61-9	Gasoline	F,A,C
7647-01-0	Hydrochloric acid	A
NA[b]	Lead/acid batteries	A,C,R
24307-26-4	Mepiquat chloride	A
245735-90-4	Mepiquat pentaborate	C
10102-44-0	Nitrogen dioxide	C,R
7647-14-5	Sodium chloride (rock salt)	A
14464-46-1	Sand	A,C
7681-52-9	Sodium hypochlorite	A
7664-93-9	Sulfuric acid	A,C,R
811-97-2	Tetrafluoroethane	P
7699-45-8	Zinc bromide	A

[a] Hazard: A = Acute; C = Chronic; F = Fire; P = Pressure; R = Reactive.

[b] NA = No Chemical Abstracts Service (CAS) Number.

2.8. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) was enacted to require chemical manufacturers and processors to develop adequate data on the health and environmental effects of their chemical substances. The EPA has promulgated regulations to implement the provisions of TSCA. These regulations provide specific authorizations and prohibitions on the manufacturing, processing, and distribution in commerce of designated chemicals. The principal impact of these regulations at the Argonne site concerns the handling of asbestos and polychlorinated biphenyls (PCBs). Suspect PCB-containing items that are subject to TSCA regulation are identified through the Argonne PCB Item Inventory Program. Argonne has a procedure to comply with the import/export of TSCA materials requirements.

2.8.1. Polychlorinated Biphenyls in Use at Argonne

Polychlorinated biphenyl (PCB) items in use or in storage for reuse are tracked in the Argonne PCB Document Log. All PCB items identified by the PCB Document Log have been labeled appropriately with a unique number for inventory and tracking purposes. The Argonne Annual PCB Document Log describes the location, quantity, manufacturer, and unique identification number for all PCBs on-site. This Log is not submitted to regulatory agencies, but is kept on file at Argonne. The Annual PCB Document Log for 2016 was to be completed in January 2017. The PCBs in use at Argonne are contained in capacitors and power supplies. Waste Management Operations (WMO) processes PCB-contaminated equipment and oil for disposal. The regulations governing the use and disposal of PCBs can be found in 40 CFR Part 761.

2.8.2. Disposal of Polychlorinated Biphenyls

Disposal of PCBs from Argonne operations includes materials from lab-packed, bulked, and aggregated solids shipped off-site through WMO. This includes PCB-containing materials that also contain radioactive substances, the combination of which is known as TSCA MW. Tables 2.7 and 2.8 include PCB wastes in the Hazardous and Mixed Low-Level categories.

2.9. Endangered Species Act

The Endangered Species Act of 1973 (ESA) is federal legislation designed to protect plant and animal resources from the adverse effects of human activities. To comply with the ESA, federal agencies are required to assess the area affected by a proposed project to determine whether it contains any threatened or endangered species, or any critical habitats of such species.

At Argonne, the applicable requirements of the ESA are identified and satisfied through the NEPA project review process. All proposed projects must provide a statement describing the potential impact on threatened or endangered species and their critical habitats. This statement is included in the general Environmental Review Form. If the potential exists for an adverse impact, this impact will be assessed further and it will be evaluated through consultation with the U.S. Fish and Wildlife Service (USFWS) and, if necessary, the preparation of a more detailed NEPA document, such as an EA or an EIS. Where appropriate, this information is shared with affected state and federal stakeholders, so that potential adverse impacts are assessed fully and any steps to minimize these impacts can be identified.

One federally-listed species is known to occur on the Argonne site. The Hine’s emerald dragonfly (*Somatochlora hineana*), federally- and state-listed as endangered, was found to be present on the Argonne site in 2016. Wetlands on the site provide habitat for adults and early life stages of the dragonfly. This species also occurs in the Waterfall Glen Forest Preserve that surrounds the Argonne property, in locations with spring-fed wetlands along the Des Plaines River floodplain. Critical habitat for the Hine’s emerald dragonfly is located along the Des Plaines River and does not occur on the Argonne site.

No other federally-listed threatened or endangered species are known to occur on the Argonne site, and no critical habitats of federally-listed species exist on the site. One additional federally-listed endangered species and one federally-listed threatened species inhabit Waterfall Glen Forest Preserve.

Leafy prairie clover (*Dalea foliosa*), which is federally- and state-listed as endangered, is associated with dolomite prairie remnants of the Des Plaines River Valley; two planted populations of this species occur in Waterfall Glen Forest Preserve. The federally-listed threatened and state-listed endangered lakeside daisy (*Tetraneuris herbacea*) occurs as a planted population in Waterfall Glen Forest Preserve. In addition, an unconfirmed capture in Waterfall Glen Forest Preserve of an Indiana bat (*Myotis sodalis*), which is federally- and state-listed as endangered, indicates that this species may occur in the area.

Additional species known to occur in DuPage County include eastern prairie fringed orchid (*Platanthera leucophaea*), Mead's milkweed (*Asclepias meadii*), prairie bush clover (*Lespedeza leptostachya*), northern long-eared bat (*Myotis septentrionalis*), eastern massasauga (*Sistrurus catenatus*), and rusty patched bumble bee (*Bombus affinis*). Each of these species is federally-listed threatened except the rusty patched bumble bee, which is listed as endangered; each is state-listed endangered except the northern long-eared bat, which is state-listed threatened, and the rusty patched bumble bee, which is not state-listed.

Although state-listed species that occur in the area are not covered by the ESA, the following state-listed species also can be found on the Argonne site or within the vicinity of Argonne:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax*)
  - Blanding's turtle (*Emydoidea blandingii*)
  - Bulrush (*Scirpus hattorianus*)
  - Osprey (*Pandion haliaetus*)
  - Tennessee milkvetch (*Astragalus tennesseensis*)
  - Tuckerman's sedge (*Carex tuckermanii*)
  - Pursh's bulrush (*Schoenoplectus purshianus*)
  - Yellow-crowned night heron (*Nyctanassa violacea*)

- Threatened
  - Black-billed cuckoo (*Coccyzus erythropthalmus*)
  - Buffalo clover (*Trifolium reflexum*)
  - Kirtland's snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)
  - Shadbush (*Amelanchier interior*)

Of these, the Kirtland's snake, Pursh's bulrush, and black-crowned night heron have been observed on Argonne property. Any impacts on these species also would be assessed during the NEPA process.

2.10. National Historic Preservation Act

Section 106 (54 U.S.C. 306108) of the National Historic Preservation Act (NHPA) of 1966 (54 U.S.C. 300101 et seq.), as amended, requires each federal agency to identify and assess the effect of its actions on historic properties and allow the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment. The goal of this process is to seek ways to avoid, minimize, or mitigate any adverse effect on historic properties. At Argonne, the Section 106 requirements are integrated with the NEPA review process, as well as the Argonne digging permit process. DOE will consult with the Illinois State Historic Preservation Officer and the ACHP if proposed actions may adversely affect properties considered eligible for listing or listed on the National Register of Historic Places (NRHP).

Argonne evaluated its structures built prior to 1989 for potential listing on the NRHP in 2001. The survey identified the Building 200 M-Wing Caves, as well as Buildings 203, 205, 212, 315/316, and 350, as individually eligible for listing on the NRHP. The Main Campus District (Buildings 200, 202, 203, 205, 208, 211) and the Freund Estate Historic District (Buildings 600, 604 and properties 603 [pool], 606 [pavilion], and 616 [tennis courts]) were established as part of the evaluation. Separate evaluations conducted as part of D&D efforts established the Chicago Pile-5 Reactor (Building 330), the Argonne Thermal Source Reactor, (Building 301), the Physics and Metallurgy Hot Laboratory, the High Voltage Electron Microscopy Facility, the Alpha-Gamma Hot Cell Facility, and Zero Power Reactors VI and IX as eligible for listing on the NRHP.

Cultural resources include both archaeological sites and historic structures. Roughly 240 ha (593.6 acres) or, nearly 40 percent, of the Argonne site has been examined through Phase I Archaeological surveys for the presence of cultural resources. Past surveys identified archaeological sites at Argonne, three of which were determined eligible for listing on the NRHP, while 35 were determined ineligible. The remaining 20 sites are yet to be evaluated for NRHP eligibility.

Projects requiring review under Section 106 of the NHPA in FY2016 included the planned removal of two of the contributing properties (pool and bathhouse) to the NRHP-eligible Freund Estate Historic District.

2.11. Floodplain Management

Federal policy on managing floodplains is contained in EO 11988, *Floodplain Management* (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this EO. The EO requires federal facilities to avoid, to the extent possible, adverse impacts associated with the occupancy and modification of floodplains. To construct a project in a floodplain, DOE must demonstrate that there is no reasonable alternative to the floodplain location.

The Argonne site is located approximately 46 m (150 ft) above the nearest large body of water (Des Plaines River); thus, it is not subject to major flooding. The 100- and 500-year floodplains are limited to low-lying areas of the site near Sawmill Creek, Freund Brook, Wards Creek, and other small streams and associated wetlands and low-lying areas. These areas are delineated in Argonne's site development plan and are generally contained within areas designated for conservation, not intended for development. No significant structures are located in these areas, although an existing pumping station and inlet structure for securing canal water as a cooling tower feedstock is situated in the floodplain of the Des Plaines River south of the site. To ensure that floodplain areas are not adversely affected, new facility construction is not permitted within these areas, unless there is no practical alternative. Any impacts on floodplains would be fully assessed in a floodplain assessment and, as appropriate, documented in the NEPA documents prepared for a proposed project. Appropriate permits from the U.S. Army Corps of Engineers (COE) are needed to conduct work inside floodplains.

2.12. Protection of Wetlands

Federal policy on wetland protection is contained in EO 11990, *Protection of Wetlands* (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this EO. The EO requires federal agencies to identify potential impacts on wetlands resulting from proposed activities and to minimize these impacts. Where impacts cannot be avoided, mitigating action must be taken by repairing the damage or replacing the wetlands with an equal or greater amount of a restored wetland or a man-made wetland as much like the original wetland as possible.

Section 404 of the CWA establishes a program to regulate the discharge of dredged and fill material into waters of the United States, including wetlands with a connection to waters of the U.S. The United States COE administers this program. Activities regulated under this program include disturbance of wetlands for development projects, infrastructure improvements, and drainage of wetlands to uplands for farming and forestry. The COE uses a permit system to identify and enforce wetland mitigation efforts.

Argonne completed a site-wide wetland delineation in 1993. All wetlands present on-site were identified and mapped following the 1987 *Corps of Engineers Wetlands Delineation Manual*.[3] The delineation map shows the areal extent of all wetlands present at Argonne down to 500 m^2 (1/8th acre). Thirty-five individual wetland areas were identified; their total area is approximately 20 ha (50 acres). The larger wetlands are illustrated in Figure 1.3. There were no actions in 2016 that adversely impacted site wetlands.

2.13. Land Management and Habitat Restoration

The Argonne site hosts a number of habitats that are interspersed and surround the research campus. The quality of the habitats are significant, contributing to the welfare of migratory birds, pollinators, and other wildlife. The goal of Argonne's land management and the habitat restoration effort is to retain these resources, improve degraded habitats, and control the proliferation of invasive species.

Argonne annually attempts to convert 1–2 ha (3–5 acres) of pasture grass to restored prairie and to control 12–24 ha (30–60 acres) of invasive species. Several species of invasive plants are monitored and controlled every year. This continued through 2016, with 1.6 ha (4 acres) of land added to prairie conversion, and 13.8 ha (34 acres) of woodland managed to control invasive shrubs and other plant species.

2.14. Wildlife Management and Related Monitoring

DOE and the Forest Preserve District of DuPage County coordinate wildlife management efforts to preserve and enhance biodiversity at Argonne and the surrounding Waterfall Glen Forest Preserve. DOE manages the numbers of white-tailed and fallow deer at the site through an interagency agreement with the U.S. Department of Agriculture (USDA). DOE began the deer management program in 1995 to alleviate traffic safety hazards and ecological damage caused by extremely high deer densities. White-tailed deer are removed as needed to achieve target densities of 15 deer/mi^2 to reduce deer and vehicle collisions, allow oak trees to regenerate, and allow deer-sensitive herbaceous species to recover. Over the past few years, the fallow deer population has decreased significantly. There is currently only one fallow deer left at Argonne.

The USDA-Wildlife Service has developed a list of migratory birds that are protected under the Migratory Bird Treaty Act (MBTA), (Title 16, United States Code [USC], Sections 703–712) of 1918. The MBTA implements agreements the United States has with Canada, Japan, Mexico, and the former Soviet Union for the protection of shared migratory bird resources. The act protects migratory birds; their eggs, parts, and nests; and any product, manufactured or not, from such items. The list can be found in Title 50, CFR, Part 10.13. In 2015, Argonne asked the USDA-Wildlife Service to conduct the official annual survey of migratory birds. They have confirmed that many of the bird species on the list pass through or nest on-site.

2.15. Environmental Permits

Table 2.11 lists all the environmental permits in effect at the end of 2016. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements.

TABLE 2.11

Environmental Permits in Effect, 2016

Permit Name	Permit ID	Permit Type	Start Date	End Date
B-203 CARIBU Project Construction Permit	05120055	Construction (Air Emission Source)	3/20/2006	–[a]
Building 108 Boiler #5 NO_x RACT Control	11030020	Construction	4/5/2011	–
Building 211 Linac	11030026	Construction	3/30/2011	–
Building 108 Temporary Boiler	11060051	Construction	7/22/2011	–
Building 308 Alkali Metal Reaction Booth	88120046[b]	Construction	1/6/2012	–
Building 366 Wakefield Accelerator	11080020	Construction	8/17/2011	–
Combined Heat and Power (CHP) Plant	12120033	Construction	6/28/2013	–
Energy Innovation Center	ILR100906	General NPDES	10/08/2014	7/31/2018
Energy Sciences Building	2011-HB-1277	Construct, own, operate (sewer connection)	4/22/2011	–
Advanced Protein Crystallization Facility	2011-HB-1916	Construct, own, operate (sewer connection)	9/30/2011	–
CAAPP Title V Permit	95090195	Operating	5/29/2015	5/29/2020
Howard T. Ricketts Laboratory Construction Project	2006-EN-6007	Construction	1/12/2006	–
NPDES Wastewater Discharge Permit[c]	IL0034592	Operating	9/1/2011	8/31/2016
General NPDES Permit for Pesticide Application Point Source Discharges	ILG870741	General NPDES	10/31/2011	10/30/2016
Open Burn Permit — Fire Training	B1612213	Operating	12/28/2016	12/28/2017
Open Burn Permit — Vegetative Management	B1608276	Operating	8/25/2016	8/25/2017
RCRA Part B Permit	IL3890008946	Operating	9/30/1997	5/6/2020
Theory and Computing Sciences (TCS) Building	2009-EN-4482	Construction	10/8/2009	–
USDA Soil Permit	P330-14-00357	Operating	12/27/2014	11/12/2017
Wastewater Discharge Permit to DuPage County	18965	Wastewater	7/29/1991	–
Wastewater Treatment Plant Land Application Permit	2015-SC-59472	Operating	2/10/2015	12/31/2019

[a] A dash indicates that the permit continues to be in effect with no expiration date.

[b] Revision of the original construction/operating permit. Converted from insignificant to significant emission unit in CAAPP permit.

[c] An NPDES permit application was submitted to IEPA during 2016. The current permit remains in effect until a new permit is received.

2.16. EPA/IEPA/DOE Inspections/Appraisals

Various inspections and appraisals were conducted during 2016. A short description of each is included in Table 2.12. The 2016 assessment schedule was finalized at the beginning of the fiscal year, October 1, 2015. The assessment schedule includes assessment to be completed by Argonne's Independent Assessment team, assessments by regulatory agencies, and assessments conducted by DOE. Any identified issues are documented in an Argonne issues management system and tracked to completion.

TABLE 2.12

EPA/IEPA/DOE Environmental Compliance Inspections/Appraisals, 2016

Agency	Type	Date
PMA	EPCRA Compliance Joint Surveillance	5/6/2016
PMA	Unbound Nanomaterial Particles Surveillance	11/15/2016
USEPA & IEPA	Annual Resource Conservation and Recovery Act Inspection	4/21/2016
IEPA	NPDES Annual Inspection	11/9-10/2016
DOE-ASO	CWA Compliance Functional Area Review	8/16/2016
DOE-ASO	Sustainable Buildings Functional Area Review	11/3/2016
DOE-ASO	EMS Functional Area Review	9/26/2016
DOE-ASO	Emergency Management Program Functional Area Review	4/29/2016
DOE-NNSS	LLRW Waste Certification Program Surveillance	Various

3. ENVIRONMENTAL MANAGEMENT SYSTEM

The Environmental Management System (EMS) is a tool that the management team at Argonne uses to effectively manage and monitor the impacts its operations and processes may have on the environment and to continually improve its environmental stewardship performance. The UChicago Argonne, LLC, Board of Governors; the Laboratory Directorate; and the Director's Safety Council are committed to ensuring that environment, safety, and health considerations are integrated into the performance of all work.

3.1. EMS Certification

DOE Order 436.1, which superseded DOE Order 450.1A, requires sites to have an established and implemented EMS. According to the DOE Order, sites must maintain their EMS as being certified to or conforming to International Organization for Standardization (ISO) 14001:2004, in accordance with the accredited registrar provisions of the International Standard or the self-declaration instructions referenced within the ISO standard.

The ISO Registrar recommended Argonne for ISO 14001:2004 certification, which was most recently issued on May 10, 2015 (see Figure 3.1). On January 9, 2017, the U.S. Department of Energy-Argonne Site Office (DOE-ASO) declared that Argonne had fully implemented its EMS, consistent with the requirements of DOE Order 436.1. In parallel with the ISO 14001:2004 certification, Argonne also obtained ISO 9001:2008 certification. A full registration audit was conducted in April 2015 and a surveillance audit was conducted in April 2016. Argonne's ISO 14001:2004 and ISO 9001:2008 certifications have been maintained. In addition, Argonne obtained OHSAS 18001:2007 certification in June 2015.


NSF ISR

Certificate of Registration

This certifies that the Environmental Management System of

Argonne National Laboratory

9700 S. Cass Ave
Argonne, Illinois, 60439-4832, United States

has been assessed by NSF-ISR and found to be in conformance to the following standard(s):

ISO 14001:2004

Scope of Registration:
The provision of basic and applied scientific research, engineering, and technical services for the U.S. Department of Energy and other customers.

Certificate Number: 6Q721-EM7
Certificate Issue Date: 10-MAY-2015
Registration Date: 17-MAY-2015
Expiration Date *: 16-MAY-2018

Carl Blazik,
Director, Technical
Operations & Business Units,
NSF-ISR, Ltd.

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789 North Dixboro Road, Ann Arbor, Michigan 48105 | (888) NSF-9000 | www.nsf-isr.org

Authorized Registration and /or Accreditation Marks. This certificate is property of NSF-ISR and must be returned upon request.
*Company is audited for conformance at regular intervals. To verify registrations call (888) NSF-9000 or visit our web site at www.nsf-isr.org

FIGURE 3.1 Argonne ISO 14001:2004 Certificate

3.2. Integration of the EMS with the Integrated Safety Management System

The Integrated Safety Management System (ISMS) is the DOE umbrella of environment, safety, and health programs and systems that provides the necessary structure for any work activity that could potentially affect a worker, the public, or the environment. The EMS is integrated into the ISMS through the Argonne Work Planning and Control (WP&C) process. As part of the work planning process, the NEPA Environmental Review Form is completed to indicate any potential environmental issues associated with the work so that the appropriate environmental subject matter expert (SME) can be engaged to assess any environmental impacts.

3.3. EMS Elements

The ISO 14001:2004 standard contains requirements that define and document the EMS program. The EMS is designed around the plan-do-check-act cycle, an interactive four-step management method used for the control and continuous improvement of processes. The most critical planning stage elements are discussed below.

3.3.1. Environmental Policy

The Argonne environmental policy is captured in LMS-POL-2 and is available to all Argonne employees and to the public via the Argonne public website. The policy states "Argonne activities (including experiments, facility operations, construction activities, and other activities) must be conducted in an environmentally safe and sound manner consistent with Argonne permit conditions. Argonne is committed to:

- Continuous environmental improvement,
- Implementation of the environmental objectives and targets process,
- Pollution prevention and waste minimization, and
- Compliance with all applicable requirements."

This environmental policy applies to all Argonne activities that could or do have a potential impact on the environment or compliance with applicable environmental regulations.

To support this commitment, Argonne:

- Ensures that technologies, facilities, processes, and operating procedures meet or exceed applicable environmental permit expectations and regulatory requirements;

- Actively explores, creates, and communicates new ways to minimize and prevent pollution arising from all levels of research, development, and operational activities and to preserve natural resources;

- Builds partnerships inside and outside of Argonne to sustain and enhance the environment; and

- Corrects conditions promptly and responsibly to eliminate or minimize potential adverse impacts on sustainable environments.

3.3.2. Environmental Aspects and Impacts

Argonne evaluates its operations to identify those aspects of its operations that can impact the environment and to determine which of those impacts are significant. When operations have the potential for significant environmental impacts, Argonne implements the EMS to minimize or eliminate potential adverse impacts. Most of the aspects are discussed in Chapter 2. The list of environmental aspects is reviewed and updated annually.

Regulatory and organizational roles and responsibilities are delineated in the EMS Description Document to address the management of the aspects and impacts. To determine which environmental aspects are significant, a scoring methodology is applied that rates each against the four criteria of regulatory compliance, environmental consequence, mission consequence, and the likelihood of occurrence. Four aspects have been identified as being significant: regulated air emissions, wastewater discharges, waste generation, and pollution prevention/waste minimization. All facilities that have significant aspects are required to have controls in place to minimize or eliminate their negative impacts.

3.3.3. Legal and Other Requirements

Argonne monitors the environmental regulations to ensure that Argonne staff is aware of proposed changes in regulations and new regulations. A number of sources of information are reviewed to identify new or changing regulations, including:

- Monitoring *Federal Register* and *Illinois Register* notices, EPA, IEPA, and DOE websites, and newsletters;

- Attending workshops and seminars; and

- Participating in professional organizations and conferences.

New requirements are communicated to the appropriate managers and supervisors by SMEs. Evaluations are conducted to determine the impacts of proposed and final regulations on Argonne activities.

In addition to new or revised DOE Orders and regulations that prescribe requirements, Argonne uses other sources to identify opportunities for environmental improvements. These include lessons-learned reports, interaction with other DOE sites, participation in forums, Occurrence Reporting and Processing System (ORPS) reports, management and independent assessments, assessments by stakeholders, and feedback from public interest groups and others.

3.3.4. Environmental Objectives and Targets

Another mechanism to improve environmental performance is the annual establishment of EMS objectives and targets. Objectives describe Argonne's goals for environmental performance. The objectives are a set of measurable or qualitative goals concerning how Argonne will address each significant environmental aspect. Targets are specific measurable interim steps to be taken to obtain objectives. Targets are documentable actions with due dates. All organizations are encouraged to establish and implement environmental targets where applicable to individual programs.

For FY 2016, 48 objectives/targets were established. Sustainability practices are a large component of Argonne's environmental objectives and targets. Sustainability practices are discussed in the following sections.

3.4. Sustainability Practices

On March 19, 2015, President Obama signed Executive Order 13693, *Planning for Federal Sustainability in the Next Decade,* to maintain Federal leadership in sustainability and GHG emission reductions. Argonne responded by assessing new and existing strategies to meet the new goals. In addition, Argonne is working to meet the goals outlined in Executive Order 13653, *Preparing the United States for the Impacts of Climate Change*. The strategies employed to meet these environmental and sustainability targets are outlined in the 2017 Argonne National Laboratory Site Sustainability Plan (SSP), issued in December 2016 and available at http://www.anl.gov/downloads/fy-2017-argonne-site-sustainability-plan. Argonne is in its seventh performance year working under a SSP. The overarching goal of the SSP is to provide support for Argonne's mission through sustainable and innovative site operations.

The SSP outlines the ways in which Argonne integrates sustainability strategies (e.g., energy and water conservation, pollution prevention, GHG reductions, climate change resilience planning, etc.) into Argonne work processes and research and development goals. Argonne continues to make measured, systematic progress toward meeting goals for increasing electricity and water efficiency, reducing GHG emissions, and utilizing green practices in infrastructure construction and site renovation projects. Argonne's FY 2017 SSP addresses the following key areas: GHG Reduction, Sustainable Buildings, Clean and Renewable Energy, Water Use Efficiency and Management, Fleet Management, Sustainable Acquisition, Pollution Prevention and Waste Reduction, Energy Performance Contracts, Electronic Stewardship and Climate Change Resilience. A detailed account of progress toward goals in the following areas is contained in the SSP report, but highlights are listed below.

- Completed the Combined Heat and Power (CHP) plant, which was financed through the Laboratory's fourth Energy Savings Performance Contract.
- Added an additional facility to the Laboratory's roster of high-performance sustainable buildings (HPSBs), bringing the total to 12 buildings and exceeding the goal of having 16 percent of facilities compliant with HPSB guiding principles.
- Acquired a sulfur hexafluoride (SF_6) recovery unity for a linear accelerator located in Building 211, which is expected to recover approximately 500 pounds of SF_6 annually, equivalent to more than 5,500 tons of CO_2.
- Expanded Argonne's employee electric vehicle charging program with 4 additional, dual-port charging stations, allowing 26 vehicles to simultaneously charge across the site.
- Reduced potable water intensity to 35 percent less than the FY 2007 baseline.
- Diverted 4,246 metric tons (99%) of construction and demolition waste from municipal landfills.
- Received the Illinois Governor's Sustainability Award for the third consecutive year.
- Completed a site stormwater assessment in partnership with the U.S. Geological Survey, to support the Laboratory's commitment to comprehensive climate resilience planning.

3.4.1. Pollution Prevention and Waste Reduction

Argonne operates a site-wide Pollution Prevention/Waste Minimization (P2) program in accordance with its RCRA Part B Permit and DOE Order 436.1. The P2 program tracks the generation of waste and recyclable material at Argonne and monitors progress toward meeting goals established in Argonne's SSP.

Argonne management fosters a work environment that promotes the development and implementation of P2 activities. Argonne has established a P2 policy statement and a requirement that all new project reviews include the use of a P2 review checklist. In addition, Argonne uses the ISMS to promote and institutionalize P2 strategies across the site.

3.4.1.1. Pollution Prevention Assessment Activities

Argonne's P2 program team identifies, develops, and performs assessments to determine the viability of programs, projects, and activities to reduce or eliminate waste or pollution. In

FY 2015, Argonne hired the Illinois Sustainable Technology Center (part of the Illinois Prairie Research Institute, a multidisciplinary state research unit charged with providing objective research, expertise, and data on the natural and cultural resources of Illinois) to conduct a Recycling and Waste Reduction Opportunity Assessment of Argonne's typical waste streams.

The assessment measured and characterized waste material generated at eight key buildings. The purpose of the assessment was to identify top opportunities for reducing or recycling common items found in the landfill stream of Argonne's waste. The assessment emphasized improving recovery rates of recyclable materials and analyzing recycling opportunity benefits and costs for materials that are not currently included in Argonne's recycling program.

The results of the Assessment indicated a significant portion of Argonne's landfill waste stream is comprised of materials that are recyclable or compostable. For example, ten percent (10%) of the sampled landfill stream (by weight) was recyclable office paper. Thirty seven percent (37%) of the sampled landfill stream (by weight) was food scraps or compostable paper towels. The final report provides potential program recommendations for waste diversion improvement.

3.4.1.2. Solid Waste Recycling Program

Argonne's comprehensive solid waste recycling program effectively recycles a wide range of materials. Many of these recycling activities result in significant savings for Argonne. For example, Argonne receives funds back each year for recycling scrap metal. Other recycled materials represent cost avoidance for Argonne, in that Argonne does not pay for disposal of the material. Table 3.1 presents a summary of recycled material volumes for 2016.

TABLE 3.1

Recycled Materials, 2016

Material	Amount Recycled (tons)
All-in-One	680
Composting	1
Scrap Metal	245
Computers	39
Batteries	6
Sanitary Sludge	27
Oils & Fluids	8
Toner Cartridges	3
Light Blubs	9

Argonne continues to utilize programs such as the Argonne Property Excess System (APES), Freecycle and the Chemical Management System to minimize waste and reuse available materials. The APES program was developed to assist Argonne employees in recycling and reusing surplus equipment, supplies and materials by promoting the availability or need for items via the Argonne email system. Freecycle allows employees to post items (for example, equipment, furniture and supplies) that can be transferred for use elsewhere at Argonne. In addition, the Chemical Management System enables surplus chemicals to be used rather than purchasing new chemicals.

3.5. Employee/Community Awareness

Argonne conducts a number of activities focused on educating and informing both its employees and the public on the status of environmental programs and efforts to promote sustainable actions and environmental awareness.

Argonne celebrated Earth Day in 2016 with weeklong series of engagement opportunities that focused on Argonne's sustainability program areas. Through the week, the Argonne community:

- learned about sustainable product choices and lifecycle science,
- enjoyed a forest walk with site ecology and restoration experts,
- commuted "green" to work,
- received a behind-the-scenes peek at ESB's sustainable design features, and
- discussed climate vulnerabilities and preparedness over themed films.

This format allowed employees and site users to select an activity that met their specific schedule needs and over 200 participated over the course of the week. The week was capped off with over 40 of our youngest community members (2-5 year olds) at the Argonne Child Care center planting a Bur Oak in the circle in front of the center.

The Argonne Communications, Education, and Public Affairs (CEPA) organization assists Argonne Sustainability and Environmental Programs with promotion of environmental achievements, programs, and best practices, both within Argonne and in the local and regional communities. Staff keep Argonne's neighbors apprised of programs and activities through the following:

- Community Leaders Round Table — Elected and appointed leaders of public and private community organizations meet quarterly for an informal update on Argonne activities that affect the surrounding communities.

- Argonne Advances E-Newsletter — Issued every month, this digital newsletter contains brief articles about the world-class discoveries, researchers, and developments at Argonne. The newsletter is emailed to more than 9,000 members of the surrounding Argonne community. Interested parties can subscribe at http://www.anl.gov/subscribe.

- "Argonne OutLoud" — This public lecture series highlights the cutting-edge research taking place at Argonne and topics of interest to the community at large. Lectures are free and open to the public. Advance registration is required.

- Argonne Now — Issued biannually, this informational science publication features stories about research and breakthroughs at Argonne and what it means for our everyday lives. It includes news, interviews with scientists and engineers, pieces about the challenges facing researchers today, and more. Interested parties can subscribe at http://www.anl.gov/subscribe.

- Tours — Each year, staff lead dozens of tours of Argonne's grounds and scientific facilities for high school, college, business, professional, and community groups.

- Argonne Speakers Bureau — Argonne provides community and business groups with speakers about a variety of topics related to Argonne activities.

- Social Media — Members of the community can follow Argonne on Facebook, flickr, YouTube, LinkedIn, Pinterest, Google+, and Twitter.

In addition to these services, Argonne maintains a public website (www.anl.gov) which contains environmental information, including the Argonne environmental policy, the Site Environmental Report (SER), the Summary SER, the SSP, and other current environmental information.

3.6. Awards

3.6.1 Pollution Prevention and Sustainability Programs

Argonne's Pollution Prevention and Sustainability Programs received the following award in 2016:

Illinois Governor's Sustainability Award
Awarding Agency/Program: Office of the Governor/Illinois Sustainable Technology Center (ISTC)
Award/Ceremony Date: November 1, 2016

Summary: Argonne was recognized as an Illinois leader for its deliberate practice of sustainability in building design, operation efficiency, renewable energy infrastructure, recycling and reduction of GHG emissions.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1. Description of Monitoring Program

The radioactivity of the environment around Argonne in 2016 was determined by measuring the radionuclide concentrations in the air, surface water, groundwater, and sediment as well as by measuring the external photon penetrating radiation exposure. Sample collections and measurements were made onsite, at the site perimeter, and offsite for comparative purposes.

Because radioactivity is primarily transported by air and water, the sample collection program concentrates on these media. In addition, sediment samples from Sawmill Creek are analyzed. The program follows the guidance provided in the DOE Environmental Regulatory Guide.[4] The results of radioactivity measurements are expressed in terms of pCi/L for water, fCi/m^3 for air, and pCi/g or fCi/g for bottom sediment. Penetrating radiation measurements are reported in units of mrem/yr, and population dose is reported in units of person-rems.

DOE has provided guidance[5] for effective dose equivalent calculations for members of the public based on International Commission on Radiological Protection (ICRP) Publications 60 and 101.[6,7] Those procedures have been used in preparing this report. The methodology requires that three components be calculated: (1) the committed effective dose equivalent (CEDE) from all sources of ingestion, (2) the CEDE from inhalation, and (3) the direct effective dose equivalent from external radiation. These three components were summed for comparison with the DOE effective dose equivalent limits for environmental exposure. To ensure that at least 90% of the total CEDE is accounted for, the DOE guidance requires that sufficient data on exposure to radionuclide sources be available. For 2016, approximately 93% of the samples that were scheduled were collected. Dry wells, dry surface water locations, weather, or equipment failures/upgrades accounted for the samples that could not be collected. The primary radiation dose limit for members of the public is 100 mrem/yr. The effective dose equivalents for members of the public from all routine DOE operations (natural background and medical exposures excluded) shall not exceed 100 mrem/yr and must adhere to the as low as reasonably achievable (ALARA) process or be as far below the limits as is practical, taking into account social, economic, technical, practical, and public policy considerations. Routine DOE operations are normally planned operations and exclude actual or potential accidental or unplanned releases.

The measured or calculated environmental radionuclide concentrations were converted to a 50-year CEDE with the use of the CEDE conversion factors[8] and were compared with the annual dose limits for uncontrolled areas. The CEDEs were calculated from the DOE Derived Concentration Standards (DCSs)[5] for members of the public on the basis of a radiation dose of 100 mrem/yr. The numerical values of the CEDE conversion factors used in this report are provided later in this chapter (Table 4.25). Occasionally, other standards are used, and their sources are identified in the text.

4.2. Air

The radioactive content of particles in the air was determined by collecting and analyzing air filter samples. The sampling locations are shown in Figures 1.1 and 1.2. Argonne uses continuously operating air samplers to collect samples for the measurement of concentrations of airborne particles contaminated by radionuclides. Currently, nonradiological air contaminants in ambient air are not monitored. Samples are collected at the site perimeter to determine whether a statistically significant difference exists between perimeter measurements and measurements taken from samples collected at various off-site locations. The off-site samples establish the local background concentrations of naturally occurring or ubiquitous man-made radionuclides, such as from nuclear weapons testing fallout. Higher levels of radioactivity in the air measured at the site perimeter may indicate radioactivity releases from Argonne, provided that the perimeter sample results are greater than the background sample results by an amount greater than the relative error of the measurement. The relative error is a result of natural variation in background concentrations as well as sampling and measurement error. This relative error is typically 5 to 20% of the measurement value for most of the analyses, but approaches 100% at values near the detection limit of the instrument.

Airborne particle samples for measurement of total alpha, total beta, and gamma-ray emitters are collected continuously at 11 perimeter locations and at 4 off-site locations on glass fiber filter media. The on-site PM_{10} air samplers were replaced in 2016 with units identical to the off-site samplers. The average flow rates for all samplers, which utilize 2-in. diameter filter media, are 2.55 m^3/hr (90 ft^3/hr). Filters are changed weekly. Argonne staff members change the filters on on-site samplers. Filters on off-site samplers are changed and mailed to Argonne by cooperating local agencies. The sampler airflow rates are recalibrated annually and the units are services as needed. Each air filter sample is analyzed twice. The first time each individual sample is mounted in a 5-cm (2-in.) low-lip stainless-steel planchet, and analyzed to determine alpha and beta activity. The individual samples from each week of the year are then composited together and analyzed for gamma-ray activity.

Table 4.1 summarizes the monthly total alpha and beta activities for the individual weekly air filter sample analyses. These measurements were made in low-background gas-flow proportional counters and the counting efficiencies used to convert counting rates to disintegration rates were those measured for a 0.30-MeV beta and a 5.5-MeV alpha on filter paper. The results were obtained by measuring the samples at least four days after they were collected to avoid counting the natural activity due to short-lived radon and thoron decay products. This activity is normally present in air and disappears within four days by radioactive decay.

The average concentrations of gamma-ray emitters, as determined by gamma-ray spectrometry performed on weekly composite samples, are given in Table 4.2. The gamma-ray detector is a shielded germanium diode calibrated for each gamma-ray-emitting nuclide measured.

TABLE 4.1

Total Alpha and Beta Activities in Air-Filter Samples, 2016
(Concentrations in fCi/m^3)

			Alpha Activity			Beta Activity		
Month	Location	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	40	1.16	0.30	2.03	25.37	17.15	34.29
	Off-Site	12	1.69	0.90	3.55	20.91	7.38	30.15
February	Perimeter	40	1.15	0.40	2.28	21.88	14.54	27.50
	Off-Site	15	0.79	< 0.10	3.03	11.37	< 0.10	25.20
March	Perimeter	50	1.04	0.50	1.86	16.67	11.75	26.06
	Off-Site	16	1.39	0.70	2.66	13.79	8.46	18.14
April	Perimeter	41	1.60	0.84	2.28	19.98	16.34	26.55
	Off-Site	15	2.02	1.00	4.15	16.41	10.94	34.79
May	Perimeter	44	1.19	0.13	1.99	15.86	9.68	25.70
	Off-Site	16	1.64	0.94	2.86	12.55	5.81	18.95
June	Perimeter	50	1.08	0.44	1.78	17.78	8.51	21.78
	Off-Site	20	1.13	0.62	2.26	15.57	9.68	20.16
July	Perimeter	38	1.09	0.29	2.20	20.45	10.98	28.94
	Off-Site	14	1.23	0.70	2.18	16.40	10.31	20.79
August	Perimeter	49	1.16	0.17	2.07	20.98	4.68	30.65
	Off-Site	19	1.27	0.58	2.62	19.37	11.30	26.96
September	Perimeter	37	1.09	0.33	2.41	24.03	14.94	45.00
	Off-Site	15	1.44	0.55	2.22	21.30	13.28	32.00
October	Perimeter	42	1.05	0.39	2.01	21.14	11.84	31.37
	Off-Site	15	1.22	< 0.10	2.81	17.17	1.45	31.64
November	Perimeter	44	1.88	0.79	3.28	34.35	15.57	55.80
	Off-Site	12	2.81	1.04	6.17	30.70	19.31	49.05
December	Perimeter	33	2.07	0.46	5.85	27.28	11.66	40.82
	Off-Site	6	1.81	0.45	3.47	23.94	7.83	39.74
Annual	Perimeter	508	1.28 ± 0.4	0.13	5.85	21.90 ± 0.9	4.68	55.80
Summary	Off-Site	175	1.48 ± 0.4	< 0.10	6.17	17.60 ± 0.9	< 0.10	49.05

TABLE 4.2

Gamma-Ray Activity in Air-Filter Samples, 2016
(Concentrations in fCi/m^3)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	96	30
	Off-Site	59	19
February	Perimeter	84	20
	Off-Site	47	9
March	Perimeter	112	15
	Off-Site	65	8
April	Perimeter	158	17
	Off-Site	112	11
May	Perimeter	141	12
	Off-Site	105	8
June	Perimeter	122	12
	Off-Site	107	10
July	Perimeter	109	12
	Off-Site	90	10
August	Perimeter	84	14
	Off-Site	70	10
September	Perimeter	100	16
	Off-Site	96	15
October	Perimeter	83	16
	Off-Site	64	12
November	Perimeter	75	22
	Off-Site	75	20
December	Perimeter	61	19
	Off-Site	53	16
Annual	Perimeter	103	17
Summary	Off-Site	79	12
Dose (mrem)	Perimeter	(0.00011)	(0.49)
	Off-Site	(0.00009)	(0.35)

The gamma-ray emitters listed in Table 4.2 are those that have been present in the air during past years and are of natural origin. The beryllium-7 concentration usually increases in the spring, which indicates its stratospheric origin. The concentration of lead-210 in the air is due to the radioactive decay of gaseous radon-222 and is similar to the concentration in 2015.

The annual average alpha and beta activities since 2000 are displayed in Figure 4.1. Figure 4.2 presents the annual average concentrations of the two major gamma-ray-emitting radionuclides in air. The changes in the beryllium-7 air concentrations have been observed worldwide by the DOE Environmental Measurements Laboratory's Surface Air Sampling Program and are attributed to changes in solar activity.[10]

The major airborne effluents released at Argonne during 2016 are listed by building location in Table 4.3. Short-lived neutron activation products were emitted from the Linear Accelerator (LINAC) and the Advanced Photon Source (APS). In addition to the radionuclides listed in Table 4.3, several other fission products also were released in millicurie or smaller amounts. Air emissions from areas that have a probability of releasing measurable concentrations of radionuclides are calculated. The results of these measurements are used to estimate the annual off-site dose using the required EPA CAP-88 (Clean Air Act Assessment Package-1988)[9] atmospheric dispersion computer code and dose conversion method.

Phytoremediation is being performed in the 317/319 Area to complete the cleanup of the groundwater in the area, which was contaminated in the past by the disposal of liquid wastes to the soil in French drains. Phytoremediation is a natural process by which woody and herbaceous plants extract pore water and entrained chemical substances from subsurface soil, degrade volatile organic constituents, and transpire water vapor to the atmosphere. The system consists of shallow-rooted willow and special deep-rooted poplar trees. Approximately 800 poplar trees were planted in the fall of 1999. In 2003, approximately 200 willow trees were planted to expand the system. During the 2012 to 2015 timeframe, it was observed that a large number of trees had died or were nearly dead. As of the end of 2015, only about 30% of the trees were still alive and many of these were sickly. The cause of the tree death is likely to be a type of canker disease that is spreading to other healthy trees, as well as an inherent weakness of the variety of poplar tree planted, and the trees reaching their natural life-span. A partial replanting effort was completed in 2015. The future of the phytoremediation system is being evaluated. It is likely that the trees will be allowed to die off naturally and will not be replaced.

One of the groundwater contaminants in the 317/319 Area is hydrogen-3, as tritiated water. The phytoremediation process translocates the hydrogen-3 from the groundwater to the air as water vapor. Since the hydrogen-3 is released over an area of approximately 2 ha (5.5 acres), traditional point source monitoring for airborne hydrogen-3 water vapor is of little value to determine the quantity of hydrogen-3 released to the air. The annual inventory of hydrogen-3 released to the air can be estimated from the hydrogen-3 content of the groundwater and the extraction rate at which various aged trees remove groundwater. On the basis of the age and type of tree, estimates are available on the average evapotranspiration rate of groundwater per tree per month of the growing season. For this estimate, it is assumed that all of the groundwater that is extracted is transpired.

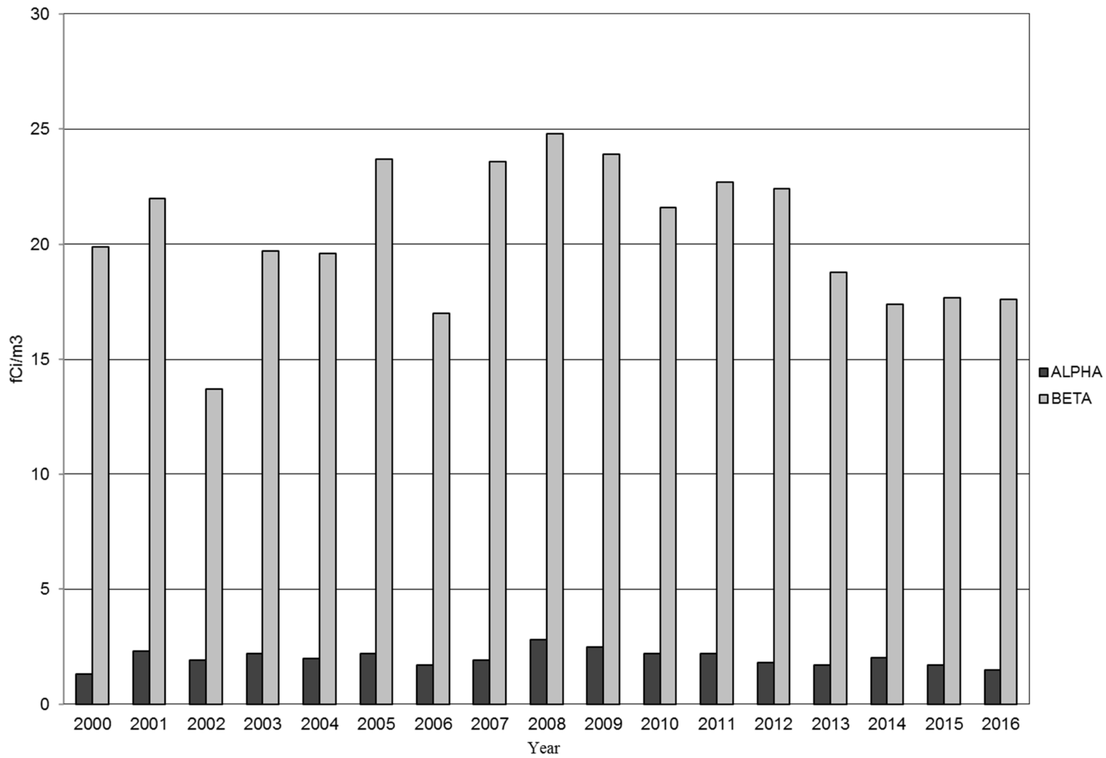


FIGURE 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples, 2000 to 2016

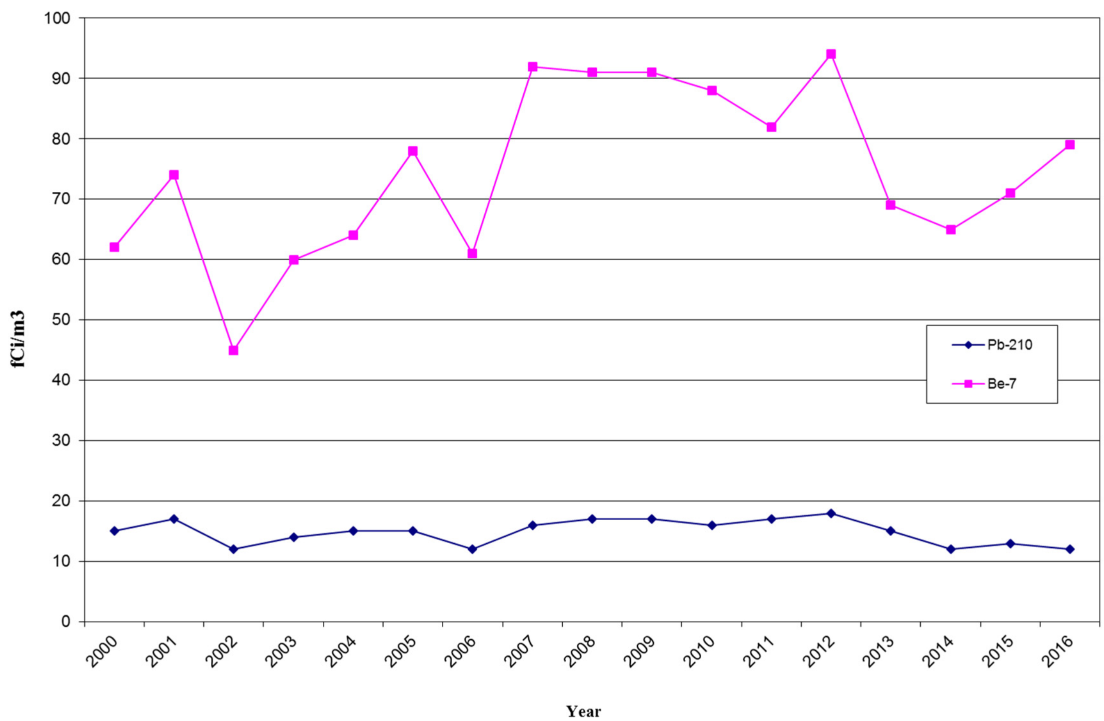


FIGURE 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples, 2000 to 2016

TABLE 4.3

Summary of Airborne Radioactive Emissions from Argonne Facilities, 2016

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	30	1.1×10^{12}
203 (CARIBU)	Xenon-138	14 min	0.1	3.7×10^{9}
211 (LINAC)	Hydrogen-3	12.3 yr	3.5×10^{-7}	1.3×10^{4}
	Beryllium-7	53 day	6.2×10^{-6}	2.3×10^{5}
	Carbon-11	20 min	0.2	7.4×10^{9}
	Nitrogen-13	10 min	19.3	7.1×10^{11}
	Oxygen-15	122 s	6.5	2.4×10^{11}
	Nitrogen-16	7 s	4.6×10^{-3}	1.7×10^{8}
	Chlorine-38	37 min	2.5×10^{-3}	9.3×10^{7}
	Chlorine-39	56 min	1.1×10^{-2}	4.1×10^{8}
	Krypton-85	10.8 yr	8.8×10^{-5}	3.3×10^{6}
	Molybdenum-99	66 hr	2.0×10^{-4}	7.4×10^{6}
	Technetium-99m	6.0 hr	2.0×10^{-4}	7.4×10^{6}
212 (AGHCF and DL114)	Hydrogen-3	12.3 yr	2.1×10^{-3}	7.8×10^{7}
	Strontium-90	28.8 yr	2.0×10^{-10}	7.4
	Antimony-125	2.7 yr	7.7×10^{-7}	2.8×10^{4}
	Iodine-129	1.6×10^{7} yr	2.3×10^{-7}	8.5×10^{3}
	Iodine-131	8.0 day	2.7×10^{-9}	1.0×10^{2}
	Americium-241	432.7 yr	1.7×10^{-11}	6.3×10^{-1}
366 (AWA)	Hydrogen-3	12.3 yr	3.8×10^{-9}	1.4×10^{2}
	Beryllium-7	53 day	6.9×10^{-8}	2.5×10^{3}
	Carbon-11	20 min	2.3×10^{-3}	8.5×10^{7}
	Nitrogen-13	10 min	1.9×10^{-1}	7.0×10^{9}
	Oxygen-15	122 s	5.2×10^{-2}	1.9×10^{9}
	Chlorine-38	37 min	2.6×10^{-5}	9.6×10^{5}
	Chlorine-39	56 min	1.2×10^{-4}	4.4×10^{6}
411/415 (APS)	Carbon-11	20 min	0.6	2.2×10^{10}
	Nitrogen-13	10 min	27.8	1.0×10^{12}
	Oxygen-15	122 s	3.0	1.1×10^{11}

Quarterly monitoring is conducted at the 13 wells that are within the phytoremediation plantation. The average hydrogen-3 concentration for 2016 for all the wells was 165 pCi/L. The estimated annual amount of hydrogen-3 released is then the product of the annual volume of water released for 800 trees multiplied by the hydrogen-3 concentration in the groundwater. For 2016, the estimated total hydrogen-3 released was approximately 0.003 Ci. Applying the CAP-88 code,[9] an estimate of the annual dose to the maximally exposed individual was approximately 0.00000002 mrem. This estimated dose is extremely small compared with the 10-mrem annual dose limit of NESHAP.

4.3. Surface Water

All water samples collected in the radiological monitoring program were filtered immediately after collection and acidified with 0.1N nitric acid, except for the hydrogen-3 samples. Total nonvolatile alpha and beta activities were determined by counting the residue remaining after evaporation of the water and then applying weight-dependent counting efficiency corrections determined for plutonium-239 (for alpha activity) and thallium-204 (for beta activity) to obtain disintegration rates. Hydrogen-3 was measured from a separate aliquot. This activity does not appear in the results for total nonvolatile beta activity. Analyses for the radionuclides were performed by specific radiochemical separations followed by appropriate counting. One-liter aliquots were used for all analyses except for hydrogen-3 and the transuranium nuclides. Hydrogen-3 analyses were performed by liquid scintillation counting of 9 mL (0.3 oz) of a distilled sample in a nonhazardous cocktail. Analyses for transuranium nuclides were performed on 10-L (3-gal) samples with chemical separation methods followed by alpha spectrometry. Plutonium-236 was used to determine the yields of plutonium and neptunium, which were separated from the sample together. A group separation of a fraction containing the transplutonium elements was monitored for recovery with an americium-243 tracer. Isotopic uranium concentrations were determined by alpha spectrometry by using uranium-232 as an isotopic tracer.

Wastewater from buildings or facilities that use or process radioactive materials is collected in retention tanks. When a tank is full, it is sampled and analyzed for alpha and beta radioactivity. If the radioactivity exceeds the release limits, the tank is processed as radioactive waste. The release limits are based on the DCSs for plutonium-239 (0.03 pCi/mL) for alpha activity and for strontium-90 (1.0 pCi/mL) for beta activity. These radionuclides were selected because of their potential for release and their conservative allowable limits in the environment. If the radioactivity is below the release limits, the wastewater is conveyed to the LWTP in dedicated pipes. The effluent monitoring program documents that no liquid releases above the DCSs have occurred and reinforces demonstration of compliance with the use of the best available technology (BAT) as required by DOE Order 458.1.[5]

Another component of the radiological effluent monitoring program is the radiological analysis of the main wastewater treatment plant discharge (Outfall 001). Metals have also been analyzed at this location for many years. The same radiological constituents that are determined in Sawmill Creek are also analyzed at this location. Samples are collected daily and then equal daily portions are combined to produce a weekly composite that is analyzed to obtain an average weekly concentration. Table 4.4 gives the radiological results for 2016. Analysis of the Argonne domestic water, which is obtained from Lake Michigan, indicates the presence of strontium-90 at about 0.3 pCi/L, thus the strontium-90 found in these samples appears to be present in the domestic water and was not introduced by Argonne. In any case, the radionuclide concentrations are well below the DOE limits. These findings confirmed Argonne compliance with DOE Order 458.1 for use of BAT for releases of liquid effluents. To estimate the total annual quantity of each radionuclide released to the environment, the product of the annual average concentration and the annual volume of water discharged (9.97×10^8 L) is computed. These results are given in Table 4.5.

TABLE 4.4

Radionuclides in Effluents from the Argonne Wastewater Treatment Plant, 2016

Activity	No. of Samples	Concentrations in pCi/L Avg.	Min.	Max.	Dose (mrem) Avg	Min.	Max.
Alpha	52	0.70	< 0.10	2.17	-[a]	-	-
Beta	52	11.88	7.11	17.24	-	-	-
Hydrogen-3	52	< 100	< 100	203	< 0.0053	< 0.0053	0.0108
Strontium-90	52	0.25	0.14	0.58	0.023	0.013	0.053
Cesium-137	52	< 2.0	< 2.0	< 2.0	< 0.066	< 0.066	< 0.066
Uranium-234	52	0.38	0.19	0.75	0.056	0.028	0.110
Uranium-238	52	0.33	0.16	0.68	0.045	0.022	0.092
Neptunium-237	52	< 0.0010	< 0.0010	0.0028	< 0.0003	< 0.0003	0.0008
Plutonium-238	52	< 0.0010	< 0.0010	0.0108	< 0.0007	< 0.0007	0.0076
Plutonium-239	52	< 0.0010	< 0.0010	0.0021	< 0.0007	< 0.0007	0.0015
Americium-241	52	< 0.0010	< 0.0010	0.0030	< 0.0006	< 0.0006	0.0018
Curium-242 and/or Californium-252	52	< 0.0010	< 0.0010	< 0.0010	< 0.0001	< 0.0001	< 0.0001
Curium-244 and/or Californium-249	52	< 0.0010	< 0.0010	< 0.0010	< 0.0004	< 0.0004	< 0.0004

[a] A hyphen indicates no CEDEs for alpha and beta.

Treated Argonne wastewater is discharged into Sawmill Creek (Location 7M in Figure 1.1). The creek runs through the Argonne grounds, drains surface water from much of the site, and flows into the Des Plaines River about 500 m (1,600 ft) downstream from the Argonne wastewater outfall. Sawmill Creek was sampled upstream from the Argonne site and downstream from the wastewater discharge point to determine whether radioactivity was added to the stream by Argonne wastewater or surface drainage. The sampling locations are shown in Figure 1.1. Samples were collected several times per day by an automatic sampler below the wastewater outfall. A composite sample was analyzed to obtain an average weekly concentration. Grab samples were collected upstream of the site monthly and analyzed for the same radionuclides measured in the below-outfall samples.

TABLE 4.5

Total Radioactivity Released to Surface Water, 2016

Radionuclide	WTP Outfall (Ci)
Hydrogen-3	0.0707
Strontium-90	0.0002
Uranium-234	0.0005
Uranium-238	0.0005
Other transuranics	<0.0001
Total	0.0720

Table 4.6 gives the annual summaries of the results obtained for Sawmill Creek. Comparison of the results and 95% confidence intervals of the averages for the two sampling locations show that the only radionuclide found in the creek water that can be attributed to Argonne operations is hydrogen-3. The hydrogen-3 concentrations are similar to previous years' results. All annual averages were well below the applicable DOE standards.

TABLE 4.6

Radionuclides in Sawmill Creek Water, 2016

Activity	Location[a]	No. of Samples	Concentrations (pCi/L) Avg.	Concentrations (pCi/L) Min.	Concentrations (pCi/L) Max.	Dose (mrem) Avg.	Dose (mrem) Min.	Dose (mrem) Max.
Alpha	16K	11	1.16	< 0.01	1.63	-[b]	-	-
(Nonvolatile)	7M	49	0.79	< 0.01	1.72	-	-	-
Beta	16K	11	4.55	3.20	7.92	-	-	-
(Nonvolatile)	7M	49	9.32	4.25	15.53	-	-	-
Hydrogen-3	16K	11	< 100	< 100	< 100	< 0.0053	< 0.0053	< 0.0053
	7M	49	< 100	< 100	159	< 0.0053	< 0.0053	0.0084
Strontium-90	16K	11	< 0.25	< 0.25	< 0.25	< 0.023	< 0.023	< 0.023
	7M	49	< 0.25	< 0.25	0.32	< 0.023	< 0.023	0.029
Cesium-137	16K	11	< 2.0	< 2.0	< 2.0	< 0.066	< 0.066	< 0.066
	7M	49	< 2.0	< 2.0	< 2.0	< 0.066	< 0.066	< 0.066
Uranium-234	16K	11	0.636	0.287	1.046	0.094	0.043	0.154
	7M	49	0.446	0.165	0.837	0.066	0.025	0.123
Uranium-238	16K	11	0.572	0.246	0.948	0.077	0.034	0.128
	7M	49	0.393	0.139	0.774	0.053	0.019	0.104
Neptunium-237	16K	11	< 0.0010	< 0.0010	0.0011	< 0.0003	< 0.0003	0.0003
	7M	49	< 0.0010	< 0.0010	0.0030	< 0.0003	< 0.0003	0.0009
Plutonium-238	16K	11	0.0013	< 0.0010	0.0067	0.0009	< 0.0007	0.0047
	7M	49	< 0.0010	< 0.0010	0.0056	< 0.0007	< 0.0007	0.0039
Plutonium-239	16K	11	< 0.0010	< 0.0010	0.0014	< 0.0007	< 0.0007	0.0010
	7M	49	< 0.0010	< 0.0010	0.0024	< 0.0007	< 0.0007	0.0017
Americium-241	16K	11	< 0.0010	< 0.0010	< 0.0010	< 0.0006	< 0.0006	< 0.0006
	7M	49	< 0.0010	< 0.0010	0.0015	< 0.0006	< 0.0006	0.0009
Curium-242 and/or	16K	11	< 0.0010	< 0.0010	< 0.0010	< 0.0001	< 0.0001	< 0.0001
Californium-252	7M	49	< 0.0010	< 0.0010	0.0018	< 0.0001	< 0.0001	0.0002
Curium-244 and/or	16K	11	< 0.0010	< 0.0010	0.0010	< 0.0004	< 0.0004	0.0004
Californium-249	7M	49	< 0.0010	< 0.0010	< 0.0010	< 0.0004	< 0.0004	< 0.0004

[a] Location 16K is upstream from the Argonne site, and location 7M is downstream from the Argonne wastewater outfall.

[b] A hyphen indicates no CEDEs for alpha and beta.

On the basis of the results of an earlier stormwater characterization study, two perimeter surface water locations that contained measurable levels of radionuclides were identified. They were south of the 319 Area, Location 7J (317/#111), and south of the 800 Area Landfill, Location 11D (NPD/#113). The sampling locations are shown in Figure 1.1. Samples were scheduled to be collected quarterly and analyzed for hydrogen-3, strontium-90, and gamma-ray emitters at Location 7J and hydrogen-3 at Location 11D. The results are presented in Table 4.7.

TABLE 4.7

Radionuclides in Stormwater Outfalls, 2016
(concentrations in pCi/L)

	Location 7J			Location 11D
Date Collected	Hydrogen-3	Strontium-90	Cesium-137	Hydrogen-3
February 2	< 100	< 0.25	< 0.1	< 100
May 10	163	< 0.25	1.8	< 100
September 30	DRY	DRY	DRY	DRY
December 31	DRY	DRY	DRY	DRY

The source of the strontium-90 at Location 7J appears to be past releases of leachate from the 319 Area Landfill. A subsurface barrier wall and leachate collection system were constructed south of the 319 Landfill in November 1995 and became operational in 1996. The final cap was installed in 1999. Since the construction and operation of the leachate collection system and cap, radionuclide concentrations in surface water at Location 7J have decreased substantially.

One of the Argonne waste management locations is within the fenced 398A radioactive waste storage area (Location 8J in Figure 1.1). Surface water drainage from this area is collected in a small pond at the south (downhill) end of the 398A Area. To evaluate whether any radionuclides are being transported by stormwater flow through the 398A Area, quarterly sampling is conducted from the 398A Area pond and analyzed for hydrogen-3 and gamma-ray-emitting radionuclides. All hydrogen-3 results were below the detection limit of 100 pCi/L and gamma-ray spectrometric analysis detected no radionuclides associated with Argonne activities above the detection limit of 2 pCi/L.

Because Sawmill Creek empties into the Des Plaines River, data about the radioactivity in this river is important in assessing the contribution of Argonne wastewater to environmental radioactivity. The Des Plaines River was sampled twice per month downstream and once per month upstream of the mouth of Sawmill Creek to determine whether the radioactivity in the creek had any effect on the radioactivity in the river. Table 4.8 gives the annual summaries of the results obtained for these two locations. The average nonvolatile alpha, beta, and uranium concentrations in the river were very similar to past averages and remained in the normal range. Average results were similar above and below the creek for all radionuclides, indicating that a measureable amount of radiation was not released.

TABLE 4.8

Radionuclides in Des Plaines River Water, 2016

Activity	Location[a]	No. of Samples	Concentrations (pCi/L) Avg.	Concentrations (pCi/L) Min.	Concentrations (pCi/L) Max.	Dose (mrem) Avg.	Dose (mrem) Min.	Dose (mrem) Max.
Alpha	A	11	1.04	0.54	1.77	-[b]	-	-
(Nonvolatile)	B	21	0.98	0.36	1.99	-	-	-
Beta	A	11	7.52	5.18	12.65	-	-	-
(Nonvolatile)	B	21	8.15	4.95	12.74	-	-	-
Hydrogen-3	A	11	< 100	< 100	< 100	< 0.0053	< 0.0053	< 0.0053
	B	21	< 100	< 100	< 100	< 0.0053	< 0.0053	0.0054
Strontium-90	A	11	< 0.25	< 0.25	< 0.25	< 0.023	< 0.023	< 0.023
	B	21	< 0.25	< 0.25	< 0.25	< 0.023	< 0.023	< 0.023
Uranium-234	A	11	0.563	0.306	0.745	0.083	0.045	0.110
	B	21	0.491	0.237	0.844	0.073	0.035	0.125
Uranium-238	A	11	0.481	0.200	0.677	0.064	0.027	0.091
	B	21	0.424	0.185	0.752	0.057	0.025	0.101
Neptunium-237	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0003	< 0.0003	< 0.0003
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0003	< 0.0003	< 0.0003
Plutonium-238	A	11	< 0.0010	< 0.0010	0.0020	< 0.0007	< 0.0007	0.0014
	B	11	< 0.0010	< 0.0010	0.0011	< 0.0007	< 0.0007	0.0008
Plutonium-239	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Americium-241	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0006	< 0.0006	< 0.0006
	B	11	< 0.0010	< 0.0010	0.0012	< 0.0006	< 0.0006	0.0007
Curium-242 and/or	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0001	< 0.0001	< 0.0001
Californium-252	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0001	< 0.0001	< 0.0001
Curium-244 and/or	A	11	< 0.0010	< 0.0010	< 0.0010	< 0.0004	< 0.0004	< 0.0004
Californium-249	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0004	< 0.0004	< 0.0004

[a] Location A, near Willow Springs, is upstream; location B, near Lemont, is downstream from the mouth of Sawmill Creek. See Figure 1.2.

[b] A hyphen indicates no CEDEs for alpha and beta.

4.4. Bottom Sediment

The radioactive content of bottom sediment was measured in Sawmill Creek. A set of sediment samples was collected on July 28, 2016, from the Sawmill Creek bed, above the outfall point where Argonne discharges its treated wastewater (Location 7M in Figure 1.1), at the outfall, and at several locations below the outfall. In addition, a sediment sample was collected at location 16K, upgradient of the entire site. A grab sample technique was used to obtain bottom sediments. After the drying and grinding, the samples were analyzed by the methods described in prior reports[11] for air filter residues. The plutonium and americium were separated from the same 10-g (0.35-oz) aliquot of sediment. Results are given in terms of the oven-dried (110°C [230°F]) weight.

The results, as listed in Table 4.9, show that the concentrations in the samples collected above the outfall at Location 7M are similar to those of the off-site samples collected in past years.[11] The plutonium and americium concentrations are elevated below the outfall, which indicates that their origin may have been past discharges of Argonne wastewater.

4.5. External Penetrating Gamma Radiation

Levels of external penetrating gamma radiation at and near the Argonne site were measured with Optically Stimulated Luminescence Dosimeters (OSL) provided and read by a commercial vendor. Dosimeters were exposed at 17 locations at the site boundary and on several interior locations. Readings were also taken at five off-site locations (Figure 1.2) for comparative purposes.

The results are summarized in Tables 4.10 and 4.11, and the site boundary and on-site readings are shown in Figure 4.3. Measurements were taken during the four successive exposure periods shown in the tables, and the results were calculated in terms of annual dose for ease in comparing measurements made for different elapsed times. The uncertainty of the averages given in the tables is the 95% confidence limit calculated from the standard deviation of the average.

The off-site results averaged 54 ± 7 mrem/yr and was the same as last year's off-site average of 57 ± 9 mrem/yr.[12] Prior to 2012, gross dose measurements had been reported, whereas, net dose measurements began being reported in 2012. Therefore, reported historical results, prior to 2012, are higher. To compare boundary results for individual sampling periods, the standard deviation of the individual off-site results is useful. This value is 9 mrem/yr; thus, individual results in the range of 57 ± 18 mrem/yr may be considered to be the average natural background with a 95% probability. Only one off-site location, Orland Park, in the fourth quarter had radiation levels above this range of natural background.

TABLE 4.9

Radionuclides in Bottom Sediment, 2016

	Concentration (pCi/g)					Concentration (fCi/g)		
Location	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241
Sawmill Creek at 16K	13.10 ± 0.46	< 0.01	1.11 ± 0.05	0.80 ± 0.03	0.81 ± 0.07	0.45 ± 0.44	1.44 ± 0.79	0.18 ± 0.35
Sawmill Creek 25 m above outfall	16.07 ± 0.68	0.03 ± 0.02	0.70 ± 0.05	0.49 ± 0.03	0.45 ± 0.07	0.54 ± 0.62	1.53 ± 0.97	0.50 ± 0.35
Sawmill Creek at outfall	13.88 ± 0.63	0.03 ± 0.02	0.65 ± 0.05	0.42 ± 0.03	0.43 ± 0.07	0.45 ± 0.44	1.85 ± 0.79	0.36 ± 0.35
Sawmill Creek 50 m below outfall	9.45 ± 0.39	< 0.01	0.42 ± 0.03	0.34 ± 0.02	0.29 ± 0.05	1.04 ± 0.62	8.42 ± 1.85	1.89 ± 0.71
Sawmill Creek 100 m below outfall	7.16 ± 0.40	0.02 ± 0.01	0.47 ± 0.04	0.33 ± 0.02	0.28 ± 0.05	0.45 ± 0.53	3.83 ± 1.32	0.86 ± 0.44
Sawmill Creek at Des Plaines River	15.04 ± 0.49	0.12 ± 0.02	0.94 ± 0.05	0.85 ± 0.03	0.77 ± 0.07	0.72 ± 0.53	11.84 ± 2.29	3.69 ± 1.32

TABLE 4.10

Environmental Penetrating Radiation at Off-Site Locations, 2016

	Dose Rate (mrem/year) Period of Measurement				
Location	Jan 8–April 8	April 8–July 15	July 15–Oct 17	Oct 17–Jan 26	Average
Lemont	51	56	57	51	54 ± 4
Oak Brook	42	50	53	46	48 ± 5
Orland Park	66	68	54	80	67 ± 11
Woodridge	53	49	53	50	52 ± 2
Palos Park	45	LOST	54	53	51 ± 6
Average	51 ± 10	56 ± 9	54 ± 2	57 ± 13	54 ± 7

TABLE 4.11

Environmental Penetrating Radiation at Argonne, 2016

	Dose Rate (mrem/year) Period of Measurement				
Location[a]	Jan 8–April 8	April 8–July 15	July 15–Oct 17	Oct 17–Jan 26	Average
10G – Guesthouse	59	49	50	51	52 ± 5
12N – Boundary	57	63	61	65	61 ± 4
14E – Boundary	52	65	42	44	51 ± 11
14G – Boundary	49	60	64	68	60 ± 8
14I – Boundary	56	60	55	54	56 ± 2
14L – Boundary	51	54	53	64	55 ± 6
7I – Inside 317	31	37	31	38	34 ±4
7I – Boundary	48	70	57	64	59 ± 9
8D – Boundary	34	32	34	37	34 ± 2
8H – Boundary	54	65	64	LOST	61 ± 6
8L – Boundary	64	66	63	62	64 ± 2
9H/I – 50 m E of Building 306	118	178	252	480	257 ± 158
9/10 I – SE of Building 331	40078	28244	29053	27904	31320 ± 5859
9I – NE of Building 350	47	58	57	64	56 ±7
9J – SW of 398A Area	156	138	144	143	145 ± 8
9/10 – EF Boundary	68	70	61	65	66 ± 4
10/11 K – Lodging Facilities	45	49	42	49	46 ± 4

[a] See Figure 1.1.

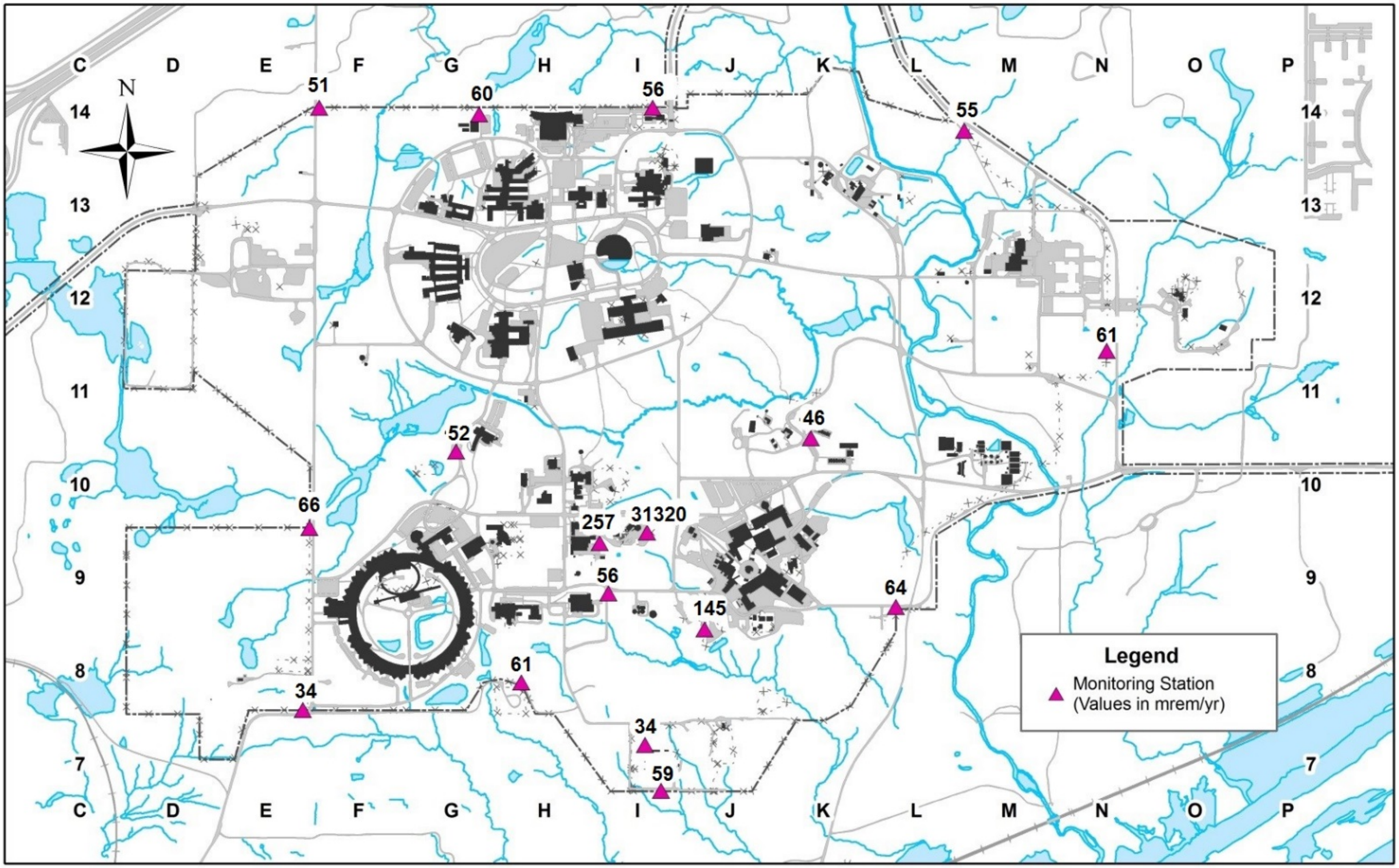


FIGURE 4.3 Penetrating Radiation Measurements at the Argonne Site, 2016

Three on-site monitoring locations indicated annual dose rates that were elevated when compared to the other Argonne site radiation monitoring locations. These three environmental radiation monitors are placed in close proximity to facilities where radioactive waste materials are stored or staged for shipping offsite. The highest of these was monitoring location 9/10 I located at the fence of the Bldg 331 storage yard approximately 25 meters southeast of the Building 331 and Building 331 yard where radioactive waste material is stored. The monitoring location 9H/I is approximately 50 meters east of Building 306. The dose rates at this location are attributed to radioactive waste storage, transfer, and packaging activities conducted within Building 306. The monitoring location 9J is southwest and adjacent to the 398A Area which is a fenced yard where radioactive material bins and containers are stored.

4.6. Compliance with DOE Orders 435.1 and 458.1

DOE Order 435.1, "Radioactive Waste Management," requires that an environmental monitoring and surveillance program be conducted to determine any releases or migration from low-level radioactive waste treatment, storage, or disposal sites. Compliance with these requirements is an integral part of the Argonne site-wide monitoring and surveillance program. Waste management operations are monitored by the perimeter air monitoring network and monitoring of the liquid effluent streams and Sawmill Creek.

During 2016, Argonne did not release any property containing residual radioactive material for recycle or reuse. All property that contained residual radioactivity, based on the criteria in DOE Order 458.1, was disposed of in an off-site low-level radioactive disposal facility.

4.7. Estimates of Potential Radiation Doses

Calculations were performed for three exposure pathways—airborne, water, and direct radiation from external sources. The biota dose was also assessed.

4.7.1. Airborne Pathway

DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,[13] which requires the use of the EPA's CAP-88 code[9] to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2016 for the air pathway is a 10-mrem/yr effective dose equivalent. The CAP-88 computer code uses a modified Gaussian plume equation to estimate both horizontal and vertical dispersion of radionuclides released to the air from stacks or area sources. For 2016, doses were calculated for various radionuclides. The radionuclides and the annual releases are those listed in Table 4.3. Separate calculations were performed for each release point. Doses were calculated for an area extending out to 80 km (50 mi) from Argonne. The population distribution of the 16 compass segments and 10 distance increments given in Table 1.1 was used.

The dose rate was calculated at the midpoint of each interval and integrated over the entire area to give the annual population cumulative dose.

Distances from the specific facilities that exhaust radiological airborne emissions (Table 4.3) to the fence line (perimeter) and nearest resident were determined in the 16 compass segments. Calculations also were performed to evaluate the major airborne pathways—ingestion, inhalation, immersion, and ground surface—both at the point of maximum perimeter exposure and to the maximally exposed resident. The perimeter and resident doses and the maximum doses are listed, respectively, for releases from Building 200 (Tables 4.12 and 4.13), Building 203 (CARIBU) (Tables 4.14 and 4.15), Building 211 (LINAC) (Tables 4.16 and 4.17), Building 212 (AGHCF, IML and DL-114) (Tables 4.18 and 4.19), Building 366 (AWA) (Tables 4.20 and 4.21), and Building 411/415 (APS) (Tables 4.22 and 4.23). The doses given in these tables are the committed whole body effective dose equivalents.

The doses from each of the CAP-88 dose assessments were combined based on the assumption that the former IPNS facility is the central emission point for the site. The 16 compass directions from the former IPNS facility were established for each perimeter and actual resident location. The individual building assessments were then overlaid on the IPNS grid, and the estimated dose was summed according to which values fell within the IPNS segments. This approach provides an estimated dose to an actual individual and is not just the sum of the maximum doses from the individual building runs.

The highest perimeter dose was in the northwest direction, with a maximum value of 0.015 mrem/yr (Location 7E in Figure 1.1). Essentially, all of this dose can be attributed to operation of the LINAC accelerator in Building 211, the Advanced Photon Source, and assumed residual activity from M-wing in Building 200. The maximum perimeter dose is significantly reduced from earlier years due to the termination of the operation of the IPNS facility on January 1, 2008. The full-time resident who would receive the largest annual dose (0.005 mrem/yr), if he or she were outdoors during the entire year, is located approximately 1.0 km (0.62 mi) north of Building 200 M-wing. The major contributor to the lung dose is inhalation dose from lead-212 (0.0024 mrem/yr). If radon-220 plus daughters were excluded from the calculation the NESHAP reportable dose to the maximally exposed individual would be 0.003 mrem/yr.

The individual doses to the maximally-exposed members of the public and the maximum fence-line dose are shown in Figure 4.4. Historically, there was a decrease in individual and population doses from 1988 to 1999, due in part, to the decrease of radon-220 emissions as a result of the cleanup of the Building 200 M-Wing hot cells. There was, also, an increase from 1999 to 2004, principally due to increased emissions from the IPNS as a result of increased operating time. The decrease since 2007 was the result of the shutdown of IPNS.

TABLE 4.12

Radiological Airborne Releases from Building 200, 2016

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	500	5.8×10^{-3}	1,000	2.6×10^{-3}
NNE	600	5.3×10^{-3}	1,100	2.4×10^{-3}
NE	750	3.7×10^{-3}	2,600	5.8×10^{-4}
ENE	1,700	1.0×10^{-3}	3,100	3.8×10^{-4}
E	2,400	$<1.0 \times 10^{-12}$	3,500	3.6×10^{-4}
ESE	2,200	6.0×10^{-4}	3,600	2.7×10^{-4}
SE	2,100	6.0×10^{-4}	4,000	2.2×10^{-4}
SSE	2,000	7.9×10^{-4}	4,000	2.7×10^{-4}
S	1,500	7.0×10^{-4}	4,000	1.6×10^{-4}
SSW	1,000	2.3×10^{-3}	2,500	5.6×10^{-4}
SW	800	3.3×10^{-3}	2,200	7.2×10^{-4}
WSW	1,100	1.6×10^{-3}	1,500	1.0×10^{-3}
W	750	3.0×10^{-3}	1,500	1.1×10^{-3}
WNW	800	2.5×10^{-3}	1,300	1.2×10^{-3}
NW	600	3.5×10^{-3}	1,100	1.5×10^{-3}
NNW	600	3.2×10^{-3}	800	2.3×10^{-3}

[a] Source term: see Table 4.3

TABLE 4.13

Maximum Perimeter and Individual Doses from
Building 200 Air Emissions, 2016
(dose in mrem/yr)

Pathway	Perimeter (500 m N)	Individual (1,000 m N)
Ingestion	1.7×10^{-6}	6.6×10^{-7}
Inhalation	5.7×10^{-3}	2.6×10^{-3}
Air immersion	3.2×10^{-6}	8.8×10^{-7}
Ground surface	2.7×10^{-5}	1.1×10^{-5}
Total	5.8×10^{-3}	2.6×10^{-3}
Radionuclide		
Bismuth-212	1.6×10^{-5}	1.7×10^{-5}
Lead-212	5.1×10^{-3}	2.4×10^{-3}
Radon-220	1.6×10^{-6}	1.4×10^{-7}
Others	6.3×10^{-4}	2.3×10^{-4}
Total	5.8×10^{-3}	2.6×10^{-3}

TABLE 4.14

Radiological Airborne Releases from Building 203 (CARIBU), 2016

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	175	2.2×10^{-4}	650	4.2×10^{-5}
NNE	250	1.7×10^{-4}	1,250	1.3×10^{-5}
NE	300	1.1×10^{-4}	2,200	4.4×10^{-6}
ENE	1,200	1.1×10^{-5}	2,650	2.8×10^{-6}
E	1,500	8.4×10^{-6}	2,600	3.3×10^{-6}
ESE	2,000	4.0×10^{-6}	3,100	1.9×10^{-6}
SE	1,800	4.4×10^{-6}	3,700	1.3×10^{-6}
SSE	2,000	4.6×10^{-6}	3,200	2.0×10^{-6}
S	1,700	3.5×10^{-6}	3,600	9.8×10^{-7}
SSW	1,800	5.6×10^{-6}	3,500	1.8×10^{-6}
SW	1,100	1.3×10^{-5}	2,300	3.9×10^{-6}
WSW	1,250	8.0×10^{-6}	1,600	5.4×10^{-6}
W	900	1.5×10^{-5}	1,300	8.4×10^{-6}
WNW	600	2.7×10^{-5}	1,000	1.2×10^{-5}
NW	250	9.8×10^{-5}	750	2.0×10^{-5}
NNW	200	1.1×10^{-4}	650	2.8×10^{-5}

[a] Source terms: see Table 4.3

TABLE 4.15

Maximum Perimeter and Individual Doses from Building 203 (CARIBU) Air Emissions, 2016 (dose in mrem/yr)

Pathway	Perimeter (175 m N)	Individual (650 m N)
Ingestion	–[a]	–
Inhalation	1.8×10^{-7}	1.4×10^{-7}
Air immersion	2.1×10^{-4}	4.1×10^{-5}
Ground surface	3.7×10^{-7}	2.9×10^{-7}
Total	2.2×10^{-4}	4.2×10^{-5}
Radionuclide		
Xenon-138	2.1×10^{-4}	3.6×10^{-5}
Cesium-138	6.7×10^{-6}	5.2×10^{-6}
Total	2.2×10^{-4}	4.2×10^{-5}

[a] A dash indicates no exposure by this pathway.

TABLE 4.16

Radiological Airborne Releases from Building 211 (LINAC), 2016

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	800	4.1×10^{-3}	1,200	1.7×10^{-3}
NNE	1,200	1.8×10^{-3}	1,200	1.8×10^{-3}
NE	1,600	8.9×10^{-4}	2,400	3.5×10^{-4}
ENE	2,200	$<1.0 \times 10^{-12}$	2,800	2.2×10^{-4}
E	2,200	4.7×10^{-4}	3,200	1.9×10^{-4}
ESE	1,700	6.4×10^{-4}	3,200	1.5×10^{-4}
SE	1,800	4.8×10^{-4}	3,400	1.0×10^{-4}
SSE	1,800	5.9×10^{-4}	3,000	1.7×10^{-4}
S	1,300	6.7×10^{-4}	3,000	9.2×10^{-5}
SSW	1,400	1.0×10^{-3}	3,000	1.6×10^{-4}
SW	700	4.8×10^{-3}	1,800	5.6×10^{-4}
WSW	800	2.7×10^{-3}	1,800	4.7×10^{-4}
W	1,200	1.2×10^{-3}	1,400	8.6×10^{-4}
WNW	1,000	1.5×10^{-3}	1,400	7.3×10^{-4}
NW	800	2.5×10^{-3}	1,200	1.0×10^{-3}
NNW	900	2.0×10^{-3}	1,050	1.5×10^{-3}

[a] Source terms: see Table 4.3

TABLE 4.17

Maximum Perimeter and Individual Doses from Building 211 (LINAC) Air Emissions, 2016 (dose in mrem/yr)

Pathway	Perimeter (700 m SW)	Individual (1,200 m NNE)
Ingestion	4.5×10^{-10}	2.1×10^{-10}
Inhalation	1.1×10^{-6}	4.3×10^{-7}
Air immersion	4.8×10^{-3}	1.8×10^{-3}
Ground surface	7.0×10^{-7}	3.2×10^{-7}
Total	4.8×10^{-3}	1.8×10^{-3}
Radionuclide		
Hydrogen-3	9.8×10^{-12}	3.8×10^{-12}
Beryllium-7	1.4×10^{-8}	6.2×10^{-9}
Carbon-11	5.6×10^{-5}	2.2×10^{-5}
Nitrogen-13	4.2×10^{-3}	1.6×10^{-3}
Nitrogen-16	2.9×10^{-13}	7.3×10^{-15}
Oxygen-15	5.5×10^{-4}	1.9×10^{-4}
Chlorine-38	1.2×10^{-6}	4.8×10^{-7}
Chlorine-39	5.4×10^{-6}	2.2×10^{-6}
Krypton-85	1.4×10^{-10}	5.3×10^{-11}
Molybdenum-99	2.4×10^{-7}	1.0×10^{-7}
Technetium-99m	6.0×10^{-8}	2.7×10^{-8}
Total	4.8×10^{-3}	1.8×10^{-3}

TABLE 4.18

Radiological Airborne Releases from Building 212
(AGHCF, IML, and DL-114), 2016

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	800	9.1×10^{-7}	2,000	2.0×10^{-7}
NNE	1,000	7.1×10^{-7}	2,500	1.5×10^{-7}
NE	1,300	4.1×10^{-7}	2,000	2.0×10^{-7}
ENE	1,500	2.9×10^{-7}	2,500	1.2×10^{-7}
E	1,600	3.1×10^{-7}	2,800	1.2×10^{-7}
ESE	1,200	3.9×10^{-7}	2,500	1.1×10^{-7}
SE	1,400	2.7×10^{-7}	3,500	5.5×10^{-8}
SSE	1,400	3.2×10^{-7}	4,500	4.5×10^{-8}
S	1,500	1.5×10^{-7}	5,000	1.9×10^{-8}
SSW	1,600	2.5×10^{-7}	5,000	3.5×10^{-8}
SW	1,400	3.2×10^{-7}	2,400	1.3×10^{-7}
WSW	1,300	3.0×10^{-7}	2,300	1.1×10^{-7}
W	1,700	2.0×10^{-7}	2,200	1.3×10^{-7}
WNW	1,500	2.1×10^{-7}	2,000	1.3×10^{-7}
NW	1,300	2.7×10^{-7}	2,000	1.3×10^{-7}
NNW	1,000	4.2×10^{-7}	2,000	1.3×10^{-7}

[a] Source terms: see Table 4.3

TABLE 4.19

Maximum Perimeter and Individual Doses from
Building 212 (AGHCF, IML, and DL-114) Air
Emissions, 2016 (dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,000 m N)
Ingestion	3.3×10^{-7}	7.0×10^{-8}
Inhalation	3.1×10^{-8}	7.7×10^{-7}
Air immersion	5.5×10^{-11}	1.4×10^{-11}
Ground surface	5.5×10^{-7}	1.3×10^{-7}
Total	9.1×10^{-7}	2.0×10^{-7}
Radionuclide		
Hydrogen-3	3.4×10^{-8}	8.7×10^{-9}
Strontium-90	2.1×10^{-11}	5.9×10^{-12}
Antimony-125	1.7×10^{-7}	4.9×10^{-8}
Iodine-129	7.0×10^{-7}	1.5×10^{-7}
Iodine-131	1.1×10^{-10}	2.2×10^{-11}
Americium-241	4.3×10^{-10}	1.1×10^{-10}
Total	9.1×10^{-7}	2.0×10^{-7}

TABLE 4.20

Radiological Airborne Releases from Building 366 (AWA), 2016

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,600	8.3×10^{-6}	3,200	1.6×10^{-6}
NNE	1,600	9.3×10^{-6}	3,100	2.1×10^{-6}
NE	1,600	8.2×10^{-6}	2,700	2.6×10^{-6}
ENE	1,500	8.5×10^{-6}	2,500	2.8×10^{-6}
E	600	6.1×10^{-5}	2,400	3.7×10^{-6}
ESE	600	4.9×10^{-5}	2,500	2.6×10^{-6}
SE	600	4.1×10^{-5}	2,500	2.1×10^{-6}
SSE	600	4.9×10^{-5}	3,000	1.7×10^{-6}
S	800	1.5×10^{-5}	3,000	8.7×10^{-7}
SSW	800	2.7×10^{-5}	3,500	1.0×10^{-6}
SW	800	2.8×10^{-5}	4,000	6.9×10^{-7}
WSW	1,500	6.6×10^{-6}	2,700	1.7×10^{-6}
W	2,100	3.2×10^{-6}	2,700	1.8×10^{-6}
WNW	1,500	5.8×10^{-6}	2,600	1.6×10^{-6}
NW	2,200	2.4×10^{-6}	2,500	1.8×10^{-6}
NNW	1,800	4.1×10^{-6}	2,200	2.6×10^{-6}

[a] Source terms: see Table 4.3

TABLE 4.21

Maximum Perimeter and Individual Doses from Building 366 (AWA) Air Emissions, 2016 (dose in mrem/yr)

Pathway	Perimeter (600 m E)	Individual (2,400 m E)
Ingestion	8.3×10^{-13}	1.1×10^{-13}
Inhalation	1.1×10^{-8}	1.0×10^{-9}
Air immersion	6.1×10^{-5}	3.7×10^{-6}
Ground surface	7.1×10^{-9}	8.6×10^{-10}
Total	6.1×10^{-5}	3.7×10^{-6}
Radionuclide		
Hydrogen-3	1.1×10^{-13}	1.2×10^{-14}
Beryllium-7	1.7×10^{-10}	2.2×10^{-11}
Carbon-11	6.8×10^{-7}	5.7×10^{-8}
Nitrogen-13	5.2×10^{-5}	3.5×10^{-6}
Oxygen-15	8.4×10^{-6}	1.2×10^{-7}
Chlorine-38	1.5×10^{-8}	1.3×10^{-9}
Chlorine-39	6.7×10^{-8}	6.4×10^{-9}
Total	6.1×10^{-5}	3.7×10^{-6}

TABLE 4.22

Radiological Airborne Releases from Building 411/415 (APS), 2016

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,500	1.3×10^{-3}	2,000	7.1×10^{-4}
NNE	1,600	1.3×10^{-3}	2,100	7.2×10^{-4}
NE	2,200	5.8×10^{-4}	3,100	2.6×10^{-4}
ENE	2,500	4.0×10^{-4}	3,300	2.1×10^{-4}
E	1,600	1.2×10^{-3}	3,400	2.4×10^{-4}
ESE	1,500	1.1×10^{-3}	3,500	1.7×10^{-4}
SE	400	8.8×10^{-3}	3,000	2.0×10^{-4}
SSE	400	1.0×10^{-2}	3,000	2.4×10^{-4}
S	350	5.0×10^{-3}	2,500	1.9×10^{-4}
SSW	400	8.9×10^{-3}	2,800	2.6×10^{-4}
SW	550	6.6×10^{-3}	3,000	2.1×10^{-4}
WSW	800	3.1×10^{-3}	1,400	1.0×10^{-3}
W	800	3.2×10^{-3}	1,500	9.4×10^{-4}
WNW	500	5.8×10^{-3}	1,400	9.3×10^{-4}
NW	350	9.2×10^{-3}	1,600	7.0×10^{-4}
NNW	1,500	8.2×10^{-4}	2,000	4.5×10^{-4}

[a] Source terms: see Table 4.3

TABLE 4.23

Maximum Perimeter and Individual Doses from Building 411/415 (APS) Air Emissions, 2016 (dose in mrem/yr)

Pathway	Perimeter (400 m SSE)	Individual (1,400 m WSW)
Ingestion	–[a]	–
Inhalation	1.7×10^{-6}	2.1×10^{-7}
Air immersion	1.1×10^{-2}	1.1×10^{-3}
Ground surface	–	–
Total	1.0×10^{-2}	1.0×10^{-3}
Radionuclide		
Carbon-11	2.2×10^{-4}	2.6×10^{-5}
Nitrogen-13	9.6×10^{-3}	1.0×10^{-3}
Oxygen-15	6.6×10^{-4}	2.5×10^{-5}
Total	1.0×10^{-2}	1.0×10^{-3}

[a] A dash indicates no exposure by this pathway.

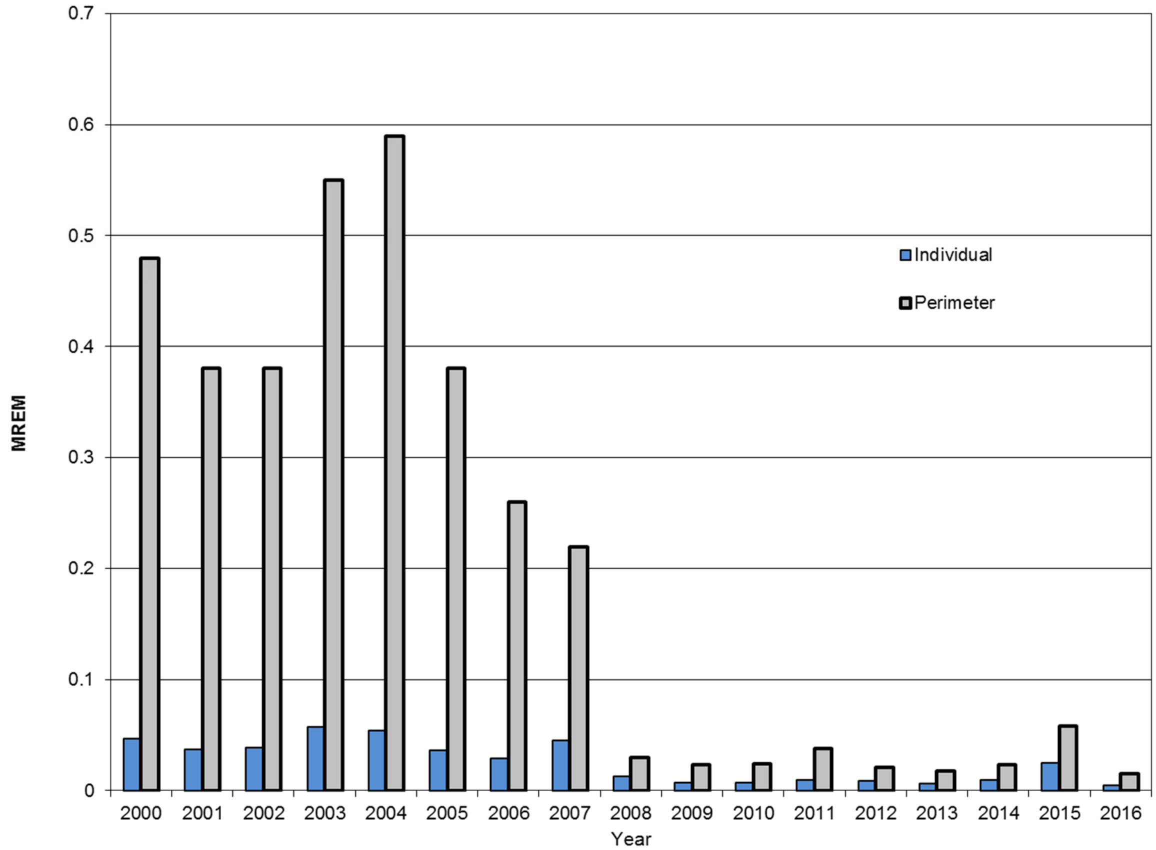


FIGURE 4.4 Individual and Perimeter Doses from Airborne Radioactive Emissions

The population data in Table 1.1 were used to calculate the cumulative population dose from airborne radioactive effluents from Argonne operations. The results are given in Table 4.24, along with the natural external radiation dose. The natural radiation dose listed is the product of the 80-km (50-mi) population and the natural radiation dose of 311 mrem/yr.[14] It is assumed that this dose is representative of the entire area within an 80-km (50-mi) radius. The population dose resulting from Argonne operations since 2000 is shown in Figure 4.5.

The significant increase in population dose in 2006 and 2007 compared with earlier years is due to a change in the dispersion calculation in Version 3.0 of CAP-88. In the past, Version 1.0 of CAP-88 was used. The change to Version 3.0 involved the replacement of the dispersion section used in Version 1.0 with the methodology from the ICRP.[6,7] Although technically more correct, the effect is to increase the apparent population dose, which is accentuated by a combination of short half-life gases coupled with a large receptor population. This appears to be the case for Argonne. However, the significant decrease in population dose since 2007 is due to the shutdown of the IPNS.

TABLE 4.24

Population Dose within 80 km (50 mi), 2016

Radionuclide	Person-rem
Carbon-11	<0.01
Nitrogen-13	0.02
Oxygen-15	<0.01
Bismuth-212	0.01
Lead-212	0.13
Actinium-227	0.01
Plutonium-239	<0.01
Total	0.18
Natural	2.9×10^6

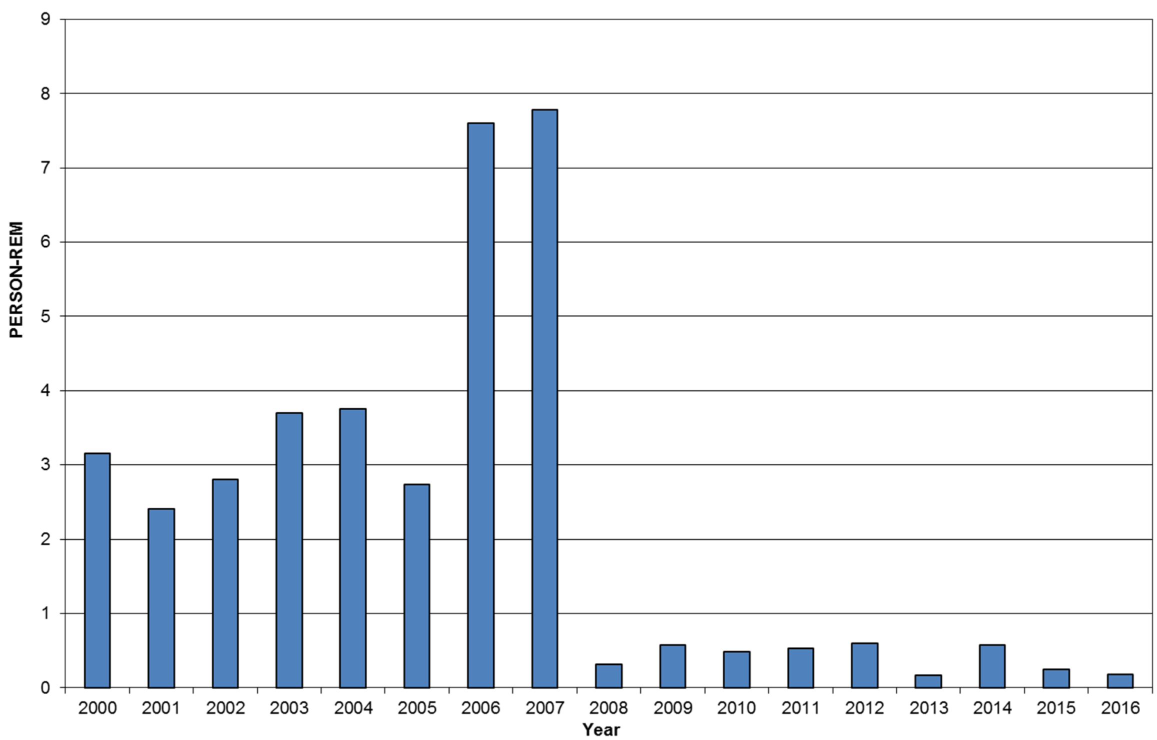


FIGURE 4.5 Population Dose from Airborne Radioactive Emissions

The potential radiation exposures by the inhalation pathway also was calculated by the methodology specified in DOE Order 458.1.[5] The total quantity for each radionuclide inhaled, in microcuries (μCi), is calculated by multiplying the annual average air concentrations by the general public breathing rate of 7,300 m^3/yr.[15] This annual intake is then multiplied by the CEDE conversion factor for the appropriate lung retention class.[5] The CEDE conversion factors are in units of rem/μCi; this calculation gives the 50-year CEDE. Table 4.25 lists the applicable CEDE factors.

4.7.2. Water Pathway

Following the methodology outlined in DOE Order 458.1,[5] the annual intake of radionuclides (in μCi) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter (μCi/mL) by the average annual water consumption of a member of the general public (7.3×10^5 mL)[15]. This annual intake is then multiplied by the CEDE conversion factor for ingestion (Table 4.25) to obtain the dose received in that year. This procedure was carried out for all detected radionuclides and the individual results were summed to obtain the total ingestion dose.

TABLE 4.25

50-Year Committed Effective Dose Equivalent Conversion Factors (rem/μCi)

Nuclide	Ingestion	Inhalation
Hydrogen-3	4.3×10^{-5}	1.8×10^{-4}
Beryllium-7	–[a]	1.5×10^{-4}
Carbon-11	–	4.4×10^{-5}
Strontium-90	0.07	0.14
Cesium-137	0.03	0.015
Lead-210	–	4.0
Radium-226	0.91	–
Thorium-228	–	145
Thorium-230	–	49
Thorium-232	–	86
Uranium-234	0.11	12.5
Uranium-235	0.11	11.4
Uranium-238	0.10	10.5
Neptunium-237	0.25	–
Plutonium-238	0.53	–
Plutonium-239	0.57	169
Americium-241	0.47	–
Curium-242	0.036	–
Curium-244	0.30	–
Californium-249	0.86	–
Californium-252	0.28	–

[a] A dash indicates that a value is not required.

The only significant location where radionuclides attributable to Argonne operations could be found in off-site water was Sawmill Creek below the wastewater outfall (see Table 4.6). Although this water is not used for drinking purposes, the 50-year effective dose equivalent was calculated for a hypothetical individual ingesting water at the radionuclide concentrations measured at that location. The radionuclides added to Sawmill Creek by Argonne wastewater, their net average concentrations in the creek, and the corresponding dose rates (if water at these concentrations was used as the sole water supply by an individual for an entire year) are given in Table 4.26. The dose rates were all well below the standards for the general population. It should be emphasized that Sawmill Creek is not used for drinking, swimming, or boating. Inspection of the area shows that there are fish in the stream; however, they do not constitute a significant source of food for any individual. Figure 4.6 is a plot (2000–2016) showing the estimated dose that a hypothetical individual would receive if ingesting only Sawmill Creek water.

As indicated in Table 4.6, occasional Sawmill Creek samples (fewer than 10%) contained traces of neptunium-237, plutonium-238, plutonium-239, and/or americium-241; however, the averages were only slightly greater than the detection limit. The annual dose to an individual consuming water at these concentrations can be calculated with the same method used for those radionuclides more commonly found in creek water. This method of estimation, however, probably overestimates the true dose. Annual doses range from 5×10^{-5} to 1×10^{-7} mrem/yr for these radionuclides.

Sawmill Creek flows into the Des Plaines River. The flow rate of Sawmill Creek (see Section 1.8) is about 0.28 m^3/s (10 ft^3/s). The flow rate of the Des Plaines River in the vicinity of Argonne is about 25 m^3/s (900 ft^3/s). Applying this ratio to the concentration of radionuclides in Sawmill Creek, as listed in Table 4.26, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.00004 mrem/yr. Significant additional dilution occurs farther downstream. Very few people, either directly or indirectly, use the Des Plaines River as a source of drinking water. If 100 people used Des Plaines River water at the hypothetical concentration at Lemont, the estimated population dose would be about 10^{-5} person-rem.

TABLE 4.26

Radionuclide Concentrations and Dose Estimates for Sawmill Creek Water, 2016

Nuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.07	18.9	<0.001
Strontium-90	0.0002	0.09	0.004
Total	0.07		0.004

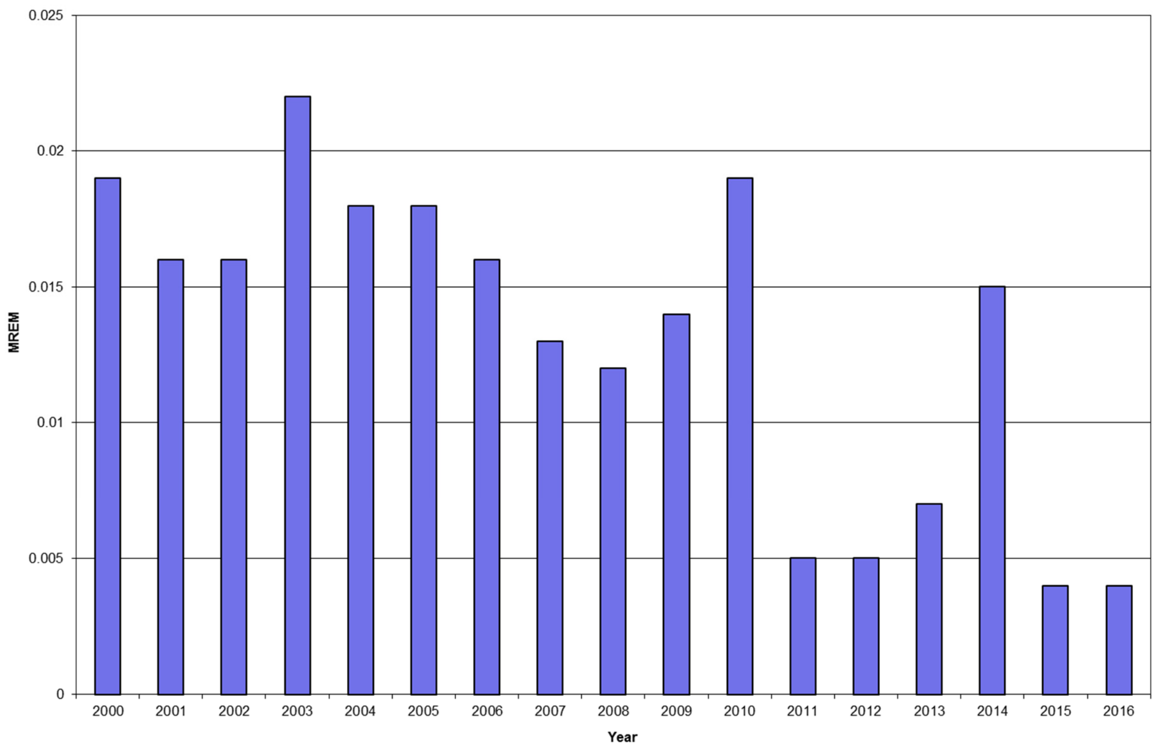


FIGURE 4.6 Comparison of Yearly Dose Estimates from Ingestion of Sawmill Creek Water, 2000–2016

4.7.3. Biota Dose Assessment

DOE Order 458.1[5] requires an evaluation of the dose to aquatic organisms from liquid effluents. The dose limit is 1 rad/day, or 365 rad/yr. The location that could result in the highest dose to aquatic organisms is in Sawmill Creek downstream of the point where Argonne discharges its treated wastewater. Inspection of the creek at this location indicates the presence of small bluegill and carp. The aquatic dose assessment of these species was conducted by using the DOE Technical Standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.[16] The assessment used the general screening approach which compares maximum water and sediment radionuclide concentrations to biota concentration guides (BCGs). Maximum water concentrations for hydrogen-3, strontium-90, neptunium-237, plutonium-238, plutonium-239, and americium-241 were obtained from Table 4.6, while maximum sediment concentrations for plutonium-238, plutonium-239, and americium-241 were obtained from Table 4.9. Summing the ratios of their respective BCGs for each radionuclide resulted in a ratio of 0.0011 to aquatic biota. This is well below a ratio of one and demonstrates compliance with the limit in DOE Order 458.1.

4.7.4. External Direct Radiation Pathway

The TLD measurements given in Section 4.5 were used to calculate the radiation dose from external sources. At Location 7I, the fence-line dose from Argonne was 59 ± 9 mrem/yr. The off-site average dose was 54 ± 7 mrem/yr.

4.7.5. Dose Summary

The total effective dose equivalent received by off-site residents during 2016 was a combination of the individual doses received through the separate pathways. Radionuclides that contributed through the air pathway are listed within Table 4.3. The highest dose from the air pathway was approximately 0.005 mrem/yr to individuals living north of the site if they were outdoors at that location during the entire year. The total annual population dose to the entire area within an 80-km (50-mi) radius was 0.18 person-rem. The dose pathways are presented in Table 4.27 and are compared with the applicable standards.

To receive the hypothetical maximum public dose, an individual would need to live at the point of maximum air and direct radiation exposure and use only water from Sawmill Creek, below the Argonne wastewater discharge. This is a very conservative and unlikely situation. To put the hypothetical maximum individual dose from all pathways of 0.009 mrem/yr attributable to Argonne operations into perspective, comparisons can be made with annual average doses (624 mrem) from natural or accepted sources of radiation received by an average American who could be living anywhere in the United States. These values are listed in Table 4.28. These site-related doses are in addition to the background doses. The magnitude of the doses received from Argonne operations is insignificant compared to these sources. Therefore, the monitoring program results establish that the radioactive emissions from Argonne are very low and do not endanger the health or safety of those living in the vicinity of the site.

TABLE 4.27

Summary of the Estimated Dose to a Hypothetical Individual, 2016 (mrem/yr)

Pathway	Argonne Estimate	Applicable Standard
Air total	0.005	10 (EPA)
Water	0.004	4 (EPA)[a]
Direct radiation	<0.001	25 (NRC)[b]
Maximum dose	0.009	100 (DOE)

[a] The 4-mrem/yr EPA value is not an applicable standard, since it applies to community water systems.[17] It is used here for illustrative purposes.

[b] NRC = U.S. Nuclear Regulatory Commission.

TABLE 4.28

Annual Average Dose Equivalent in the U.S. Population[a]

Source	Dose (mrem)
Natural	
Radon	228
Internal (^{40}K and ^{226}Ra)	29
Cosmic	33
Terrestrial	21
Medical	
Computed Topography	147
Nuclear Medicine	77
Interventional Fluoroscopy	43
Conventional Radiography & Fluoroscopy	33
Consumer	13
Building Materials	
Commercial Air Travel	
Cigarette Smoking	
Mining and Agricultural	
Combustion of Fossil Fuels	
Highway and Road Construction Materials	
Glass and Ceramics	
Industrial	0.3
Nuclear-power Generation	
DOE Installations	
Decommissioning and Radioactive Waste	
Industrial, Medical, Educational, and Research Activities	
Contact with Nuclear-medicine Patients	
Security Inspection Systems	
Occupational	0.5
Medical	
Aviation	
Commercial Nuclear Power	
Industrial and Commercial	
Education and Research	
Government, DOE, and Military	
Total	624

[a] National Council on Radiation Protection & Measurements (NCRP) report No. 160.[14]

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5.1. Introduction

In addition to monitoring for the release of radioactive materials, Argonne monitors to detect release of certain chemicals and changes in environmental conditions. The nonradiological monitoring program involves monitoring of point-source air discharges and the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. This chapter discusses the monitoring of chemicals released to the air and surface water. Argonne's groundwater monitoring program is discussed separately in Chapter 6.

5.2. Air Discharges

Argonne operations and research activities utilize a large number of nonradioactive volatile chemicals, fuels, and combustion products. However, most of these materials are used in small quantities and the potential impact is negligible, should a release to the environment occur. Because of the nature and quantity of these air emissions, Argonne is not required to monitor the ambient air for chemical pollutants. Rather than monitoring, the amounts of chemicals discharged to the atmosphere are estimated each year. These estimates are shown in Table 2.2 in Chapter 2. The vast majority of air releases in 2016 were combustion products discharged from the on-site natural gas-fueled steam boilers.

Other significant air discharges include combustion products from several backup power generators, which operate periodically for maintenance reasons, and a transportation research facility that studies internal combustion engines. The pollutants discharged are similar to those released from the boiler house. The quantities released are small, compared to the quantities released from the boilers.

One nonradioactive air pollutant that is monitored is methane gas generated by the decomposition of solid waste in the 800 Area Landfill. The primary purpose of this monitoring is to determine if a potential safety concern exists due to combustible gas migrating into areas or structures around the landfill. Monitoring in 2016 indicated that the gas within the landfill waste mound contained up to 77% methane. However, methane was not detected in any of the perimeter wells. While the quantity of gas generated by the landfill is not measured, it is thought to be very low, based on gas pressure and observations made during routine quarterly sampling.

Small amounts of research-related volatile organic chemicals are released into the air when laboratory wastewater is treated in the LWTP. The amount of volatile organic chemicals released to the air from the LWTP wastewater is calculated each month based on the analysis of a monthly sample of wastewater flowing into the plant. The total amount released to the air is discussed in Chapter 2. The individual results from analysis of the influent wastewater samples are shown in Table 5.1. The 2016 results are similar to those from recent years. Low concentrations of bromodichloromethane, bromoform, chloroform, and dibromochloromethane were found in the samples. These compounds are trihalomethane (THM) organic chemicals that are produced when chlorine is added to the water supply during treatment. Some of these compounds remain in the wastewater and are detected in the influent samples. The drinking

TABLE 5.1

Laboratory Influent Wastewater, 2016
(concentrations in μg/L)

Compound	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Chlorination By-Products												
Bromodichloromethane	1	1	1	0.9 [a]	1	0.9	2	1	0.6	1	1	1
Bromoform	3	1	3	2	12	3	4	3	3	3	2	2
Chloroform	1	0.8	1	0.9	1	1	4	1	0.8	1	0.8	1
Dibromochloromethane	2	1	2	1	2	1	3	2	1	2	1	2
Laboratory Chemicals												
1,1-Dichloroethane	1	<1 [b]	0.3	0.9	1	1	<1	<1	0.3	0.3	0.3	<1
2-Propanol	33	– [c]	–	22	–	–	68	–	–	–	–	–
Acetone	105	84	72	22	36	–	7	–	–	74	14	4
Benzaldehyde	4	–	–	–	–	–	–	–	–	–	–	–
Ethyl Acetate	–	–	–	–	1	–	–	–	–	–	–	–
Ethyl Ether	–	–	3	–	–	–	–	–	–	–	–	–
Isobutyraldehyde	–	–	–	7	–	–	–	–	–	–	–	–
Tetrahydrofuran	2	–	–	–	–	–	–	–	–	–	3	–
Trichloroethene	–	–	–	–	–	–	0.4	–	–	–	–	–

[a] Values less than 1.0 in this table are estimated since they are less than the reporting limit of 1 μg/L.

[b] A "less than" (<) sign indicates this compound was not found above analytical reporting limits. The number after the "<" sign is the reporting limit.

[c] A dash indicates the compound was not detected in the sample. Detection limits ranged from 1 to 5 μg/L. Reporting limits for this compound were not determined.

water limit for the sum of all of the THM compounds is 80 μg/L. The sum of the concentrations detected in Argonne's water, provided by the City of Chicago and purchased from the DuPage Water Commission, is below this limit.

In addition to the THMs, a number of other chemicals from laboratory operations were detected in at least one sample, as shown in Table 5.1. The only chemicals detected in more than one sample were 1,2-dichloroethane, acetone, 2-propanol (isopropyl alcohol), and tetrahydrofuran. The presence of these chemicals is likely the result of equipment cleaning. Since 1998, concentrations of chemicals in the wastewater have been consistently low, largely due to educational efforts to minimize the use and discharge of chemicals into the laboratory sinks.

5.3. Surface Water

Samples of wastewater discharged into on-site streams and Sawmill Creek are routinely collected and analyzed for a number of parameters. Most of the sampling performed is required by the site's NPDES wastewater discharge permit. Sampling frequency and analyses conducted are determined by permit-mandated monitoring requirements for each outfall. The results of the analyses are compared with the permit limits for each outfall to determine whether they comply with the permit. The results are transmitted monthly to the IEPA in a DMR.[18]

Besides the NPDES permit-required sampling, surface water is sampled at several locations near the site as part of the environmental surveillance program. The overall effect of Argonne site discharges on Sawmill Creek and the Des Plaines River is monitored by sampling downstream of the site and comparing the results with samples collected upstream of the site. The results from radiochemical analysis of these samples are discussed in Chapter 4.

5.3.1. Treated Wastewater Discharges

Wastewater from Argonne is treated in two on-site wastewater treatment facilities before it is discharged to Sawmill Creek. Sanitary wastewater is generated at Argonne by the cafeteria, sanitary facilities, and custodial operations. Wastewater from these activities is conveyed to the sanitary wastewater treatment plant (SWTP) through dedicated sanitary sewers. A separate laboratory wastewater system collects wastewater generated in laboratories, other research operations, and the 317/319 groundwater extraction system. This wastewater is treated in the laboratory wastewater treatment plant (LWTP). Section 2.2 contains a description of the wastewater treatment facilities. In addition, in several areas, wastewater which does not require treatment prior to discharge (i.e., steam condensate, non-contact cooling water, and air compressor condensate), is discharged directly into storm drains.

The treated wastewater from the SWTP is known as Outfall A01. The treated wastewater from the LWTP is Outfall B01. These outfalls are internal monitoring points; their flows combine before they discharge into Sawmill Creek. The combined discharge is known as Outfall 001, which is also located at the WTP. The combined wastewater flows through an outfall pipe that discharges into Sawmill Creek approximately 1,100 m (3,500 ft) south of the WTP, at the location designated as 7M in Figure 1.1.

The NPDES permit requires monitoring of the direct discharge outfalls. These outfalls also contain stormwater after a rain. However, the permit limits and monitoring requirements apply only to the process wastewater discharges; therefore, the outfalls associated with those discharges are not sampled during periods when stormwater is also flowing, when no flow is visible, or when an outfall is completely frozen.

Four stormwater-only outfalls convey stormwater from potentially contaminated areas in the 800 Area and the 317/319 Area. For these outfalls, stormwater runoff is sampled after a rain event. If no runoff occurs during the sampling period, no samples are collected. Eight such samples were collected in 2016.

5.3.2. Sample Collection and Analysis

Wastewater samples are collected from Argonne outfalls as specified by the current NPDES permit. Sample collection, preservation, holding times, and analytical methods utilized are consistent with those approved by the EPA. All samples are collected in specially cleaned and labeled sample bottles with appropriate preservatives added. Custody seals and chain-of-custody sheets are used as needed. Samples are submitted to the appropriate testing laboratory for analysis. Testing is completed within the required holding time.

Samples are analyzed by using EPA-approved analytical methods found in 40 CFR Part 136, "Test Procedures for the Analysis of Pollutants under the Clean Water Act"[19], "Test Methods for Evaluating Solid Waste" (EPA-SW-846)[29], and Standard Methods.[20] Analyses are conducted by the Argonne Environmental Protection laboratory, as well as by commercial laboratories. Field measurements, including pH, temperature, and dissolved oxygen, are performed by Argonne personnel.

5.3.3. Wastewater Treatment Facility Outfall Monitoring

Outfall A01. This outfall consists of treated sanitary wastewater from the SWTP. The monitoring requirements and the range of individual results from monitoring during 2016 are shown in Table 5.2. This table also lists the permit limits in effect during 2016 and the number of instances when these limits were exceeded. Two sets of limits are listed; one is a maximum limit for any single sample (daily maximum limit) and the other is for the average of all weekly samples collected during the month (30-day average limit). There was only one permit exceedance at outfall A01 in 2016 for BOD and no exceedances for pH and Total Suspended Solids (TSS).

TABLE 5.2

Outfall A01 Effluent Limits and Monitoring Results, 2016
(concentrations mg/L except where noted)

	NPDES Permit Requirements		Monitoring Results	
Constituent	30-Day Average Limit	Daily Maximum Limit	Range	2016 Exceedances
Flow (MGD)[a]	NA[b]	NA	0.174–1.017 (0.252 Average)	NA
pH (pH units)	NA	6.0–9.0	6.8–7.6	0
BOD, 5 Day	10.0	20.0	<2[c]–11.7	1
TSS	12.0	24.0	0.2–4.4	0

[a] MGD = Million Gallons per Day.

[b] NA indicates that there is no limit or value of the type shown.

[c] A concentration value shown with a “less than” (<) sign indicates that the constituent was not present above the detection limits of the analytical method. The value shown is the method detection limit.

Outfall B01. This outfall consists of treated wastewater from the LWTP. Table 5.3 lists monitoring requirements, effluent limits, and a summary of the 2016 monitoring results for this outfall. This outfall is subject to both concentration limits and mass discharge limits. A mass discharge limit is the maximum weight of material that can be discharged per day. The mass discharge amount is calculated by using the constituent concentration and the flow rate measured the day the sample was collected. There were no exceedances of the 30 Day Average TSS limit in 2016. None of the mass discharge limits was exceeded.

Outfall B01 is also monitored semiannually (June and December) for priority pollutants. Priority pollutants are 124 organic and inorganic constituents that the EPA has determined deserve special attention in monitoring programs as listed in Appendix A to 40 CFR Part 423 (note that IEPA does not require Argonne to analyze for dioxin or asbestos). The June sample is to be collected at the same time as the sample for aquatic toxicity testing at Outfall 001. Table 5.4 gives the results for those constituents found to be above the analytical detection limits during 2016. Both samples also contained very low concentrations of several THMs, which result from the chlorination of drinking water. Traces of these chemicals remain after treatment. Low, estimated concentrations of 1,2-dichloroethane were found in the June sample but not in December. The results for the other priority pollutants not shown in this table were less than their respective detection limits. In general, these results indicate that the treated wastewater is free of measureable amounts of toxic chemicals on the priority pollutant list.

TABLE 5.3

Outfall B01 Effluent Limits and Monitoring Results, 2016
(concentrations in mg/L except where noted)

	NPDES Permit Requirements		Monitoring Results	
Constituent	30-Day Average Limit	Daily Maximum Limit	Range	2016 Exceedances
Flow (MGD)	NA[a]	NA	0.353–0.987 (0.471 Average)	NA
pH (pH units)	NA	6.0–9.0	7.04–8.11	0
BOD, 5 Day concentration	10	20	<2–20.6[b]	0
BOD, 5 Day mass (lb/day)	41.9	83.7	<5.14–60.1[c]	0
TSS concentration	12	24	0.2–7	0
TSS mass (lb/day)	50.2	100.5	0.89–28.5	0
Mercury concentration	0.003	0.006	<0.0002	0
Mercury mass (lb/day)	0.0126	0.0251	<0.00046–<0.00129	0
Oil and grease concentration	15	30	<5	0
Oil and grease mass (lb/day)	62.8	125.6	<11.47–<32.32	0
Iron	NA	NA	<0.5	NA
COD	NA	NA	<20–134	NA
Priority pollutants	NA	NA	–[d]	NA

[a] NA = Not applicable; this indicates that there is no limit or value of the type shown.

[b] A concentration value shown with a "less than" (<) sign indicates that the constituent was not present above the detection limits of the analytical method. The value shown is the method detection limit.

[c] A calculated value shown with a "less than" (<) sign indicates that one or more values used in the calculation was not present above the detection limits of the analytical method. The value used in the calculation was the method detection limit.

[d] Priority Pollutant results are presented in Table 5.4.

TABLE 5.4

Outfall B01 Effluent Priority Pollutant Monitoring Results, 2016

Element or Compound[a]	June	December
1,1-Dichloroethane (µg/L)	0. 3[b]	<1
Bromodichloromethane (µg/L)	0. 6[b]	0.8[b]
Bromoform (µg/L)	1	1
Chloroform (µg/L)	0.8[b]	0.9[b]
Dibromochloromethane (µg/L)	0.8[b]	1

[a] All 124 priority pollutants were analyzed. Only those found are shown in this table.

[b] This result was estimated since it was less than the reporting limit of 1 µg/L.

Outfall 001. This outfall contains the combined wastewater from both treatment plants. Composite and grab samples of the combined effluent are collected weekly or monthly, as required by the permit. Table 5.5 lists the monitoring requirements, the permit limits, and the range of values recorded during 2016. The number of permit limit exceedances during 2016 is also shown.

There were two permit limit exceedances at this outfall during 2016. One sample exceeded the limit for chloride. The source of the chloride is road salt (sodium chloride) used on the roads in the winter that enters the sanitary sewers through infiltration. One dissolved oxygen measurement was below the limit in 2016 (for a DO measurement, an exceedance means the measured value was less than the permit limit).

The permit requires annual biological toxicity testing of Outfall 001. This test was performed using a composite sample collected on June 7 and June 8, 2016. Two types of organisms, water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*), were introduced into samples consisting of various ratios of Argonne effluent and dilution water. Survival was measured over two to four days and mortality was reported as a function of effluent concentration. An off-site contract laboratory performed the analyses. This testing concluded that the concentration of wastewater that produces 50% mortality in the test population (i.e., the median lethal concentration [LC50]) was greater than 100%, meaning that even the undiluted effluent is not toxic to these species. Previous toxicity tests conducted since 2001 have all concluded that the combined effluent is not toxic to these species.

5.3.4. Direct Discharge Outfalls

In addition to the three outfalls at the wastewater treatment plant, nine other outfalls were monitored in 2016. Five of these outfalls currently discharge, or have discharged at some time in the past, process wastewater that does not require treatment prior to release, as well as stormwater. Four of the nine outfalls discharge only stormwater. The sampling requirements and a summary of the results of the 2016 monitoring are contained in Table 5.6.

None of the direct discharge outfalls monitored in 2016 experienced permit exceedances. Two outfalls, Outfall 004 and Outfall 006, require sample collection and analysis only when certain pieces of emergency back-up process equipment are operating. These pieces of equipment discharge cooling water (potable water) into storm drains, necessitating monitoring. Throughout 2016, neither of these pieces of equipment was operated. As a result, no samples were collected from these outfalls.

Stormwater at Outfall 021 is analyzed once per year for priority pollutants. Because of ongoing remedial actions in the 317 and 319 Areas, the potential for release of toxic organic chemicals into stormwater runoff exists. The 2016 sample was collected on June 1, 2016. None of the 124 compounds contained on the priority pollutant list was detected in this sample above analytical reporting limits. Chloroform was identified in the sample at an estimated concentration of 0.7 μg/L, below the reporting limit of 1 μg/L. This compound is present in the soil and groundwater in the 317 Area, so its presence in stormwater is not unexpected. The very low

TABLE 5.5

Outfall 001 Monitoring Results and Effluent Limits, 2016
(concentrations in mg/L except where noted)

NPDES Permit Requirements		Monitoring Results	
Constituent	Limits	Range	2016 Exceedances
Flow (MGD)	NA[a]	0.559–2.004 (0.723 Average)	NA
pH (pH units)	6.0–9.0	7.11–8.32	0
Dissolved oxygen	March—July: Weekly Avg. Min.=6 Daily Min.=5.5 August—February: 30 Day Avg. Min.=5.5 Weekly Avg. Min.=4 Daily Min.=3.5	Monthly Avg.: 7.4–10.5 Weekly Avg.: 7.1–9.9	1
Ammonia nitrogen	March—May: 30 Day Avg.=1.6 Weekly Avg.=4.1 Daily Max.=9.1 June—August: 30 Day Avg.=1.6 Weekly Avg.=4.1 Daily Max.=14.7 September—October: 30 Day Avg.=1.6 Weekly Avg.=4.1 Daily Max.=9.1 November—February: 30 Day Avg.=4.8 Daily Max.=10.9	Monthly Avg.: <0.133–0.588 Weekly Avg.: <0.10–0.40	0
Chloride	Daily Max.=500	150–520	1
Sulfate	Daily Max.=500	62–167	0
Copper	30 Day Avg.=0.0244 Daily Max.=0.0395	<0.020–0.020	0
Total Nitrogen	NA	4.8–9.1	NA
Phosphorus	NA	0.31–0.90	NA
Beta radioactivity (pCi/L)	NA	5.2–13.1	NA
Low-level mercury	NA	<0.0000026–0.000020	NA

[a] NA = Not applicable.

TABLE 5.6

Summary of Monitored Direct Discharge NPDES Outfalls, 2016

			Sample Results	
Outfall	Constituent	Permit Limit	Range	2016 Exceedances
D03	Flow (MGD)	NA[a]	0.002–0.018	NA
	pH	6–9	7.3–7.9	0
	Temperature (°C)	<2.8°C rise	19.9–24.1	0
G03	Flow (MGD)	NA	<0.001-0.028	NA
	pH	6–9	7.2–8.3	0
	Temperature (°C)	<2.8°C rise	3.8–21.7	0
004	Flow (MGD)	NA	No flow[b]	NA
	TRC[c] (mg/L)	0.05		
C05	Flow (MGD)	NA	0.001–0.036	NA
	pH	6–9	7.2–8.1	0
006	Flow (MGD)	NA	No flow	NA
	TRC (mg/L)	0.05		
021[c]	Flow (MGD)	NA	<0.0204–0.30	NA
	Hydrogen-3 (pCi/L)	Monitor only	<100	NA
	Iron (mg/L)	Monitor only	<0.5–2.8	NA
	Priority pollutants	Monitor only	–[d]	NA
A22[c]	Flow (MGD)	NA	<0.0161	NA
	Hydrogen-3 (pCi/L)	Monitor only	<100	NA
B22[c]	Flow (MGD)	NA	0.550	NA
	Hydrogen-3 (pCi/L)	Monitor only	<100	NA
023[c]	Flow (MGD)	NA	<0.001-0.018	NA
	Hydrogen-3 (pCi/L)	Monitor only	<100	NA

[a] NA = Not applicable. The parameter is a monitor-only constituent and the limit exceedance is not applicable.

[b] No process wastewater was present at this outfall; therefore, no samples were collected.

[c] TRC = Total Residual Chlorine

[d] A dash indicates that priority pollutant results are presented in Section 5.3.4.

concentration indicates that very small amounts of this chemical are released from the soil into stormwater runoff. Trichloroethene was also identified in the sample at an estimated concentration of 0.2 µg/L.

5.4. Surface Water Surveillance

To supplement the permit-required monitoring, other analyses are voluntarily conducted on samples collected from the combined treatment plant effluent (Outfall 001), and Sawmill Creek upstream and downstream of the site. These samples are analyzed for a number of inorganic constituents and radiological parameters. The results of the radiological analyses are discussed in Chapter 4. The results of the inorganic analyses are presented in this chapter. The results for Outfall 001 and Sawmill Creek are compared with the IEPA's General Effluent Standards and Stream Quality Standards listed in IAC, Title 35, Subtitle C, Part 304.[21] While Argonne is not required to meet these standards in the effluent or Sawmill Creek, they provide a useful frame of reference against which the effluent and stream quality can be compared.

Combined treatment plant effluent. Composite samples were collected from Outfall 001 each week and analyzed for inorganic constituents. The results of the analysis are shown in Table 5.7. As shown in this table, the pH was within the acceptable range throughout the year. All 52 samples contained low, but detectable, levels of fluoride. None of the parameters exceeded the IEPA's General Effluent Limits.[22]

Sawmill Creek. To determine the impact that Argonne wastewaters have on Sawmill Creek, composite samples of the creek downstream of all Argonne discharge points were collected weekly and analyzed. Samples were not collected for three weeks in 2016 since heavy snow and ice blocked access to the sampler. The results were compared with IEPA General Use Water Quality Standards found in 35 IAC, Subtitle C, Part 302.[23]

The results obtained for 2016 are shown in Table 5.8. The pH was in the appropriate range throughout the year. Fluoride was present in all of the samples, but below the standard. Only manganese was above the detection levels in any of the samples. None of the results was higher than the General Use Water Quality Standards.

TABLE 5.7

Chemical Constituents in Effluents from the Argonne Wastewater Treatment Plant, 2016

		Concentration (mg/L except pH)		
Constituent	No. of Samples	Average	Maximum	IEPA Limit
Arsenic	52		<0.025[a]	0.25
Barium	52		<0.5	2.0
Beryllium	52		<0.0025	–[b]
Cadmium	52		<0.0025	0.15
Chromium	52		<0.05	1.0
Cobalt	52		<0.25	–
Copper	52		<0.025	0.5
Fluoride	52	0.74	0.93	15.0
Iron	52		<0.5	2.0
Lead	52		<0.09	0.2
Manganese	52		<0.075	1.0
Mercury	52		<0.0002	0.0005
Nickel	52		<0.05	1.0
Silver	52		<0.0025	0.1
Thallium	52		<0.002	–
Vanadium	52		<0.075	–
Zinc	52		<0.05	1.0
pH	52	NA[c]	7.20–8.07[d]	6.0–9.0

[a] If all values were less than the detection limit for a constituent, only the detection limit value is given.

[b] A dash indicates that there is no effluent limit for this constituent.

[c] NA = Not applicable. pH values are not averaged since they are log functions.

[d] The lowest and highest pH values are given.

TABLE 5.8

Chemical Constituents in Sawmill Creek, Location 7M[a], 2016

	Concentration (mg/L except pH)			
Constituent	No. of Samples	Average	Maximum	IEPA Limit
Arsenic	49	0.036	0.036	0.36[b]
Barium	49		<0.5[c]	5.0[d]
Beryllium	49		<0.0025	–[e]
Cadmium	49		<0.0025	0.024[c]
Chromium	49		<0.05	1.15[c]
Cobalt	49		<0.25	–
Copper	49		<0.025	0.040[c]
Fluoride	49	0.559	1.32	16.3[c]
Iron	49		<0.5	1.0[d]
Lead	49		<0.09	0.20[c]
Manganese	49		<0.0002	8.2[c]
Mercury	49		<0.0002	0.0022[c]
Nickel	49		<0.05	0.18[c]
Silver	49		<0.0025	0.005[d]
Thallium	49		<0.002	–
Vanadium	49		<0.075	–
Zinc	49		<0.5	0.26[c]
pH	49	NA[f]	7.34–7.89[g]	6.5–9.0

[a] Location 7M is downstream of the Argonne wastewater outfall.

[b] Value is the acute standard for protection of aquatic organisms calculated from equations given in 35IAC302.208, using a hardness value of 246 mg/L.

[c] If all values were less than the detection limit for a constituent, only the detection limit is given.

[d] Value is the general surface water standard given in 35IAC302.208 g.

[e] A dash indicates that there is no effluent limit for this

[f] NA = Not applicable. pH values are not averaged since they are log functions.

[g] The lowest and highest pH values are given.

5.5. Additional Stormwater Monitoring

The Postclosure Care Plan[24] for the 800 Area Landfill requires the quarterly sampling of stormwater discharges from the landfill site. Stormwater flows from the landfill area through two outfalls, 023 and 114. These two outfalls are monitored for TDS, TSS, and pH. No limits are included in the plan. Two stormwater samples were collected from Outfall 023 in 2016 but no samples were collected from Outfall 114 due to the absence of flow. The 2016 results for Outfall 023 are shown in Table 5.9. Comparing these values with other NPDES discharges in 2016 suggests no indication of stormwater contamination from landfill operations.

TABLE 5.9

Monitoring Results for 800 Area Landfill Stormwater (Outfall 023), 2016

Date	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	pH
February 2	86	39	7.26
May 10	270	12	7.63

The Argonne Long-Term Stewardship (LTS) Program monitors stormwater downstream of the 317 Area and 319 Landfill to determine if any contaminants from the remediation area are being released into surface water. Because of the characteristics of the drainage area, flow is present only immediately after a major storm event. Only one sample of stormwater was collected during 2016. The results are summarized in Table 5.10. Results showed that 1,1,1-trichloroethane, carbon tetrachloride, chloroform, tetrachloroethene, and hydrogen-3 were detected in this sample at very low concentrations. The results below the reporting limit of 1 µg/L are considered to be estimated values. The hydrogen-3 result is slightly above the detection limit of 100 pCi/L. The compounds detected are also present in the soil and groundwater in these areas. The presence of these compounds in stormwater indicates that small amounts of these chemicals are migrating from the soil into rainwater runoff.

TABLE 5.10

Results for 319 Landfill Surface Water, 2016

Analyte	May 12
Organic Compounds (µg/L)	
1,1,1-Trichloroethane	0.6[a]
Carbon Tetrachloride	1
Chloroform	1
Tetrachloroethene	0.2
Radionuclides (pCi/L)	
Hydrogen-3	134

[a] Values in this table that are less than 1 µg/L are estimated values since they are less than the detection limit for the VOC analytical method used.

6. GROUNDWATER PROTECTION

6.1. Groundwater Protection at Argonne

Groundwater is present in several aquifers, or water-saturated layers of porous soil, sand and rock, located beneath the Argonne site. Protecting the quality of this groundwater is a high priority for Argonne. The uppermost layer of soil beneath the Argonne site consists of glacial drift; a mixture of clay, silt, sand, and gravel deposited during past glacial retreat periods. Some regions within the drift layer contain high proportions of sand and gravel that are saturated with groundwater. Some of these regions are interconnected and they provide a path for groundwater migration, while others are isolated and have limited potential for movement. Dolomite bedrock underlies the glacial drift throughout the site. The dolomite contains numerous cracks, fissures, and solution cavities that allow groundwater to migrate through the stone. This region of groundwater constitutes the uppermost aquifer used near Argonne as a source of drinking water for low-capacity wells. Several hundred feet below the dolomite is a layer of porous sandstone that contains the most commonly used aquifer in this region. The sandstone is isolated from overlying soil and groundwater by a thick layer of shale. Argonne monitors the quality of groundwater in the glacial drift and in the dolomite. The sandstone aquifer is too deep to be affected by Argonne operations.

Regulatory standards intended to protect groundwater resources are contained in Illinois Environmental Protection Agency (IEPA) Groundwater Quality Standards (GQS), 35 IAC, Subtitle F, Part 620.[25] Argonne groundwater is considered Class I (potable resource groundwater) under these regulations. The IEPA's approach to determining remediation objectives for cleaning up contaminated groundwater is contained in the Tiered Approach to Corrective Action Objectives (TACO) regulations found at 35 IAC 742. The TACO Tier 1 groundwater standards are standards established for Class I groundwater. Most of these standards are identical to the Class I GQSs. In addition, DOE Order O 458.1 contains groundwater protection requirements for DOE sites, including the need for a groundwater monitoring program. This chapter documents Argonne's compliance with these requirements. Both radiological analysis results and nonradiological analysis results are discussed in this chapter.

Groundwater quality is maintained through Argonne's environmental protection efforts, including the proper handling and disposal of chemical waste from Argonne's research and support operations, a prohibition on the disposal of chemicals into the laboratory sewer system, the reporting and rapid clean-up of any spills or releases of chemicals, and periodic inspection of outdoor storage areas. Groundwater beneath several closed waste disposal units is protected by the placement and maintenance of impermeable covers over the waste and by routine monitoring of groundwater near the units. In the 317/319 Area, groundwater quality has been impaired by the disposal, during the 1950s, of liquid wastes into a unit known as a French drain. The contaminated soil and groundwater in this area are being cleaned up by using several remedial technologies discussed in Section 6.3.

Groundwater quality is monitored by collecting and analyzing samples from groundwater monitoring wells on and adjacent to the Argonne site. A critical element of this program involves permit-required groundwater monitoring at several former waste management units, including the former 800 Area Landfill, the 317/319 Area remedial action site, and the former East-Northeast (ENE) Landfill. Argonne is also voluntarily conducting groundwater monitoring around the perimeter of the 317/319 Area and near the former Chicago Pile-Five (CP-5) reactor. Samples are also collected from an artesian well located in the Waterfall Glen Forest Preserve, south of the site.

Monitoring wells are sampled in accordance with EPA protocols described in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[26] Prior to collecting samples, stagnant water is removed from the well. For those wells that recharge rapidly, at least three well volumes are purged by using dedicated submersible pumps or bailers. Shallow wells in the 800 Area are sampled using a low-flow purging technique which minimizes disturbance of the groundwater, resulting in samples that are more representative of in situ groundwater. During well purging, field parameters (pH, specific conductivity, turbidity, oxidation-reduction potential, and temperature) are measured. Sampling is conducted after field parameters have stabilized. For wells in the glacial drift that recharge slowly, the well is emptied completely and allowed to refill. After the well refills, samples are collected using a dedicated Teflon® bailer or pump. Samples for VOCs, Semivolatile Organic Compounds (SVOCs), PCBs, pesticides, metals, inorganics, and radionuclides are collected in that order. The samples are placed in precleaned bottles, labeled, and preserved in accordance with EPA guidance. Groundwater samples are analyzed for parameters that are determined by the various permits and objectives of the sampling program. Analyses are conducted using analytical methods approved by the EPA. Radiological analysis methods are based on methods developed by the DOE.

6.2. Groundwater Monitoring at Former Waste Management Areas

During the early years of operation at the present site, some wastes were disposed in a number of on-site disposal units. These ranged from pits and ditches filled with construction and demolition debris used in the 1950s, to a sanitary landfill used for nonhazardous solid waste disposal, which operated until 1992. Several on-site disposal units were used to dispose of chemically hazardous wastes. No radioactive waste was knowingly placed in any of these units for disposal; however, radiologically contaminated equipment and debris were placed in some of these units and several areas were contaminated with radioactive materials as they were being used for temporary storage of waste.

Extensive site characterization and remediation of these units was conducted under Argonne’s RCRA Corrective Action program administered by the IEPA. Two RCRA Facility Investigations (RFIs) and a number of similar studies were completed. For those sites where contamination was found, a list of Contaminants of Concern (CoCs) and remediation objectives for soil and groundwater were established. Most of the sites were closed by the removal of buried waste and contaminated soil, and no further action was required. However, several waste units were closed with waste or contamination still in place, requiring ongoing remedial actions and monitoring. These units are managed and monitored as part of Argonne’s Long-Term Stewardship (LTS) Program. Units that require routine monitoring include the 317/319 Area, the 800 Area Landfill, and the ENE Landfill. The LTS Program and related groundwater monitoring are integrated with the Argonne Environmental Monitoring Program.

6.3. Groundwater in the 317/319 Area

The 317/319 Area contained seven units that were used for handling or disposal of various types of waste. The 317 Area currently is used for storage of empty radioactive waste containers. It also contains the North Vault, an in-ground radioactive material container storage vault, which is currently empty. Five similar waste storage vaults in this area were cleaned and demolished in place during remedial actions. Low levels of hydrogen-3 are present in the groundwater below this area as a result of past radioactive waste-management practices. General features of the 317 and 319 Areas are shown in Figure 6.1.

During the 1950s, various nonradioactive liquid chemical wastes were disposed of in a unit known as a French drain. The 317 French drain consisted of a shallow trench filled with gravel into which an unknown quantity of liquid waste was poured. The wastes were primarily petroleum products and chlorinated solvents. Because of these past disposal practices, there is a region of contaminated soil in the northern half of the 317 Area. The most highly contaminated sections of the 317 French Drain Area were treated by using a deep soil mixing, steam stripping, and metallic iron treatment technique in 1998. However, areas of untreated soil remain and groundwater below and downgradient of this area contains significant amounts of these chemicals.

To prevent the migration of contaminated groundwater away from the 317 French Drain Area, an underground footing drain pipe associated with the North Vault and four of the five former vaults was sealed by injecting grout into and around the pipe. A groundwater collection system was then installed in the southern end of the 317 Area. This system consists of 15 groundwater extraction wells that remove contaminated groundwater so it does not migrate off-site. Contaminated groundwater collected by this system is discharged to the on-site WTP for treatment and disposal.

The 319 Area contains a closed landfill that was used for disposal of a variety of solid wastes generated on-site prior to 1969. It was not intended for disposal of radioactive waste; however, a small amount of radioactive material, most notably hydrogen-3, was detected in the soil and leachate during site characterization activities. The 319 Area consists of two distinct segments: the waste mound, where the bulk of the waste was buried, and an adjacent burial trench, which contains a much smaller amount of inert waste. This landfill also contained a French drain that was used for several years after the French drain in the 317 Area was closed. The levels of chemical contamination in the 319 Area are lower than the levels in the 317 Area; however, hydrogen-3 levels are higher.

In the 319 Area, remedial actions included constructing a subsurface clay barrier wall to prevent migration of leachate, installing a leachate and groundwater collection system to remove leachate and contaminated groundwater from under the waste mound, and installing a multilayered impermeable cap over the landfill mound and a clay cap over the burial trench.

Groundwater below the 317/319 Area is present in a network of shallow sand and gravel units, up to 6 m (20 ft) thick, within the glacial drift as well as in the upper portion of the dolomite bedrock. The disposal of chemical wastes in the 317 and 319 French Drains, as well as

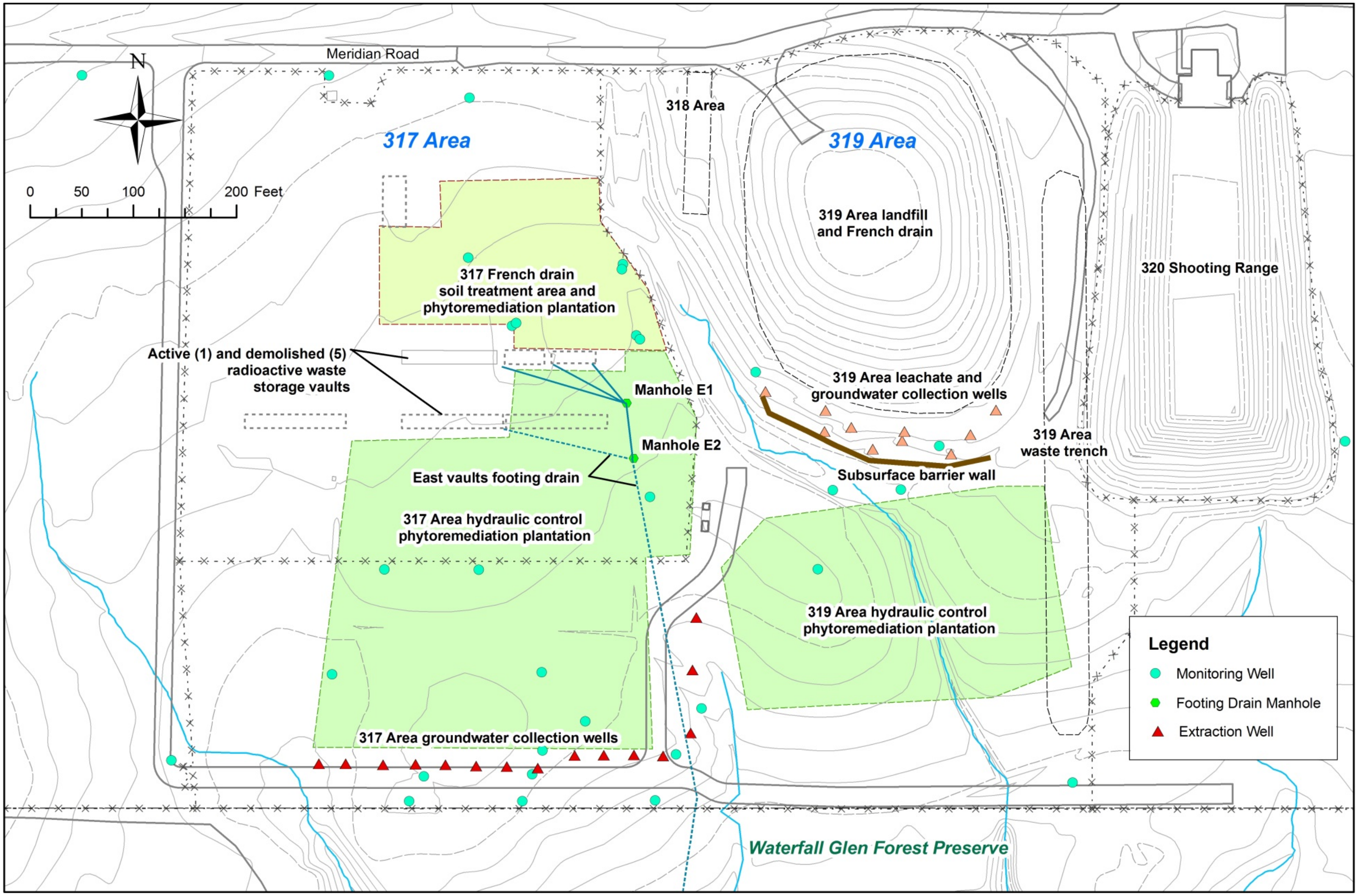


FIGURE 6.1 Locations of Components within the 317/319/ENE Area

the presence of hydrogen-3 in the 319 Area Landfill, have resulted in the generation of a plume of contaminated groundwater extending to the south about 200 m (600 ft). Most of the contamination is present in a porous zone 6 to 10 m (20 to 30 ft) deep in the glacial drift; however, low levels of contamination have been found in the dolomite aquifer. A small amount of contaminated groundwater from the 317/319 Area comes to the surface approximately 360 m (1,200 ft) south of the 319 Landfill in several small groundwater seeps located at the base of a ravine in the Waterfall Glen Forest Preserve. The seeps contain low levels of several VOCs.

A phytoremediation system was installed in 1999 to address the contamination in the 317 French Drain Area and groundwater plume south of the 317/319 Area. Phytoremediation is a technology that uses green plants to remove contaminated groundwater by evapotranspiration. The Argonne system consists of a dense planting of willows and other trees in the vicinity of the 317 French drain and a larger planting of hybrid poplar trees downgradient of the 317/319 Area. Approximately 950 poplar and willow trees were planted. Most of the poplar trees were installed in special lined boreholes designed to guide the tree roots toward the contaminated zones.

An extensive groundwater monitoring program is required by the IEPA in the 317/319 Area. In addition to the permit-required monitoring, Argonne also voluntarily conducts groundwater surveillance in the 317/319 Area. The groundwater surveillance well network was established during the early years of the site remediation program and it has allowed Argonne to monitor changes in contaminant levels as remedial actions have progressed and it provides information about background levels of groundwater constituents upgradient of the area.

6.3.1. Permit-Required Groundwater Monitoring at the 317/319 Area

The LTS monitoring program involves the collection of groundwater data from an extensive network of monitoring wells and other sampling points located throughout the 317/319 Area. The current set of LTS wells is shown in Figure 6.2. The purpose of this monitoring network is to track the movement of contaminated groundwater, to determine the rate at which contaminant levels are decreasing, and to monitor the performance of the various remedial actions constructed in the 317 and 319 Areas. During 2016, the LTS wells were sampled quarterly or semiannually, as specified in the RCRA Permit, and they were analyzed for VOCs and hydrogen-3. The results of the LTS groundwater monitoring were transmitted to the IEPA on a quarterly basis through the submittal of Quarterly Progress Reports.

Because of the number of wells and other sampling points that are sampled in this area, the volume of analytical data generated is quite large. To simplify the presentation of the monitoring data in this report, only a summary of the most significant results is presented. Table 6.1 shows the average VOC concentrations from the 2016 quarterly samples of four of the most highly contaminated wells in the French Drain Area. Wells 317321 and 317331 are constructed in the uppermost saturated zone (4 to 5 m [13 to 16 ft] deep) and wells 317332 and

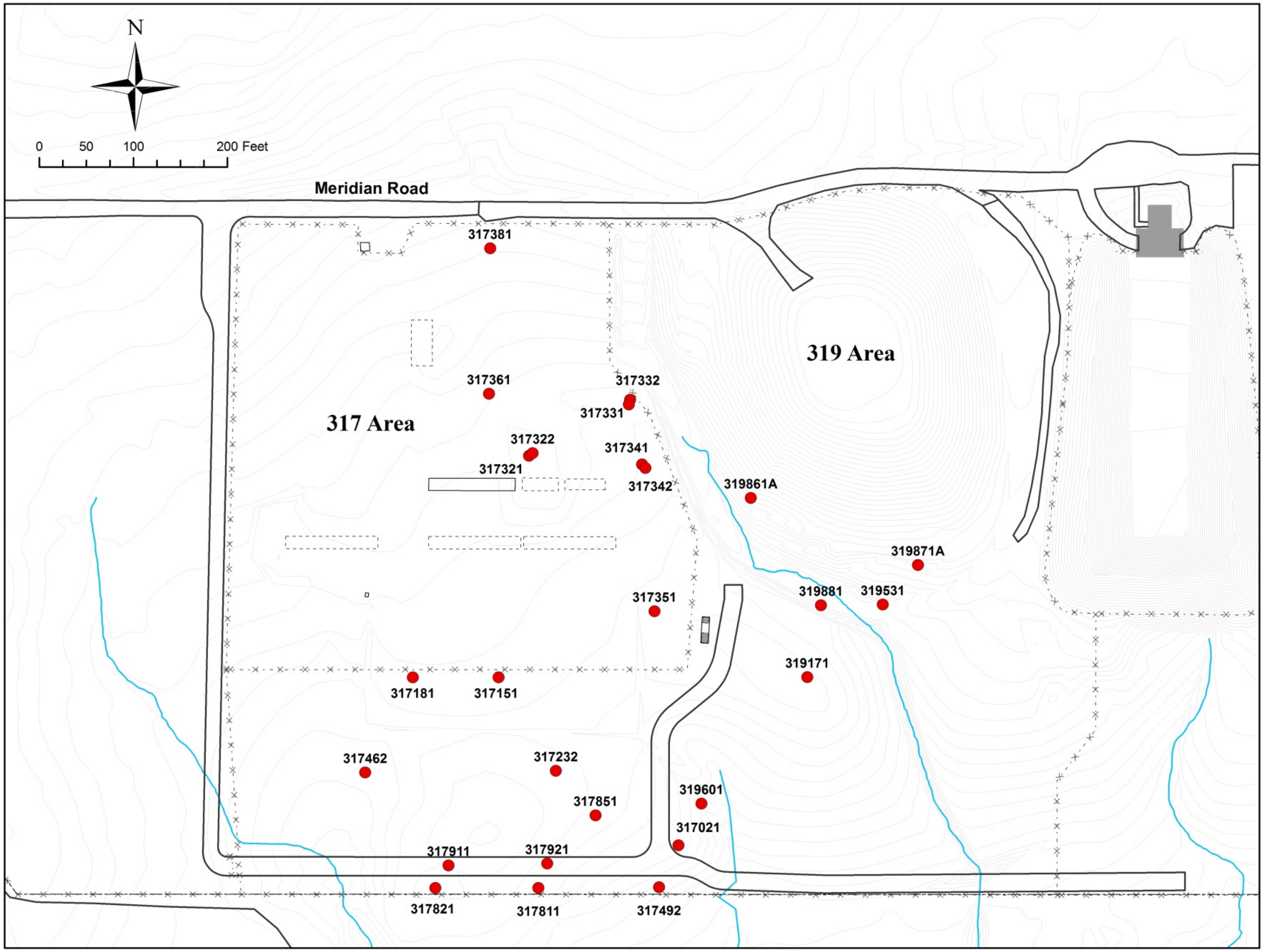


FIGURE 6.2 317/319 Area LTS Monitoring Wells

TABLE 6.1

Annual Average Contaminant Concentrations of 317 French Drain Well Water Constituents, 2016

Parameter	Well No.				TACO Tier 1 Groundwater Remediation Objective[a]
	317321	317331	317332	317342	
VOC (μg/L)					
1,1 Dichloroethane	<1	**15,000**[b]	1,200	550	1400
1,1 Dichloroethene	**156**	**6,800**	**55**	**11**	7
1,1,1 Trichloroethane	<1	**220,000**	**2,300**	**350**	200
1,2 Dichloroethane	<1	**3,500**	**52**	**22**	5
1,4 Dioxane	ND[c]	**4,200**	**340**	**450**	7.7
2-Butanone	**32,000**	**9,900**	ND	ND	4,200
2-Hexanone	1,789	ND	ND	ND	NA[d]
4-Methyl-2Pentanone	17,000	3,900	ND	ND	NA
Acetone	**19,000**	5,300	ND	ND	6,300
Benzene	**9,000**	**460**	**8**	2	5
Carbon Tetrachloride	**290,000**	<1	<1	2	5
Chlorobenzene	<1	<1	<1	6	NA
Chloroethane	5	290	11	9	NA
Chloroform	**47000**	**870**	7	6	70
Chloromethane	<5	<5	<5	6	NA
cis 1,2 Dichloroethene	**1,200**	**26,000**	**410**	36	70
Dichlorodifluoromethane	5	170	8	2	1400
Methylene Chloride	**530**	**110**	<1	<1	5
Tetrachloroethene	**860**	<1	<1	<1	5
Toluene	980	<1	<1	<1	1,000
trans 1,2 Dichloroethene	<1	**1,500**	36	3	100
Trichloroethene	**44,000**	**61,000**	**350**	**35**	5
Trichlorofluoromethane	920	91	<1	<1	NA
Vinyl Chloride	<2	**360**	**22**	**3**	2
Radioactivity (pCi/L)					
Hydrogen-3	245	<100	<100	250	20,000

[a] TACO = Tiered Approach to Corrective Action Objectives, Tier 1 standards found in Table E of Appendix B of 35 IAC742 (except radionuclides).

[b] Bold type indicates that the value exceeds applicable standards.

[c] ND = Not detected. It indicates this compound was not detected. Detection limits do not exist.

[d] NA = Not applicable. It indicates that no standard exists for this compound.

317342 are constructed in the deeper saturated zone (9 to 10 m [29 to 33 ft] deep). VOCs that were below the quantitation limit in all samples from these four wells are not shown in this table. Values that exceed the applicable IEPA's TACO Tier 1 Groundwater Remediation Objective (GRO) are shown in bold type. A number of constituents that were found are not contaminants of concern and do not have a GRO.

The data in Table 6.1 indicate that elevated concentrations of VOCs remain in the French Drain Area. The contaminants present and their concentrations in these wells vary tremendously from well to well, illustrating the heterogeneity of the area. Figure 6.3 shows the long-term trend in annual average total VOC concentrations (the concentrations of all detected VOCs added together) in the two most contaminated wells in the 317 French Drain Area since 1999. This chart indicates that the contaminant levels vary from year to year, but no long-term trend is seen, indicating that contamination levels have not decreased.

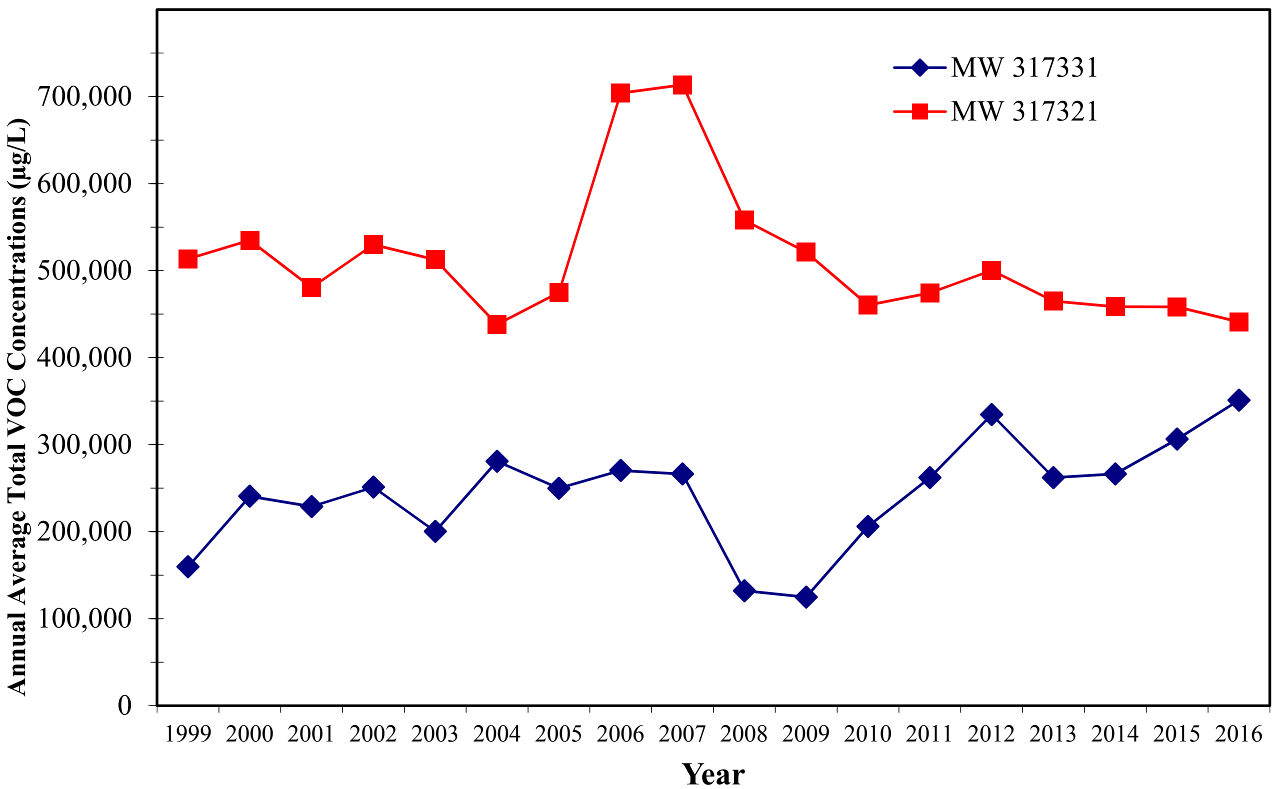


FIGURE 6.3 Annual Average Total VOC Concentrations in 317 Area French Drain Wells

Table 6.2 summarizes the 2016 results for detected VOCs in four downgradient wells south of the French drain. Two wells (317151 and 317351) are approximately midway between the French drain and the southern fence line. Wells 317492 and 317811 are immediately north of the fence line. The concentrations found in these wells are much lower than in the French Drain Area; however, several of the constituents are present above Tier 1 GROs.

TABLE 6.2

Annual Average Concentrations of Downgradient 317 French Drain Well Water Constituents, 2016

	Well No.				
	Wells Midway to Fence		Wells Near Fence Line		TACO Tier 1 Groundwater Remediation Objectives[a]
Parameter	317151	317351	317492	317811	
VOC (μg/L)					
1,1 Dichloroethane	28	1	0.8	6	1,400
1,1 Dichloroethene	3	<1	<1	0.3	7
1,1,1 Trichloroethane	157	<1	0.6	7	200
1,2 Dichloroethane	1	<1	<1	<1	5
2-Butanone	98	ND[b]	ND	ND	4,200
2-Hexanone	10	ND	ND	ND	NA[c]
3-Heptanone	6	ND	ND	ND	
3-Hexanone	3	ND	ND	ND	
3-Pentanone	9	ND	ND	ND	
Acetone	63	ND	ND	ND	6,300
Carbon Tetrachloride	<1	**274**[d]	<1	0.3	5
Chloroform	<1	**266**	<1	<1	70
cis 1,2 Dichloroethene	2	25	<1	<1	70
Methylene Chloride	2	<1	<1	<1	5
Tetrachloroethene	**34**	**220**	<1	0.6	5
trans 1,2 Dichloroethene	<1	0.6	<1	<1	100
Trichloroethene	**58**	**7**	<1	2	5
Vinyl Chloride	<2	2	<2	<2	2
Radioactivity (pCi/L)					
Hydrogen-3	<100	<100	<100	<100	20,000

[a] TACO = Tiered Approach to Corrective Action Objectives, Tier 1 standards found in Table E of Appendix B of 35 IAC742 (except radionuclides).

[b] ND = Not detected. It indicates this compound was not detected. Detection limits do not exist.

[c] NA = Not applicable. It indicates that no standard exists for this compound.

[d] Bold type indicates that the value exceeds applicable standards.

Figure 6.4 is a chart showing contaminant levels in well 317811 since 1997. This chart shows that contaminant levels have been consistently decreasing since 1999, when the phytoremediation system was installed. The contaminant levels in 2016 were some of the lowest since monitoring began for this well. Other monitoring wells in the vicinity of the Argonne property line exhibit similar decreasing contaminant levels.

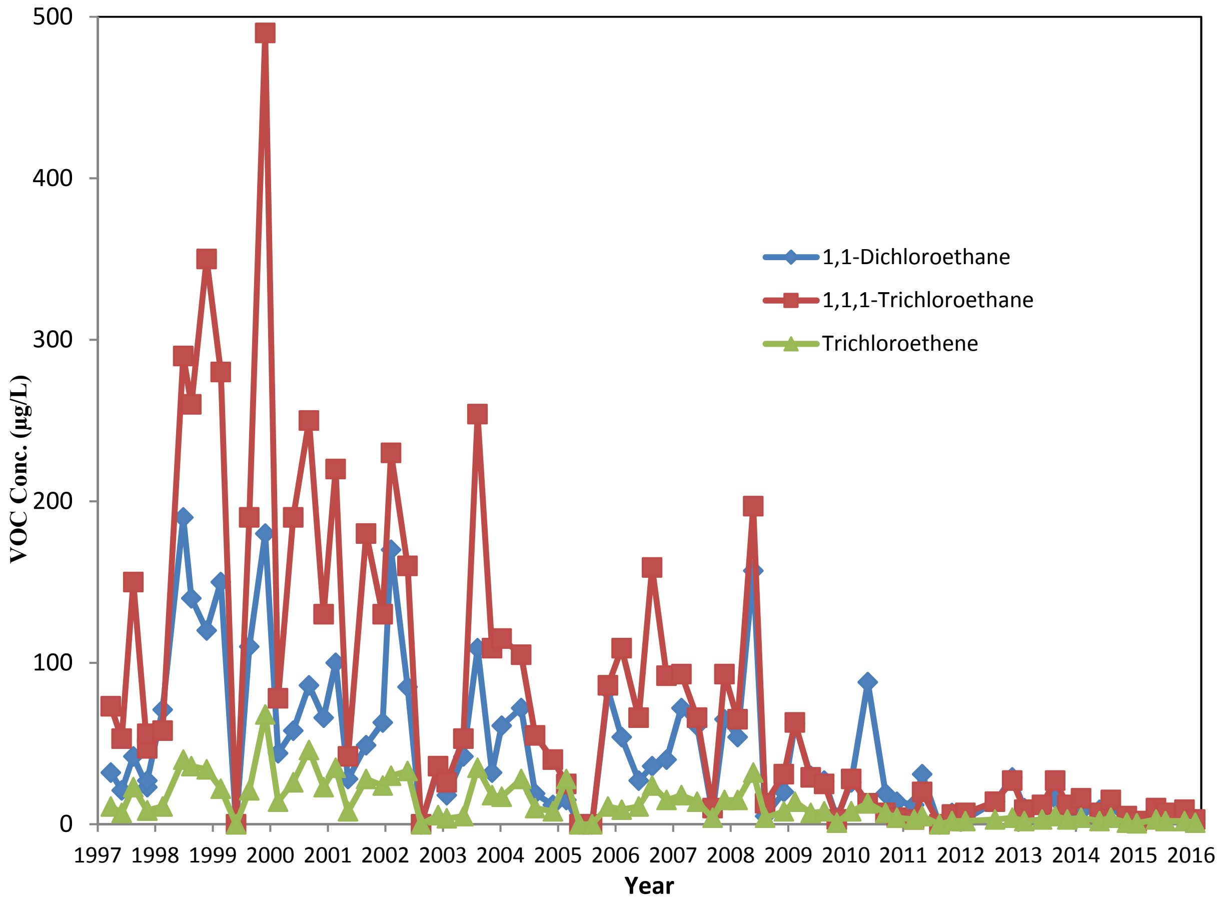


FIGURE 6.4 VOC Concentrations in Well 317811 since 1997

Figure 6.5 is a map showing the approximate location of the region of impacted groundwater within the contaminated aquifer, based on the 2016 data. The core of the plume extends from the French Drain Area to the southwest. The edge of the plume extends a small distance off-site into Waterfall Glen Forest Preserve, though the extent of the plume off-site is poorly understood since there are a limited number of monitoring wells in this area. Compared with similar plume maps prepared for previous SERs, the plume has decreased in size to the south and southeast of the 317 French drain. The most highly contaminated part of the plume emanates from the 317 French Drain Area; however, compared to previous years, the leading edge of the plume has receded approximately 200 feet north, in the direction of the French drain. The contaminant levels in wells south and east of the 317 French Drain Area continue to decrease. Contaminant concentrations at the Argonne fence line are very low and steadily decreasing.

Table 6.3 summarizes the 2016 results for the five wells near the 319 Landfill. Two of the wells are located upgradient of the subsurface clay barrier wall and the other three are downgradient of the barrier wall. The VOC concentrations are much lower in the 319 Area than the 317 French Drain Area; however, the hydrogen-3 levels are higher as a result of past disposal of hydrogen-3 contaminated equipment or soil. 1,4 Dioxane is only constituent that exceeded the GROs in 319 area during 2016.

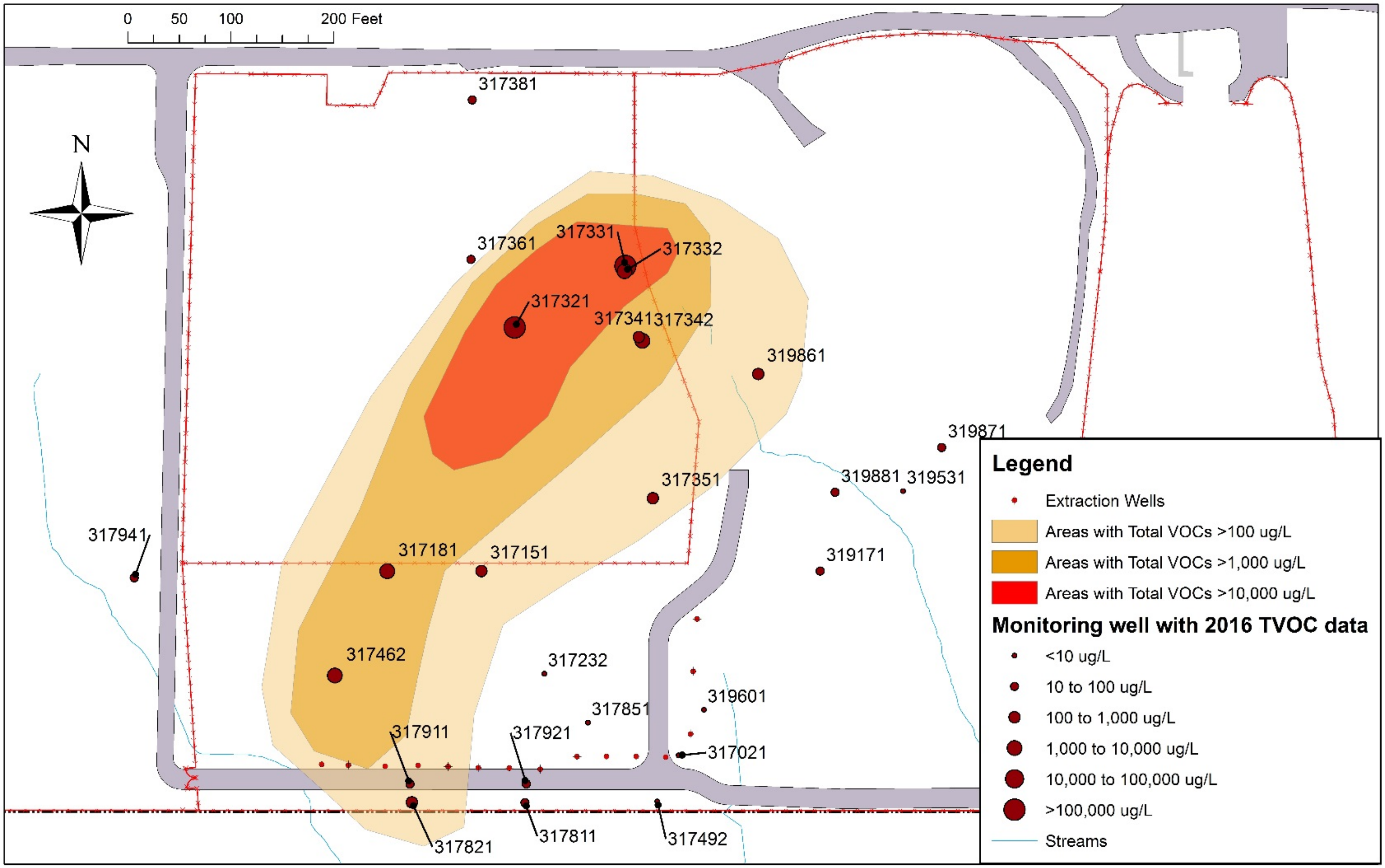


FIGURE 6.5 Region of Contaminated Groundwater in the 317/319 Area during 2016

TABLE 6.3

Annual Average Concentrations of 319 Area Landfill Well Water Constituents, 2016

	Well No.					
	Upgradient of Barrier Wall		Downgradient of Barrier Wall			TACO Tier 1 Groundwater Remediation Objectives[a]
Parameter	319861A	319871A	319171	319531	319881	
VOC (μg/L)						
1,1 Dichloroethane	27	0.8	6	0.6	7	1400
1,1 Dichloroethene	3	0.9	<1	<1	2	7
1,1,1 Trichloroethane	57	0.6	51	<1	9	200
1,2 Dichloroethane	2	<1	<1	<1	0.4	5
1,4 Dioxane	**29**[b]	4	ND[c]	ND	**8**	7.7
2-Butanone	ND	10	ND	ND	ND	4200
2-Hexanone	ND	0.6	ND	ND	ND	NA[d]
Chloroethane	4	<5	<5	<5	<5	NA
Chloroform	0.4	0.6	0.5	<1	<1	70
Dichlorofluoromethane	ND	0.4	ND	ND	ND	NA
Tetrachloroethene	<1	0.6	0.8	<1	<1	5
Tetrahydrofuran	ND	3	ND	ND	ND	NA
trans 1,2 Dichloroethene	<1	0.5	<1	0.6	0.6	100
Trichloroethene	0.4	2	0.5	3	0.6	5
Radioactivity (pCi/L)						
Hydrogen-3	<100	2,460	485	238	624	20,000

[a] TACO = Tiered Approach to Corrective Action Objectives, Tier 1 standards found in Table E of Appendix B of 35 IAC742 (except radionuclides).

[b] Bold type indicates that the value exceeds applicable standards.

[c] ND = Not detected. It indicates this compound was not detected. Detection limits do not exist.

[d] NA = Not applicable. It indicates that a TACO Remediation objective does not exist for this compound.

6.3.2. Monitoring of the Seeps South of the 300 Area

In 1996, during the RFI of the 317/319 Area, three groundwater seeps were discovered in two steeply eroded ravines in the Waterfall Glen Forest Preserve 360 m (1,200 ft) southeast of the 317 and 319 Areas. The ravines carry stormwater drainage from the 317 and 319 Areas. An exposed sandy layer of soil contains groundwater that comes to the surface in the ravine, forming three seeps. A shallow hand-dug well of unknown age is located near one of the seeps. Approximately 30 m (100 ft) downstream, the water from the seeps is usually no longer visible because it drains back into the soil in the bed of the ravine or it evaporates. During extended dry-weather conditions, the seeps disappear completely. The water in these seeps was found to contain VOCs and low levels of hydrogen-3, presumably from the 317 and 319 Areas.

Shallow monitoring wells were installed near the seeps. The locations are shown in Figure 6.6. SP04 is located adjacent to the hand-dug well. All three seeps have been monitored on a regular basis since discovery. Only hydrogen-3 and three VOCs (carbon tetrachloride, chloroform, and tetrachloroethene) have been consistently found. 1,4-Dioxane is occasionally detected at very low concentrations and was not detected in the seep in 2016. During 2016, the seeps were sampled quarterly for VOCs and hydrogen-3. Table 6.4 summarizes the results. VOCs were noted in all three seeps, but levels of VOCs in SP01 and SP02 were very low, most below analytical quantitation limits (less than 1 µg/L). As usual, Seep SP04 showed the highest levels in all four quarters, and it was the only seep that contained tetrachloroethene (PCE) above detection limits. Figure 6.7 contains a series of charts showing annual average concentrations for these three constituents since 1996. The VOCs in SP01 and SP04 increased during 2016 compared to the previous two-three years. These fluctuations are consistent since the seep sampling started in 1996.

The hydrogen-3 concentrations in the seeps have decreased from approximately 2,000 pCi/L when they were first discovered. Since 2006, the hydrogen-3 concentrations have been at or below detection levels. None of the 2016 samples had detectable amounts of hydrogen-3. Therefore, it appears that the remedial actions implemented in the 1990s were effective at preventing any further discharge of hydrogen-3. The samples were also analyzed for cesium-137, but none was detected.

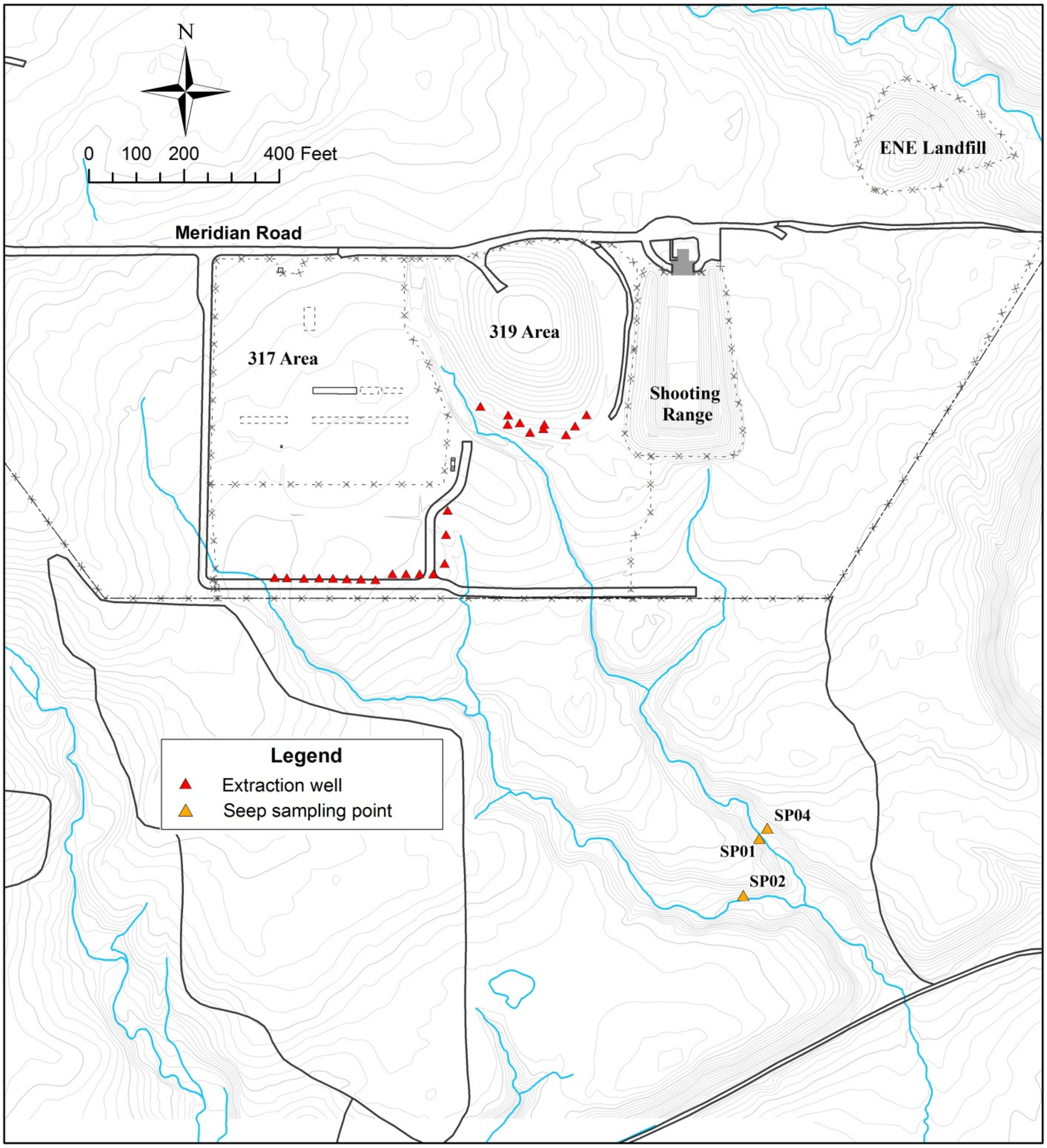


FIGURE 6.6 Seep Locations South of the 317/319 Area

TABLE 6.4

Average Contaminant Concentrations in Offsite Seep Water, 2016

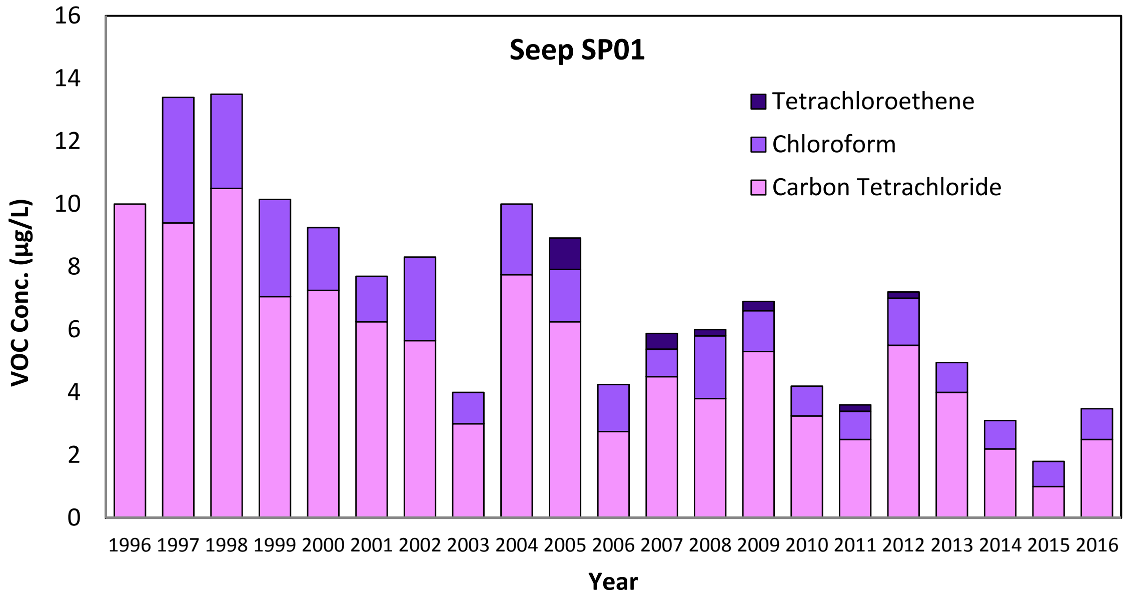
Parameter	Sampling Location: SP01	SP02	SP04	TACO Tier 1 Standard[a]
Volatile Organic Compounds (µg/L)				
1,4 Dioxane	0.8	0.9	<1[b]	7.7
Carbon Tetrachloride	3	0.6	**114**[c]	5
Chloroform	<1	0.7	16	70
Tetrachloroethene	0.8	<1	**5**	5
Toluene	<1	<1	0.8	1,000
Trichloroethene	<1	<1	0.9	5
Radionuclides (pCi/L)				
Hydrogen-3	<100	<100	<100	20,000
Cesium-137	<2	<2	<2	NA[d]

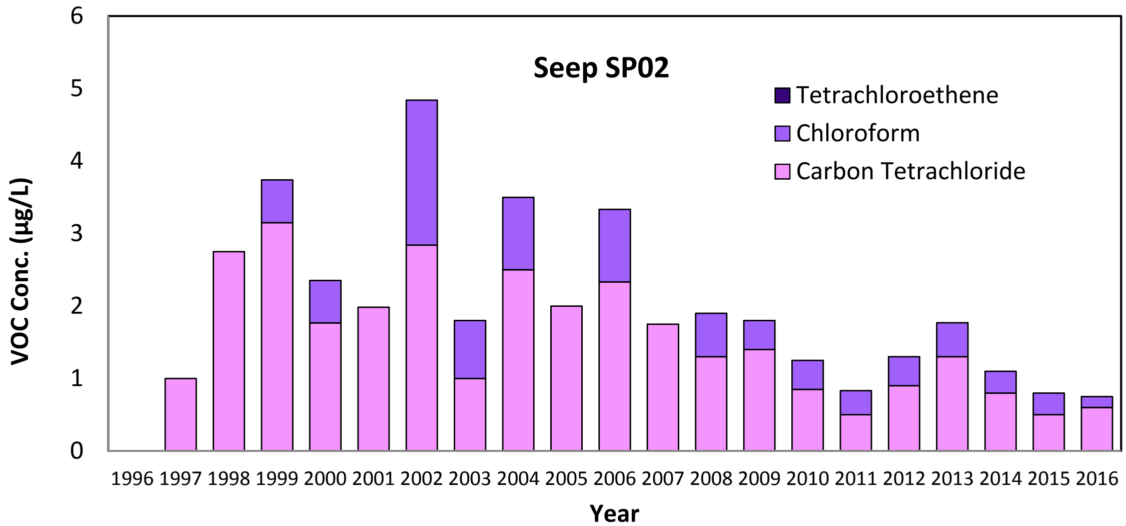
[a] TACO = Tiered Approach to Corrective Action Objectives, Tier 1 standards found in Table E of Appendix B of 35 IAC742 (except radionuclides).

[b] A concentration value shown with a "less than" (<) sign indicates that the constituent was not present above the detection limits of the analytical method. The value shown is the method detection limit.

[c] Bold type indicates that the value exceeds applicable standards.

[d] NA = Not applicable. It indicates no standard exists for this compound.





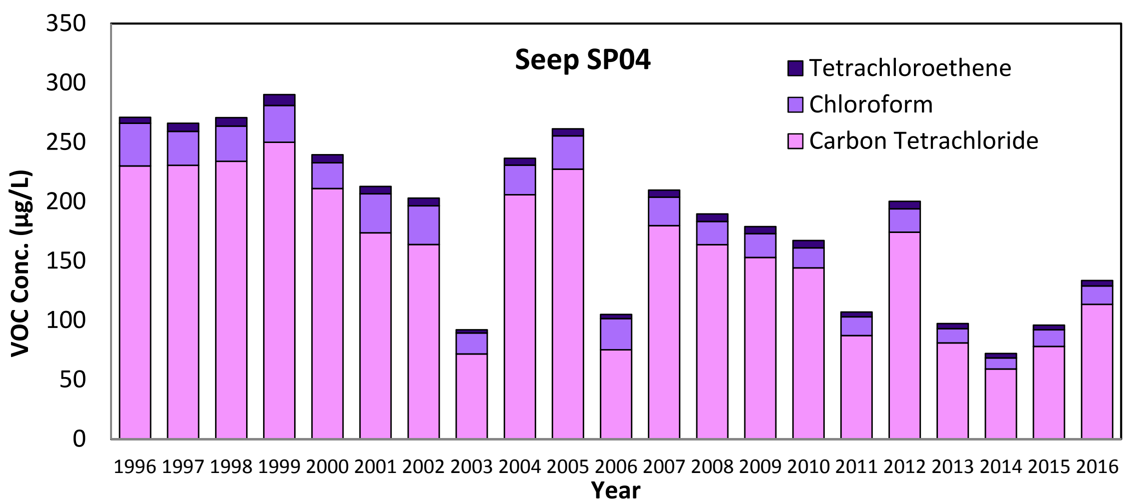


FIGURE 6.7 Groundwater Seeps Annual Average VOC Concentrations since 1996

6.3.3. Monitoring the Groundwater Management Zone

Because of the nature, extent, and depth of contamination and site constraints, it was not feasible to remove all contaminated soil or groundwater from the 317/319 Area. The remedial systems in place are intended to contain residual contamination and slowly reduce contaminant levels until the GROs are attained. The regulatory tool the IEPA utilizes to oversee such a remedial process is a Groundwater Management Zone (GMZ). A GMZ is a three-dimensional region that contains groundwater that exceeds one or more applicable GROs, but is being actively remediated. For a GMZ to be sustained, the groundwater within the GMZ must be managed properly to ensure that cleanup continues until GROs are achieved. A GMZ was approved for this area by the IEPA on November 22, 2000. The GMZ encompasses the 317 Area, the 319 Area, and the area extending down to the seeps.

The boundaries of the GMZ are delineated by a set of nine monitoring wells that are located on the outer boundary of the region of contaminated groundwater, both laterally and vertically. These wells are intended to be in clean groundwater, unaffected by past releases. Figure 6.8 shows the locations of these boundary wells.

Samples from the GMZ wells were collected semiannually. The samples were analyzed for the list of Contaminants of Concern for the 317 and 319 Areas and hydrogen-3. The results of the samples collected in 2016 are shown in Table 6.5. These results indicate that 1,4-dioxane was the only compound in the GMZ wells that was present above GROs and it was elevated only in Well 317951D at a concentration of 14 µg/L. The presence of 1,4-dioxane above the GRO in one of the two deepest GMZ wells indicates that the vertical extent of the contaminated region is not yet defined near this well. In late 2012, a replacement well (317981D) was drilled near and deeper than, existing well 317951D. This well was installed to better delineate the bottom of the contaminated region. Monitoring of this well in 2016 indicated that 1,4-dioxane levels were 6 µg/L, which exceeds the GRO of 1 µg/L. Therefore, the vertical extent of the GMZ is still uncertain.

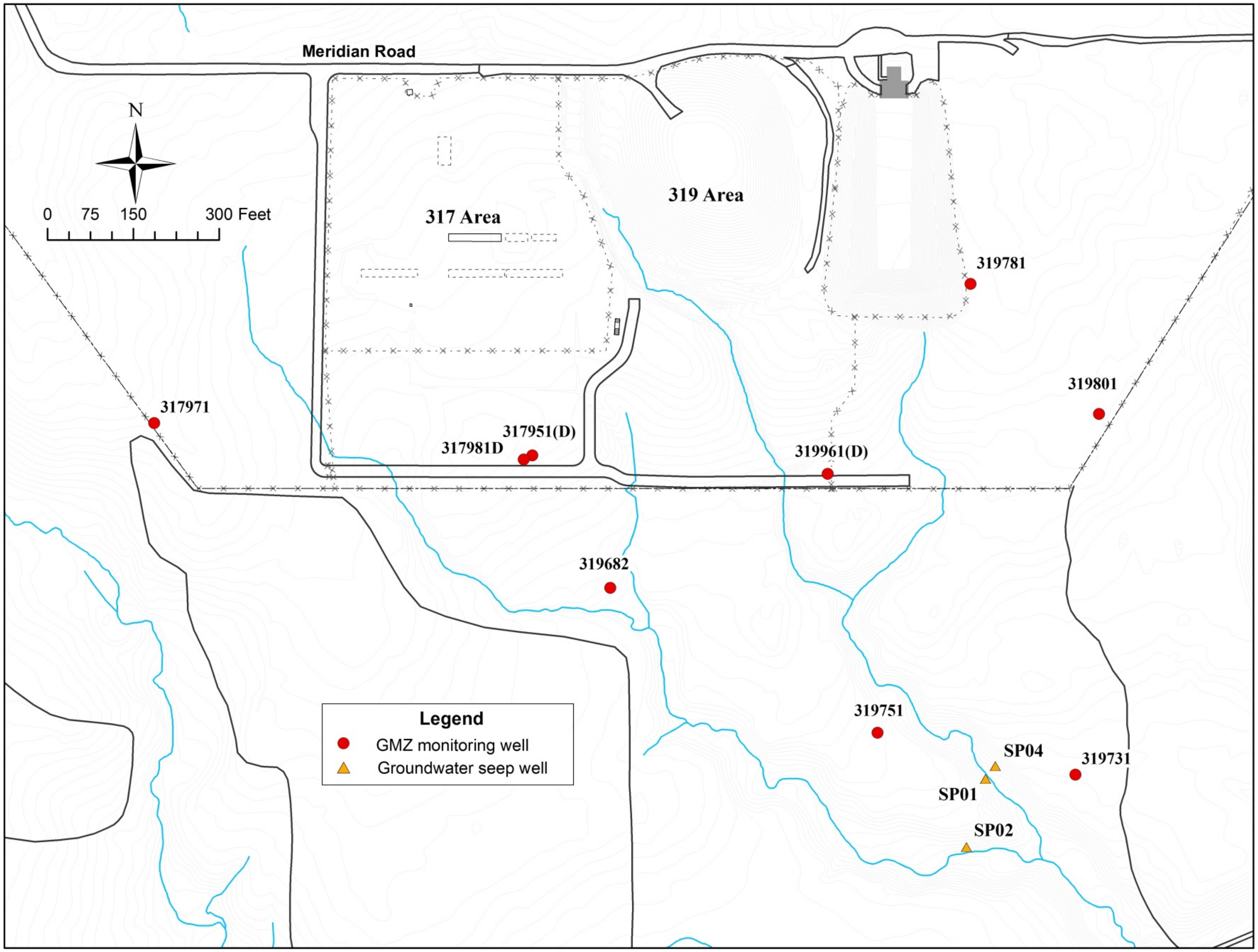


FIGURE 6.8 GMZ Monitoring Wells

TABLE 6.5

Annual Average Results from the GMZ Monitoring Wells, 2016

Parameter	Well No. 317971	319682	319731	319751[a]	GRO
Volatile Organic Compounds (µg/L)					
1,1-Dichloroethane	<1	<1	<1	<1	1400
1,1-Dichloroethene	<1	<1	<1	<1	7
1,1,1-Trichloroethane	<1	<1	<1	<1	200
1,1,2-Trichloroethane	<1	<1	<1	<1	0.5
1,2-Dichloroethane	<1	<1	<1	<1	5
1,4-Dioxane	<1	<1	<1	<1	7
Benzene	<1	<1	<1	<1	5
Carbon Tetrachloride	<1	<1	<1	<1	5
Chloroform	<1	<1	<1	<1	0.2
cis-1,2-Dichloroethene	<1	<1	<1	<1	70
Methylene Chloride	<1	<1	<1	<1	5
Nitrobenzene	<3.5	<3.5	<3.5	<3.5	3.5
Tetrachloroethene	<1	<1	<1	<1	5
Trichloroethene	<1	<1	<1	<1	5
Vinyl Chloride	<2	<2	<2	<2	2
Radionuclides (pCi/L)					
Hydrogen-3	<100	<100	<100	127	20,000

Parameter	Well No. 319781	319801	317951D	317981D	319961D	GRO
Volatile Organic Compounds (µg/L)						
1,1-Dichloroethane	<1	<1	3	0.3	<1	1400
1,1-Dichloroethene	<1	<1	<1	<1	<1	7
1,1,1-Trichloroethane	<1	<1	<1	<1	<1	200
1,1,2-Trichloroethane	<1	<1	<1	<1	<1	0.5
1,2-Dichloroethane	<1	<1	<1	<1	<1	5
1,4-Dioxane	<1	**2**[b]	**14**	**6**	1	1
Benzene	<1	<1	<1	<1	<1	5
Carbon Tetrachloride	<1	<1	<1	<1	<1	5
Chloroform	<1	<1	<1	<1	<1	0.2
cis-1,2-Dichloroethene	<1	<1	<1	<1	<1	70
Methylene Chloride	<1	<1	<1	<1	<1	5
Nitrobenzene	<3.5	<3.5	<3.5	<3.5	<3.5	3.5
Tetrachloroethene	<1	<1	<1	<1	<1	5
Trichloroethene	<1	<1	<1	<1	<1	5
Vinyl Chloride	<2	<2	<2	<2	<2	2
Radionuclides (pCi/L)						
Hydrogen-3	<100	<100	<100	<100	579	20,000

[a] This well was dry the fourth quarter of 2016, thus only one sample was collected in 2016.

[b] Bold type indicates that the value exceeds the GRO.

6.3.4. Supplementary Groundwater Surveillance at the 317/319 Area

In addition to the groundwater monitoring required by the RCRA permit, Argonne has conducted additional groundwater surveillance monitoring in and around the 317 and 319 Areas since the 1980s. This monitoring was started before the remedial actions were begun. The current groundwater surveillance monitoring well network in this area is shown in Figure 6.9. Wells 317101 and 317111 are upgradient of the 317 Area and Well 319011 is upgradient of the 319 Area Landfill. These serve as background reference wells for the downgradient wells.

The surveillance wells are analyzed for a more extensive list of analytes than the LTS wells. With one exception, Well 317021, the wells are not located in the contaminated groundwater plume associated with the 317/319 Area, and thus, the contaminants and concentrations are not representative of the degree of groundwater contamination in other parts of the 317/319 Area.

To determine if groundwater quality at these locations has been impacted, the analytical results were compared to the Class I GQS. The 2016 average results of the filtered chloride and soluble metals analyses, as well as the radionuclides cesium-137, hydrogen-3, and strontium-90, are summarized in Table 6.6. The average results for those VOCs that were detected in at least one of the quarterly samples are shown in Table 6.7. All of the wells were analyzed once per year for SVOCs, PCBs, and pesticides; however, none of the samples had detectable amounts of any of these compounds. To simplify the tables, these results are not shown.

Well 317101 had chloride levels that exceeded the GQS. This is thought to be related to its proximity to the road, where the road salt is used in the winter. The wells with the highest chloride concentrations are all located adjacent to the road. Five of the wells had detectable amounts of metals during 2016. Cadmium was detected in three wells at concentrations just above the detection limits. Manganese was found in Wells 317052 and 317941. Nickel was found in Wells 317061R and 317941 with the nickel concentration exceeding the GQS in Well 317941 above the GQS.

Hydrogen-3 was detected in four of the wells; however, all amounts were far below the GQS of 20,000 pCi/L. The highest concentration was found in 319961D, which is downgradient of the 319 landfill. A small amount of strontium-90 was found in 317941, the well closest to a series of demolished radioactive waste storage vaults. No cesium-137 was found in any of the wells.

The only organic chemicals detected were several VOCs shown in Table 6.7. The compounds found were the same as those found in the 317 Area remediation site; however, the concentrations found were much lower than many of the wells associated with that site. The only compound that exceeded the GQS was 1,4-dioxane in three wells, including one of two dolomite wells. The presence of 1,4-dioxane in several of the surveillance wells is a result of the characteristics of this compound, which is highly soluble in water and moves easily through the soil. It often appears on the outer edge of plumes.

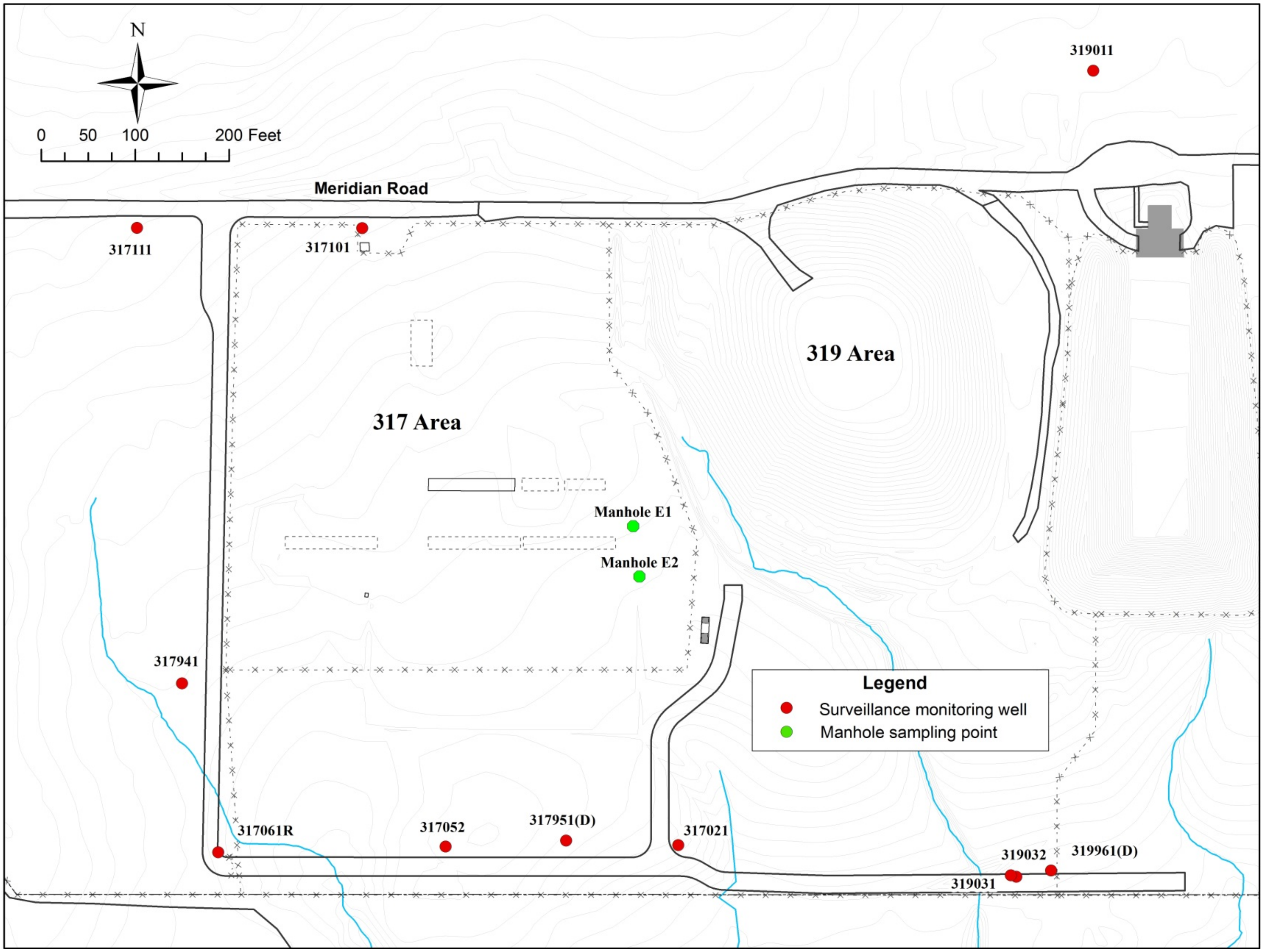


FIGURE 6.9 Groundwater Surveillance Sampling Locations in the 317/319 Area

TABLE 6.6

Annual Average Results from the 317/319 Surveillance Wells, 2016

		Upgradient Background Wells			Downgradient Wells							
Parameter	GQS	317101	317111	319011	317021	319031[b]	319032	317052	317061R	317941	317951D	319961D
Filtered Chloride (mg/L)	200	**288**[a]	144	38	26	14	7	10	77	139	71	65
Filtered Metals (mg/L)												
Arsenic	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Barium	2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Beryllium	0.004	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Cadmium	0.005	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	0.0026	<0.0025	0.0025	0.003
Chromium	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt	1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Copper	0.65	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Iron	5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	0.0075	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Manganese	0.15	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	0.091	<0.075	0.10	<0.075	<0.075
Mercury	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.09	**0.11**	<0.05	<0.05
Silver	0.05	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Thallium	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium	NA[c]	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Zinc	5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Radionuclides (pCi/L)												
Cesium-137	NA	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Hydrogen-3	20,000	<100	<100	<100	<100	127	<100	<100	<100	164	107	675
Strontium-90	8	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.54	<0.25	<0.25

[a] Bold type indicates that the value exceeds applicable standards.

[b] Well 319031 was dry during the fourth quarter of 2016.

[c] NA = Not applicable.

TABLE 6.7

Annual Average VOC Results from the 317/319 Surveillance Wells, 2016

		Upgradient Background Wells			Downgradient Wells							
Parameter	GQS	317101	317111	319011	317021	319031	319032	317052	317061R	317941	317951D	319961D
VOCs Detected (µg/L)												
1,1-Dichloroethane	700	–[a]	–	–	–	–	1.5	–	–	3.0	2.6	–
1,1,1-Trichloroethane	200	–	–	–	0.4	1.0	0.9	–	–	–	1.0	0.3
1,2-Dichloroethane	NA	–	–	–	–	–	0.3	–	–	–	–	–
1,4-Dioxane	1	–	–	–	–	**11**[b]	**24**	–	–	–	**20**	–
2-Butanone		–	–	–	–	–	–	–	10	6	–	–
Acetone[c]	6,300	–	–	–	–	–	–	–	7	21	–	–
Carbon Tetrachloride	5	–	–	–	–	–	–	–	–	–	–	0.3
Chloroethane	NA	–	–	–	–	–	–	–	–	0.2	–	–
cis-1,2-Dichloroethene	70	–	–	–	–	–	–	–	0.3	26	–	1.8
Tetrahydrofuran[c]	NA	–	–	4	–	–	–	–	4	–	–	–
trans-1,2-Dichloroethene	100	–	–	–	–	–	–	–	–	1.0	–	–
Trichloroethene	5	–	–	–	–	1.7	–	–	–	–	–	0.4
Trichlorofluoromethane	NA	–	–	–	–	0.3	0.2	–	–	–	0.2	–
Vinyl Chloride	2	–	–	–	–	–	–	–	0.5	1.0	–	–

[a] A dash indicates this compound was not detected in any of the samples from this well during 2016.

[b] Bold font indicates this average result exceeded the GQS for this compound.

[c] These two compounds are likely to be laboratory artifacts. They are not consistently present in the samples.

In general, the number of compounds detected and their concentrations were comparable to, or lower than, the previous years' results. Figure 6.10 shows the 1,1,1-trichloroethane and 1,1-dichloroethane (DCA) concentrations in Well 317021 since 1988, a period that spans all of the remediation activities completed in this area. The levels were low and relatively consistent until 1991, at which time the concentrations increased. During 1995 a rapid decrease in concentrations began. This period includes the time when active remediation of the 317/319 Area was underway. The remedial actions, completed in 1999, may be responsible for the rapid decrease in VOC concentrations in this well. Since 1999, only very low residual amounts of VOCs have been present.

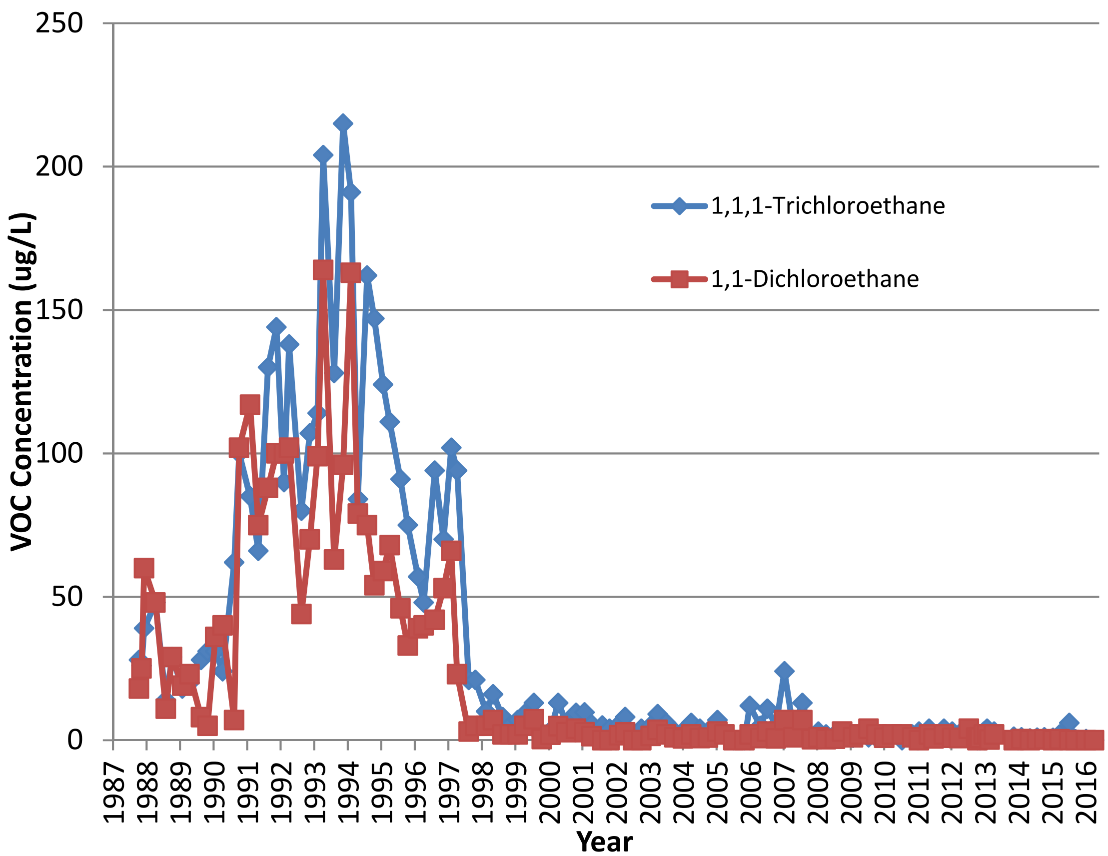


FIGURE 6.10 VOC Concentrations in Well 317021 since 1988

6.3.5. 317 Area Manhole Sampling

In addition to the wells in this area, two manholes associated with the waste storage vault footing drain system are monitored monthly. Figure 6.9 shows the location of these two manholes. This system conveys water from an interior drain in the North Vault and footing drains around several of the now-demolished vaults (the footing drains were left in place after the vaults were demolished), through Manhole E1, and on to Manhole E2. A pump located in Manhole E2 pumps the water to the on-site LWTP. It is treated and discharged into Sawmill

Creek. Since 1997, water collected by the 317 and 319 leachate and groundwater collection systems has also been discharged to Manhole E2, from where it is pumped to the treatment plant. Thus, the water in these manholes — particularly Manhole E2 — is a mixture of groundwater from footing drains around the vaults in the 317 Area, leachate and groundwater from the 319 Area Landfill, and groundwater from the 317 Area groundwater collection system. Monitoring contaminant concentrations in these manholes provides additional information about the progress of remedial actions in the 317 French Drain Area, as well as contaminants discharged to the LWTP.

Manholes E1 and E2 were sampled monthly and analyzed for VOCs and hydrogen-3. The results for 2016 are summarized in Table 6.8. Some of the VOC concentrations in Manhole E1 were higher than in Manhole E2 and some were lower. The different concentrations are due to the fact that groundwater from the 319 and 317 Area groundwater extraction systems is mixed with footing drain water in Manhole E2, changing the composition of water in this manhole. The VOC concentrations found during 2016 were similar to the last few years.

TABLE 6.8

Annual Average VOC Results from the 317/319 Manholes, 2016

	Manhole E1	Manhole E2
VOCs (µg/L)		
1,1 Dichloroethane	2.4	73
1,1 Dichloroethene	0.2	0.5
1,1,1 Trichloroethane	1.5	13
1,1,2,2 Tetrachloroethane	0.7	<1
1,2 Dichloroethane	0.23	1.7
1,4 Dioxane	9	10
Benzene	0.3	<1
Carbon Tetrachloride	327	25
Chloroethane	<5	0.8
Chloroform	248	24
cis 1,2 Dichloroethene	12	7
Dichlorofluoromethane	0.6	ND[a]
Ethyl Ether	0.6	ND
Methylene Chloride	0.3	<1
Naphthalene	0.2	<1
Tetrachloroethene	26	8
trans 1,2 Dichloroethene	1.2	0.4
Trichloroethene	83	14
Trichlorofluoromethane	0.5	<1
Vinyl Chloride	0.9	0.6
Radionuclides (pCi/L)		
Cesium-137	<2	<2
Hydrogen-3	124	117

[a] ND = Not detected.

Hydrogen-3 was detected in most of the samples; however, all of the results are below the GQS of 20,000 pCi/L. The hydrogen-3 concentrations in 2016 were much lower than previous years. Cesium-137 was not found in any of the samples.

6.4. ENE Landfill Groundwater Monitoring

The ENE Landfill was used in the early years of the site for the disposal of demolition debris, discarded equipment, and other items. In 2001, the waste material was consolidated and a clay cap was constructed over the waste mound. In April 2003, the IEPA issued a RCRA corrective action determination covering post-closure care and groundwater monitoring for the ENE Landfill. As required by the IEPA, monitoring at the ENE Landfill is being conducted twice per year throughout the 15-year post-closure care period, which started in December 2002.

Seven monitoring wells are currently used to collect groundwater samples from near the landfill. Figure 6.11 shows the well locations. The purpose of groundwater monitoring at the ENE Landfill is to verify that contaminants found in the landfill contents, including metals and the PCB Aroclor 1254, which were all above their respective Tier 1 soil remediation objectives, are not migrating to shallow groundwater. Hydrogen-3 is also monitored at this location.

Parameters analyzed twice in 2016 included total PCBs and five soluble (filtered) metals (arsenic, chromium, lead, manganese, and nickel). The same metals are analyzed once per year in unfiltered samples. Some of the wells are equipped with low flow samplers to reduce the impact of suspended sediment in the samples and to produce a more representative groundwater sample. Samples are collected using these samplers whenever possible; however, typically, groundwater levels are too low or site conditions are too poor to allow this type of sampler to be used. In such a situation, the pump is removed from the well and the sample is collected by hand with a bailer. In these instances, the amount of silt in the sample is much higher, which results in elevated levels of total metals. During 2016, only well ENE051 had sufficient water to use the low flow sampling pump.

The 2016 results from this program are summarized in Table 6.9. In this table, the two semiannual filtered metals results are averaged. As shown in Table 6.9, the GQSs for total arsenic, chromium, lead, and manganese, were exceeded in three of the seven wells sampled. Well ENE041 had total (unfiltered) arsenic, lead, and manganese concentrations higher than the standard, probably because of a large amount of silt in this sample. Except for this one sample, the highest unfiltered metals levels were found in the upgradient wells ENE061 and ENE071, indicating that the elevated concentrations of metals are of natural origin and are not related to the landfill. Except for one manganese result, which exceeded the GQS, the filtered samples from these wells did not contain detectable metals, indicating the elevated concentrations in the unfiltered samples were primarily the result of suspended sediment in the sample. No PCBs were detected in any of the wells. Hydrogen-3 was detected in one well at concentrations only slightly above the detection limit of 100 pCi/L.

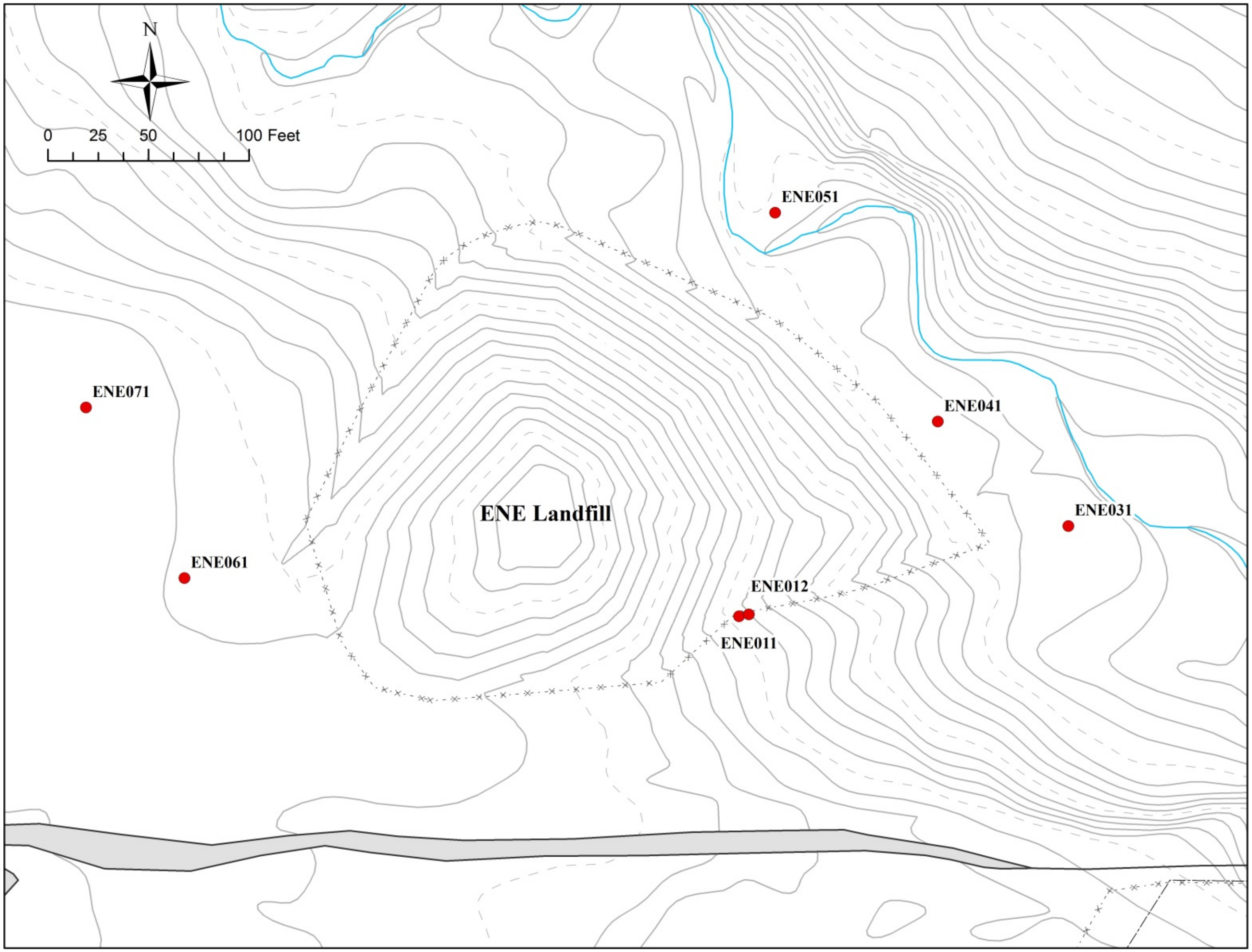


FIGURE 6.11 ENE Area Groundwater Monitoring Wells

TABLE 6.9

Annual Average Concentrations of ENE Landfill Groundwater Constituents, 2016

	Well No.							
Parameter[a]	ENE011	ENE012	ENE031	ENE041	ENE051[b]	ENE061[c]	ENE071[c]	Standard
Unfiltered Metals (mg/L)								
Arsenic	<0.025	<0.025	**0.30**[d]	**0.41**	<0.025	**0.076**	0.035	0.05
Chromium	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	0.1
Lead	<0.004	<0.004	**0.031**	**0.019**	<0.004	**0.019**	**0.021**	0.0075
Manganese	<0.075	<0.075	**1.60**	**2.07**	0.078	**0.82**	**0.49**	0.15
Nickel	<0.05	<0.05	<0.05	0.054	<0.05	0.056	<0.05	0.1
Filtered Metals (mg/L)								
Arsenic	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.05
Chromium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Lead	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.0075
Manganese	<0.075	<0.075	**0.18**	<0.075	<0.075	<0.075	0.093	0.15
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
PCB–total (µg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1
Hydrogen-3 (pCi/L)	<100	<100	104	<100	<100	<100	<100	20,000

[a] Concentrations in mg/L except where noted otherwise.

[b] Well ENE-051 was sampled using low-flow purging techniques. All other wells were sampled by using a bailer.

[c] Wells ENE-061 and ENE-071 are upgradient, background wells.

[d] Bold type indicates that the value exceeds the GRO.

6.5. 800 Area Sanitary Landfill Monitoring

The former 800 Area sanitary landfill is located on the western edge of the site (see Figure 1.1). The 8.8-ha (21.8-acre) landfill received solid waste from 1966 until September 1992 and was operated under IEPA Permit No. 1981-29-OP, which was issued in 1981. The landfill received general refuse, construction debris, boiler house ash, and other nonradioactive solid waste. The landfill was also used for the disposal of approximately 109,000 L (29,000 gal) of liquid waste consisting of used oil or used machining coolant (an oil-water emulsion), though small quantities of chemical wastes that would be considered hazardous waste by current regulations were also placed in the landfill.

The landfill was closed in 1992, in accordance with the closure plan established under the operating permit. Closure included the installation of a 0.6-m (2-ft) thick compacted clay cap over the waste mound. A RFI was conducted in 1997 under the RCRA Corrective Action Program to determine if any hazardous materials had migrated from the landfill. Measurable amounts of several hazardous materials were identified in leachate in the waste mound. The most common contaminants in the landfill were PCBs and pesticides (Aroclor 1260, DDE, and DDT), several VOCs (toluene, acetone, and methylene chloride), and SVOCs (several phthalates). The VOCs and SVOCs were thought be laboratory artifacts and likely not actually present in the waste. None of these compounds was found in groundwater near the landfill during the RFI. A No Further Action (NFA) determination was received from the IEPA in 2003. This letter specified that post-closure groundwater monitoring activities would be carried out for the 15-year post-closure care period, which began in 1999. This section discusses the groundwater monitoring results for 2016.

The 15-year post-closure care period was completed in September 2014. As required by the IEPA, a report was prepared that summarized the monitoring results throughout the 15-year period and assessed the results in relation to GQS and background concentrations. The report was submitted to the IEPA in January of 2015. The report concluded that exceedances of GQS occurred throughout the 15-year post-closure care period, although the causes of the exceedances were not known and additional monitoring is needed. Thus, a request was made to extend the post-closure care monitoring period for an additional 10 years. Several changes to the monitoring program were also requested based on the past monitoring results. As of the writing of this report, there had not yet been a response from the IEPA. Until a response is received, the monitoring and post closure care practices currently in place will continue.

The current monitoring well network is shown in Figure 6.12. The network consists of two types of wells. Fifteen shallow wells are screened in glacial till between 4 and 14 m (13 and 46 ft) deep. These wells have well screens situated in porous sandy zones within the glacial till. They provide samples of the uppermost layers of groundwater adjacent to the landfill. Six deep wells are screened in the top of the dolomite limestone bedrock underlying the glacial till. Five of these wells are situated near five of the shallow wells, forming five well clusters. Two wells are considered background wells (Wells 800271 and 800273D) and they are located approximately 670 m (2,200 ft) to the northeast of the landfill mound. These wells are out of the influence of the landfill and provide information on the background level of groundwater constituents.

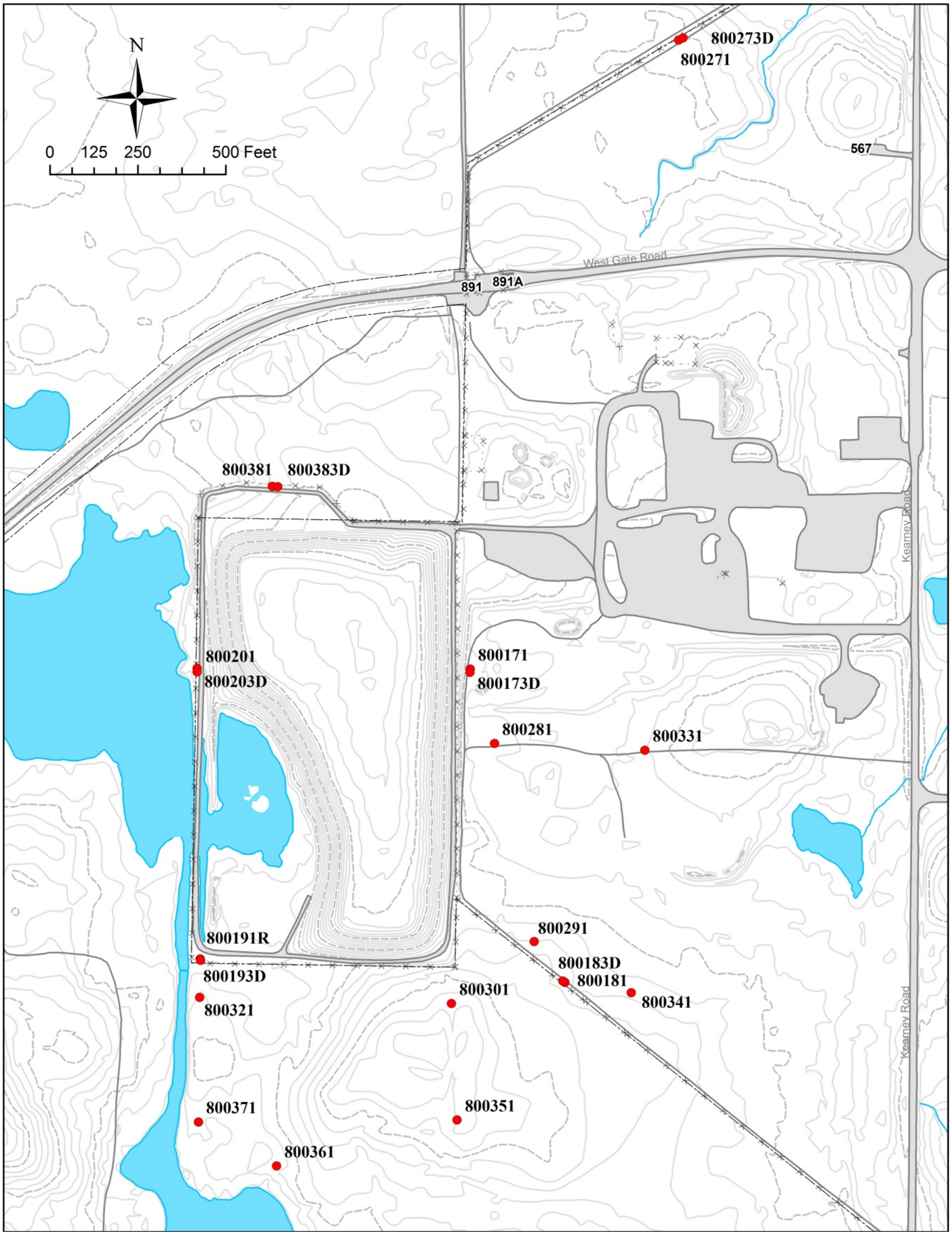


FIGURE 6.12 800 Area Landfill Groundwater Monitoring Wells

Since 2009, all shallow wells have utilized low-flow pumps for purging and sample collection. These pumps improve the quality and representativeness of the samples recovered from these wells since they do not disturb the sediment in the wells during sampling. A bailer agitates the water in the well which disturbs sediment, resulting in silty samples and elevated values of some metals. Samples from the dolomite wells are collected by using an electronic submersible pump. These wells are screened in fractured rock that does not produce as much sediment as the glacial drift does. Thus, low-flow pumps are not necessary in these wells.

Each well is sampled quarterly for permit-required parameters. During the first, third, and fourth quarters, only the List 1 (field parameters of groundwater depth, pH, specific conductivity, and temperature) and List 2 constituents (filtered metals, sulfate, chloride, TDS, cyanide, phenols, total organic carbon [TOC], and total organic halogens [TOX]) are measured. During the second quarter, additional samples are collected and analyzed for List 3 and 3A parameters (unfiltered metals and certain VOCs, SVOCs, PCBs, pesticides, and herbicides). In addition to the required annual analyses, VOCs and hydrogen-3 are monitored voluntarily by Argonne during all quarters to provide better documentation of conditions under the landfill.

6.5.1. Basis for Evaluation of Analytical Results

In 2005, the IEPA approved a set of background concentrations for groundwater constituents monitored at the landfill. The background values were developed from five years of monitoring results from the two upgradient monitoring wells, Well 800271 in the shallow glacial drift, and Well 800273D in the dolomite bedrock. The quarterly monitoring results are evaluated by comparing the results with either the IEPA-approved background values or the GQS for each constituent, where such limits exist. For routine indicator parameters (Lists 1 and 2), the permit requires the comparison of the individual results with background values. For unfiltered metals and organic constituents, the results are compared with the GQSs for Class I Potable Resource Groundwater (35 IAC Part 620.410), where such standards exist. Where GQS values do not exist, the results are compared with two times the practical quantitation limit for that compound, as listed in the permit. Table 6.10 lists the applicable permit limits for the 800 Area Landfill. Footnotes to this table explain the source of the individual groundwater quality limits. To simplify the table, the limits for the long list of organics (two times PQL) are not shown. In the data tables that follow, values that exceed applicable limits are shown in bold print.

TABLE 6.10

Permit Limits for 800 Area Landfill Groundwater

Parameter	Unit	Permit Limit — Shallow Wells	Source[a]	Permit Limit — Deep Wells	Source[a]
Field Parameters					
Conductivity	µS/cm	703	4	1,306	1
pH	pH	6.57–7.88	1	6.48–7.74	1
Filtered Samples					
Ammonia nitrogen	mg/L	0.90	4	1.0	4
Chloride	mg/L	20	4	140	1
Sulfate	mg/L	58	1	150	1
TDS	mg/L	428	1	880	1
Arsenic	mg/L	0.010	2	0.0048	4
Cadmium	mg/L	0.001	2	0.001	2
Iron	mg/L	0.099	4	1.60	1
Lead	mg/L	0.01	2	0.01	2
Manganese	mg/L	0.097	4	0.021	4
Mercury	mg/L	0.002	2	0.002	2
Unfiltered Samples					
Chloride	mg/L	200	3	200	3
Cyanide (total)	mg/L	0.011	4	0.04	2
Fluoride	mg/L	4.0	3	4.0	3
Nitrate	mg/L	10.0	3	10.0	3
Phenols	mg/L	0.033	4	0.033	4
Sulfate	mg/L	400	3	400	3
TOC	mg/L	2.71	5	5.3	4
TOX	mg/L	0.086	4	0.041	4
Arsenic	mg/L	0.05	3	0.05	3
Barium	mg/L	2.0	3	2.00	3
Boron	mg/L	2.0	3	2.00	3
Cadmium	mg/L	0.005	3	0.005	3
Chromium	mg/L	0.10	3	0.10	3
Cobalt	mg/L	1.0	3	1.00	3
Copper	mg/L	0.65	3	0.65	3
Iron	mg/L	5.0	3	5.0	3
Lead	mg/L	0.008	3	0.008	3
Manganese	mg/L	0.15	3	0.15	3
Mercury	mg/L	0.002	3	0.002	3
Nickel	mg/L	0.10	3	0.10	3
Selenium	mg/L	0.05	3	0.05	3
Silver	mg/L	0.05	3	0.05	3
Zinc	mg/L	5.0	3	5.0	3

[a] The various permit limits were generated in the following manner:

1 = Calculated from 95% upper confidence interval of the data set. Calculation used one-half the detection limits for values less than the detection limits.

2 = Background values equal the PQL. All measured values in background wells were below PQLs.

3 = IEPA's Class I Groundwater Quality Standard.

4 = Background value based on nonparametric statistical methods for data sets with more than 15%, but less than 100% of measured values below detection limits.

5 = Calculated from 95% upper confidence interval for data set that was first transformed by calculating the natural log of the measured values.

6.5.2. Results of Analyses — Shallow Wells

Field parameters and the results of chemical and radiological analyses for the shallow wells are summarized in Table 6.11. This table lists the average of the quarterly results that were above detection limits. It also lists the individual results for those parameters that were analyzed only once during 2016. Only results for constituents that were above detection limits in one or more samples during 2016 are shown. Other metals were analyzed, but not detected above their respective detection limits in any of the samples, and these results are not shown. None of the VOCs, SVOCs, PCBs, and pesticides was detected. To simplify the data tables, results for these constituents are not shown.

The monitoring results for the shallow wells in the 800 Area Landfill during 2016 were similar to the previous years' results. Many of the downgradient wells exhibited levels of dissolved inorganic matter (expressed by conductivity, TDS, sulfate, and chloride concentrations) higher than the background values. These elevated parameters are thought to result from the proximity of the downgradient wells to roadways and parking areas that are salted in the winter. It is thought that the salt in road runoff has migrated to the shallow wells, increasing the concentration of salts in the groundwater which results in elevated readings for these parameters. The background wells are far from roadways or paved areas and no roadway runoff passes near these wells; thus, these parameters are much lower in the background wells than the wells near the developed areas around the landfill.

In addition to the dissolved salts, several naturally-occurring metals were found to be present above the background levels. Soluble iron and manganese were found to be higher than background values in several of the wells. These elevated levels are thought to result from the natural variation in soil composition around the landfill as well as from the influence of the nearby wetland area, immediately west of the landfill. The organic matter in the wetland soil generates acidic water which can solubilize naturally occurring metals, increasing their concentrations in groundwater. Most of the wells with elevated levels of metals are near this wetland area. These wells also exhibited higher than the background level of total organic carbon (TOC), and one of these wells (800201) was also elevated in ammonia, which may also be related to the presence of the wetland. Total metals results (from unfiltered samples) exceeded the GQS for manganese in two wells, lead in one well, iron in one well, and cyanide in one well.

One well exhibited pH values that were slightly lower than the lower range of background values of pH. This is thought to result from natural variation in soil composition. No hydrogen-3 was detected above the detection limit of 100 pCi/L during 2016.

TABLE 6.11

Annual Average Concentrations of 800 Area Landfill Shallow Groundwater Constituents, 2016

Parameter	Limit[a]	800171	800181	800191	800201	800271[b]	800281	800291	800301
Field Parameters									
Conductivity (µS/cm)	703	**928**	**1,091**	**1,580**	**1,183**	580	**1,146**	**1,186**	**1,050**
pH	6.56–7.88	6.63 - 6.76	7.15 - 7.47	**6.52** - 6.62	6.66 - 6.88	6.90 - 7.16	6.72 - 6.81	6.93 - 7.05	6.76 – 7.08
Filtered Samples (mg/L)[c]									
Ammonia Nitrogen	0.90	0.43	<0.1	<0.1	**3.47**	<0.1	<0.1	0.12	0.19
Chloride	20	6	13	**47**	**22**	3	**66**	15	8
Sulfate	59	49	**78**	**203**	**82**	9	**115**	**170**	**148**
TDS	428	**556**	**639**	**891**	**778**	341	**700**	**732**	**674**
Arsenic	0.010	<0.003	0.006	<0.003	0.005	<0.003	<0.003	<0.003	<0.003
Iron	0.099	<0.021	<0.021	**0.14**	**4.08**	<0.021	0.064	**0.165**	**0.714**
Manganese	0.097	<0.01	0.040	**0.28**	**0.19**	<0.01	**0.27**	**0.64**	**0.12**
Unfiltered Samples (mg/L)[c]									
Cyanide	0.01	<0.01	<0.01	<0.01	**0.02**	**0.02**	<0.01	<0.01	<0.01
Phenols (total)	0.033	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.005
TOCs	2.71	2.1	1.9	**5.0**	**28.5**	1.3	3.5	2.1	1.4
TOXs	0.086	<0.020	0.023	0.056	0.026	<0.020	0.077	0.028	0.025
Fluoride	4.00	0.03	0.34	0.45	0.31	<0.01	0.23	0.42	0.38
Chloride	200	7	13	62	17	3	75	13	7
Sulfate	400	46	89	320	89	7	147	156	158
Nitrate	10	3.7	<0.1	<0.1	0.30	9.1	<0.1	<0.1	<0.1
Arsenic	0.05	<0.003	<0.003	<0.003	0.008	<0.003	<0.003	<0.003	<0.003
Barium	2	0.056	0.038	0.032	0.29	0.013	0.047	0.018	0.020
Boron	2	0.10	<0.10	<0.10	<0.10	<0.10	0.16	<0.10	<0.10
Copper	0.65	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Iron	5	0.110	<0.021	0.46	**5.04**	<0.021	<0.021	0.060	0.33
Lead	0.0075	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Manganese	0.15	<0.01	0.01	**0.28**	**0.20**	<0.01	0.02	0.04	0.08
Hydrogen-3 (pCi/L)	20,000	<100	<100	<100	<100	<100	<100	<100	<100

TABLE 6.11 (Cont.)

Annual Average Concentrations of 800 Area Landfill Shallow Groundwater Constituents, 2016

Parameter	Limit[a]	800321	800331	800341	800351	800361	800371	800381
Field Parameters								
Conductivity (µS/cm)	703	**2,628**	**877**	**982**	**960**	**934**	**893**	**1,368**
pH	6.56–7.88	**6.48** - 6.57	6.97 - 7.18	6.97 - 7.02	6.88 - 7.02	6.65 - 7.21	6.90 – 6.98	6.58 - 6.70
Filtered Samples (mg/L)[c]								
Ammonia Nitrogen	0.90	0.23	<0.1	0.11	0.29	0.16	0.29	<0.1
Chloride	20	15	7	11	4	16	4	8
Sulfate	59	**625**	**90**	**107**	53	**148**	**100**	**292**
TDS	428	**1,456**	**522**	**601**	**581**	**632**	**577**	**1003**
Arsenic	0.010	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003
Iron	0.099	<0.021	<0.021	0.062	**4.420**	<0.021	0.073	<0.021
Manganese	0.097	0.015	<0.01	0.043	0.021	0.039	**0.098**	**0.108**
Unfiltered Samples (mg/L)[c]								
Cyanide	0.01	<0.01	**0.02**	<0.01	<0.01	<0.01	<0.01	<0.01
Phenols (total)	0.033	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TOC	2.71	1.9	1.3	1.9	1.9	2.3	1.4	**3.1**
TOXs	0.086	0.034	0.021	0.037	0.024	0.028	<0.020	0.022
Fluoride	4.0	0.44	0.37	0.32	0.30	0.10	0.44	0.38
Chloride	200	12	6	11	4	18	3	9
Sulfate	400	340	90	118	60	149	109	275
Nitrate	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5
Arsenic	0.05	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003
Barium	2	0.015	0.034	0.030	0.100	0.034	0.036	0.027
Boron	2	<0.10	<0.10	<0.10	<0.10	<0.10	0.11	<0.10
Copper	0.65	<0.025	<0.025	0.080	<0.025	<0.025	<0.025	<0.025
Iron	5	<0.021	0.130	0.061	3.93	<0.021	0.34	<0.021
Lead	0.0075	<0.004	<0.004	**0.008**	<0.004	<0.004	<0.004	<0.004
Manganese	0.15	<0.01	<0.01	0.02	0.014	0.030	0.08	0.07
Hydrogen-3 (pCi/L)	20,000	<100	<100	<100	<100	<100	<100	<100

[a] Refer to Table 6.10 for an explanation of groundwater quality limits for the 800 Area Landfill.

[b] Background well.

[c] In addition to the parameters shown, these samples were also analyzed for cadmium, chromium, cobalt, mercury, nickel, selenium, silver, and zinc but none of the samples contained these elements above their detection limits.

[d] Bold type indicates that the value exceeds the GRO.

6.5.3. Results of Analyses — Bedrock Monitoring Wells

The average 2016 results for the deep wells are shown in Table 6.12. No VOCs, SVOCs, or PCBs/pesticides were found in any of the samples above analytical detection limits, so these results are not shown. Several other metals, in addition to those parameters shown, were analyzed but none was detected. These results are not shown.

The amount of dissolved salts in the deep wells was much lower than in the shallow wells. The lower dissolved salt concentrations may be a result of the greater depth of these wells, which reduces the impact of salt in road runoff. However, several of the wells contained conductivity, chloride, or TDS values above the background limit. Three of the chloride results exceeded the Class I groundwater quality standards. One well had elevated ammonia levels. Four of the downgradient wells had soluble manganese concentrations higher than background levels. All six wells, including the background well, exhibited low, but above-background levels of TOX. Hydrogen-3 was not detected above the detection limits in any of the deep wells.

Groundwater monitoring results indicate that there is no evidence of the release of toxic chemicals or radioactive materials from the landfill. The parameters that are elevated are likely not related to releases from the landfill, but are caused by natural or unrelated man-made factors such as road salt in roadway runoff.

6.6. CP-5 Reactor Area Monitoring

In addition to the required sampling of former waste sites, Argonne is voluntarily monitoring the condition of groundwater near the site of the former CP-5 reactor. The CP-5 reactor was a five megawatt research reactor that was used from 1954 until operations ceased in 1979. Decontamination of the interior of the structure, an investigation of the area surrounding the reactor, and corrective actions were completed by 2002. The IEPA issued a notice of NFA in 2003. In 2011, the final decontamination and demolition of the CP-5 structure was completed with the removal of all of the remaining structures above and below the ground.

TABLE 6.12

Annual Average Concentrations of 800 Area Landfill Dolomite Bedrock Groundwater Constituents, 2016

Parameter	Limit[a]	800173D	800183D	800193D	800203D	800273D[b]	800383D
		G06D	G08D	G11D	G14D	G16D	G03D
Field Parameters							
Conductivity (µS/cm)	1,306	1,073	1,264	**1,692**	1,215	1,049	**1,389**
pH	6.48–7.74	6.97 - 7.02	6.92 - 7.05	6.88 – 6.97	6.89 – 7.01	6.75 – 6.96	6.91 - 7.17
Filtered Samples (mg/L)[c]							
Ammonia Nitrogen	1.0	0.56	0.82	0.83	**2.03**	0.52	0.48
Chloride	137	65	**143**	**343**	134	28	**245**
Sulfate	154	94	118	106	29	102	83
TDS	880	829	769	**977**	680	652	829
Arsenic	0.0048	0.0031	<0.003	<0.003	0.0038	**0.005**	<0.003
Iron	1.6	1.27	0.63	1.19	0.92	1.12	0.62
Manganese	0.021	**0.043**	0.012	0.020	**0.033**	<0.01	**0.055**
Unfiltered Samples (mg/L)[c]							
Cyanide	0.04	<0.01	<0.01	<0.01	0.01	0.01	<0.01
Phenols	0.033	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
TOC	5.3	1.4	1.7	2.5	4.6	1.2	2.5
TOX	0.041	**0.068**	**0.095**	**0.107**	**0.080**	0.040	**0.062**
Fluoride	4	0.45	0.52	0.22	0.16	0.36	0.53
Chloride	200	63	140	**360**	168	30	170
Sulfate	400	100	106	117	38	107	123
Nitrate	10	<0.1	<0.1	<0.1	<0.1	0.20	<0.1
Arsenic	0.05	<0.003	<0.003	<0.003	0.004	0.005	0.004
Barium	2	0.060	0.041	0.067	0.13	0.047	0.160
Boron	2	0.18	0.19	0.16	0.16	0.17	<0.10
Chromium	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	**0.69**
Iron	5	1.68	0.75	1.86	1.15	1.14	4.92
Manganese	0.15	0.030	0.013	0.030	0.030	<0.010	0.100
Nickel	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Hydrogen-3 (pCi/L)	20,000	<100	<100	<100	<100	<100	<100

[a] Refer to Table 6.10 for an explanation of groundwater quality limits for the 800 Area landfill.

[b] Background well.

[c] In addition to the parameters shown, these samples were also analyzed for cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, zinc, and cyanide, but none of the samples contained these compounds above their detection limits.

[d] Bold type indicates that the value exceeds the GRO.

Groundwater adjacent to the reactor complex has been monitored since 1989. Figure 6.13 shows the current monitoring well network. All wells are screened in the glacial drift. The current network of wells is sampled quarterly and analyzed for soluble metals, chloride (filtered samples), and radioactive materials (cesium-137, hydrogen-3, and strontium-90). The results are presented in Table 6.13. The results are compared to Class I GQS and any results above these limits are shown in bold.

Elevated chloride levels were found in four wells. The two wells with the highest chloride results are located near the current road salt storage facility (a steel dome, designated as 330J on Figure 6.13, that had been part of the reactor complex but was converted to salt storage). Salt-laden runoff from this area is thought to be migrating to the wells, increasing chloride levels.

Five of the six wells had at least one sample with soluble metals above analytical detection limits, but only manganese and nickel had average concentrations above GQS. It is thought that these metals are of natural origin. There are no known man-made sources of these metals near the CP-5 reactor.

Hydrogen-3 was detected during at least one quarter in three wells, but only one was close to the GQS of 20,000 pCi/L. Well 330031R had an average hydrogen-3 concentration of 17,048 pCi/L. This well is located near the former reactor's sewer line. It is thought that contaminated wastewater released into the sewer system during its operational lifetime leaked out into the soil surrounding the sewer. Well 330031R (a replacement well) happened to encounter a region of soil containing some of this contaminated wastewater. An investigation performed in 2006 confirmed that the groundwater with elevated hydrogen-3 is isolated in a small porous zone and there is little migration of groundwater away from the reactor. Cesium-137 and strontium-90 were not found above their analytical detection limits in any of the wells.

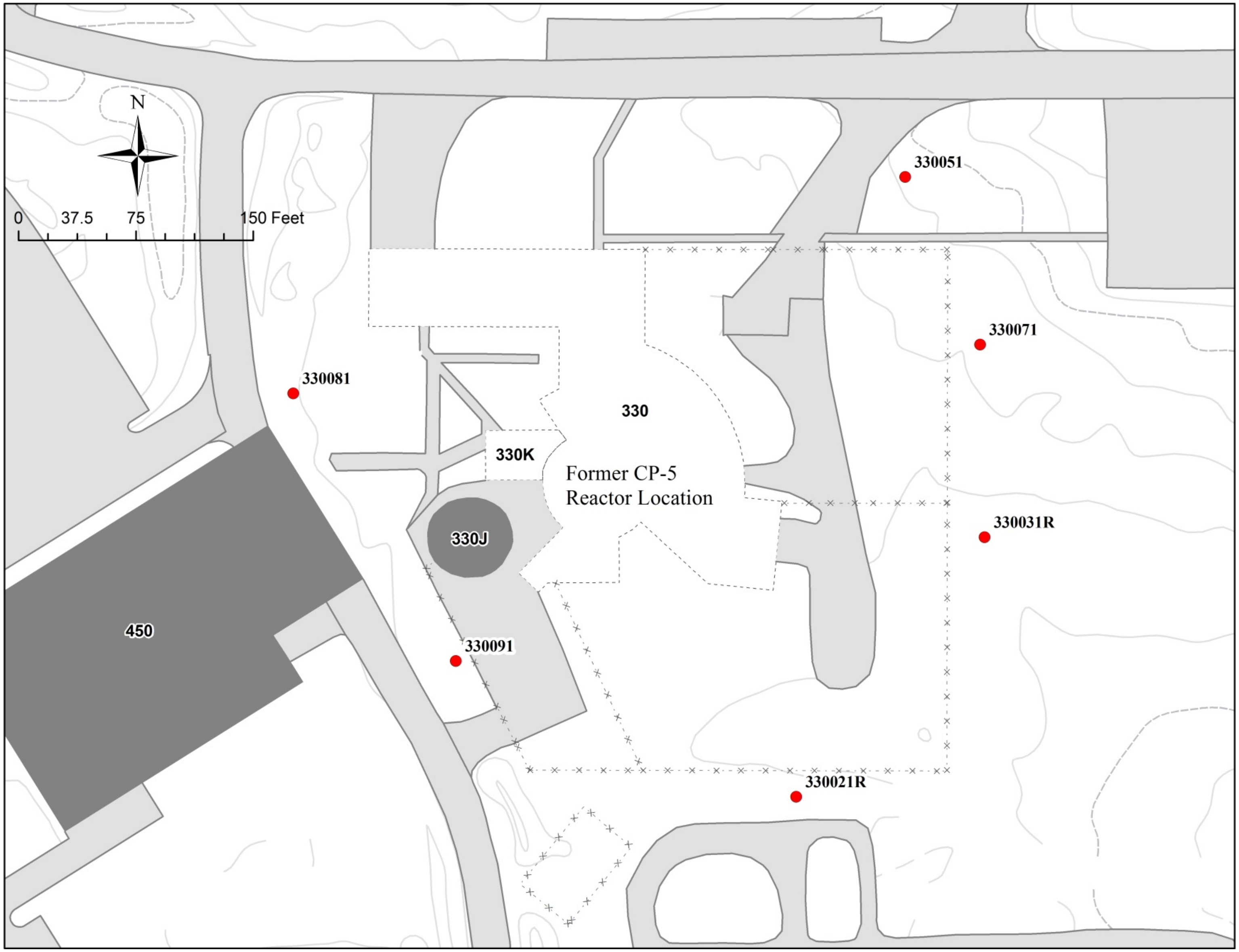


FIGURE 6.13 Monitoring Wells in the CP-5 Reactor Area

TABLE 6.13

Annual Average Concentrations of CP-5 Groundwater Constituents, 2016

		Well Number					
Parameter	Standards	330021R	330031R	330051	330071	330081	330091
Inorganics (mg/L)							
Chloride	200	162	**771**[a]	**280**	41	**1,325**	**3,925**
Filtered Metals (mg/L)							
Arsenic	0.05	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Barium	2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Beryllium	0.004	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Cadmium	0.005	0.0026	0.0027	<0.0025	<0.0025	<0.0025	<0.0025
Chromium	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt	1	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Copper	0.65	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Iron	5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	0.0075	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Manganese	0.15	<0.075	<0.075	<0.075	<0.075	0.12	**2.56**
Mercury	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel	0.1	<0.05	0.056	0.090	<0.05	**0.105**	<0.05
Silver	0.05	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Thallium	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium	NA	<0.075	<0.075	<0.075	<0.075	<0.075	<0.075
Zinc	5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Radionuclides (pCi/L)							
Cesium-137	NA	<2	<2	<2	<2	<2	<2
Hydrogen-3	20,000	128	17,048	<100	144	<100	237
Strontium-90	8	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25

[a] Bold font indicates results above the Class I GQS limit.

6.7. Artesian Well Monitoring

An artesian well is located about 2,000 m (6,000 ft) southwest of the 317 Area in the Waterfall Glen Forest Preserve (grid location 3E in Figure 1.1). The water from this well was sampled twice during 2016 and analyzed for hydrogen-3. All hydrogen-3 concentrations in 2016 were below the detection limit of 100 pCi/L.

6.8. Groundwater Monitoring Program Summary

Argonne groundwater sampling activities during 2016 are summarized in Table 6.14. The monitoring program is a critical element of Argonne's groundwater protection program. The groundwater monitoring strategy focuses resources on those areas that have the potential to

TABLE 6.14

Summary of Groundwater Monitoring by Area, 2016

Groundwater Monitoring Element	Purpose	Number of Wells in Network	Number of Wells Sampled	Number of Sampling Events	Number of Analyses Performed	Percent of Results Nondetectable
317/319 Area wells and manholes	Environmental Surveillance	13	13	67	4,963	92%
317/319/ENE and GMZ wells and seeps	Permit Compliance/ LTS Program	71	43	137	7,194	88%
800 Area Landfill wells	Permit Compliance	24	21	84	8,337	93%
CP-5 wells	Environmental Surveillance	6	6	24	480	88%

impact groundwater. The analytical results generated by the monitoring program demonstrate the degree of compliance with applicable groundwater standards and limits and they identify the need for groundwater remediation.

Overall, groundwater quality at Argonne is good, with significant contamination present at only one location, the 317/319 Area, where concentrations of VOCs in groundwater are above applicable standards. Some of this groundwater comes to the surface in several small groundwater seeps in an isolated part of the Waterfall Glen Forest Preserve. Several remedial actions are underway in this area to reduce contaminant levels, including two groundwater extraction systems, an impermeable cap over the 319 Landfill, and a phytoremediation system.

Groundwater under the 800 Area Landfill exhibits elevated levels of a number of naturally-occurring metals and inorganic constituents; however, they are probably not related to landfill operations. Elevated levels of hydrogen-3 have been found in one well adjacent to the CP-5 reactor; however, hydrogeological studies have determined that this water is not migrating away from the reactor, and it does not represent a hazard. There is little evidence of contamination in the dolomite aquifer, which is the uppermost usable aquifer under the site. Only one dolomite well in the 317 Area contains man-made contamination above applicable limits.

As shown in Table 6.14, the vast majority of the analytical results in 2016 were below analytical detection limits. Of the results that were above detection limits, only a small fraction were above applicable standards for chemicals or radioactive materials.

7. QUALITY ASSURANCE

Quality assurance is an integral part of every activity at Argonne. A comprehensive Quality Assurance/Quality Control (QA/QC) program is in place to ensure that all environmental monitoring samples are representative and all associated data are reliable. The environmental samples are collected by Argonne personnel. About 95% of the samples are analyzed by Argonne scientists in an in-house analytical laboratory. The remaining samples are sent to various contracted laboratories for analysis. Quality control is maintained through calibration and calibration verifications of laboratory and field-portable instrumentation; processing blanks, spikes, and duplicates; and processing intercomparison samples. Results are reviewed and verified before being used to support decision making.

Quality assurance is maintained through data quality objectives, internal and external audits, management reviews and assessments, quality assurance plans, quality control plans, standard operating procedures, sampling plans, and procurement contracts. Quality assurance plans and associated documents exist for both radiological and nonradiological analyses. These documents were prepared in accordance with DOE Order 414.1D.[27] The *Uniform Federal Policy (UFP) for Implementing Environmental Quality Systems* (March 2005) and the associated *Uniform Federal Policy for Quality Assurance Project Plans* (March 2005) documents have been used as guidance in the quality assurance programs.

7.1. Sample Collection

Environmental monitoring samples (soils, waters, and air filters) are collected as specified in various documents, including standard operating procedures, Quality Assurance plans, Quality Control plans, and various Argonne permits. Obtaining representative samples is of utmost importance. Samples are collected and stored in a manner that is designed to maintain the integrity of the analytical constituents. For example, samples for trace radionuclide analyses are acidified immediately after collection to prevent hydrolytic loss of metal ions and are filtered to reduce leaching from suspended solids.

A weekly sample collection schedule is processed using a computer database system. This computer system is used to track all pertinent information regarding sample collection, all requested analyses, and the analytical results. Sample log-in information is transferred to the in-house analytical laboratory, along with chain-of-custody transfer documents. After the samples have been analyzed, resultant data is electronically transferred to this computer system. Multi-level reviews are performed to validate sampling schedules, sample collection information, and the resultant data.

7.2. Radiochemical Analysis

All radiological analyses are performed by the in-house analytical laboratory. Details about the radiological analyses are maintained in standard operating procedures. Standard sources obtained from or traceable to the National Institute of Standards and Technology (NIST) are used to calibrate instrumentation for efficiency. Secondary counting standards are used to verify proper instrument response. All results recorded by the in-house laboratory contain an activity level and a total propagated uncertainty, regardless of detection limits. Non-detects are reported as “less than” (<) the detection limit found in this annual report. A nuclide is considered as not detected if the activity level is below the analytical method detection limit. Detection limits are chosen so the measurement uncertainty at the 95% confidence level is equal to the measured value. Detection limits for air and water are listed in Table 7.1.

TABLE 7.1

Air and Water Detection Limits

Parameter	Air (fCi/m^3)	Water (pCi/L)
Americium-241	–[a]	0.001
Beryllium-7	5	–
Californium-249	–	0.001
Californium-252	–	0.001
Cesium-137	0.1	2
Curium-242	–	0.001
Curium-244	–	0.001
Hydrogen-3	–	100
Lead-210	1	–
Neptunium-237	–	0.001
Plutonium-238	–	0.001
Plutonium-239	–	0.001
Strontium-90	0.01	0.25
Uranium-234	–	0.01
Uranium-235	–	0.01
Uranium-238	–	0.01
Alpha	0.2	0.2
Beta	0.5	1

[a] A dash indicates that a value is not required.

Relative error in a result decreases with increasing concentration. At a concentration equal to twice the detection limit, the error is approximately 50% of the measured value; at 10 times the detection limit, the error is approximately 10% of the measured value. Radiological activity levels are measured by observing radionuclide decay. For radionuclides with few decays over time (e.g., long half-lives), the number of decay observations can be small. This can make the relative error in a result as important as the result itself.

Within this annual report, average values at a given location are accompanied by a plus-or-minus (±) limit value. Unless otherwise stated, this value is the standard error at the 95% confidence level calculated from the standard deviation of the average. The ± limit value is a measure of the range in the concentrations encountered at that location. This value does not represent the conventional uncertainty in the average of repeated measurements on the same or identical samples. Many of the variations observed in environmental radioactivity are not random, but occur for specific reasons (e.g., seasonal variations). Samples collected from the same location at different times are not replicates. The more random the variation in activity at a particular location, the closer the confidence limits will represent the actual distribution of values at that location. The averages and confidence limits should be interpreted with this in mind.

7.3. Chemical Analysis

Most non-radiological chemical analyses are performed by the in-house analytical laboratory. Approximately 5% of non-radiological analyses are performed by contracted analytical laboratories. Chemical analyses details are maintained in standard operating procedures of the individual analytical laboratories. Contract laboratories are subject to the procurement technical specifications defined by Argonne, in addition to reviews conducted by Argonne employees.

Standard reference materials, traceable to NIST, are utilized to ensure the accuracy of most inorganic analyses and are replaced annually. Detection limits for metal analyses are listed in Table 7.2. In general, the detection limit is the measure of the variability of a standard material measurement at 5 to 10 times the instrument detection limit over an extended time period. Recovery of inorganic metals, as determined by "spiking" unknown solutions with a known amount, must be within the range of 80 to 120%. The precision, as determined by the analysis of duplicate spike samples, must be within 20%. These measurements must be obtained for at least 10% of the samples. Standards certified by the American Association for Laboratory Accreditation (A2LA) are utilized to ensure the accuracy of most organic analyses. At least one standard mixture is analyzed each month. Quantification limits vary with the analytical method and are listed within the appropriate standard operating procedure.

TABLE 7.2

Metals Detection Limits, 2016

Parameter	AA[a] (mg/L)	ICP[b] (mg/L)
Antimony	0.003	NA[c]
Arsenic	0.003	0.025
Barium	NA	0.012
Beryllium	0.0025	0.0025
Boron	NA	0.10
Cadmium	0.0002	0.0025
Chromium	NA	0.05
Cobalt	NA	0.25
Copper	NA	0.025
Iron	NA	0.021
Lead	0.004	0.09
Manganese	NA	0.010
Mercury	0.0002	NA
Nickel	NA	0.05
Selenium	0.003	NA
Silver	0.001	0.0025
Thallium	0.002	NA
Vanadium	NA	0.075
Zinc	NA	0.02

[a] AA = atomic absorption spectroscopy

[b] ICP = inductively coupled plasma-optical emission spectroscopy

[c] NA = not analyzed

7.4. Demonstration of Proficiency

In 2016, Argonne participated in two environmental proficiency testing programs: the Mixed Analyte Performance Evaluation Program (MAPEP) administered by the Radiological and Environmental Sciences Laboratory (RESL), which is operated by the U.S. Department of Energy Idaho Operations Office, and the Discharge Monitoring Report-Quality Assurance Program (DMR-QA), administered by the U.S. Environmental Protection Agency (EPA). Proficiency testing programs involve an accredited proficiency test provider sending a series of intercomparison samples to Argonne and its contracted laboratories. The laboratories analyze the samples and submit the analytical results to the provider. The Laboratory's proficiency is determined by comparing the analytical results with the provider's reference values. Argonne and its contracted laboratories combined have consistently performed very well on these tests.

The MAPEP program consists of a semiannual distribution of sample matrices containing combinations of radionuclides. The results are provided in Tables 7.3 and 7.4. The 2016 Argonne performance resulted in 86% (43 out of 50) of the analyses being in the MAPEP acceptable range. Four of the 50 results were within the 'Acceptable With Warning' range. The remaining three out of 50 results were within the 'Not Acceptable' range. The "not acceptable' results were investigated, followed by corrective action statements issued.

The DMR-QA program consists of an annual distribution of sample proficiency testing samples containing combinations of non-radiological components. The results are provided in Table 7.5. Argonne and its contracted laboratories' performance resulted in 100% (39 out of 39) of the analyses being in the DMR-QA acceptable range.

TABLE 7.3

Summary of MAPEP Series 34 Intercomparison Sample Results, April 2016

Analyte	Matrix	Units	Reported Value	Reference Value	Acceptance Range	Performance Evaluation
Am-241	air filter	Bq/filter	0.078	0.0805	0.0564-0.1047	Acceptable
Cs-134	air filter	Bq/filter	0.0001	–[a]	False Positive Test	Acceptable
Cs-137	air filter	Bq/filter	2.16	2.30	1.61–2.99	Acceptable
Co-57	air filter	Bq/filter	2.75	2.94	2.06–3.82	Acceptable
Co-60	air filter	Bq/filter	3.95	4.02	2.81–5.23	Acceptable
Mn-54	air filter	Bq/filter	4.60	4.53	3.17–5.89	Acceptable
Pu-238	air filter	Bq/filter	0.069	0.0637	0.0446–0.0828	Acceptable
Pu-239/240	air filter	Bq/filter	0.097	0.099	0.069–0.129	Acceptable
Sr-90	air filter	Bq/filter	1.19	1.38	0.97–1.79	Acceptable
U-234/233	air filter	Bq/filter	0.141	0.165	0.116–0.215	Acceptable
U-238	air filter	Bq/filter	0.150	0.172	0.120–0.224	Acceptable
Zn-65	air filter	Bq/filter	3.52	3.57	2.50–4.64	Acceptable
Am-241	water	Bq/L	0.01	–	False Positive Test	Acceptable
Cs-134	water	Bq/L	14.69	16.1	11.3–20.9	Acceptable
Cs-137	water	Bq/L	21.35	21.2	14.8–27.6	Acceptable
Co-57	water	Bq/L	0.03	–	False Positive Test	Acceptable
Co-60	water	Bq/L	12.26	11.8	8.3–15.3	Acceptable
H-3	water	Bq/L	-1.98	–	False Positive Test	Not Acceptable
Mn-54	water	Bq/L	10.82	11.1	7.8–14.4	Acceptable
Pu-238	water	Bq/L	1.178	1.244	0.871–1.617	Acceptable
Pu-239/240	water	Bq/L	0.593	0.641	0.449–0.833	Acceptable
Sr-90	water	Bq/L	7.577	8.74	6.12–11.36	Acceptable
U-234/233	water	Bq/L	1.26	1.48	1.02–1.92	Acceptable
U-238	water	Bq/L	1.31	1.53	1.07–1.99	Acceptable
Zn-65	water	Bq/L	12.55	13.6	9.5–17.7	Acceptable

[a] A dash indicates no reference value is needed.

TABLE 7.4

Summary of MAPEP Series 35 Intercomparison Sample Results, October 2016

Analyte	Matrix	Units	Reported Value	Reference Value	Acceptance Range	Performance Evaluation
Am-241	air filter	Bq/filter	0.001	–[a]	False Positive Test	Acceptable
Cs-134	air filter	Bq/filter	1.65	2.04	1.43–2.65	Acceptable
Cs-137	air filter	Bq/filter	1.71	1.78	1.25–2.31	Acceptable
Co-57	air filter	Bq/filter	2.29	2.48	1.74–3.22	Acceptable
Co-60	air filter	Bq/filter	3.27	3.26	2.28–4.24	Acceptable
Mn-54	air filter	Bq/filter	2.83	2.75	1.93–3.58	Acceptable
Pu-238	air filter	Bq/filter	0.100	0.0693	0.0485–0.0901	Not Acceptable
Pu-239/240	air filter	Bq/filter	0.082	0.0535	0.0375–0.0696	Not Acceptable
Sr-90	air filter	Bq/filter	0.92	1.03	0.72–1.34	Acceptable
U-234/233	air filter	Bq/filter	0.142	0.150	0.105–0.195	Acceptable
U-238	air filter	Bq/filter	0.137	0.156	0.109–0.203	Acceptable
Zn-65	air filter	Bq/filter	0.01	–	False Positive Test	Acceptable
Am-241	water	Bq/L	0.65	0.814	0.570–1.058	Acceptable With Warning
Cs-134	water	Bq/L	22.27	23.9	16.7–31.1	Acceptable
Cs-137	water	Bq/L	0.14	–	False Positive Test	Acceptable
Co-57	water	Bq/L	27.42	27.3	19.1–35.5	Acceptable
Co-60	water	Bq/L	0.15	–	False Positive Test	Acceptable
H-3	water	Bq/L	338	334	234–434	Acceptable
Mn-54	water	Bq/L	15.70	14.8	10.4–19.2	Acceptable
Pu-238	water	Bq/L	1.420	1.13	0.79–1.47	Acceptable With Warning
Pu-239/240	water	Bq/L	0.029	0.013	Sensitivity Evaluation	Acceptable
Sr-90	water	Bq/L	0.0293	–	False Positive Test	Acceptable
U-234/233	water	Bq/L	1.46	1.86	1.30–2.42	Acceptable With Warning
U-238	water	Bq/L	1.48	1.92	1.34–2.50	Acceptable With Warning
Zn-65	water	Bq/L	17.62	17.4	12.2–22.6	Acceptable

[a] A dash indicates no reference value is needed.

TABLE 7.5

Summary of DMR-QA Study 36 Intercomparison Sample Results, 2016

Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Antimony	ug/L	541	496	400–577	Acceptable
Arsenic	ug/L	767	751	635–857	Acceptable
Barium	ug/L	1600	1620	1380–1860	Acceptable
Beryllium	ug/L	297	302	257–347	Acceptable
Boron	ug/L	1060	1030	876–1180	Acceptable
Cadmium	ug/L	376	385	327–443	Acceptable
Chromium	ug/L	257	251	213–289	Acceptable
Cobalt	ug/L	475	487	414–560	Acceptable
Copper	ug/L	323	323	275–371	Acceptable
Iron	ug/L	1800	1780	1510–2050	Acceptable
Lead	ug/L	747	731	621–841	Acceptable
Manganese	ug/L	1710	1680	1430–1930	Acceptable
Mercury	ug/L	7.41	7.44	5.21–9.67	Acceptable
Mercury (Low-Level)[a,b]	ng/L	84.6	93.5	73.1–113	Acceptable
Nickel	ug/L	613	603	527–683	Acceptable
Selenium	ug/L	266	248	211–285	Acceptable
Silver	ug/L	575	563	479–647	Acceptable
Thallium	ug/L	269	261	208–308	Acceptable
Vanadium	ug/L	552	543	462–624	Acceptable
Zinc	ug/L	425	422	359–485	Acceptable
Chloride	mg/L	123	124	109–139	Acceptable
Fluoride	mg/L	3.05	3.39	2.74–3.90	Acceptable
Sulfate	mg/L	33	38.7	31.5–44.5	Acceptable
Phosphorus	mg/L	2.94	2.96	2.52–3.40	Acceptable
Biochemical Oxygen Demand[a,c]	mg/L	91	101	51.5–168	Acceptable
Chemical Oxygen Demand	mg/L	87	99.0	75.2–119	Acceptable
Ammonia Nitrogen[a,c]	mg/L	11.4	10.3	8.22–12.4	Acceptable
Nitrate as Nitrogen[a]	mg/L	11.7	12.2	10.1–14.2	Acceptable
Nitrite as Nitrogen[a]	mg/L	1.86	1.89	1.60–2.18	Acceptable
Total Kjeldahl Nitrogen as Nitrogen[a]	mg/L	4.93	5.45	3.83–7.20	Acceptable
Total Residual Chlorine (Low-Level)	ug/L	90	100	40.0–160	Acceptable
Total Cyanide[a,d]	mg/L	0.895	0.846	0.550–1.14	Acceptable
pH	S.U.	7.50	7.50	7.30–7.70	Acceptable
Total Phenolics[a,d]	mg/L	1.39	1.83	0.602–2.01	Acceptable
Total Suspended Solids	mg/L	33.7	35.1	25.6–41.4	Acceptable
Total Dissolved Solids	mg/L	374	368	323–413	Acceptable
Oil & Grease	mg/L	60.1	68.0	46.2–80.9	Acceptable
Fathead Minnow Acute Toxicity[a]	LC_{50}	60.29%	58.4	31.7–85.2	Acceptable
Ceriodaphnia dubia Acute Toxicity[a]	LC_{50}	34.37%	42.6	19.1–66.2	Acceptable

[a] Analysis performed by contract laboratory.

[b] Results from Water Pollution Study WP0416 used for DMRQA36.

[c] Results from Water Pollution Study WP0416 used for DMRQA36.

[d] Results from Water Pollution Study WP0116 used for DMRQA36.

8. APPENDIX

8.1. References

1. U.S. Department of Energy. 2011. "Department Sustainability." DOE Order 436.1. May 2.

2. U.S. Department of Energy. 2011. "Environment, Safety, and Health Reporting." DOE Order 231.1B. June 27.

3. U.S. Army Corps of Engineers. 1987. *Corps of Engineers Wetlands Delineation Manual*. Technical Report Y-87-1. Washington, DC.

4. U.S. Department of Energy. 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. DOE/EH-0173T. Washington, DC.

5. U.S. Department of Energy. 2011. "Radiation Protection of the Public and the Environment." DOE Order 458.1. June 6.

6. International Commission on Radiological Protection. 1991. *Recommendations of the International Commission on Radiological Protection*. ICRP Publication 60, Annals of the ICRP, 21(1-3), Pergamon Press, New York, NY.

7. International Commission on Radiological Protection. 2006. *Assessing Dose of the Representative Person for the Purpose of Radiation Protection*. ICRP Publication 101. Annuals of the ICRP, 36 (3), Pergamon Press, New York, NY.

8. U.S. Department of Energy. 2011. *Derived Concentration Technical Standard*. DOE-STD-1196-2011, Washington, DC.

9. Parks, B.S. 1992. *User's Guide for CAP88-C*, *EPA 402-B-92-001*, Office of Radiation Programs, U.S. Environmental Protection Agency, Las Vegas, NV.

10. Larsen, R.J. 1993. "Global Decrease of Beryllium-7 in Surface Air." *Journal of Environmental Radioactivity* 18:85-87.

11. Golchert, N.W. and R.G. Kolzow. 1998. *Argonne National Laboratory-East Site Environmental Report for Calendar Year 1997*, ANL-98/02, Argonne National Laboratory, Argonne, IL.

12. Davis, T.M., J.L. Gomez, and L.P. Moos. 2016. *Argonne National Laboratory Site Environmental Report for Calendar Year 2015*, ANL-16/02, Argonne National Laboratory, Argonne, IL.

13. U.S. Environmental Protection Agency. 1990. "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, Title 40, Part 61, Subpart H.

14. National Council on Radiation Protection and Measurements. 2009. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 160. Washington, DC.

15. International Commission on Radiological Protection. 2002. *Basic Anatomical and Physiological Data for Use in Radiological Protection Reference Values*. ICRP Publication 89. Pergamon Press. New York, NY.

16. U.S. Department of Energy. 2002. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002. Washington, DC. July.

17. U.S. Environmental Protection Agency. 1993. "National Primary Drinking Water Regulations." *Code of Federal Regulations*, Title 40, Part 141.

18. U.S. Environmental Protection Agency. 1984. "EPA Administered Permit Program: The National Pollutant Discharge Elimination System." *Code of Federal Regulations*, Title 40, Part 122.

19. U.S. Environmental Protection Agency. 1986. "Test Procedures for the Analysis of Pollutants under the Clean Water Act." *Code of Federal Regulations*, Title 40, Part 136.

20. American Water Works Association. 2005. *Standard Methods for the Examination of Water and Wastewater*, 21st ed. American Public Health Association, American Water Works Association, and Water Environment Federation, Oct. 15.

21. State of Illinois, *Rules and Regulations*. 1985. Title 35, "Environmental Protection," Subtitle C, Water Pollution, Chapter 1.

22. State of Illinois, *Rules and Regulations*. 2002. Title 35, "Environmental Protection," Subtitle C, Part 304, Dec. 20.

23. State of Illinois, *Rules and Regulations*. 2002. Title 35, "Environmental Protection," Subtitle C, Part 302, Dec. 20.

24. Argonne National Laboratory. 1991. *800 Area Landfill Closure Plan, Post-Closure Care Plan, and Cost Estimate*, Argonne National Laboratory's Environmental and Waste Management Program, Document Number J0500-101-W-T003.

25. State of Illinois, *Rules and Regulations*. 2002. Title 35, "Groundwater Quality Standards," Subtitle F, Part 620, Dec. 20.

26. U.S. Environmental Protection Agency. 1986. *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document,* OSWER-9950.1, Office of Solid Waste and Emergency Response, Washington, DC.

27. U.S. Department of Energy. 2011. "Quality Assurance," DOE Order 414.1D. April 25.

28. U.S. Environmental Protection Agency. 1986. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, EPA-SW-846, 3rd ed., Nov. 1986 and subsequent updates, Office of Solid Waste, Washington, DC.

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