

Site Environmental Report

for Calendar Year 2006

Environment, Safety, and Health/Quality Assurance Oversight Division



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Argonne National Laboratory Site Environmental Report for Calendar Year 2006

Preceding Report in This Series: ANL-06/02

by
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Argonne_{LLC}



This Site Environmental Report (SER) was prepared by the Environment, Safety, and Health/Quality Assurance Oversight (EQO) Division at Argonne National Laboratory for the U.S. Department of Energy (DOE). 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 and those for recent years are available on the Internet at <http://www.anl.gov/ESH/anleser/>.



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ACM	Asbestos-Containing Material
AEA	Atomic Energy Act of 1954
AOC	Area of Concern
APES	Argonne Property Excess System
APS	Advanced Photon Source
Argonne	Argonne National Laboratory
ATLAS	Argonne Tandem Linac Accelerating System
BAT	Best Available Technology
BCG	Biota Concentration Guide
BOD₅	Biochemical Oxygen Demand
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CAP-88	Clean Air Act Assessment Package-1988
CARB	California Air Resources Board
CCA	Compliance Commitment Agreement
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	<i>Code of Federal Regulations</i>
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
COE	U.S. Army Corps of Engineers
CP-5	Chicago Pile-Five
CRMP	Cultural Resources Management Plan
CWA	Clean Water Act
D&D	Decontamination and Decommissioning
DCA	1,1-Dichloroethane
DCE	Dichloroethylene
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOE-ASO	DOE Argonne Site Office
EA	Environmental Assessment
ECR	Environmental Compliance Representative
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
EQO	Environment, Safety, and Health/Quality Assurance Oversight
EQO-AS	EQO, Analytical Services

ACRONYMS

ESA	Endangered Species Act of 1973
ES&H	Environment, Safety, and Health
FFCA	Federal Facility Compliance Act of 1992
FMS	Facilities Management and Services
FY	Fiscal Year
GMZ	Groundwater Management Zone
GQS	Groundwater Quality Standard
GRO	Groundwater Remediation Objective
HAP	Hazardous Air Pollutant
HSWA	Hazardous and Solid Waste Amendments of 1984
HTRL	Howard T. Ricketts Laboratory
IAC	<i>Illinois Administrative Code</i>
ICRP	International Commission on Radiological Protection
IDNS	Illinois Department of Nuclear Safety
IEPA	Illinois Environmental Protection Agency
IHPA	Illinois Historic Preservation Agency
IPNS	Intense Pulsed Neutron Source
ISMS	Integrated Safety Management System
LEPC	Local Emergency Planning Committee
LTS	Long-Term Stewardship
LWTP	Laboratory Wastewater Treatment Plant
MAPEP	Mixed Analyte Performance Evaluation Program
MOU	Memorandum of Understanding
MSDS	Material Safety Data Sheet
MW	Mixed Waste
MY	Model Year
NBL	New Brunswick Laboratory
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
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRHP	National Register of Historic Places
P2	Pollution Prevention
PBT	Persistent, Bioaccumulative Toxic
PCB	Polychlorinated Biphenyl

PCE	Tetrachloroethene
PPOA	Pollution Prevention Opportunity Assessment
PQL	Practical Quantitation Limit
PSTP	Proposed Site Treatment Plan
PWA	Process Waste Assessment
QA	Quality Assurance
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act of 1974
SER	Site Environmental Report
SERC	State Emergency Response Commission
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
SWPPC	Stormwater Pollution Prevention Committee
SWPPP	Stormwater Pollution Prevention Plan
SWTP	Sanitary Wastewater Treatment Plant
TCA	1,1,1-Trichloroethane
TCE	1,1,2-Trichloroethene
TDS	Total Dissolved Solids
THM	Trihalomethanes
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOX	Total Organic Halogen
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
UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound

ACRONYMS

WM	Waste Minimization
WMO	Waste Management Operations
WTP	Wastewater Treatment Plant
ZPR	Zero Power Reactor

This report discusses the status and the accomplishments of the environmental protection program at Argonne National Laboratory for calendar year 2006. The status of Argonne environmental protection activities with respect to compliance with the various laws and regulations is discussed, along with the progress of environmental corrective actions and restoration projects. 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 Argonne effluent water were analyzed. External penetrating radiation doses were measured, and the potential for radiation exposure to off-site population groups was estimated. Results are interpreted in terms of the origin of the radioactive and chemical substances (i.e., natural, fallout, Argonne, and other) and are compared with applicable environmental quality standards. A U.S. Department of Energy dose calculation methodology, based on International Commission on Radiological Protection recommendations and the U.S. Environmental Protection Agency's CAP-88 Version 3 (Clean Air Act Assessment Package-1988) computer code, was used in preparing this report.

ABSTRACT

This report summarizes the ongoing environmental protection program activities conducted by Argonne National Laboratory (Argonne) in calendar year 2006. It includes descriptions of the site, Argonne missions and programs, the status of compliance with environmental regulations, environmental protection and restoration activities, and the environmental surveillance program. Members of the surveillance program regularly conduct monitoring for radiation, radioactive materials, and nonradiological constituents on the Argonne site and in the surrounding region. These activities document compliance with appropriate standards and permit limits, identify trends, provide information to the public, and contribute to a better understanding of Argonne's impact on the environment. The surveillance program supports the Argonne policy of protecting the public, employees, and the environment from harm that may result from Argonne activities, while reducing environmental impacts to the greatest degree practicable.

Executive Order 13148 and U.S. Department of Energy (DOE) Order 450.1 require that an Environmental Management System (EMS) be implemented at Argonne by December 31, 2005. The DOE EMS Implementation Assessment Team conducted its visit November 14–18, 2005. The team issued its report on December 16, 2005, and on December 22, 2005, the DOE Argonne Site Office (DOE-ASO) manager certified that the EMS had been implemented. Part of the implementation of the EMS was the integration of the EMS into the Integrated Safety Management System (ISMS).

Compliance Summary

Radionuclide emissions, the management of asbestos, and conventional air pollutants from Argonne facilities are regulated under the Clean Air Act (CAA). A number of airborne radiological emission points at Argonne are subject to National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations for radionuclide releases from DOE facilities (Title 40 of the *Code of Federal Regulations*, Part 61, Subpart H [40 CFR Part 61, Subpart H]). All such air emission sources were evaluated to ensure that these requirements are being addressed properly. The estimated hypothetical individual off-site radiation dose from Argonne activities required to be reported by U.S. Environmental Protection Agency (EPA) regulations for 2006 was 0.029 mrem/yr. This is 0.3% of the 10 mrem/yr standard. This dose does not include contributions from radon-220 and radon-222 emissions, which are exempted in the regulations.

At Argonne, asbestos-containing material (ACM) frequently is encountered during maintenance or renovation of existing facilities and equipment. Asbestos is removed and disposed of in strict accordance with NESHAP and Occupational Safety and Health Administration worker protection standards. A deviation in the 2006 Title V compliance certification involved the failure to provide a notification of an asbestos removal project. Approximately 44.9 m³ (1,585 ft³) of ACM was removed and disposed of at off-site landfills in Illinois during 2006.

The Argonne site contains sources of conventional air pollutants. The steam plant, the emergency generators at the Advanced Photon Source (APS), and the engine test facility are significant sources of continuous air pollutants. The Illinois Environmental Protection Agency

EXECUTIVE SUMMARY

(IEPA) issued the final Argonne Clean Air Act Permit Program (CAAPP) permit in April 2001 and renewed it in October 2006. All previous air operating permits (with the exception of the open burning permits) were incorporated into this sitewide permit for all emission sources and activities. The Argonne CAAPP Title V permit requires continuous opacity and sulfur dioxide monitoring of the steam plant smoke stack from Boiler No. 5, the only boiler equipped to burn coal. Low-sulfur coal was burned in Boiler No. 5 for 8 months during 2006. During the period coal was burned no exceedances were recorded.

The goals of the Clean Water Act (CWA) are achieved primarily through the National Pollutant Discharge Elimination System (NPDES) permit program. The federal government has delegated implementation of the NPDES program to the State of Illinois. The IEPA reissued the permit effective September 1, 2005. During 2006, 21 exceedances of NPDES permit limits were reported out of approximately 1,700 measurements.

The IEPA issued a Resource Conservation and Recovery Act (RCRA) Part B permit on September 30, 1997, which became effective on November 4, 1997. The permit addresses 24 hazardous waste treatment and storage facilities and establishes corrective action procedures and requirements for 49 Solid Waste Management Units (SWMUs) and 3 Areas of Concern (AOCs). Since the issuance of the permit, three additional AOCs have been added to the permit. By September 30, 2003, all planned remediation work was completed. However, ongoing activities are being conducted at five SWMUs and two AOCs. These seven units require monitoring as part of the Argonne Long-Term Stewardship (LTS) Program.

Argonne has prepared and implemented a sitewide underground storage tank (UST) compliance plan. The Argonne site contains 13 USTs, which are in compliance with UST regulations.

The only Toxic Substances Control Act (TSCA)-regulated compounds present in significant quantities at Argonne are polychlorinated biphenyls (PCBs) contained in electrical capacitors, power supplies, and small transformers. The Argonne PCB Item Inventory Program was initiated in 1995 to identify all suspect PCB-containing items. All pole-mounted transformers and circuit breakers containing PCBs have been replaced or retrofilled with non-PCB oil. All removal and disposal activities were conducted by licensed contractors specializing in such operations.

In 2006, most projects requiring National Environmental Policy Act (NEPA) assessment were determined to be Categorical Exclusions. A supplement Environmental Assessment (EA) was completed for remote-handled transuranic waste. This analysis was performed so that transuranic waste could be characterized and disposed of offsite.

Ongoing compliance issues at Argonne during 2006 were concentrations of total dissolved solids and total residual chlorine in excess of NPDES permit effluent limits and elevated levels of some routine indicator parameters in the groundwater at the former sanitary landfill.

Environmental Surveillance Program

Airborne emissions of radioactive materials from Argonne were monitored during 2006. The effective dose equivalents were estimated at the site perimeter and to a hypothetical maximally exposed member of the public by using the EPA's CAP-88 Version 3.0 (CAA Assessment Package-1988) computer code. The estimated maximum perimeter dose from airborne releases was 0.26 mrem/yr in the southwest direction, while the estimated maximum dose to a member of the public was 0.029 mrem/yr. If the contribution of radon-220 is excluded from reporting, as required by 40 CFR Part 61, Subpart H, the estimated dose to a maximally exposed member of the public would remain 0.029 mrem/yr. The estimated population dose from releases to the approximately nine million people living within 80 km (50 mi) of the site was 7.60 person-rem.

Monitoring of radioactivity associated with particulates in ambient air was conducted for total alpha activity, total beta activity, and gamma-ray emitters at the Argonne site perimeter and at off-site locations. No statistically significant difference was identified between samples collected at the Argonne perimeter and samples collected off-site. Monitoring was not conducted for hazardous chemical constituents in ambient air.

The only detectable radionuclides in surface water due to Argonne releases were in Sawmill Creek below the wastewater discharge point. At various times, measurable levels of hydrogen-3, strontium-90, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 0.07 Ci of hydrogen-3. The other radionuclides released totaled less than 0.001 Ci. The hydrogen-3 was added to the wastewater as part of normal Argonne operations. The dose to a hypothetical individual using water from Sawmill Creek as his or her sole source of drinking water would be 0.016 mrem/yr. However, no one uses this water for drinking, and dilution by the Des Plaines River reduces the concentrations of the measured radionuclides to levels below their respective detection limits downstream from Argonne at Lemont. Sawmill Creek also is monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards. No parameters were detected above the limits established by the standards.

Sediment samples were collected from Sawmill Creek above, at, and below the point of wastewater treatment plant effluent discharge. Elevated levels of plutonium-239 (up to 0.06 pCi/g) and americium-241 (up to 0.01 pCi/g) were detected in the sediment below the outfall and are attributed to past Argonne releases.

Dose rates from penetrating radiation (gamma rays) were measured at 17 perimeter and on-site locations and at 5 off-site locations in 2006 by using thermoluminescent dosimeters. The off-site results averaged 101 ± 6 mrem/yr, which is similar to the long-term average dose. At the south fence, radiation from a temporary storage facility for radioactive waste resulted in an average dose of 92 ± 19 mrem/yr for 2006, although no one occupies this area. The estimated dose from penetrating radiation to the nearest resident south of the site was less than 0.01 mrem/yr.

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The potential radiation doses to members of the public from all sources and pathways due to Argonne operations during 2006 were estimated by combining the exposures from inhalation, ingestion, and direct radiation pathways. The inhalation pathway would be primary. The highest estimated dose was approximately 0.046 mrem/yr to a hypothetical individual living east of the site, assuming that he or she was outdoors at that location during the entire year and drinking Sawmill Creek water. Estimated doses from other pathways were not significant by comparison. The doses from Argonne operations are well within all applicable standards and are insignificant when compared with doses received by the public from natural radiation (≈ 300 mrem/yr) or other sources, for example, medical x-rays and consumer products (≈ 60 mrem/yr).

Radiological and chemical constituents in the groundwater were monitored in several areas of the Argonne site in 2006. The former Argonne domestic water supply is monitored by collecting quarterly samples from the three inactive supply wells. All results from water supply wells were less than the limits established by the Safe Drinking Water Act (SDWA).

Ten monitoring wells screened in glacial drift and two in dolomite were sampled quarterly at the 317 and 319 Areas and analyzed for radiological, volatile organic, semivolatile, PCB, pesticide, and herbicide constituents. The major organic contaminants detected were 1,4-dioxane, 1,1,1-trichloroethane, 1,1-dichloroethane, and tetrahydrofuran. Measurable levels of hydrogen-3 were present in several of the wells. Remediation continued in these areas using phytoremediation and groundwater extraction to remove volatile organic compounds (VOCs) and hydrogen-3 from groundwater.

Argonne conducts a Long Term Stewardship (LTS) program to operate and monitor environmental cleanup actions implemented in recent years. This program focuses primarily on several former waste management units in the 317, 319, and East-Northeast (ENE) areas at the extreme southern end of the site. Remedial actions managed by this program include inspection and maintenance of two landfill caps, operation and maintenance of two groundwater collection systems and a phytoremediation system, and a groundwater monitoring program. Monitoring of these systems indicates that contaminated groundwater is no longer migrating off-site; however, significant contamination of groundwater exists below two of the waste units. High concentrations of VOCs are present in and downgradient of a former chemical waste disposal unit (French drain) in the 317 Area. Measurable levels of hydrogen-3 are found under the 319 Area Landfill, though these concentrations are currently much lower than in previous years. Very low concentrations of several VOCs and hydrogen-3 are routinely found in several small off-site groundwater seeps in the Waterfall Glen Forest Preserve. Ongoing remedial actions should continue to reduce the concentrations of these contaminants in coming years. A Groundwater Management Zone (GMZ) has been established around the 317/319 Area to facilitate the remediation of contaminated groundwater. Monitoring of the GMZ perimeter wells indicates that the groundwater plume had not migrated beyond the original boundaries. Monitoring of the landfill in the ENE Area indicates that hazardous materials in the waste are not being released to the groundwater.

Twenty-six monitoring wells at the 800 Area Landfill were sampled on a quarterly basis and analyzed for hydrogen-3, metals, cyanide, phenols, total organic carbon (TOC), total organic halogens (TOX), and VOCs, and annually for semivolatile organic compounds (SVOCs), PCBs,

pesticides, and herbicides. As in previous years, levels exceeding background concentrations for ammonia, chloride, iron, lead, manganese, sulfate, TOC, and total dissolved solids (TDS) were found in some wells. Above-background levels of hydrogen-3 were detected in several of the wells, with concentrations up to 282 pCi/L.

Nine monitoring wells are screened in the glacial drift and one in the dolomite adjacent to the Chicago Pile-Five reactor. These wells were sampled quarterly, and samples were analyzed for selected radionuclides and metals. Elevated levels of hydrogen-3 and strontium-90 were detected regularly; however, these concentrations are localized.

An extensive quality assurance program is maintained to cover all aspects of the environmental surveillance sampling and analysis programs. Approved documents are in place, along with supporting standard operating procedures. Newly collected data were compared with recent results and historical data to ensure that deviations from previous conditions were identified and evaluated promptly. Samples at all locations were collected using well-established and documented procedures to ensure consistency. Samples were analyzed by means of documented standard analytical procedures. Data quality was verified by a continuing program of analytical laboratory quality control, participation in interlaboratory cross-checks, and replicate sampling and analysis. Data were managed and tracked by a dedicated computerized data management system that assigns unique sample numbers, schedules collection and analysis, checks status, and prepares tables and information for this annual report.

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1. INTRODUCTION



1. INTRODUCTION

1.1. General

This annual report for calendar year 2006 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 and 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 and remediation. The report was prepared in accordance with the guidelines of DOE Orders 450.1¹ and 231.1A² and supplemental DOE guidance.

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. The detection of any releases of such materials to the environment from Argonne operations is of special interest, because one important function of this program is verification of the adequacy of the site's pollution control systems.

Argonne is a DOE research and development (R&D) laboratory with several principal objectives. It conducts a broad program of research in the basic energy and related sciences (i.e., physical, chemical, material, computer, nuclear, biomedical, and environmental) and serves as an important engineering center for the study of nuclear and nonnuclear energy sources. Energy-related research projects conducted during 2006 included safety studies for light-water reactors; high-temperature superconductivity experiments; development of electrochemical energy sources, including fuel cells and batteries for vehicles and energy storage; and studies to promote clean, efficient transportation.

Other R&D areas include basic biological research, heavy-ion research into the properties of super-heavy elements, the immobilization of radioactive waste products for safe disposal, fundamental studies of advanced computers, and the development of advanced computing technologies. Environmental research studies include the biological activity of energy-related mutagens and carcinogens, characterization and monitoring of energy-related pollutants, and new technologies for cleaning up environmental contaminants. A significant number of these laboratory studies require the controlled use of radioactive and chemically toxic substances.

The principal radiological facilities at Argonne are the Advanced Photon Source (APS), a superconducting heavy-ion linear accelerator (Argonne Tandem Linac Accelerating System [ATLAS]), a 22-MeV pulsed electron linac, several other charged-particle accelerators (principally of the Van de Graaff and Dynamitron types), a large fast neutron source (Intense Pulsed Neutron Source [IPNS]) in which high-energy protons strike a uranium target to produce neutrons, chemical and metallurgical laboratories, and several hot cells and laboratories designed for work with multicurie quantities of the actinide elements and with irradiated reactor fuel materials. The DOE New Brunswick Laboratory (NBL), a plutonium and uranium measurements and analytical chemistry laboratory, is located on the Argonne site.

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The principal nonnuclear activities at Argonne in 2006 that could have measurable impacts on the environment include the use of a coal-fired boiler (No. 5) and the discharge of wastewater from various sources.

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. 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 (I-55), and west of Illinois Highway 83. Figures 1.1 and 1.2 are maps of the site and the surrounding area 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 in 1973 for use as a public recreational area, nature preserve, and demonstration forest. In this report, facilities are identified by the alphanumeric designations in Figure 1.1 to facilitate their location.

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 30 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,

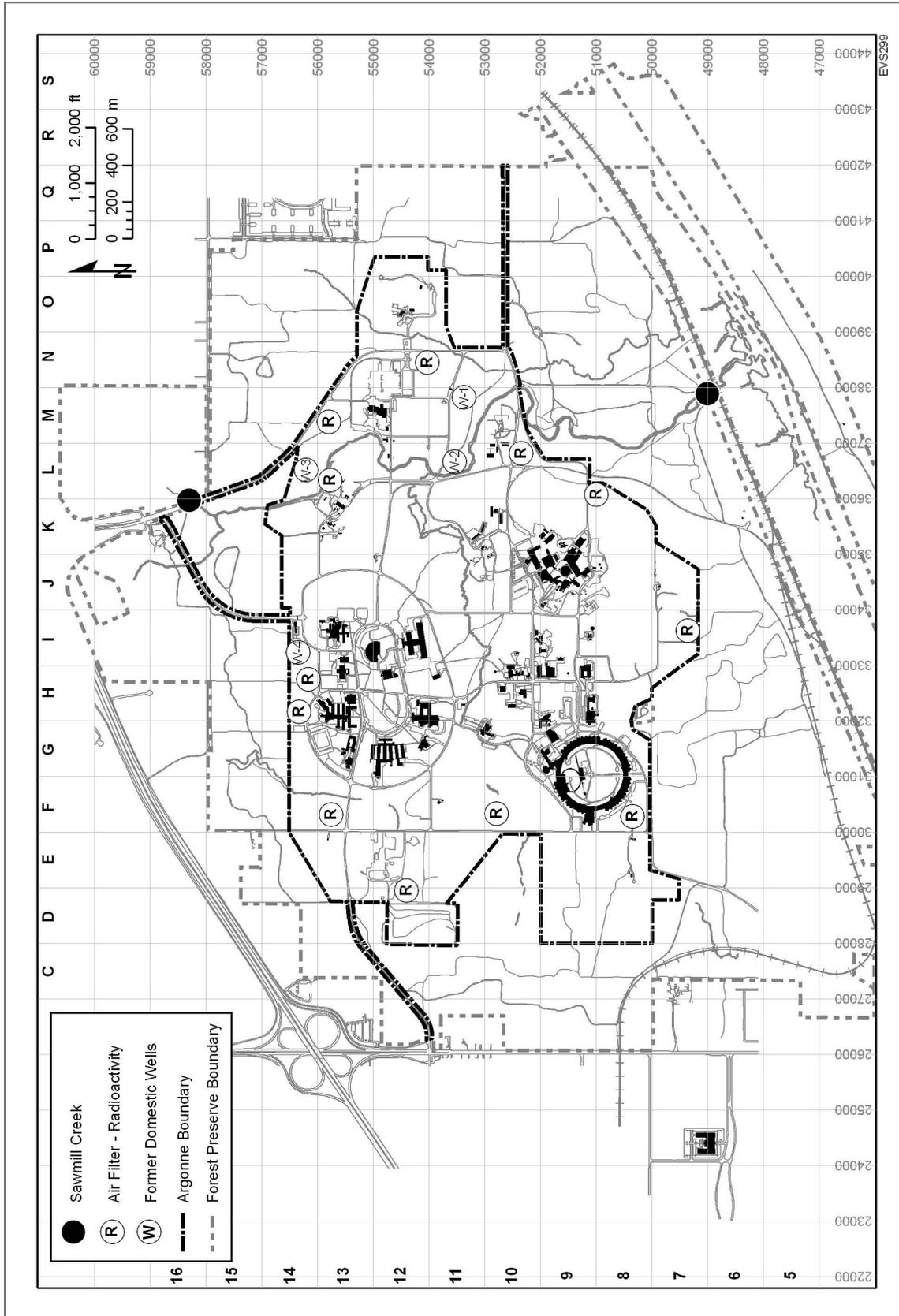


FIGURE 1.1 Sampling Locations at Argonne National Laboratory

1. INTRODUCTION

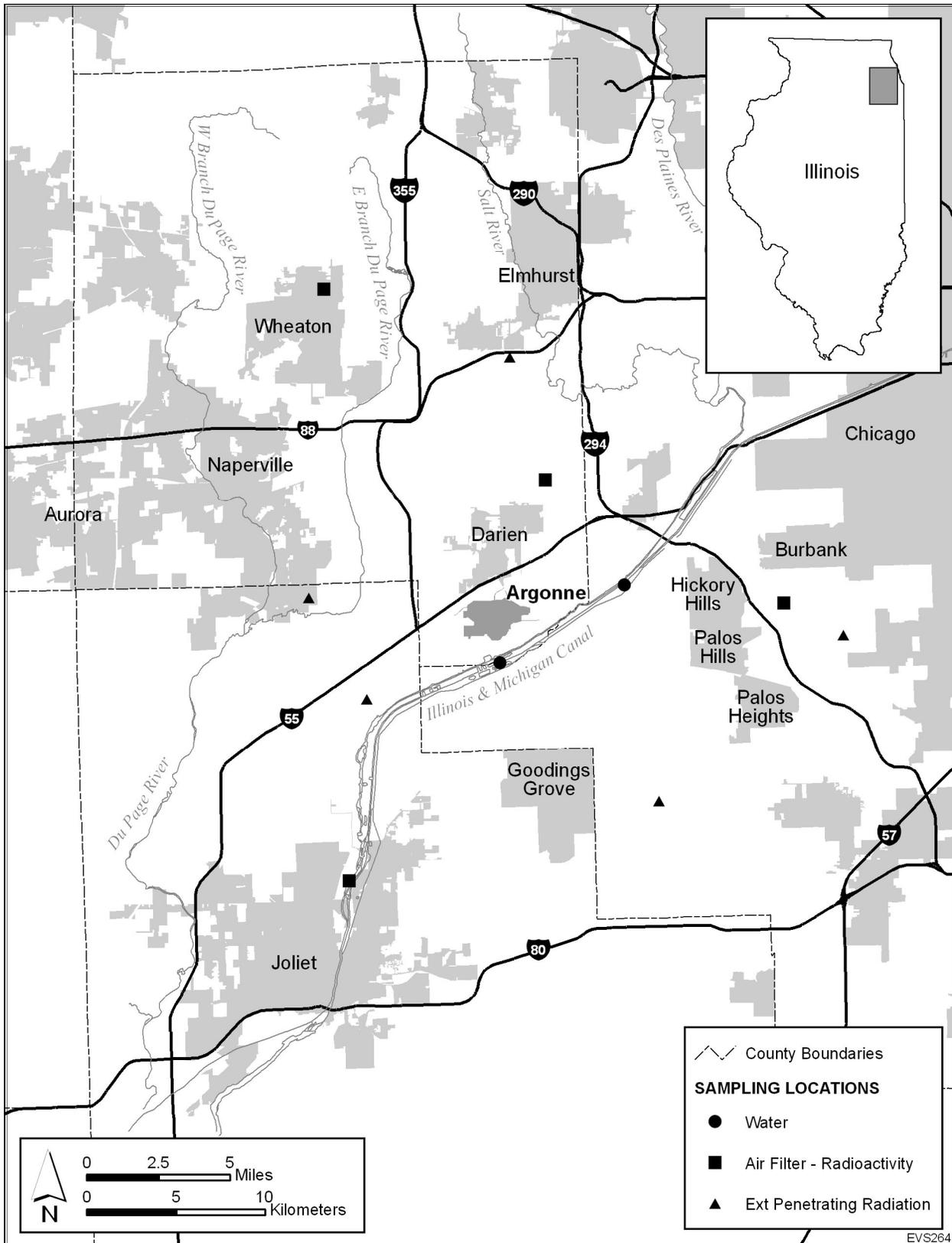


FIGURE 1.2 Sampling Locations near Argonne National Laboratory

TABLE 1.1
Population Distribution in the Vicinity of Argonne, 2005

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	1,260	3,745	6,359	9,913	47,865	187,957	350,601	235,346	314,363
NNE	0	585	4,226	6,133	6,337	41,311	30,0391	488,056	106,733	1,177
NE	0	816	2,064	2,198	1,876	42,287	706,197	958,769	0	0
ENE	0	1,005	1,307	2,349	1,974	33,622	618,433	190,117	0	0
E	0	1,069	554	363	383	42,134	463,231	215,304	9,899	27,578
ESE	0	424	267	368	505	18,327	188,712	294,596	224,205	95,839
SE	0	193	269	456	939	23,793	111,879	101,003	32,401	17,261
SSE	0	406	396	1,004	1,448	10,466	43,222	1,873	13,635	16,443
S	0	582	2,280	2,129	1,399	9,998	37,982	3,641	36,598	37,792
SSW	0	484	2,307	2,621	1,047	22,183	108,907	14,750	16,781	7,838
SW	0	173	590	342	10	18,024	81,243	14,503	18,929	7,564
WSW	0	129	127	559	3,112	21,066	29,434	7,213	9,429	11,717
W	0	147	567	7,818	10,530	46,610	100,304	30,268	19,165	7,087
WNW	0	500	863	2,973	4,708	46,580	162,138	44,204	8,317	62,884
NW	0	687	2,377	7,248	7,979	47,247	86,635	130,674	27,822	21,825
NNW	0	1,074	2,700	6,124	9,714	34,933	222,946	267,024	183,404	138,432
Total	0	9,534	24,639	49,044	61,874	506,446	3,449,611	3,112,596	942,664	767,800
Cumulative totals ^b	0	9,534	34,173	83,217	145,091	651,537	4,101,148	7,213,744	8,156,408	8,924,208

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

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

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centered on the 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 to 2005 on the basis of 2000 census data.

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. The wind data are used to select air sampling locations and distances from sources and to calculate radiation doses from air emissions. Temperature and precipitation data are useful in interpreting some of the monitoring results. The 2006 data were obtained from the on-site Argonne meteorological station. The 2006 average monthly and annual wind rose at the 60-m (200-ft) level is shown in Figure 1.3. The wind rose is a polar coordinate plot in which the lengths of the radii represent the percentage frequency of wind speeds in classes of 2.01 to 6 m/s (4.5 to 13.4 mph), 6.01 to 10 m/s (13.4 to 22.4 mph), and greater than 10.01 m/s (22.4 mph). The number in the center of each wind rose represents the percentage of observations of wind speed less than 2 m/s (4.5 mph) in all directions. The directions of the radii from the center represent the directions from which the wind blows. Sixteen radii are shown on each plot at 22.5° intervals; each radius represents the average wind speed for the direction covering 11.25° on either side of the radius. The annual average wind rose for 2006 is consistent with the long-term average wind direction, which usually varies from the west to south, but with a significant northeast component.

Table 1.2 gives 2006 precipitation and temperature data. The monthly precipitation data for 2006 shows significant differences from the Argonne historical average. The annual total was 27% above the annual average for the Argonne data. The monthly temperatures were generally higher during the summer months when compared with the long-term monthly average. The 2006 annual monthly average was 10% higher than the long-term annual average. The climatology information was provided by the Atmospheric Research Section of the Environmental Science Division.

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 Niagaran 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. Niagaran and Alexandrian dolomite is approximately 60 m (200 ft) thick but has an irregular, eroded upper surface.

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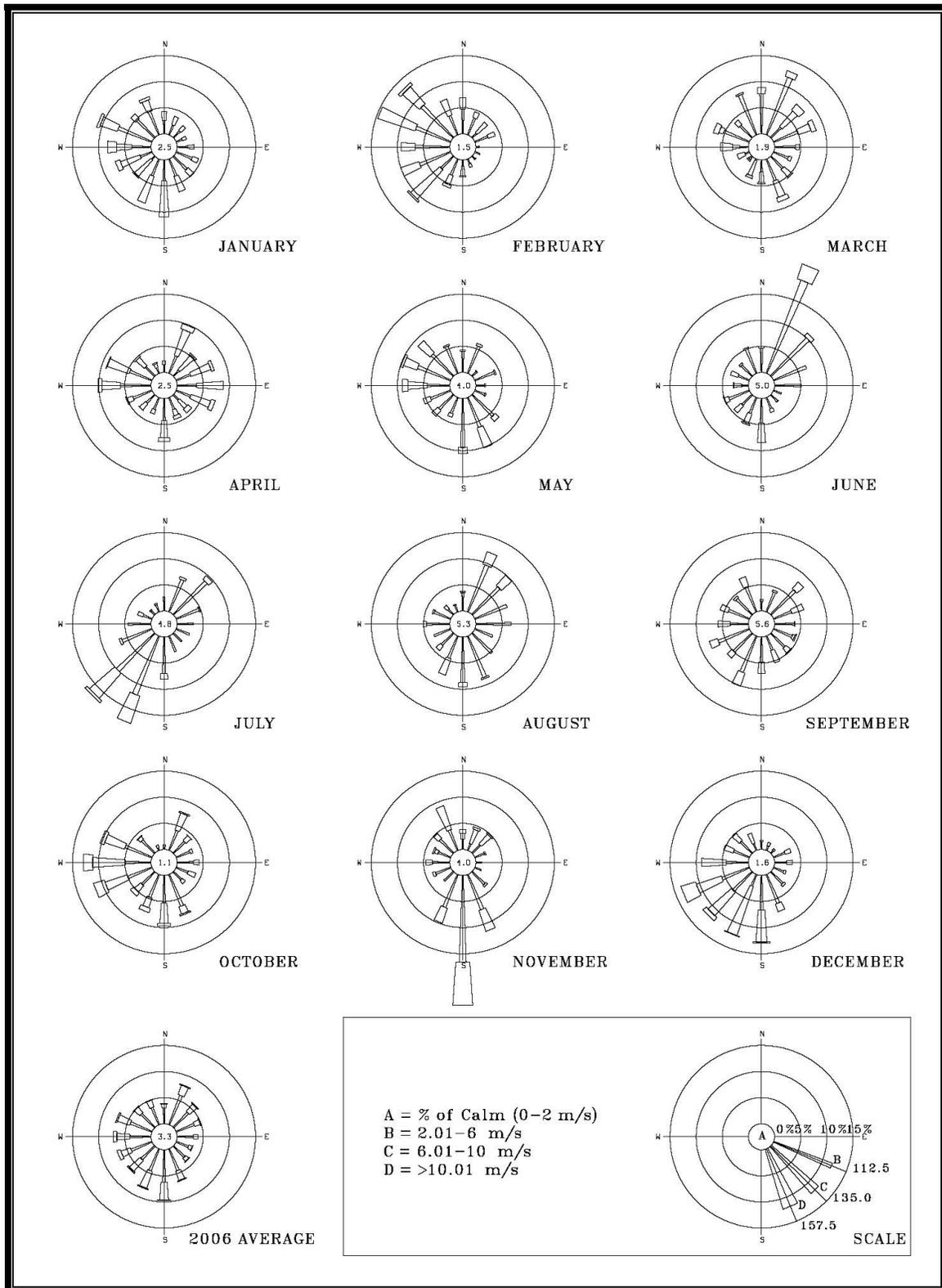


FIGURE 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory, 2006

1. INTRODUCTION

TABLE 1.2

Argonne Weather Summary, 2006

Month	Precipitation (cm)		Temperature (°C)		
	Argonne 2006	Argonne Historical ^a	Argonne 2006	Argonne Historical ^a	
January	8.86	4.29	1.7	-4.7	
February	3.68	4.19	-2.4	-1.9	
March	7.77	6.05	3.4	3.1	
April	10.15	8.34	12.1	9.4	
May	7.34	9.69	15.4	14.0	
June	11.62	8.52	20.4	20.7	
July	8.51	10.55	24.4	23.1	
August	14.06	10.34	22.8	22.1	
September	13.91	8.28	16.9	18.2	
October	14.14	8.07	9.6	11.4	
November	11.27	8.87	6.1	4.4	
December	<u>5.27</u>	<u>4.58</u>	<u>1.0</u>	<u>-2.9</u>	
Total	116.58	91.57	Monthly Average	11.0	10.0

^a Averages were obtained from the Argonne meteorological tower by using data from the last 24 years (1983–2006).

The southern boundary of Argonne follows the bluff of a broad valley, which is now occupied by the Des Plaines River and the Chicago Sanitary and Ship 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 135 km (62 mi) of Argonne are known to be seismically active. The longest inactive local feature is the Sandwich Fault. Smaller local features are the Des Plaines disturbance, a few faults in the Chicago area, and a fault of apparently Cambrian age.

Although a few minor earthquakes have occurred in northern Illinois, none have 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 moderate distances (i.e., hundreds of kilometers) from Argonne. These areas include the New Madrid Fault zone (southeast Missouri) in the St. Louis area, the Wabash Valley Fault zone along the southern Illinois-Indiana border, and the Anna region of western Ohio. Although high-intensity earthquakes have occurred along the New Madrid Fault zone, their relationship to plate motions remains speculative at this time.

According to estimates, ground motions induced by near and distant seismic sources in northern Illinois are expected to be minimal. However, peak accelerations in the Argonne area may exceed 10% of gravity (the approximate threshold of major damage) once in approximately 600 years, with an error range of -250 to +450 years.

1.7. Groundwater Hydrology

Two principal aquifers are used as water supplies in the vicinity of Argonne. The upper aquifer is 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 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 hydraulic connection between the two aquifers.

Up until 1997, most groundwater supplies in the Argonne area were derived from the Niagaran, and to some extent, the Alexandrian dolomite bedrock. Dolomite well yields are variable, but many approach 3,028 L/min (800 gal/min). In DuPage County, groundwater pumpage over the past 100 years has led to severe overdraft; in northeastern Illinois, the piezometric surface has been lowered in areas of heavy pumping. Delivery of Lake Michigan water to the nearby suburban areas, which began in 1992, is expected to relieve this overdraft problem. Argonne now obtains all of its domestic 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. Along the southern margin of the property, the terrain slopes abruptly downward, forming forested bluffs. These bluffs are dissected by ravines containing intermittent streams that discharge some site drainage into

1. INTRODUCTION

the Des Plaines River. In addition to the streams, various ponds and cattail marshes are present on the site. A network of ditches and culverts transports surface runoff toward the smaller streams.

The greater portion of the Argonne site is drained by Freund Brook. Two branches of Freund Brook flow from west to east, drain the interior portion of the site, and ultimately discharge 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.

Residential and commercial development in the area have resulted in the collection and channeling of runoff water into Sawmill Creek. Treated sanitary and laboratory wastewater from Argonne are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. In 2006, this effluent averaged 2.79 million L/day (0.75 million gal/day), which is below the averages for the last few years. The combined Argonne effluent consisted of 62% laboratory wastewater and 38% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 29 million L/day (7.7 million gal/day) during 2006.

Sawmill Creek and the Des Plaines River upstream of Joliet, about 21 km (13 mi) southwest of Argonne, receive very little recreational or industrial use. A few people fish in these waters downstream of Argonne, and some duck hunting takes place on the Des Plaines River. 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 1.7 million L/day (0.45 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 complex 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 water is used as a community water supply system is at Peoria, 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 east and 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 also 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 morainal 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 1.4 shows the vegetation communities.

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.

DOE and Argonne are members of the Chicago Wilderness Coalition, a partnership of more than 170 public and private organizations that have joined forces to protect, restore, and manage 81,000 ha (200,000 acres) of natural areas in the Chicago metropolitan region. Several activities are planned or are in progress to enhance oak woodland, savanna, wetland, and prairie habitats on the approximately 285 ha (700 acres) that remain undeveloped at the Argonne site.

1.10. Fauna

Terrestrial vertebrates that are commonly observed or likely to occur on the site include about 5 species of amphibians, 7 of reptiles, 40 of summer resident birds, and 25 of mammals. More than 100 other bird species can be found in the area during migration or 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. A population of native white-tailed deer also inhabits the Argonne site. The white-tailed and fallow deer populations are each maintained at a target density of 15 deer/mi² under an ongoing deer management program.

1. INTRODUCTION

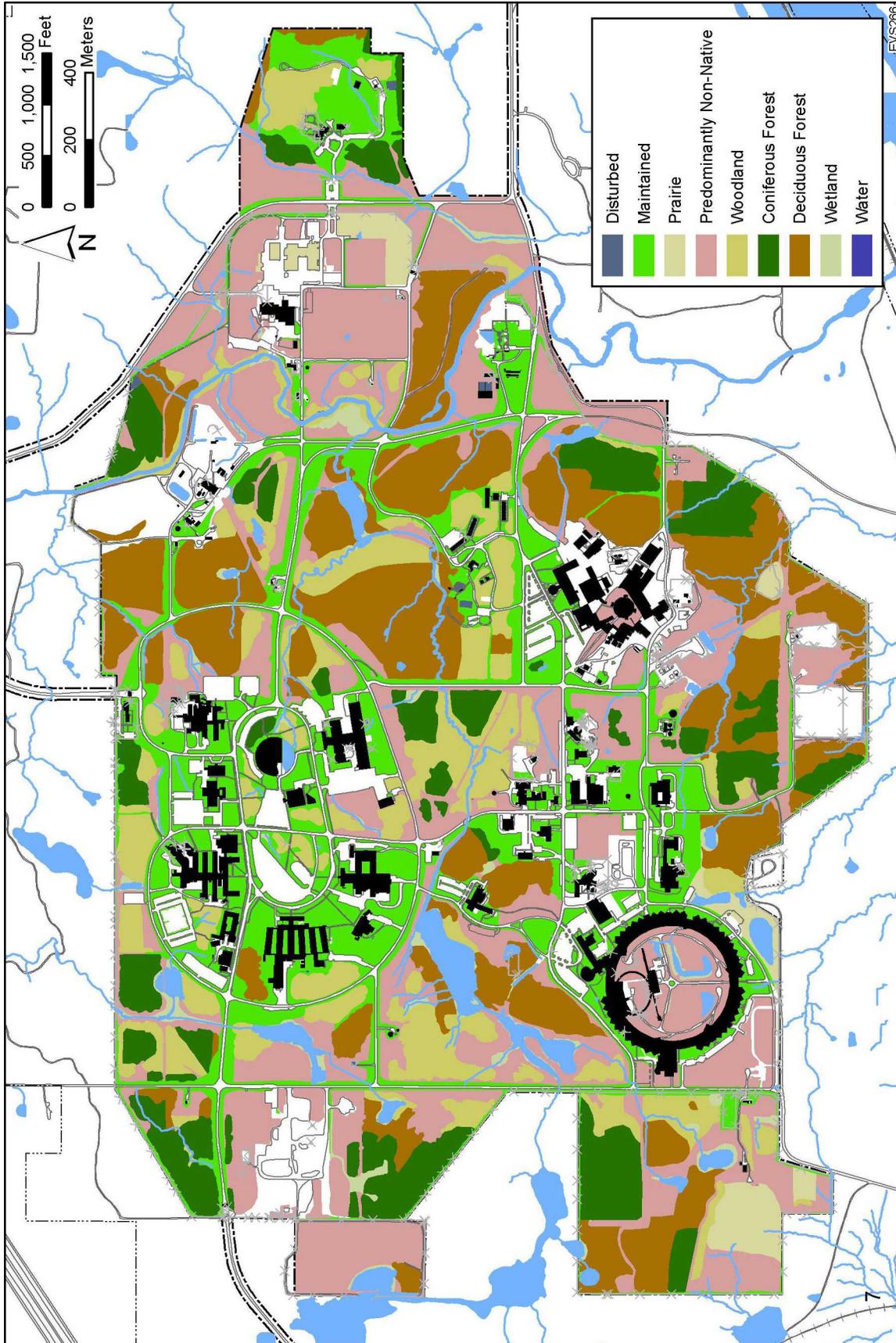


FIGURE 1.4 Argonne Vegetation Communities

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, sunfishes, 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.

The U.S. Fish and Wildlife Service (USFWS) has rated the Des Plaines River system, including Argonne streams, as "poor" in terms of the fish species present because of domestic and industrial pollution and stream modification.

1.11. Cultural Resources

Argonne, which is located in the Illinois and Michigan Canal National Heritage Corridor, is situated in an area known to have a long and complex cultural history. All periods listed in the cultural chronology of Illinois, with the exception of the earliest period (Paleo-Indian), have been documented in the Argonne area either by professional cultural resource investigators or through interviews of local artifact collectors by Argonne staff. A variety of site types, including mounds, quarries, lithic workshops, and habitation sites, have been reported by amateurs within a 25-km (16-mi) radius.

Forty-six archaeological sites have been recorded at Argonne. These sites include prehistoric chert quarries, special-purpose camps, base camps, and historical farmsteads. The range of human occupation spans several time periods (Early Archaic through Mississippian Prehistoric to Historical). Four sites have been determined to be eligible for the *National Register of Historic Places* (NRHP); 21 sites have been determined to be ineligible; and 21 sites have not been evaluated for eligibility.

Cultural resources also include historic structures. Historic property surveys over the past several years identified two areas at Argonne, the 200 Area campus and the 300 Area reactor development buildings, that are eligible for listing in the NRHP as historic districts, as well as several buildings that are individually eligible for listing in the NRHP.

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1.12. Endangered Species

No federally listed threatened or endangered species are known to occur on the Argonne site, and no critical habitat of federally listed species exists on the site. Three federally listed endangered species and one federally listed threatened species are known to inhabit the Waterfall Glen Forest Preserve that surrounds the Argonne property or are known to occur in the area.

The Hine's emerald dragonfly (*Somatochlora hineana*), federally and state listed as endangered, occurs in locations with calcareous seeps and wetlands along the Des Plaines River floodplain. 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. An unconfirmed capture of an Indiana bat (*Myotis sodalis*), which is federally and state listed as endangered, indicates that this species may occur in the area. The federally listed threatened lakeside daisy (*Hymenoxys herbacea*) has a planted population in Waterfall Glen Forest Preserve. Additional state-listed species that occur in the area are identified in Section 2.10.

2. COMPLIANCE SUMMARY



2. COMPLIANCE SUMMARY

2. COMPLIANCE SUMMARY

Argonne is a U.S. government-owned, contractor-operated 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 to numerous DOE Orders and Executive Orders (EOs). The status of Argonne during 2006 with regard to these authorities is discussed in this chapter.

The Atomic Energy Act of 1954 (AEA) was promulgated 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., 10 CFR Part 820, 10 CFR Part 830, and 10 CFR Part 835, DOE Order 435.1, and DOE Order 5400.5) to protect public health and the environment from potential risks associated with radioactive materials. This Site Environmental Report (SER) is used to demonstrate compliance with these regulations and orders.

Argonne has made a commitment to comply with all applicable environmental requirements, as described in the following statement in Section 7.3 of the Argonne Policy Manual:

Argonne activities (including experiments, facility operations, construction activities, and other activities) will be conducted in an environmentally safe manner consistent with Argonne permit conditions. Argonne commits to continuous environmental improvement, pollution prevention, and compliance with all applicable requirements. To support this policy, Argonne is committed to leadership in environmental management by integrating environmental accountability into day-to-day activities and into long-term planning processes.

2.1. Clean Air Act

The Clean Air Act (CAA) is a federal statute that sets emission limits for air pollutants and determines emission limits and operating criteria for certain hazardous air pollutants (HAPs). The program for compliance with the requirements of the CAA is implemented by individual states through a State Implementation Plan (SIP) that describes how that state will ensure compliance with the air quality standards for stationary sources.

Under Title V of the Clean Air Act Amendments of 1990, Argonne submitted a Clean Air Act Permit Program (CAAPP) application to the IEPA for a sitewide, federally enforceable operating permit to cover emissions of all regulated air pollutants at the facility. The finalized CAAPP Title V permit was issued on April 3, 2001. 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 90.72 t/yr (100 tons/yr), carbon

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monoxide in excess of 90.72 t/yr (100 tons/yr), or sulfur dioxide in excess of 90.72 t/yr (100 tons/yr) at the Building 108 central heating plant.

On October 26, 2004, Argonne received a renewal notice from the IEPA notifying Argonne that a permit renewal application was due no later than 9 months prior to expiration of the CAAPP permit (April 3, 2006). The CAAPP permit renewal application was submitted to the IEPA on April 15, 2005, and received a completeness determination on April 21. Three revisions to the application were submitted to the IEPA between September and December 2005. On December 21, 2005, the IEPA issued the draft CAAPP permit. Argonne had raised a number of significant concerns in its comments on the draft permit. On February 16, 2006, representatives from the IEPA came to Argonne to discuss these issues. All major concerns raised by Argonne were addressed. On March 15, 2006, an emission test for carbon monoxide and particulates, required as a portion of the draft permit, was conducted on coal-fired Boiler No. 5. The test indicated that the boiler complied with all regulatory limits and permit requirements. One outstanding permit issue involved the delay of the California Air Resources Board (CARB) to certify Stage II vapor recovery equipment for use on E85 dispensing facilities. Argonne agreed to have such CARB-certified equipment installed within 180 days of it becoming commercially available in Illinois. After resolving these issues, the final permit was transmitted from the IEPA to Argonne effective October 17, 2006.

Facilities 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), HAPs (a list of 188 chemicals, including radionuclides), and ozone-depleting substances. 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) they are allowed to emit.

The Argonne site contains a large number of air emission point sources. The vast majority are laboratory ventilation systems that are exempt from state permitting requirements, except for those systems emitting radionuclides. In 2006, there was one construction permit issued for the Building 203 Californium Rare Ion Beam Upgrade (CARIBU) project.

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 emissions limits and other requirements, such as monitoring, recordkeeping, and operational and reporting requirements, for activities generating emissions of certain HAPs. The only standards affecting Argonne operations are those for asbestos and radionuclides. By the time of the issuance of the sitewide Argonne Title V permit, the IEPA had issued a total of 23 air pollution control permits to Argonne for NESHAP sources. All Argonne operating NESHAP permits were incorporated into the sitewide Argonne Title V permit.

2.1.1.1. Asbestos Emissions

Many buildings on the Argonne site contain large amounts of asbestos-containing material (ACM), such as thermal system 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 these and other regulatory requirements. ACM is removed from buildings either by Argonne personnel or outside contractors licensed by the Illinois Department of Public Health. All removal work is performed in accordance with both NESHAP and Occupational Safety and Health Administration requirements governing worker safety at ACM removal sites.

Approximately 44.9 m³ (1,585 ft³) of ACM was generated from Argonne asbestos removal projects during 2006. The 86 small removal projects that were completed generated 19.3 m³ (680 ft³) of ACM waste. Five large removal projects generated the remaining 25.6 m³ (905 ft³) of ACM waste. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2006 that no more than 71 m³ (2,500 ft³) of ACM waste is expected to be generated from small-scale projects during 2007.

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. Until closure of the Argonne landfill in September 1992, asbestos from small-scale projects was disposed of on-site in a designated location within the 800 Area Landfill.

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 emissions points at Argonne are subject to these requirements and are operated in compliance with them. These points include ventilation systems for hot cell facilities for storage and handling of radioactive materials (Building 212), ventilation systems for particle accelerators (Building 375, IPNS facility, and the Building 411 APS linac), and several ventilation systems associated with the Building 350 NBL. In addition, many ventilation systems and fume hoods are used occasionally for processing small quantities of radioactive materials.

The amount of radioactive material released to the atmosphere from Argonne emission sources is extremely small, thereby contributing little to the off-site dose. The maximum off-site dose to a member of the general public for 2006 was 0.029 mrem, which is less than 0.3% of the 10 mrem/yr EPA standard. Section 4.8.1 contains a more detailed discussion of these emission points and compliance with the standard.

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TABLE 2.1

Large-Scale Asbestos Abatement Projects DOE/IEPA Notification, 2006

Completion Date	Asbestos Abatement Contractor	Notification Quantity			Material	Building	Disposal Quantity (ft ³)	Landfill
		ft	ft ²	ft ³				
February 22	Waste Management Operations	0	360	0	Floor tile and mastic	302	8	Environtech ^a
March 11	Waste Management Operations	0	650	0	Carpet mastic, floor tile, and mastic ^b	310	120	Environtech
June 2	Waste Management Operations	75	480	0	Pipe and HVAC insulation	200	675	Environtech
October 28	Waste Management Operations	0	1,260	0	Floor tile and mastic	350	56	Environtech
December 20	Waste Management Operations	0	450	0	Floor tile and mastic	362	46	Environtech ^c

^a Environtech Landfill, Morris, IL.

^b Courtesy notification, nonfriable material removed intact.

^c On-site, pending disposal to Environtech.

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, two alkali metal reaction booths, two dust collection systems, an engine test facility, a number of diesel generators, and fire training activities. These facilities are operated and the associated activities are conducted in compliance with applicable regulations and permit conditions.

The Title V permit requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only one of the five boilers at the steam plant that is equipped to burn coal. The permit requires submission of a quarterly report listing any exceedances beyond emission limits for this boiler (30% opacity averaged over 6 min or 0.82 kg [1.8 lb] of sulfur dioxide per million Btu averaged over a 1-hour period). Table 2.2 gives the hours that Boiler No. 5 operated on low-sulfur coal during 2006, as well as the amount of low-sulfur coal burned. There were no exceedances at Boiler No. 5 in 2006.

An annual compliance certification must be submitted to the IEPA and EPA each May 1 for the previous calendar year, detailing any deviations from the Title V permit and subsequent corrective actions. During 2006, there were two deviations identified regarding compliance with the Title V permit. A functional area review conducted in August 2006 discovered that a waste treatment facility unit in Building 306 had been upscaled from bench scale R&D to a full size waste treatment without having it recategorized under the Title V permit. Notification of this

2. COMPLIANCE SUMMARY

change was submitted to the IEPA in September 2006. A second deviation was identified in November 2006. This deviation involved the failure to file an asbestos removal notification with the IEPA for the demolition of Building 374A. A corrective action is being developed to include a hold point in the project based tracking system to address this deficiency.

Landfill gas monitoring is conducted quarterly at the 800 Area Landfill via 3 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 two nearby buildings and at three open-air locations to assess the presence of methane. The gas monitoring near the landfill determines whether methane is migrating from the landfill. In the first two quarters of 2006, methane was detected in an eastside landfill well. The levels detected (0.5% and 0.3%) were well below the action level of 2.5%.

A fuel-dispensing facility is at Building 46, Grounds and Transportation. Except for ethanol vapors from alternate-fuel usage, this facility has VOC emissions typical of any commercial gasoline service station.

Pursuant to *Illinois Administrative Code*, 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 2006 is presented in Table 2.3.

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) 2006 (September 1, 2005–August 31, 2006) vehicles because all current MY vehicles meet clean fuel fleet standards. Because the requirements are still in effect, in lieu of a report, Argonne submitted a letter to the IEPA on September 28, 2006, certifying that all vehicles acquired in MY 2006 meet federal emission standards.

TABLE 2.2

Boiler No. 5 Operation, 2006		
Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	519.0	1,722.7
February	638.0	1,983.3
March	561.5	1,822.0
April	720.0	1,967.0
May	520.8	1,426.0
June	0	0
July	208.5	526.6
August	488.5	1,354.1
September	15.5	30.4
October	0	0
November	0	0
December	0	0
Total	3,671.8	10,832.1

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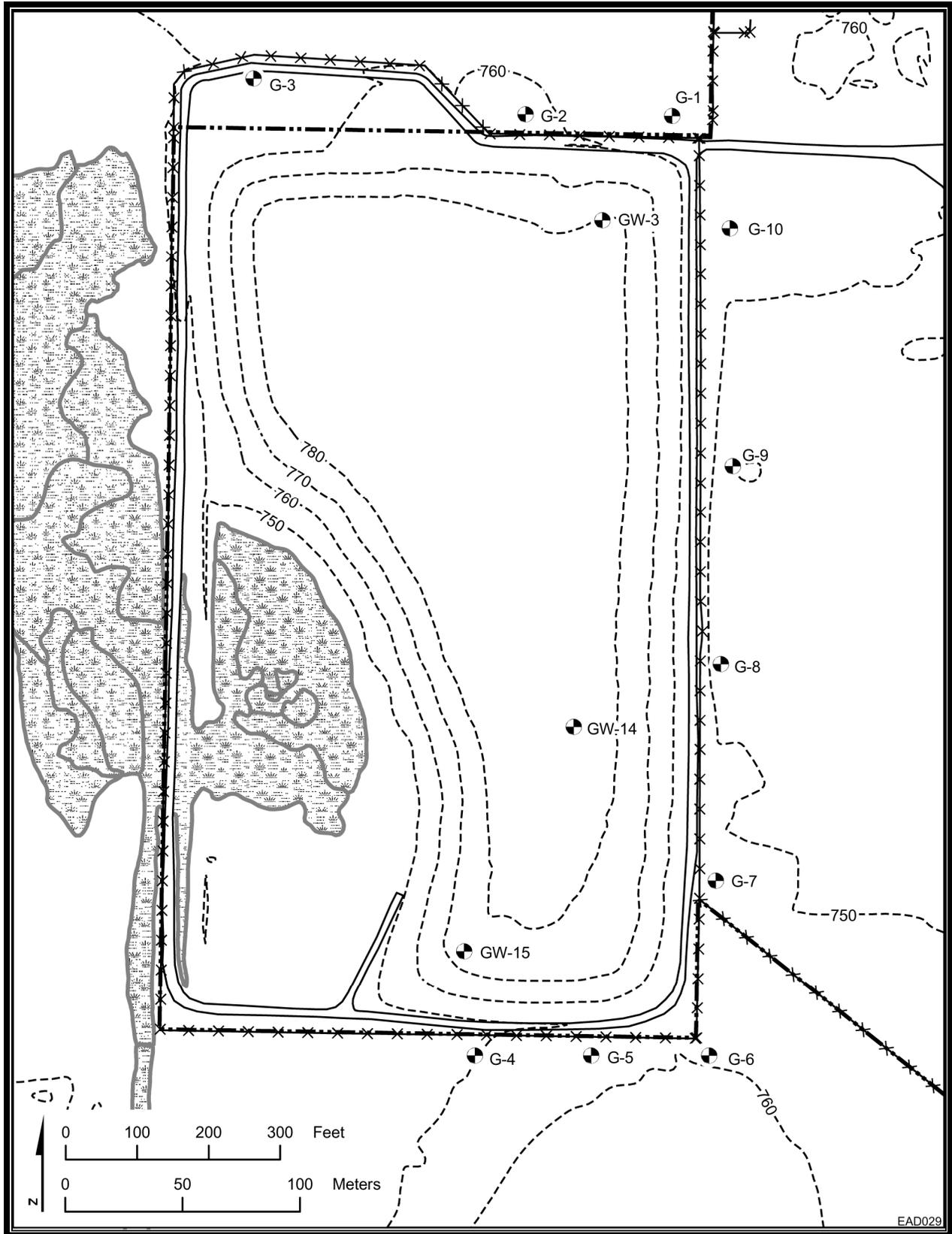


FIGURE 2.1 800 Area Landfill Gas Monitoring Wells

2. COMPLIANCE SUMMARY

TABLE 2.3

2006 Annual Emissions Report: Emissions Summary^a

Building No. and Source	CO	NO _x	PM/PM ₁₀	PM _{2.5} ^b	SO ₂	VOM	HAP ^c	NH ₃ ^b
108: Boiler 1 (gas-fired)	14,065	42,026	634	318	102	367	— ^d	82
108: Boiler 2 (gas-fired)	3,282	4,038	294	74	23	216	—	19
108: Boiler 3 (gas-fired)	12,571	32,162	703	284	91	453	—	73
108: Boiler 4 (gas-fired)	10,585	23,881	673	239	76	438	—	62
108: Boiler 5 (gas-fired)	0	0	0	0	0	0	—	0
108: Boiler 5 (coal-fired)	56,327	119,131	845	347	216,866	394	14,606	6
200: Peak-shaving generator	44	193	6	6	18	6	—	0.1
202: Peak-shaving generator	33	145	4	4	14	4	—	0.1
400: APS generator (Caterpillar)	515	2,684	95	95	222	72	—	2
400: APS generators, Kohler (2)	626	3,262	115	115	270	89	—	1
Transportation research facility	22,338	8,983	635	373	574	1,711	—	8
PCB tank cleanout	—	—	—	—	—	0	—	—
46: Ethanol/gasoline	—	—	—	—	—	0.7	—	—
46: 10,000 gal gasoline	—	—	—	—	—	11.6	—	—
206: Alkali reaction booth (R) ^e	—	—	0	—	—	—	—	—
208: Surface preparation facility	—	0.1	<0.2	<0.1	—	—	<0.1	—
WM portable HEPA - (6) (R) ^e	—	—	4.8	4.8	—	—	—	—
206: Alkali reaction booth (R) ^e	—	—	—	—	—	—	—	—
306: Building vents (R) ^e	—	—	<1	—	—	—	—	—
306: Vial crusher/chemical photooxidation unit (R) ^e	—	—	—	—	—	0	—	—
306: Waste bulking sheds ^e	—	—	2.9	2.9	—	48.8	1.7	—
315: MACE project (R) ^e	0	—	—	—	—	—	—	—
400: APS facility (R) ^e	—	71	—	—	—	—	—	—
595: Lab Wastewater Plant (R) ^e	—	—	—	—	—	1,121	5.9	—
Total (lb/yr)	120,387	236,576	4,011	1,864	218,256	4,931	14,613	253
Total (ton/yr)	60.19	118.28	2.00	0.93	109.12	2.46	7.30	0.12
CAAPP permit limit (ton/yr)	(237.60)^f	395.20	65.93	—	332.20	21.53	10.00	—

^a Abbreviations: APS = Advanced Photo Source; CAAPP = Clean Air Act Permit Program; CO = carbon monoxide; HAP = hazardous air pollutant; HEPA = high-efficiency particulate air; MACE = melt attack and coolability experiment; NH₃ = ammonia; NO_x = oxides of nitrogen; PCB = polychlorinated biphenyl; PM = particulate matter; PM₁₀ = particulate matter less than 10 microns; PM_{2.5} = particulate matter less than 2.5 microns; SO₂ = sulfur dioxide; VOM = volatile organic matter; WMO = Waste Management Operations.

^b As of 2003, emissions of PM_{2.5} and a precursor, ammonia, must be included in the Annual Emission Report.

^c HAPS not included in VOM or particulates (hydrochloride, hydrogen fluoride, methyl chloroform, methylene chloride).

^d A dash indicates that the pollutant is not permitted from that particular unit (or it is classified as an insignificant activity); a zero means that the source is permitted for emissions of that pollutant but that there were no emissions for the year..

^e (R) = radionuclide source regulated by NESHAP (40 CFR Part 61, Subpart H).

^f Not a permit limit, but the maximum potential emission level for CO.

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2.2. Clean Water Act

The Clean Water Act (CWA) was established in 1977 as a major 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, which is the regulatory mechanism designed to achieve this goal. The authority to implement the NPDES program has been delegated to those states, including Illinois, that have developed a program substantially the same and at least as stringent as the federal NPDES program.

The 1987 amendments to the CWA significantly changed the thrust of regulatory activities. Greater emphasis is placed on the monitoring and control of toxic constituents in wastewater, the permitting of outfalls composed entirely of stormwater, and the imposition of regulations governing sewage sludge disposal. These changes in the NPDES program resulted in much stricter discharge limits in the 1990s and greatly expanded the number of chemical constituents monitored in the effluent.

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 5 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 discharge at Argonne is permitted by NPDES Permit No. IL 0034592. The IEPA issued a renewal permit effective September 1, 2005.

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, and steam boiler blowdown), laboratory wastewater (from laboratory sinks and other industrial wastewater sewers), and stormwater. Water softener regenerant from boiler house activities is discharged into the DuPage County sewer system. Cooling water and cooling tower blowdown are generally sent to the laboratory wastewater sewer, although a small volume is still discharged into stormwater ditches that are monitored as part of the NPDES permit. The permit authorizes the release of wastewater 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 2.4 describes these outfalls and Figure 2.2 shows the outfall locations.

2. COMPLIANCE SUMMARY

TABLE 2.4

Characterization of NPDES Outfalls at Argonne, 2006

Outfall Number	Description	Average 2006 Dry Weather Flow ^a
A01	Sanitary Treatment Plant	0.277
B01	Laboratory Treatment Plant	0.461
001	Combined outfall	0.735
B03	300 Area (condensate) and groundwater	0.015
C03	Building 205 footing tile drainage	0.029
D03/E03	Steam trench drainage (condensate)	0.012/0.0
F03	Building 201 fire pond overflow stormwater	Stormwater only
G03	North Building 201 storm sewer (condensate)	0.028
H03	Building 212 cooling tower blowdown	<0.001
I03	Buildings 200 and 211 cooling tower blowdown	Stormwater only
J03	Building 213 and Building 213 parking lot stormwater	0.005
K03 ^b	Stormwater, APS	Stormwater only
L03 ^b	Stormwater, APS	Stormwater only
M03 ^b	Stormwater, APS	Stormwater only
N03 ^b	Stormwater, 212 East	Stormwater only
004	Building 203 cooling tower and Building 221 footing drainage and stormwater	0.036
A05	Westgate Road stormwater	Stormwater only
B05	800 Area east stormwater	Stormwater only
C05	Building 200 West	0.030
D05	Stormwater	Stormwater only
E05	Building 203 west footing drainage and condensate	0.004
006	Cooling tower blowdown and stormwater	0.059
007	Domestic cooling water for compressor and stormwater	0.02
008	Transportation and grounds stormwater	Stormwater only
011	North fence line marsh storm discharge	Stormwater only
012	100 Area stormwater discharge	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 and cooling 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, and 316 cooling water, eastern and southern APS area	0.009
026	Water Treatment Plant area stormwater	Stormwater only
027 ^b	CNM ^c fire suppression system water and stormwater	Stormwater only

^a Flow is measured in million gallons per day, except for outfalls with stormwater only.

^b Outfall added by September 1, 2005, NPDES permit.

^c CNM = Center for Nanoscale Materials.

2. COMPLIANCE SUMMARY

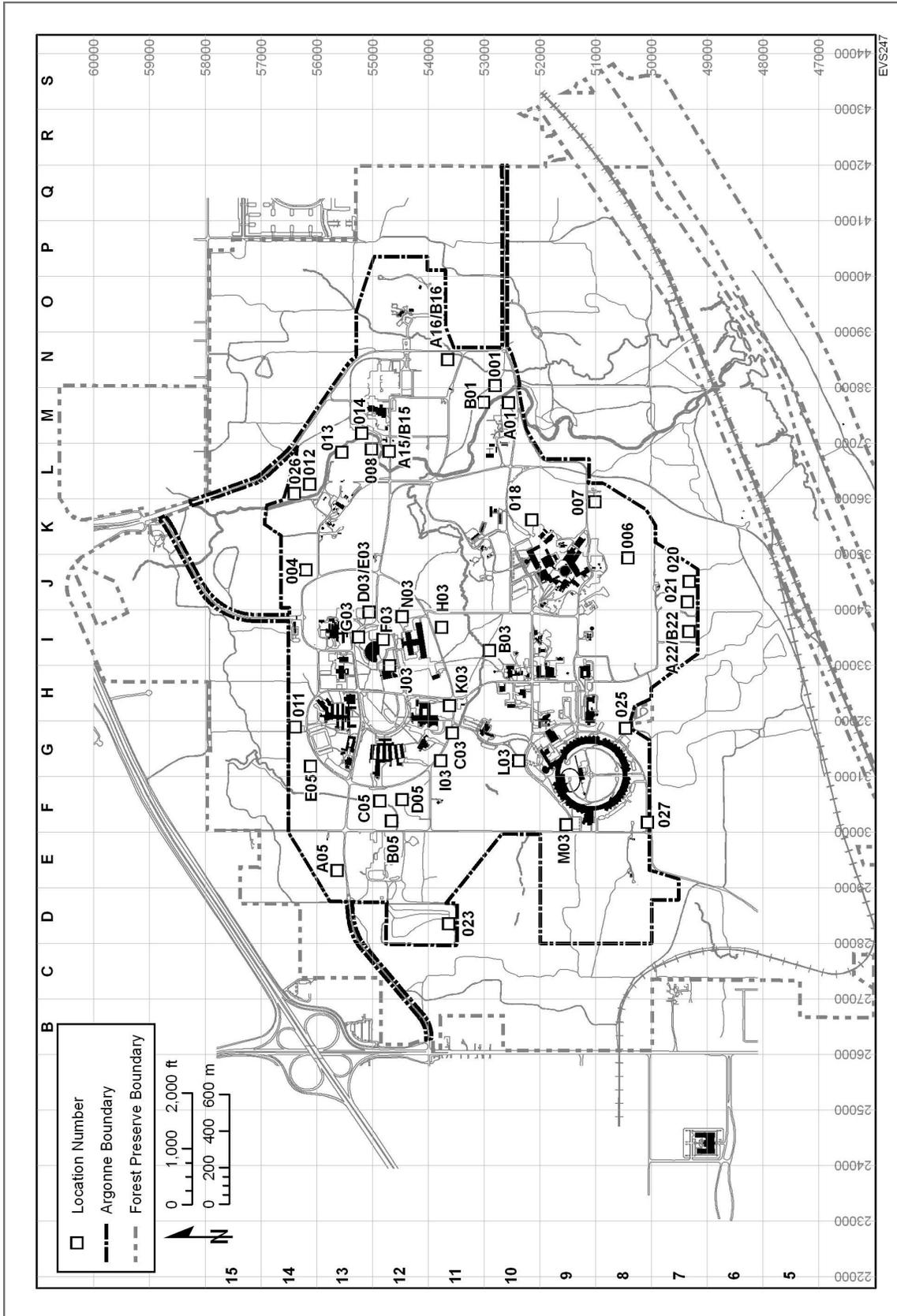


FIGURE 2.2 NPDES Outfall Locations

2.2.1.1. NPDES Permit Activities

Argonne submitted an application to modify the NPDES permit (IL0034592) in order to include the Howard T. Ricketts Laboratory (HTRL) wastewater discharge to the Laboratory's wastewater treatment plants, as well as other changes to the permit. The HTRL will be a University of Chicago-owned building located on the Argonne site. The complete modification included:

1. Addition of the HTRL wastewater with high biochemical oxygen demand (BOD₅) to the Sanitary Wastewater Treatment Plant (SWTP);
2. Addition of the non-BOD₅ laboratory wastewater to the Laboratory Wastewater Treatment Plant (LWTP);
3. Addition of a new stormwater outfall for the HTRL – Outfall 028;
4. Addition of a phosphorous discharge limit to the LWTP to enable acceptance of phosphorous-containing wastewater; and
5. Request for a change in status for Outfall 018 in order to allow receipt of air compressor condensation wastewater.

This modification package was sent to the DOE Argonne Site Office (DOE-ASO) on November 11, 2005, which sent it on to the IEPA on November 22, 2005. The IEPA provided a revised draft permit as a public notice on December 7, 2006.

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 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 a biological wastewater treatment system 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-contact clarification, and pH adjustment. Additional steps can be added, including powdered-activated carbon addition for organic removal, alum addition, and polymer addition or adjustment, if analysis demonstrates that any of these are required.

Figure 2.3 shows the two wastewater treatment systems that are located adjacent to each other. The volume of wastewater discharged from these facilities in 2006 averaged

2. COMPLIANCE SUMMARY

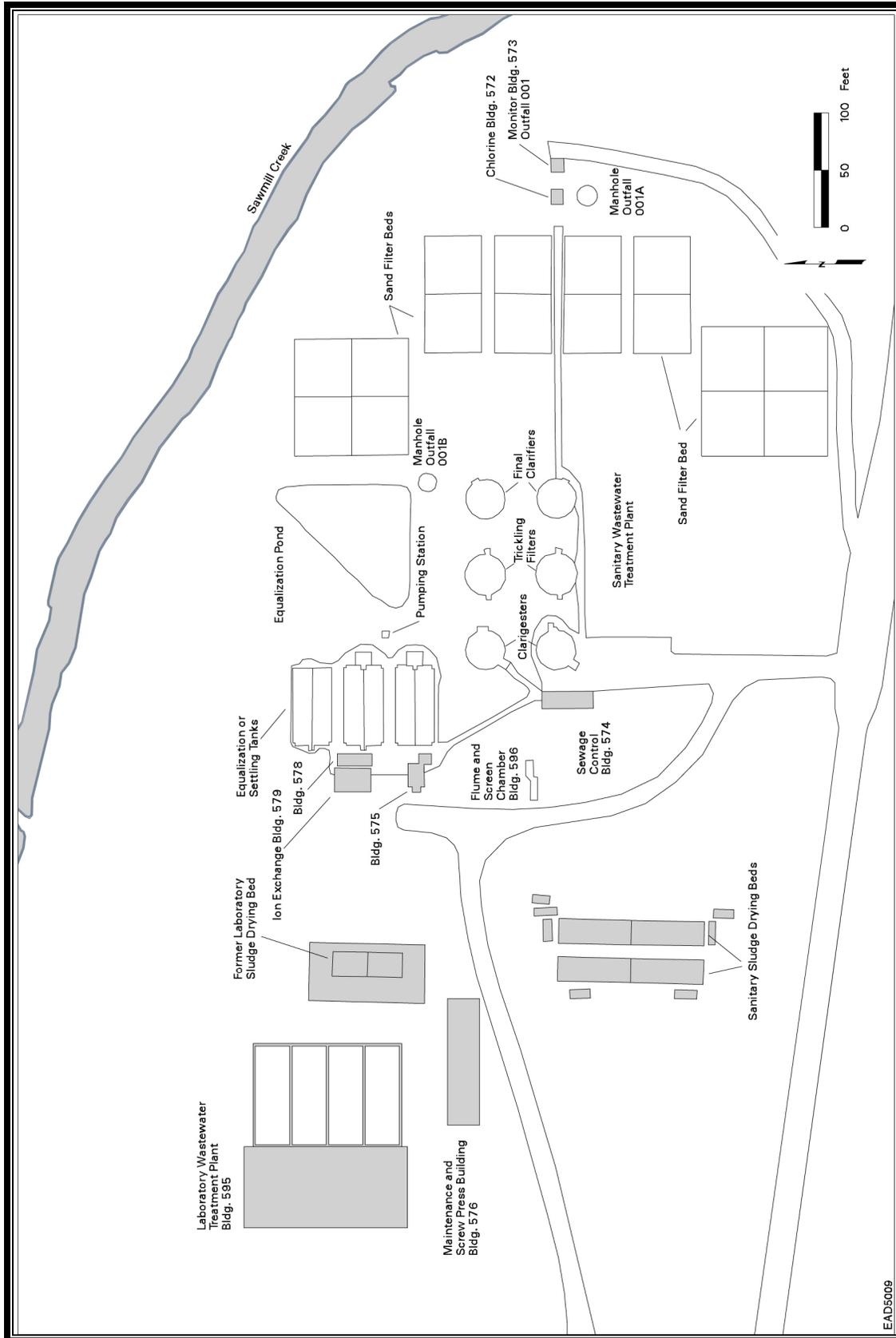


FIGURE 2.3 Argonne Wastewater Treatment Plant

2. COMPLIANCE SUMMARY

1.05 million L/day (0.278 million gal/day) for the sanitary wastewater and 1.76 million L/day (0.461 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 2006, there were 22 exceedances of NPDES permit limits out of approximately 1,700 measurements. The September 1, 2005, NPDES permit placed additional limits for total residual chlorine (TRC – Outfalls H03, J03, 004, E05, 006, and 025), total suspended solids (TSS – Outfalls B03, D03, E03, and H03), and total dissolved solids (TDS – Outfalls H03, J03, 006, and 025).

Two exceedances of the TRC limit were noted at Outfall H03 in 2006. In order to identify and remove the offending discharge(s) from the outfall, Argonne organized an investigation of the sources, and shortly after the last violation (March 6, 2006), the source was discovered and stopped. There have been no violations of the TRC limit at this outfall since that time.

Two exceedances of the TDS limit were noted at Outfall 001 that were attributed to road salt associated with snowmelt. There were 10 exceedances of the TDS limit at Outfall J03 and 7 exceedances of the TDS limit at Outfall H03. These exceedances resulted in Argonne receiving a Notice of Violation Letter from the IEPA in May 2006 for these discharges. Argonne responded to the IEPA with a Compliance Commitment Agreement (CCA) in June 2006, which committed Argonne to the following actions:

- Reroute/repair suspected high TDS discharge sources to Outfalls H03 and J03;
- Amend monitoring methodology to ensure that standing water is not sampled and, therefore, a representative sample is collected;
- Investigate contributing discharges to both outfalls and collect samples to identify contributing sources;
- Investigate modifications to snow management practices; and
- Identify and remove additional contributing TDS sources.

The IEPA accepted Argonne's CCA in July 2006. Argonne completed the following activities as proposed in the CCA:

- The cooling tower discharges originating from Building 212 that were contributing to high TDS at Outfall H03 were rerouted;
- Faulty equipment contributing to the Building 213 high TDS cooling tower overflow to Outfall J03 was repaired;
- The monitoring methodology was amended;

2. COMPLIANCE SUMMARY

- The Building 212 sump discharging high TDS was rerouted, which solved the low flow TDS issue at Outfall H03;
- An extensive soil/water investigation was performed in the Outfall J03 watershed to identify contributing sources;
- Snow management practices were modified, including:
 - Increased use of pretreated salts, which reduces the amount of raw salt applied;
 - Increased snow management personnel training;
 - Initiated use of liquid deicing agents as a presnow event strategy resulting in decreased raw salt usage;
 - A process was implemented to track salt usage, resulting in the establishment of a baseline in the 2006–2007 season for future tracking and trending;
 - Weather tracking and notification systems were improved; and
 - Equipment was upgraded to include two small pickup trucks with mounted salt spreaders used to plow and salt small lots, docks, and pull-offs, thereby reducing salt usage resulting from larger truck overspray; and
- No additional contributing high TDS sources to Outfalls H03 and J03 were confirmed.

At the end of 2006, Argonne continued its investigation into the appropriate remedy to the TDS at Outfall J03, with a plan of reducing the TDS discharge at this outfall to below the permit limit in 2007.

One phenol exceedance was noted at Outfall 006. The source of this exceedance was considered an anomaly since, during investigation activities, there was no evidence of a phenol source in the watershed. Figure 2.4 presents the data for the total number of permit limit exceedances each year over the past 11 years.

2.2.1.3. Priority Pollutant Analysis and Biological Toxicity Testing

The NPDES permit requires semiannual testing of Outfall B01 (the LWTP outfall) and annually at Outfall 021 for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2006, the Outfall B01 sampling was conducted in June and December. Results were similar to past years. Organic compound concentrations were very low. Chloroform was detected at 3 µg/L and dichlorobromomethane at 2 µg/L in both the June and December samples and dibromochloromethane was detected at 2 µg/L in June and 0.7 µg/L in December. Bromoform was detected at 1 µg/L in June. It is suspected that the chloroform, dibromochloromethane, and bromodichloromethane result from the contact of chlorinated water with organic chemicals and residues from cooling tower biocide

2. COMPLIANCE SUMMARY

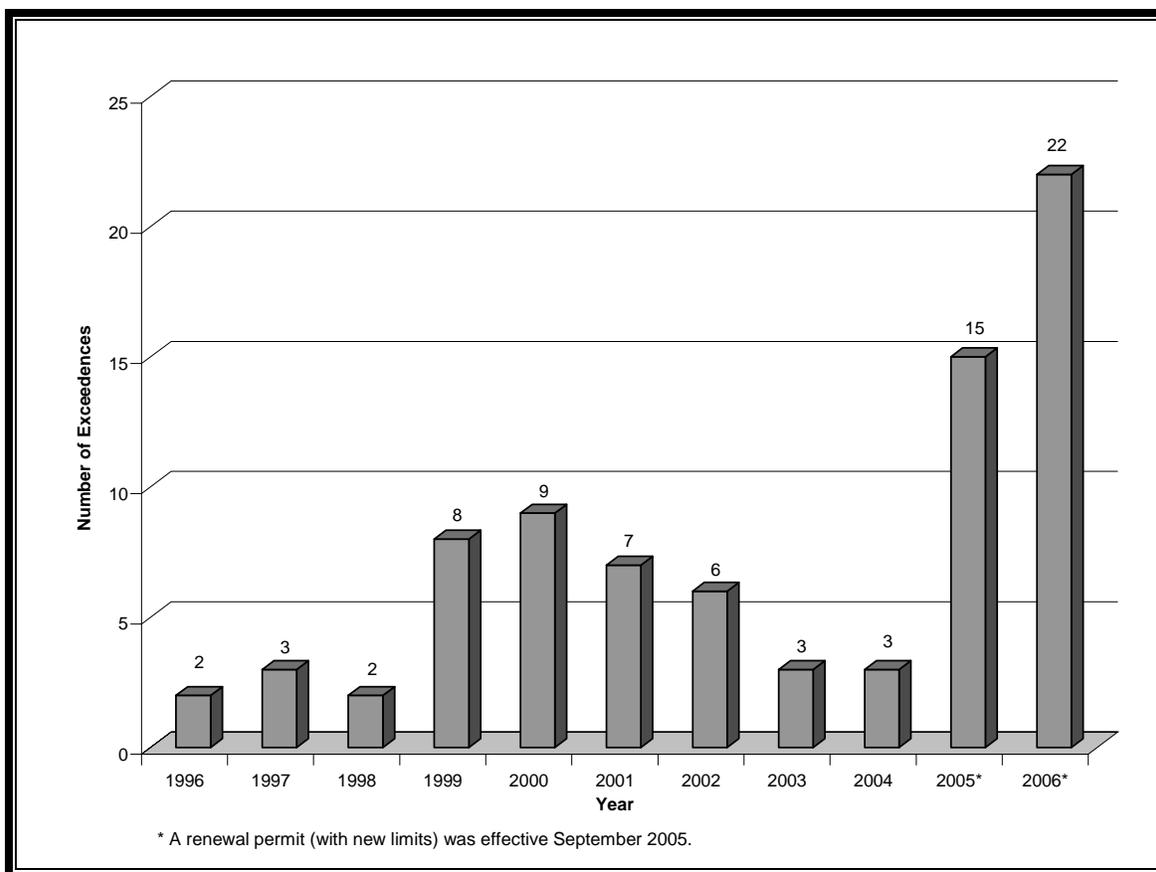


FIGURE 2.4 Total Number of NPDES Exceedances, 1996 to 2006

treatment chemicals. All semivolatile concentrations in the June sample were below the detection limits. Low concentrations of zinc (0.63 mg/L) were detected at levels well below the corresponding effluent limit (see Table 5.9). Low levels of copper (0.07 mg/L) and lead (0.014 mg/L) were also found in this sample; however, there are no effluent limits for these metals at this outfall. These findings are discussed further in Chapter 5.

Outfall 021 is sampled annually and analyzed for the priority pollutant list of constituents. The 2006 sample was collected on January 30, 2006. Only two compounds of the 124 compounds measured by this test were detected above the analytical detection limits. 1,1-Dichloroethane (DCA) and 1,1,1-trichloroethane (TCA) were found at 0.2 and 0.3 $\mu\text{g/L}$, respectively. The concentration of TCA found is well below the standard of 200 $\mu\text{g/L}$ for this chemical in drinking water. No drinking water standard exists for DCA.

In addition to the priority pollutant analysis, the permit required annual biological toxicity testing of the combined effluent stream, Outfall 001. This testing was conducted June 12 through June 16, 2006. The data indicate that the effluent was not acutely toxic to either the fathead minnow or the water flea. Data from the past 10 years suggest that cessation of chlorination of Argonne effluent can be correlated with a beneficial effect on aquatic life in the receiving streams.

2. COMPLIANCE SUMMARY

The biomonitoring plan calls for acute toxicity testing of the effluent from direct discharge Outfalls H03, J03, 006, and 025. Prior to 2006, toxicity testing had been required at Outfalls I03 and 004 as well. Prior testing results confirmed that no more testing was needed at these outfalls, and they were removed from the list. The same testing protocol used for Outfall 001 is used for these outfalls. The testing was performed during the periods of July 24–28, and August 21–25, 2006. No toxicity was observed to the fathead minnow or to the water flea in any of the 2006 samples.

2.2.1.4. Stormwater Regulations

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

The NPDES permit was reissued on July 28, 2005, and became effective September 1, 2005. As a portion of the effective permit, there are special conditions that include a number of requirements that Argonne must fulfill, including monitoring, reporting, and investigations. One of these requirements, Special Condition 9, requires Argonne to maintain its existing Stormwater Pollution Prevention Plan (SWPPP), as well as to modify it as necessary to continue compliance with all provisions of the regulations regarding stormwater. Special Condition 9 requires Argonne to inspect and report annually on the effectiveness of the sitewide SWPPP. In 2006, the annual inspection was completed and a report was submitted to the IEPA in December. The Stormwater Pollution Prevention Committee noted that the SWPPP was still in need of rewriting. A draft of the SWPPP was completed in December and is scheduled for finalization in early 2007.

2.2.2. Spill Prevention Control and Countermeasures Plan

Argonne maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as required by the 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 to 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. Regular training is conducted on implementation of this plan. No reportable spills occurred in 2006 that required activation of the SPCC Plan.

The SPCC Plan was revised to address new EPA requirements and was certified in December 2004. Among the new regulatory requirements are secondary containment for all oil storage containers 55 gallons or greater, tank integrity testing, and additional training. In October 2006, the EPA extended the deadline for amending and implementing the revised SPCC Plan to September 30, 2008.

2.2.3. Clean Water Action Plan

The Clean Water Action Plan Program, instituted in 1998, constitutes a voluntary commitment by federal agencies to work cooperatively to improve water quality in the United States. The approach is for federal agencies to form partnerships to identify watersheds with the most critical water quality problems. The goals of the plan are to establish initiatives to reduce public health threats, improve stewardship of natural resources, strengthen control of polluted runoff, and make water quality information more accessible to the public.

Although no formal plans related to this initiative have been established at Argonne, several activities have been undertaken to support this initiative. Argonne has worked with IEPA to reduce or eliminate surface water discharges of regulated pollutants. Special focus has been on exceedances of NPDES permit parameter limits. Past upgrades to the Argonne physical plant included acquisition of Lake Michigan water to replace dolomite well water as the source of domestic water. Lake Michigan water has a much lower TDS content than dolomite water, and the use of Lake Michigan water has reduced the amounts of TDS that are discharged. The rehabilitation of the Sanitary Wastewater Treatment Plant (SWTP) resulted in compliance with the ammonia-nitrogen limit. The upgrade of the LWTP also was completed, which gives Argonne a number of options for treating various waste streams, such as coal pile runoff and laboratory sink discharge, more effectively.

The Clean Water Action Plan included a strategy to achieve a net national increase of 100,000 wetland acres per year by 2005. Argonne is contributing to this effort by increasing the size of an existing wetland by up to 3 ha (6 acres). This wetland restoration effort is discussed further in Section 2.13.

2.3. Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (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 require 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 became effective on November 4, 1997. The permit has been modified eight times.

The Argonne remediation program was designed to achieve compliance with all applicable environmental requirements related to assessing and cleaning up releases of hazardous materials from inactive waste sites. The corrective action portion of the RCRA Part B permit

2. COMPLIANCE SUMMARY

provides the primary regulatory vehicle. This program was completed on September 30, 2003. However, seven SWMUs could not be remediated to No Further Action (NFA). The long-term monitoring of these inactive waste sites has been incorporated into the Argonne Long-Term Stewardship (LTS) Program. Quarterly reports are transmitted to the IEPA for these inactive sites. The LTS Program is described in greater detail in Chapter 6.

Also, one new SWMU and one new Area of Concern (AOC) have been identified since the remediation was completed. Argonne sent a notice about SWMU No. 746 (Building 300 Floor Drains) to DOE in July 2004. The IEPA added this SWMU to the Argonne corrective action program in March 2005. Argonne sent a notice about AOC-J (lead in soil near water towers) to DOE in November 2004. The IEPA added this AOC to the Argonne corrective action program in February 2005. Since the remediation was ended, the new SWMU and AOC are being investigated by Argonne's Facilities Management and Services (FMS) Division.

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 20 Hazardous Waste Management Units: 13 container storage units (the IEPA approved closure of Building 352C East and West in June 2006), 1 tank storage unit, 3 miscellaneous treatment units, and 3 tank chemical treatment units. Table 2.5 provides descriptions of these units. Closure reports for Building 325C East and West and the Dry Ice Pellet Decontamination Unit were submitted to the IEPA for review and approval in December and April 2005, respectively. Figure 2.5 shows the locations of the major active hazardous waste treatment, storage, and disposal areas at Argonne.

Argonne prepares an annual Hazardous Waste Report. The report is submitted to the IEPA by March 1 of each year and describes the activity of the previous year. It is a summation of all RCRA waste activities, including generation, storage, and treatment. The report describing such activities during 2006 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. Argonne's on-site permitted treatment facilities address a small number of hazardous wastes generated by Argonne operations. Off-site treatment and disposal take place at approved hazardous waste treatment and disposal facilities. Hazardous wastes that were generated, disposed of, or recycled during 2006 are described in Table 2.6.

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 during 2006.

2. COMPLIANCE SUMMARY

TABLE 2.5

Permitted Hazardous Waste Treatment and Storage Facilities, 2006

Description	Location	Purpose
<i>Storage</i>		
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 Mixed Waste 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.
Dry Mixed Waste Storage Area	Building 374A	Storage of solid MW and radioactively contaminated lead bricks. Closure activities were conducted in Nov./Dec. 2006. The Closure Report was submitted to the IEPA in March 2007.
Portable Storage Units (4)	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).
Tank Storage	Building 306	Storage of corrosive and toxic mixed waste and radiological liquid wastes (4,000 gal; currently not used).
Mixed Waste 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 oxidizer MW.
	Building 306 – Storage Room D-001	Storage of solid MW containing toxic metal constituents.

2. COMPLIANCE SUMMARY

TABLE 2.5 (Cont.)

Description	Location	Purpose
<i>Treatment</i>		
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.
Mixed Waste Immobilization/ Macroencapsulation Unit	Building 306	Treatment of solid, semisolid, and organic liquid MW containing RCRA metals.
Transuranic (TRU) ^a Waste Treatment Unit	Building 306	Treatment of corrosive, aqueous MW containing TRU radionuclides and RCRA metals.

^a Not in use.

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

The hazardous component of mixed waste is governed by RCRA regulations, while the radioactive component is subject to regulation under the AEA as implemented by DOE Orders. Accordingly, facilities storing or disposing of mixed waste must comply with both DOE requirements and RCRA permitting and facility standards. Argonne generates several types of mixed waste, including acids, solvents, and 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 and transuranic (TRU) corrosive aqueous wastes and the stabilization of sludge and soil. In addition, some of the mixed waste was sent off-site to Envirocare of Utah, Inc., a commercial treatment and disposal facility, during 2006. Mixed wastes that were generated, disposed of, or recycled during 2006 are described in Table 2.7.

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 mixed waste. The Proposed Site Treatment Plan (PSTP) for mixed waste generated at Argonne was submitted

2. COMPLIANCE SUMMARY

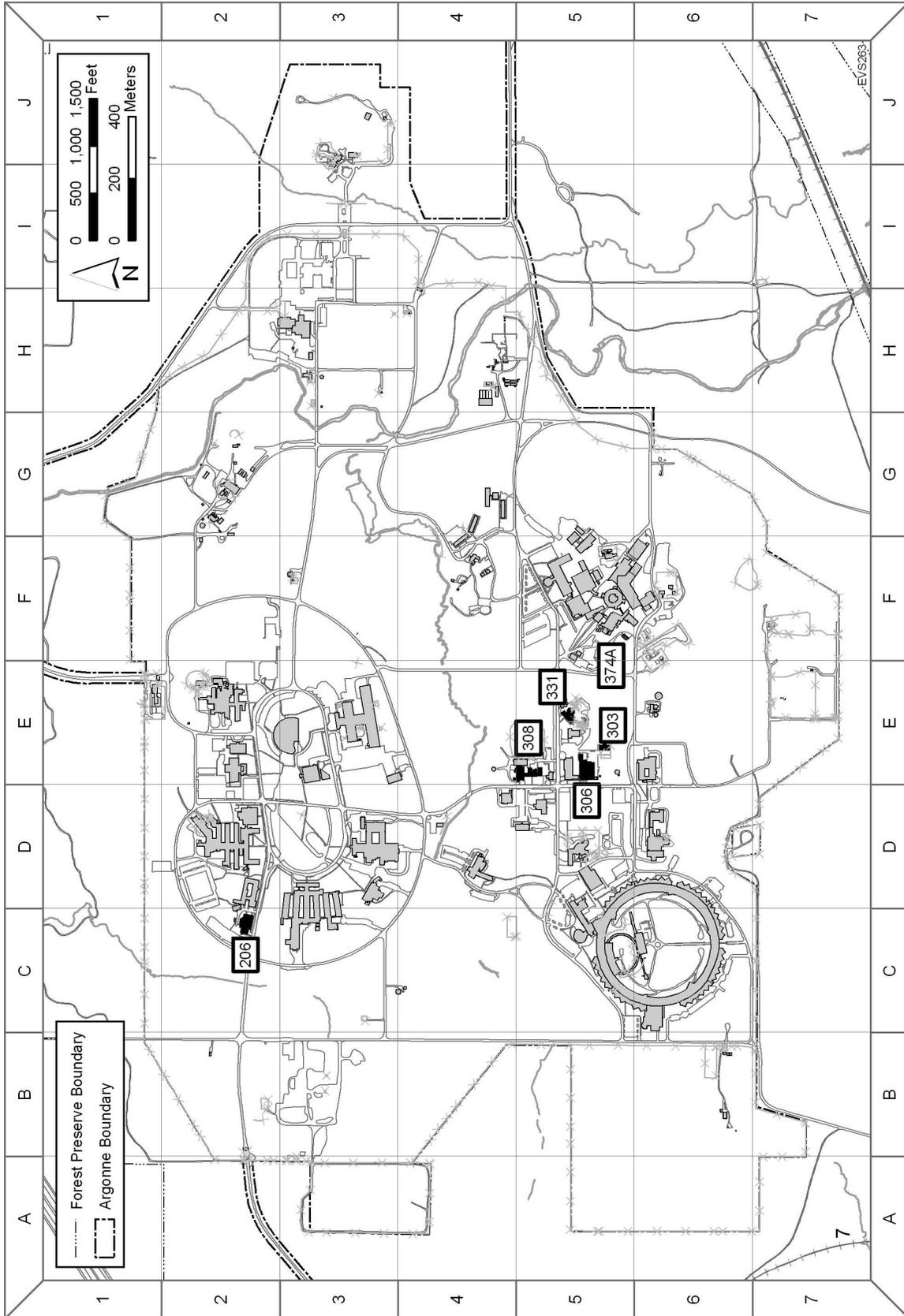


FIGURE 2.5 Major Treatment, Storage, and/or Disposal Areas at Argonne

2. COMPLIANCE SUMMARY

TABLE 2.6

Waste Generation, Treatment, Disposal, or Recycle, 2006^a

Waste (amount generated and shipped for disposal)	Volume	Weight (lb)
<i>Nonhazardous Special Waste</i>		
Used oil ^b	1,440 gal	10,368
Petroleum Naptha ^b (parts washers)	851 gal	5,149
Nonhazardous brine solution	1,700 gal	15,600
Nonhazardous potash solution	2,300 gal	21,200
Nonhazardous solid chemicals (Lithium)	55 gal	86
Nonhazardous liquid chemicals	55 gal	248
Medical waste	138 ft ³	690
<i>Nonhazardous Nonspecial Waste</i>		
Nonspecial Laboratory sewage sludge	30 yd ³	60,000
Fly ash (boiler house)	3,537 yd ³	2,988,780
Soil from spill cleanup	10 yd ³	20,000
<i>TSCA Special Waste</i>		
Asbestos	105 yd ³	105,000
PCBs	205 gal	2,390
<i>Universal Hazardous Waste</i>		
Mercury containing lamps ^b	4,932 gal	4,932
Lead acid batteries ^b	300 gal	3,000
Other batteries ^b	210 gal	2,100
Lead scrap ^b	450 yd ³	5,400
<i>Hazardous Waste</i>		
Brake cleaner fluid ^b	12 gal	100
Immersion cleaner fluid	14 gal	111
Aerosol cans	63 gal	313
Compressed gases	15 gal	77
Bulked laboratory solvents	361 gal	2,615
Cutting oils with lead and solvents	68 gal	492
Hazardous used oil	335 gal	2,513
Caustic solutions with heavy metals	423 gal	3,383
Debris contaminated with lead	116 gal	813
Debris contaminated with diesel fuel	10 gal	50
Debris contaminated with solvents	65 gal	259
Labpacks of solid chemicals	1,656 gal	13,250
Labpacks of liquid chemicals	152 gal	1,212
Waste lithium	1,145 gal	13,250

^a Abbreviations: PCB = polychlorinated biphenyl; TSCA = Toxic Substances Control Act.

^b Amount generated and shipped for recycling.

2. COMPLIANCE SUMMARY

TABLE 2.7

Mixed Waste Generation, Treatment, Storage, and Disposal, 2006

Waste	Volume	Weight (lb)
<i>Radioactive Mixed Waste Generated</i>		
RMW acidic solutions with heavy metals	28 gal	252
RMW flammable liquids	173 gal	1,213
RMW soils with heavy metals	5 gal	45
RMW debris with heavy metals	2,675 gal	6,750
TRU acids with heavy metals	115 gal	1,035
TRU acids	5 gal	45
<i>Radioactive Mixed Waste Shipped for Disposal</i>		
RMW debris with heavy metals	2,675 gal	26,752
RMW lead articles	243 ft ³	170,100
<i>Radioactive Mixed Waste Treated</i>		
	0	0
<i>Radioactive Mixed Waste in Storage</i>		
RMW acidic solutions with heavy metals	753 gal	2,279
RMW flammable liquids	756 gal	5,292
TRU acids with heavy metals	648 gal	5,830
TRU acids	5 gal	45
<i>Radioactive TSCA Waste in Storage</i>		
RMW PCB soil and debris	170 gal	1,000
RMW PCB articles	50 gal	360
RMW PCB oil	40 gal	240

to the IEPA and the Illinois Department of Nuclear Safety (IDNS) in March 1995. Argonne's RCRA Part B permit provides for on-site treatment of certain mixed waste as required by the PSTP. During 2006, Argonne did not complete the established treatment milestones; however, an update to the PSTP was provided to DOE with the treatment schedule for the remaining mixed waste in storage. The schedule shows that mixed waste governed by the plan will be treated by the end of 2009.

2.3.5. Underground Storage Tanks

The Argonne site currently contains 13 USTs. Seven of the existing tanks are being used to store fuel oil for emergency generators. The on-site maintenance facility (Building 46) uses underground tanks to store diesel, gasoline, used oil, antifreeze, and an ethanol/gasoline blend. On August 28, 2006, the Illinois State Fire Marshal certified that the USTs at Argonne are in compliance with the regulations. Argonne compliance staff conducted a compliance assessment in February and March 2006. Compliance issues were identified for follow up by the responsible staff.

2. COMPLIANCE SUMMARY

2.4. Solid Waste Disposal

In September 1992, Argonne ceased operation of its 800 Area Landfill, which had begun operating in 1966. The IEPA issued the original operating permit in 1981 in accordance with 35 IAC Part 807 and several subsequent supplemental permits. On March 25, 2003, the IEPA determined that the postclosure care of the 800 Area Landfill would be carried out under the corrective action provisions (Section V) of Argonne's RCRA Part B permit.

Groundwater Quality Standards of some routine indicator parameters have been consistently exceeded, such as TDS, iron, and manganese. Exceedances occur primarily in shallow, perched pockets of groundwater in the glacial drift that are not in direct communication with the deeper dolomite bedrock aquifer. To aid in the determination of the nature and extent of these exceedances, in 1999, additional groundwater monitoring wells were installed around the landfill. Hydrogen-3 has been measured in several wells at the 800 Area Landfill at concentrations ranging from <100 pCi/L to 282 pCi/L. The 800 Area Landfill groundwater monitoring program is discussed in detail in Section 6.3.

Argonne generates a large volume and variety of nonhazardous special wastes. Some otherwise special waste, such as sanitary sewage sludge, is certified to the IEPA as "nonspecial waste" pursuant to IEPA regulations. Table 2.6 gives the nonhazardous special and nonspecial wastes generated, stored, disposed of, or recycled during 2006. All nonhazardous special and nonspecial wastes generated at Argonne in 2006 were disposed of at permitted off-site special waste landfills. The IEPA began requiring annual nonhazardous special waste reporting in 1991. The report is required to be submitted by February 1 of each year to describe the activity of the previous year. It is a summation of all manifested nonhazardous and polychlorinated biphenyl (PCB) wastes shipped out of state.

2.5. 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 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 EISs were prepared during 2006. A supplement analysis was completed for remote handled transuranic waste. This analysis was performed so that TRU waste could be characterized and disposed of off-site.

2.6. 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

2. COMPLIANCE SUMMARY

out through the institution of national drinking water quality standards, such as 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).

2.6.1. Applicability to Argonne

In January 1997, Argonne incorporated Lake Michigan water as its domestic source water, thereby replacing the dolomite groundwater that formerly constituted its source of drinking water. Because the Lake Michigan water is purchased from the DuPage County 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 applicable to a “non-transient, non-community” public water supply were no longer applicable. Nevertheless, Argonne voluntarily provides to on-site personnel the Consumer Confidence Report on drinking water quality that Argonne receives as a customer of the DuPage County Water Commission. The annual report indicates that all measured contaminants meet the drinking water standards.

2.6.2. Water Supply Monitoring

During 2006, Argonne continued an informational monitoring program at the previously used dolomite domestic wells; quarterly samples were analyzed for radionuclides and VOCs. No radionuclides or VOCs were detected.

2.7. Federal Insecticide, Fungicide, and Rodenticide Act

During 2006, all restricted-use pesticides and herbicides at Argonne were applied by a licensed contractor who provides the chemicals used and removes any unused portions. 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.

In addition, routine applications of pesticides are performed within buildings, as needed. Indoor pesticide applications are provided by Illinois Department of Public Health-licensed contractors under the direction of FMS-Custodial Services or on-site contractors, depending on the building involved. The indoor applications involve EPA “Restricted Use” products.

In 2006, approximately 33,364 L (8,780 gal) of commercial-grade herbicide was applied throughout the Argonne site. Fertilizer with weed control is included in the quantity of herbicide.

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2.8. 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.

2.8.1. 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 information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including providing responses 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 2.8 gives Argonne's status in regard to EPCRA.

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. The Section 302 information for 2006 was transmitted to the LEPC and SERC during June, October, and December of 2006.

TABLE 2.8

Status of EPCRA Reporting, 2006

EPCRA Section	Description of Reporting	Status
Section 302	Planning notification	Required
Section 304	Extremely hazardous substance release notification	Not required in 2006
Section 311–312	Material Safety Data Sheet chemical inventory	Required
Section 313	Toxic Release Inventory reporting	Required

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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 is notified if a release exceeds the CERCLA Reportable Quantity for that particular hazardous substance. The procedures for notification are described in the Argonne Emergency Plan Implementing Procedures. There were no incidents requiring notification during 2006.

Under SARA Title III, Section 311, Material Data Safety Sheet (MSDS)/Chemical Inventory, Argonne is required to provide applicable emergency response agencies with MSDSs, or a list of MSDSs, for each hazardous chemical stored on-site. The 2006 information was transmitted to the LEPC and the Illinois Emergency Management Agency during June, October, and December of 2006.

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. Petroleum products need to be reported. However, 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 2006 was provided to DOE during February 2006. Table 2.9 lists the hazardous chemicals reported.

Section 313 of SARA Title III, Toxic Release Inventory (TRI) Reporting, requires facilities to prepare an annual report entitled "Toxic Chemical Release Inventory, Form R," if annual usage of listed toxic chemicals exceeds certain thresholds. Argonne is not within the range of Standard Industrial Codes specified in the statute. Argonne reports this information, however, because DOE, which is subject to EO 13148, "Greening the Government through Leadership in Environmental Management" (April 21, 2000), directs Argonne to do so. No reports were filed from 1997 to 2000, because no listed chemicals were used in amounts that

TABLE 2.9

SARA, Title III, Section 312, Chemical List, 2006

Compound	Physical Hazard			Health Hazard	
	Fire	Pressure	Reactivity	Acute	Chronic
Ethanol/gasoline	X	— ^a	—	X	—
Aluminum sulfate	—	—	—	X	—
Diesel fuel/heating oil	X	—	—	—	—
Gasoline	X	—	—	X	—
Mepiquat chloride	—	—	—	X	—
Mepiquat pentaborate	—	—	—	X	—
Optibor [®] boric acids	—	—	—	X	—
Sulfuric acid	—	—	—	X	—

^a A dash indicates that the compound does not fall within the particular hazard class.

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exceeded reporting thresholds. However, new requirements regarding a class of TRI compounds called persistent, bioaccumulative toxics (PBTs) came into effect in 2000. As a result, Argonne filed one report under Section 313 in 2006 for activities in 2005 for lead. Use of lead included machining of various types of lead articles in excess of the 45 kg (100 lb) reporting threshold.

2.9. 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 are found in CFR Title 40, "Protection of the Environment, Chapter I: Environmental Protection Agency, Subchapter R – Toxic Substances Control Act." 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 PCBs. Suspect PCB-containing items that are subject to this act are identified through the Argonne PCB Item Inventory Program. Argonne has developed procedures to deal with the import/export of TSCA materials by relying on U.S. Customs Service processes.

2.9.1. PCBs in Use at Argonne

PCB items in use or in storage for reuse are tracked by the Argonne PCB Item Inventory Program. All PCB items identified by the PCB Item Inventory Program have been labeled appropriately with a unique number for inventory and tracking purposes. These items are included in the Argonne Annual PCB Report, which describes the location, quantity, manufacturer, and unique identification number for all PCBs on-site. This report is not submitted to regulatory agencies, but is kept on file at Argonne. The Annual PCB Report for 2006 was completed on April 10, 2007. 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.

2.9.2. Disposal of PCBs

Disposal of PCBs from Argonne operations includes materials lab-packed and bulked and aggregated solids shipped off-site through WMO. This includes PCB-containing materials that also contain radioactive substances known as TSCA mixed waste. Table 2.6 contains the amount of PCBs and PCB-contaminated materials and TSCA mixed waste in storage and shipped by Argonne during 2006.

2.10. 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 critical habitat 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 to threatened or endangered species and critical habitat. 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 will be evaluated through consultation with the USFWS, and, if necessary, the preparation of a more detailed NEPA document, such as an EA or 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.

No federally listed threatened or endangered species are known to occur on the Argonne site, and no critical habitat of federally listed species exists on the site. Three federally listed endangered species and one federally listed threatened species are known to inhabit the Waterfall Glen Forest Preserve that surrounds the Argonne property, or to occur elsewhere in the area.

The Hine's emerald dragonfly (*Somatochlora hineana*), federally and state listed as endangered, occurs in locations with calcareous seeps and wetlands along the Des Plaines River floodplain. 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. An unconfirmed capture of an Indiana bat (*Myotis sodalis*), which is federally and state listed as endangered, indicates that this species may occur in the area. The federally listed threatened and state-listed endangered lakeside daisy (*Tetraneuris herbacea*) has a planted population in Waterfall Glen Forest Preserve.

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

- Endangered
 - Black-crowned night heron (*Nycticorax nycticorax*)
 - Eastern massasauga (*Sistrurus catenatus catenatus*)
 - Great chickweed (*Stellaria pubera*)
 - Prairie Bush clover (*Lespedeza leptostachya*)
 - Quillwort (*Isoetes butleri*)
 - Spotted turtle (*Clemmys guttata*)
 - Tennessee milkvetch (*Astragalus tennesseensis*)
 - Tuckerman's sedge (*Carex tuckermani*)
 - Yellow-crowned night heron (*Nyctanassa violacea*)

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- Threatened
 - Blanding's turtle (*Emydoidea blandingii*)
 - Buffalo clover (*Trifolium reflexum*)
 - Common moorhen (*Gallinula chloropus*)
 - Henslow's sparrow (*Ammodramus henslowii*)
 - Kirtland's snake (*Clonophis kirtlandi*)
 - Least bittern (*Ixobrychus exilis*)
 - Marsh speedwell (*Veronica scutellata*)
 - Shadbush (*Amelanchier interior*)
 - Slender sandwort (*Minuartia patula*)
 - White lady's slipper (*Cypripedium candidum*)

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

2.11. National Historic Preservation Act

The National Historic Preservation Act of 1966 (NHPA), as amended, requires federal agencies to assess the impact of proposed projects on historic or culturally important sites, structures, or objects within the sites of proposed projects. It further requires federal agencies to assess all archaeological sites, historic buildings, and objects on such sites to determine whether any qualify for inclusion in the NRHP. The act also requires federal agencies to consult with the State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation, as appropriate, when determining if proposed actions would adversely affect properties that are eligible for listing on the NRHP.

The NHPA is implemented at Argonne through the NEPA review process, as well as through the Argonne digging permit process. All proposed actions must consider the potential impact to historic or culturally important properties or artifacts and document this consideration on the Environmental Review Form. Prior to disturbing the soil, an Argonne digging permit must be obtained from the FMS Division. This permit must be signed by the designated permit reviewer after verifying the location of nearby archaeological sites and documenting the fact that no significant cultural resources would be affected. If the proposed site has not been surveyed for the presence of historic properties, a cultural resources survey is conducted by qualified personnel, and any artifacts found are documented and carefully removed. At Argonne, DOE consults with the Illinois SHPO through the Illinois Historic Preservation Agency (IHPA) and the Advisory Council on Historic Preservation, as appropriate, if proposed actions would adversely affect properties eligible for listing on the NRHP.

In fall 2001, DOE entered into a programmatic agreement with the IHPA and the Advisory Council on Historic Preservation for management of cultural resources at Argonne. This agreement streamlines compliance with the NHPA by allowing standard mitigation measures and by excluding from Section 106 review certain categories of activities that are

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unlikely to adversely affect historic structures. Argonne's Cultural Resources Management Plan (CRMP) was provided to DOE in 2005 and forwarded to the SHPO for approval/concurrence.

Cultural resources include both historic structures and archaeological sites. Phase I archaeological surveys have been completed for the entire Argonne facility, and 46 archaeological sites have been recorded. Three of the sites are eligible for the NRHP. Twenty-two sites have been determined to be ineligible, and 21 recorded sites have not yet been formally evaluated for eligibility. An excavation was conducted in August 2003 north of the APS ring to reevaluate the eligibility of a farmstead site. A final determination was made in 2005, which found the site to be ineligible for listing. Some of the areas surveyed previously may require additional survey documentation because of insufficient coverage and coordination.

In fall 2001, Argonne completed a two-phased Sitewide Historic Property Inventory. The historic context portions of this inventory add significantly to the nuclear energy and nuclear science portions of the DOE Cold War story. On the basis of inventory reports, DOE determined that two areas — the Main Campus District (also known as the 200 Area) and the Freund Estate District — are eligible for listing on the NRHP as historic districts and that seven buildings are individually eligible for listing on the NRHP. In addition to the special facilities that were identified as part of the decontamination and decommissioning (D&D) program, including the decommissioned reactors Chicago Pile-Five (CP-5), Argonne Thermal Source Reactor (removed), Experimental Boiling Water Reactor (removed), and Zero Power Reactors (ZPRs) VI and IX, the survey also identified the Alpha-Gamma Hot Cell Facility (AGHCF) and High-Voltage Electron Microscopy (HVEM) microscope.

The 200 Area Historic District includes six scientific buildings: Buildings 200, 202, 203, 205, 206, and 211. These buildings were identified on the basis of their contribution in association with advancements in nuclear research and the development of nuclear power reactors (Criterion A), and for the engineering and design value of each as a unique specialized and cohesive scientific facility (Criterion C). The Freund Estate District includes five facilities: the former Freund Lodge (Building 600), the pool (603), bathhouse (604), pavilion (606), and tennis courts (616). All are eligible for listing under Criterion B, on the basis of their association with an important local personality, Erwin O. Freund.

Buildings 200 (M-Wing), 203, 205, 212, 350, and Buildings 315/316 of the 314/315/316 complex are the seven buildings that are eligible for individual listing. In addition to these seven active Argonne facilities, three other buildings — Buildings 301, 330, and 331 — were found to be eligible, but subsequently have been mitigated by recordation for disposal. Building 203 is significant because of its association with a Nobel Prize winner, Maria Goeppert-Mayer. In January 2002, the IHPA concurred with the results of the sitewide survey regarding the eligible districts and facilities. Argonne is developing management plans to augment the procedural mechanisms identified in the programmatic agreement and CRMP. Argonne also conducted Historic American Building Survey/Historic American Engineering Record documentation of ZPRs VI and IX as part of the D&D process for the reactors. In October 2006, a Cultural Resources brochure was completed. The brochure documents Argonne's historic aspects, the development of the Argonne site, Argonne's important scientific milestones, and the

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goals of Argonne's cultural program. This brochure was distributed at Argonne's 2006 Open House.

2.12. 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 modifications 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 contained within areas designated as conservation use, not intended for development. No significant structures are located in these areas, although an existing pumping station 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 these areas are not adversely affected, new facility construction is not permitted within these areas, unless there is no practical alternative. Any impacts to floodplains would be fully assessed in a floodplain assessment, and, as appropriate, documented in the NEPA documents prepared for a proposed project.

2.13. 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 to 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. The COE administers this program. Activities regulated under this program include disturbance of wetlands for development projects, infrastructure improvements, and conversion of wetlands to uplands for farming and forestry. The COE uses a permit system to identify and enforce wetland mitigation efforts.

Argonne completed a sitewide wetland delineation in 1993. All wetlands present on-site were identified and mapped following the 1987 *Corps of Engineers Wetlands Delineation*

2. COMPLIANCE SUMMARY

Manual.³ The delineation map shows the areal extent of all wetlands present at Argonne down to 500 m² (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 1.4.

In February 1989, the COE issued a permit to DOE under Section 404 of the CWA, addressing the construction of the APS facility at Argonne. The permit was required because construction of the APS involved the filling of three small wetland areas, known as Wetlands A, B, and E, which totaled 0.7 ha (1.8 acres) in size. Issuance of the permit was contingent upon approval of a mitigation plan submitted to the COE by DOE. The plan outlined procedures for the construction of a new wetland area, Wetland R, and also identified actions to be taken to avoid impacts to a fourth wetland, Wetland C, just under 0.4 ha (1 acre), during APS construction activities.

During October 1996, the COE inspected Wetlands C and R and determined that they were no longer being managed in accordance with the original APS construction permit. The deficiencies noted were excessively dry soil conditions in Wetland C, caused by altered hydrology, and a poor quality biological community in Wetland R. In response to this finding, Argonne prepared a management plan for Wetland R in January 1997 and began investigating the cause of the problems with Wetland C. The COE verbally agreed with these response actions. Implementation of the plan began in 1997.

Mitigative actions for Wetland R, as described in the 1997 management plan, involved improving the mix of vegetation through controlled burns, herbicide application, and planting of desirable plants. Controlled burns were completed in 1997, March 2000, March 2001, April 2002, and April 2005. Planting, herbiciding, and monitoring of the wetland continued in 2006.

Argonne's wetland management strategy as described in a September 2001 DOE Environmental Assessment included creating advanced compensatory mitigation as approved by the COE. The advanced compensatory mitigation is similar to a wetland "bank" and is to be used to offset wetland losses at Argonne.

Argonne restored several acres of high-quality wetland in the 400 Area by disabling a drainage tile network installed when the land had been farmed. One of the restored wetlands acres will replace a small wetland lost after construction of the APS and resolve a COE enforcement order. Once the vegetation quality is acceptable to the COE, the remaining restored wetland acreage will be available to offset losses of small wetlands in other portions of the Argonne site, many of which are so small and of such poor quality that they have little ecological value. Monitoring data for the past two years show improving vegetation quality on several acres of restored wetland.

2.14. Wildlife Management and Related Monitoring

DOE manages the numbers of white-tailed and fallow deer at the site through an interagency agreement with the U.S. Department of Agriculture. DOE began the deer

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management program in 1995 to alleviate traffic safety hazards and ecological damage caused by extremely high deer densities. More than 600 deer were removed in the winter of 1995 to 1996, and more than 80 deer were removed the following winter to achieve target densities of 20 deer/mi² for each species. Smaller numbers of deer have been removed each year since 1997.

DOE lowered its target density for white-tailed deer to 15 deer/mi² in 2001 to better achieve its objectives of reducing deer and vehicle collisions, allowing oak trees to regenerate, and allowing deer-sensitive herbaceous species to recover.

DOE and the Forest Preserve District of DuPage County coordinate deer management efforts in order to preserve and enhance biodiversity at Argonne and the surrounding Waterfall Glen Forest Preserve.

2.14.1. Deer Population Monitoring

The deer population is monitored frequently by spotlight survey to meet the requirements of Deer Population Control Permits and to aid in making deer management decisions. No white-tailed deer were removed in 2006, but 15 were removed in early 2007.

The health of the white-tailed deer herd is evaluated by assessing the deer that are removed each year for mean live and dressed weights and the amounts of fat stored in various organs. The health of the white-tailed deer herd has been improving since the deer management program began in 1995.

Samples taken from the muscles of deer are analyzed periodically for radionuclides to verify that deer meat donated to charity does not pose a radiological health hazard. Samples sent to the IDNS radiochemistry laboratory in November 2005 were analyzed for gamma-ray-emitting radionuclides and hydrogen-3. Naturally occurring potassium-40 (at background levels) was the only gamma-ray-emitting radionuclide identified. Hydrogen-3 was not detected in any sample.

2.14.2. Vegetation Damage

Woodland vegetation is monitored periodically to determine the effects of browsing by deer on woody vegetation and to assess forest health. This monitoring is conducted to meet conditions of Deer Population Control Permits and to help make deer and habitat management decisions. DOE changed its vegetation monitoring protocol in the fall of 2000 to better gauge overall forest health. The new protocol is an adapted form of the Illinois Forest Watch Monitoring Manual issued by the Illinois Department of Natural Resources. It calls for fall surveys of woody vegetation and spring surveys of herbaceous vegetation and tree seedlings. Data collected in two sampling plots from 2000 through 2005 indicate limited success in recovery of deer-sensitive herbaceous species. Oak seedlings were identified for the first time in Spring 2004 and again in Spring 2005.

2.15. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 2006. Table 2.10 lists all water effluent exceedances reported during 2006. Exceedances of the NPDES wastewater discharge limits and Ground Water Quality Standards at the 800 Area Landfill Area are discussed in Chapters 5 and 6, respectively.

2.15.1. Clean Water Act — NPDES

As in previous years, Argonne exceeded NPDES permit limits in 2006 (see Table 2.10). In past years, the TDS concentration was the most persistent exceedance of the NPDES permit limits. The limit for TDS was exceeded 18 times at the Wastewater Treatment Plant (WTP) discharge point Outfall 001 (2), Outfall H03 (6), and Outfall J03 (10). Road salt runoff associated

TABLE 2.10

Summary of 2006 Water Effluent Exceedances

Date	Outfall	Parameter	Assessment
January 3	001	TDS	Road salt associated with melting snow
January 9	J03	TDS	Road salt associated with melting snow
January 9	H03	TDS	Road salt associated with melting snow
January 30	H03	TRC	Biocides from the Building 212 cooling tower
January 31	001	TDS	Road salt associated with melting snow
February 17	H03	TDS	Road salt associated with melting snow
February 17	J03	TDS	Road salt associated with melting snow
March 6	H03	TRC	Biocides from the Building 212 cooling tower
March 15	H03	TDS	Road salt associated with melting snow
March 15	J03	TDS	Road salt associated with melting snow
April 18	H03	TDS	Road salt associated with melting snow
April 18	J03	TDS	Road salt associated with melting snow
May 8	J03	TDS	Under investigation
May 22	H03	TDS	Under investigation
June 20	H03	TDS	Under investigation
June 20	J03	TDS	Under investigation
July 19	J03	TDS	Under investigation
September 20	H03	TDS	Under investigation
September 20	J03	TDS	Under investigation
October 9	006	Phenol	Anomaly
October 25	J03	TDS	Under investigation
November 22	J03	TDS	Under investigation

2. COMPLIANCE SUMMARY

with snowmelt appears to be the main contributor to high TDS concentrations. The limit for total residual chlorine was exceeded two times at various outfalls due to the discharge of potable water. The limit for phenol was exceeded one time at Outfall 006. Investigations regarding cause and corrective actions are underway, as listed in Table 2.10.

Argonne has had occasional positive toxicity test results at several outfalls. These appear to be due to residual chlorine from the discharge of chlorinated drinking water into these outfalls and from cooling tower blowdown that may contain antifouling agents. Many of these discharges have been redirected into the sewer system to be processed at the WTP.

2.15.2. 800 Area Groundwater Monitoring

The IEPA-approved 800 Area Landfill groundwater monitoring program continues to indicate that the Ground Water Quality Standards of some inorganic parameters, such as TDS, iron, and manganese, consistently are being exceeded in several wells. The 1999 expansion of the groundwater monitoring well network is providing additional information about the nature of these exceedances. Additional information about the source and extent of these exceedances is needed before a plan of action to resolve the issue can be formulated. Hydrogen-3 concentrations in a few of the 800 Area Landfill wells were evaluated. The groundwater monitoring program is discussed in detail in Section 6.3.

2.15.3. Long-Term Stewardship Activities

Remediation of waste management units was completed in 2003. During 2004, the long-term operation, maintenance, and monitoring of these sites, recognized as Argonne's LTS Program, were incorporated, in their entirety, into Argonne's environmental monitoring and surveillance program. Ongoing activities during 2006 are described in detail in Chapter 6.

2.15.4. CP-5 Monitoring

Elevated levels of hydrogen-3 in CP-5 Monitoring Well 330031R (up to 45,000 pCi/L) were measured in quarterly groundwater samples after the original well was removed and the well replaced with a new well screened at a lower depth. Although the hydrogen-3 concentrations are decreasing, expanded monitoring activities in this area determined that the hydrogen-3 distribution was localized.

2.16. Environmental Permits

Table 2.11 lists all the environmental permits in effect at the end of 2006. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements.

2. COMPLIANCE SUMMARY

TABLE 2.11

Environmental Permits in Effect December 31, 2006

Permit Name	Permit ID	Status	Start Date	End Date
B-203 CARIBU Project Construction Permit	05120055	Effective	3/20/2006	– ^a
CAAPP Title V Permit	95090195	Effective	10/17/2006	10/17/2011
Federal Fish and Wildlife Permit	MB100283-1 Amend	Effective	10/6/2006	2/14/2008
Land Application of SWTP Filter Sand	20041-SC-1419	Effective	8/12/2004	7/31/2009
NPDES Wastewater Discharge Permit	IL0034592	Effective	9/1/2005	8/31/2010
Open Burn Permit – Fire Training	B0701142	Effective	4/19/2005	4/18/2007
Open Burn Permit – Vegetative Control	B0610022	Effective	1/30/2005	1/29/2007
RCRA Part B Permit	B-75-M-12/13	Effective	9/30/1997	11/4/2007
USDA Soil Permit	S-64308	Effective	12/31/1998	12/31/2008
Wastewater Discharge Permit to DuPage County	18965	Effective	7/29/1991	–
Wastewater Treatment Plant Land Application Permit	2004-SC-1419	Effective	8/12/2004	7/31/2009

^a A dash indicates that permit continues to be in effect until it is revised.

2.17. IEPA/DOE Inspections/Appraisals

Various inspections and appraisals were conducted during 2006. A short description of each is included in Table 2.12.

2.18. Outstanding Compliance Issues/Actions/Agreements

The outstanding compliance issues, actions, or agreements for 2006 include only the TDS compliance agreement discussed in Section 2.2.1.2 (compliance with NPDES permit).

2. COMPLIANCE SUMMARY

TABLE 2.12

IEPA/DOE Environmental Compliance Inspections/Appraisals, 2006

Agency	Type	Dates	Results/Issues
IEPA	CWA/NPDES Inspection	October 25, 2006	Request for more information only; no issues identified.
IEPA	RCRA Inspection	July 19, 2006	No identified issues; no report received as of this writing.
DOE-ASO	CAA Functional Area Review (FAR) (Title V Air Permit)	August 28–31, 2006	1 noncompliance (a NEPA requirement), 4 opportunities for improvement, and 1 strength.
DOE-ASO	Pollution Prevention Program	March 6–10, 2006	0 noncompliances, 4 opportunities for improvement, and 6 strengths.
DOE-ASO	CWA FAR	December 12–15, 2006	10 noncompliances, 2 opportunities for improvement, and 1 strength.

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DOE Order 450.1, “Environmental Protection Program,” was issued on January 15, 2003, to implement the requirements in EO 13148. The objective of DOE Order 450.1 is to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources potentially impacted by operations. Through these practices, DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection laws, regulations, and DOE requirements. This objective must be accomplished by implementing Environmental Management Systems (EMSs) at DOE sites. These EMSs must be part of Integrated Safety Management Systems (ISMSs). The requirements of EO 13148 and DOE Order 450.1 are imposed on the contractors by the Contractors Requirements Document of DOE Order 450.1.

3.1. Argonne Environmental Management System

DOE and Argonne policies require that all operations be conducted in compliance with applicable environmental statutes, regulations, and standards, and that environmental obligations be carried out consistently across all operations and organizations. Protection of the environment and human health and safety are given high priority. A number of programs and organizations exist at Argonne to ensure compliance with these authorities and to monitor and minimize the impact of Argonne operations on the environment.

As part of its commitment to environmentally responsible operations, Argonne has an EMS. An EMS ensures that environmental issues are systematically identified, controlled, and monitored, and it provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement.

3.1.1. Argonne’s EMS Approach

The Argonne approach to an EMS was to prepare an Environmental Management System Description Document that described the elements identified in DOE Order 450.1. The EMS document was structured to mirror the organizational structure of the Argonne ISMS in order to demonstrate integration between the two documents. DOE-ASO approved the Argonne EMS on July 14, 2003. A critical component of the EMS is the identification of environmental aspects, that is, those activities and operations at Argonne that have the potential to impact the environment. Examples of environmental aspects include waste generation, air emissions, liquid effluents, consumption of natural resources, and disturbance to endangered species/protected habitats. A training course was prepared and implemented on January 24, 2004, that provided information on DOE Order 450.1, EO 13148, and the Argonne EMS. The course is part of the implementation process for the Argonne EMS.

As part of the annual review and revision of the EMS in 2004, a new section was added to establish a process for the annual preparation of objectives and targets for the following year. Through the achievement of the objectives and targets, Argonne addresses its significant environmental aspects, including its compliance, mission, and reduction of its environmental risk. To be confident that the objectives and targets will be effective in addressing the significant

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environmental aspects, it is important that they be systematically established, periodically reviewed, and reconsidered within the management review process. Incorporation of the process into the EMS institutionalizes the annual preparation of objectives and targets. The DOE-ASO manager certified that the Argonne EMS had been implemented on December 22, 2005.

3.1.2. Compliance with EO 13148

Argonne continues to support DOE in meeting its responsibilities for compliance and reporting required by EO 13148. During 2006, Argonne reported to DOE that milestones for EMS implementation had been completed.

3.2. EMS Components

The Argonne EMS covers the elements that are identified in DOE Order 450.1. These elements are also similar to the topics covered in the International Organization for Standardization (ISO) 14001 standard. A number of the most critical elements are discussed below.

3.2.1. Environmental Policy

Within the Argonne Environment, Safety, and Health (ES&H) policy, Argonne has established an environmental protection policy. This policy applies to all Argonne activities that could or do have an impact on the environment or on compliance with environmental regulations. The policy states that “Argonne activities (including experiments, facility operations, construction activities, and other activities) will be conducted in an environmentally safe and sound manner and consistent with Argonne permit condition. To support this policy, Argonne is committed to leadership in environmental management by integrating environmental accountability into day-to-day activities and into long-term planning processes.”

3.2.2. Environmental Aspects and Impacts

When operations have an environmental aspect, Argonne implements the EMS to minimize or eliminate any potential adverse impact. Argonne evaluates its operations, identifies aspects of its operations that can impact the environment, and determines which of those impacts are significant. The environmental aspects addressed in the Argonne EMS are air emissions, water effluents, drinking water, waste management, waste minimization/pollution prevention, floodplain/wetlands, endangered species, habitat restoration, wildland fire management, wildlife management, pesticide management, cultural resources management, PCB management, management of TSCA chemicals, UST management, EPCRA reporting, and long-term stewardship. Regulatory responsibilities as well as organizational roles and responsibilities are delineated in the EMS to address the management of the aspects and impacts.

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3.2.3. Objectives and Targets

The objectives describe Argonne's goals for environmental performance. The objectives are a set of measurable or qualitative goals concerning how Argonne will address each environmental aspect. Targets are specific and measurable interim steps that the organization takes to obtain the objective. Typically, objectives are broken down into more specific subordinate targets.

The process for the establishment of the objectives and targets is part of the annual management review of the EMS document. Each year, typically in July, the EMS is reviewed and the objectives evaluated for relevance, while targets are revised to reflect the next set of targets established for continuous improvement in that area. A subject matter expert is assigned to each environmental aspect; that person is responsible for administering that area and for the creation and annual updates of the objectives and targets. In July 2006, Argonne generated the fiscal year (FY)2007 objectives and targets. A listing of the FY2007 objectives and targets can be found in the Argonne EMS Description Document.

For FY2006, Argonne established 19 environmental targets covering many of the aspects addressed in the EMS Description Document. All were completed by the committed date. Examples of these targets included: development of selected environmental training courses, addressing wetland and native species enhancements, conducting environmental assessments, and preparing environmental-based reports. For FY2007, Argonne established 25 targets. In addition to several core activities, a set of targets was established to encourage line management to increase its participation in the process.

3.2.4. Waste Minimization and Pollution Prevention

During 2006, Argonne continued its pollution prevention and waste minimization efforts. Argonne implements a sitewide Pollution Prevention/Waste Minimization (P2/WM) Program in accordance with DOE Order 450.1, and site-specific P2 performance measures. The P2 program tracks the generation of waste and recyclable material at Argonne and monitors the progress with regard to performance measures.

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

3.2.4.1. P2 Assessments and Reviews

Historically, those involved in the Argonne P2 program have identified, developed, and performed Pollution Prevention Opportunity Assessments (PPOAs). PPOAs are reviews of

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programs, projects, and activities to determine what changes can be made to reduce or eliminate pollution. During 2006, the following were performed:

- The use of biodiesel in fuel tanks for emergency generators was evaluated,
- Alternatives for the disposal of circuit boards and hard drives were evaluated,
- Alternatives for the final disposition of coffee grounds from the Building 201 coffee shop were evaluated,
- Alternatives for the disposal of steel lecture bottles were evaluated,
- The reuse or recycling of Styrofoam was evaluated, and
- The reuse or recycling of high-density polyethylene or polypropylene was evaluated.

During 2006, the Electronic Equipment Recycling Program shipped approximately 40 t (43 tons) of excess computers, monitors, and printers to Fermilab, which works with a demanufacturer that disassembles the equipment to recycle the useful materials. By transferring this material Argonne realized a cost savings of approximately \$16,000. During 2006, the Battery Recycling Program was available to all of the buildings at Argonne and diverted 1,964 kg (4,320 lb) of routinely used batteries from the Argonne waste stream. The batteries are sent to a facility that recovers metals that can be reused as a secondary raw material.

3.2.4.2. Waste Reduction and Recycling

Argonne's comprehensive solid waste recycling program effectively recycles/reduces the following waste/materials: surplus laboratory chemicals, mixed office paper, cardboard, aluminum, glass, metals, toner cartridges, construction and demolition debris, fly ash, coal fines, sanitary waste sludge, lead, lead-acid batteries, transparencies, fluorescent lightbulbs, computers, and electronic equipment.

Argonne continues to utilize programs, such as the Argonne Property Excess System (APES) which allow employees and contractors 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 e-mail system. Plans are being developed for other programs, such as the Argonne Chemical Exchange System and the Surplus Office Supply Exchange, which are in need of upgrade.

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3.2.4.3. Affirmative Procurement Program (EO 13101)

Argonne's commitment to environmental quality, as demonstrated by the purchase of environmentally preferable products, has resulted in an award-winning Affirmative Procurement Program. These efforts have made it easier for employees to purchase recycled-content products, made it less difficult to track purchases, and heightened the overall awareness level for buying recycled items. In 2006, the Affirmative Procurement purchases were 90% of purchases containing recycled products.

3.2.4.4. Sustainable Design

Sustainable design and environmentally preferable building materials and construction methods are included in all phases of project design. In 2006, DOE's Office of Science awarded George Norek and Keith Trychta with the "Best in Class" award for pollution prevention in the design and conversion of old storage space into office space. The award recognized work that protects the environment in sustainable design/green buildings while saving money and resources.

3.2.5. Environmental Training

Argonne has a comprehensive training program that includes mechanisms to identify, track, and document training requirements for every employee. Environmental protection training for Argonne personnel is provided primarily by the EQO Training Section, although some training may be delivered by subject-matter experts from other organizations. Personnel training addresses various requirements, such as those contained in DOE orders, or EPA and U.S. Department of Transportation regulations, in addition to specifying Argonne requirements. Required training is identified by a Job Hazards Checklist form that is completed by every employee and is reviewed by each employee's supervisor.

Designation of training and records of training are managed through the Training Management System, an on-line computer-based system that tracks the training status of each employee. Environmental protection training courses and course descriptions are listed in the Training Course Catalog available from divisional training management system representatives, the EQO Training Section, or Human Resources.

3.2.6. Assessment Programs

In line with the principles of integrated safety management, line management is responsible for internal self-assessments. This process focuses on the activities of an individual organization and is intended to stimulate continuous improvement. The results are reported to those who have the authority and responsibility for the organization's performance. At the beginning of the calendar year, each organization develops an agenda of activities to be reviewed.

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A schedule is prepared and assignments are made to manage the organization's self-assessment program. The Argonne-wide results and conclusions of the assessment programs are summarized by line management and submitted to the Director of EQO. The actual performance during the year is monitored by the line organization as well as by the oversight organization assisting senior management in fulfilling its oversight responsibilities.

3.2.7. Ecological Restoration Program

DOE and Argonne recognize the importance of enhancing and preserving biodiversity and have committed to supporting the Biodiversity Recovery Plan prepared by the Chicago Wilderness partnership organizations. Ongoing ecological restoration activities include enhancing oak woodland, savanna, wetland, and prairie habitats in undeveloped areas on the Argonne site. Controlled burns and hand clearing of invasive shrubs are restoring sunlight to oak woodlands, so that native flowers and grasses can grow. The upland area around a site wetland has been planted with prairie species to cleanse water feeding the wetland. The area surrounding a man-made pond outside the main administration building is being used to demonstrate the use of native plants for landscaping after invasive weedy plants were removed and replaced by native species.

3.3. Environmental Support Programs

Argonne established a number of environmental support programs to facilitate the implementation of the EMS and enhance the management of the various environmental aspects.

3.3.1. Environmental Monitoring and Surveillance Program

As required by DOE Orders 450.1 and 231.1A, supplemental DOE guidance, and permit conditions, Argonne conducts a routine environmental monitoring program designed to determine the effects of Argonne operations on the environment surrounding the site. The program involves collection of environmental media samples — air, surface water, groundwater, and sediment — in addition to direct radiation measurements and analysis of those radiological and chemical constituents known to be used or generated at Argonne. The potential dose to members of the public is estimated from radiological releases, and chemical concentrations are compared with regulatory limits. The results are compiled, and a number of reports (including this Argonne Site Environmental Report [SER]) are prepared. In 2006, a total of 2,215 samples were collected and 29,170 analytical results were generated. A discussion of the rationale for sampling and analyses for each media is presented in the Argonne Environmental Monitoring Plan.

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3.3.2. Long-Term Stewardship Program

By September 30, 2003, Argonne had completed all corrective actions required by the IEPA at that time. The remediation work on all units then listed in the RCRA Part B permit — 49 SWMUs and 6 AOCs — was completed. Argonne also completed three voluntary cleanup projects. However, 5 SWMUs and 2 AOCs were not able to be cleaned up sufficiently to meet the IEPA groundwater/soil cleanup standards. These seven locations and maintenance procedures for the remediation systems that were established by the remediation program were incorporated into the Argonne LTS Program.

During 2006, members of the LTS Program conducted quarterly groundwater monitoring of water from wells in the 317/319/ENE (East-Northeast) Area and the 800 Area Landfill. The samples were analyzed for the parameters identified in IEPA permits or in response letters. The results were reported quarterly to the IEPA and summarized in Chapter 6. Maintenance activities included well cleaning, servicing of pumps and compressors, and grass mowing. Argonne scientific staff continue to study the VOC decomposition process within the trees at the phytoremediation plantation.

3.3.3. Site Environmental Performance Measures Program

Effective FY1995, the Prime Contract between DOE and The University of Chicago to operate Argonne made provisions for a fee based on the performance of various research and operations activities, including ES&H and Projects and Infrastructure Management performance. Performance objectives and supporting metrics have been developed as a part of the contract and for determining the performance fee. At the end of the performance period, a rating (A+, A, A-, B+, B, B-, etc.) is assigned to each set of activities subject to the evaluation process. These ratings are part of the basis for the performance fee.

For the period of the performance-based contract of October 1, 2005 to September 30, 2006, the environmental measures were included in two categories: (1) ES&H and (2) Projects and Infrastructure Management. The ratings for the measures in these categories directly affected the performance fee. The environmental measures and their corresponding ratings include the following:

- Develop comprehensive FY2007 EMS objectives and targets (B+);
- Complete FY2006 Land Management and Habitat Restoration Work Plan activities (A);
- Conduct waste minimization pollution prevention opportunity assessments and provide implementation action plan to DOE (A);
- Complete FY2005 targets and achieve FY2006 milestones against Old Waste Disposition Plan (C);

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- Number of reportable unpermitted releases at Argonne (A);
- Quarters with air effluent violation at Argonne boiler house (A);
- Number of water effluent violations at Argonne (B); and
- Assess Vault 40 inventory and update excess material report (A).

The overall rating for the environmental performance measures, based on a rollup of the individual performance ratings during the contract period, was (B).

3.4 Strengthening Federal Environmental, Energy, and Transportation Management (EO 13423)

On January 24, 2007, the President signed EO 13423 entitled, “Strengthening Federal Environmental, Energy, and Transportation Management.” This new EO consolidates and replaces five previous EOs and two Memoranda of Understanding (MOUs). It establishes new and updated goals, practices, and reporting requirements for environmental, energy, and transportation performance and accountability. This EO lists requirements to implement certain sustainable practices and to meet specific goals in specific areas, such as increasing alternative fuel usage, increasing renewable power usage, increasing sustainability strategies for building performance and construction, increasing electronic product management, expanding affirmative procurements, reducing petroleum consumption, reducing energy intensity, reducing greenhouse gas emissions, decreasing water usage, and, decreasing the use of chemicals and toxic materials. In preparation for the establishment of the EO goals, examples of the EO 13423 goals and Argonne’s usage follow.

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Water Usage: Beginning in FY2008, the EO 13423 goal is to reduce water consumption intensity by 2% annually through the end of FY2015 or by 16% by the end of FY2015 relative to the baseline water consumption established in FY2007. Argonne receives water from two sources (Lake Michigan and the Canal Plant). Figure 3.1 shows Argonne's annual water usage from 2000 to present. The EO 13423 goal is indicated as a dashed line within the figure. Since the FY2007 baseline was not available, the baseline used was derived from 2006 water usage data.

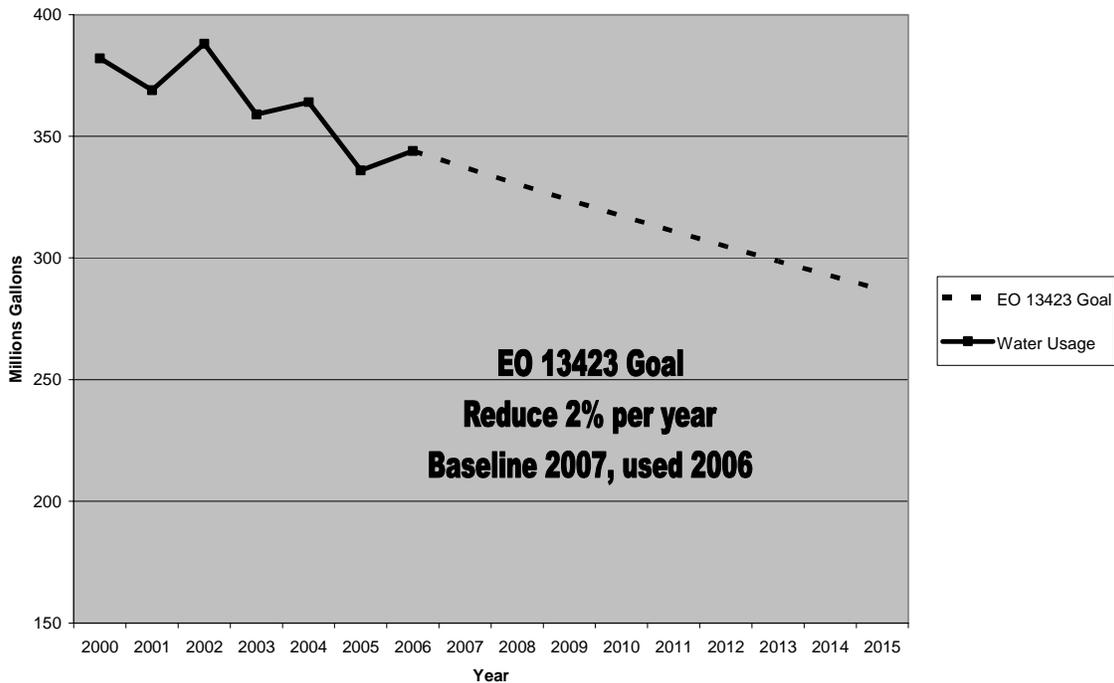


FIGURE 3.1 Water Usage

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Electrical Usage: The EO 13423 goal is to improve energy efficiency and reduce greenhouse gas emissions through the reduction of energy intensity by 3% per year through the end of FY2015 or by 30% by the end of FY2015, relative to the baseline of energy usage in FY2003. Figure 3.2 shows Argonne’s electrical usage from 2000 to present. The EO 13423 goal is indicated by the dashed line within the figure.

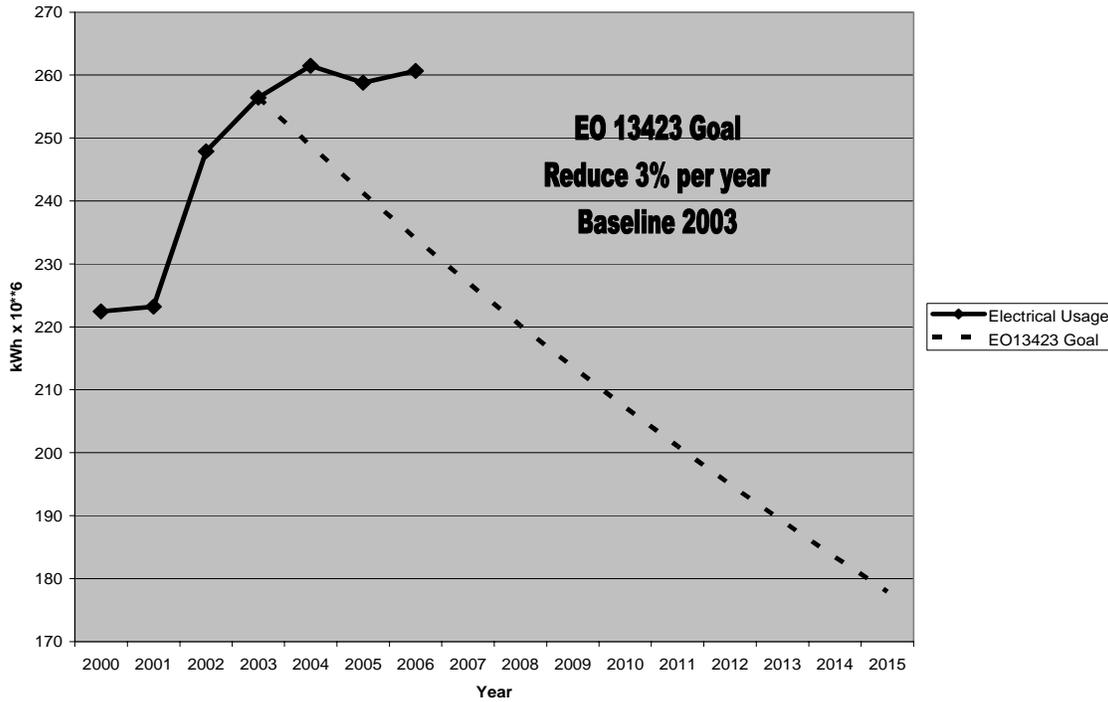


FIGURE 3.2 Electrical Usage

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Motor Vehicle Fuel Usage: The EO 13423 goal is to reduce consumption of petroleum products by 2% per year through the end of FY2015, to increase the total fuel consumption that is nonpetroleum-based by 10% annually, and to use plug-in hybrid vehicles when commercially available at a cost reasonably comparable to non-plug-in hybrid vehicles. Figure 3.3 shows Argonne’s petroleum fuel usage from 2000 to present. Figure 3.4 shows Argonne’s E85 (an example of an alternative fuel) usage from 2000 to present. The EO 13423 goals are depicted by a dashed line within each figure.

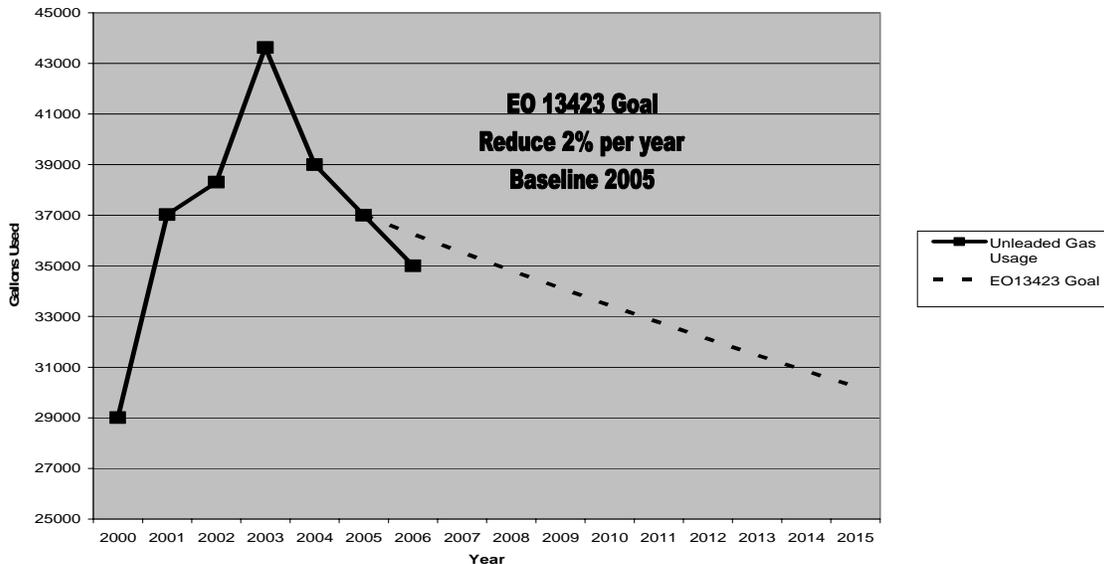


FIGURE 3.3 Unleaded Gasoline Usage

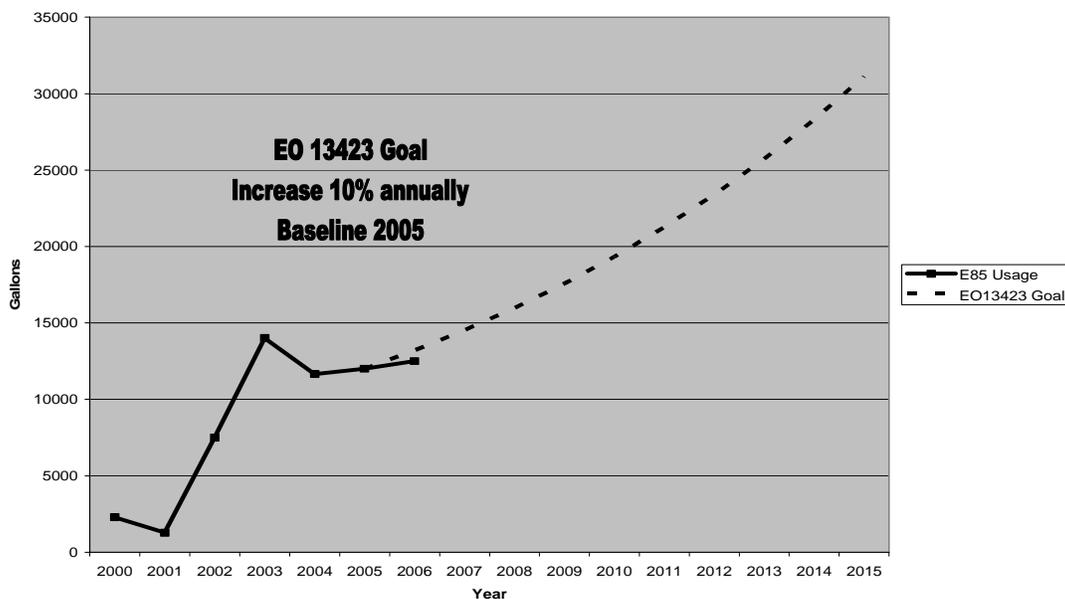


FIGURE 3.4 E85 Fuel Usage

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4.1. Description of Monitoring Program

The radioactivity of the environment around Argonne in 2006 was determined by measuring radionuclide concentrations in air, surface water, subsurface water, and sediment, and by measuring the external photon penetrating radiation and potential neutron exposure. Sample collections and measurements were made at the site perimeter and off-site for comparative purposes. Some on-site results are also reported when they are useful in interpreting perimeter and off-site results.

Because radioactivity is primarily transported by air and water, the sample collection program concentrates on these media. In addition, samples of materials from the streambeds also 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/m³ for air, and pCi/g and 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 guidance⁵ for effective dose equivalent calculations for members of the public based on International Commission on Radiological Protection (ICRP) Publications 26 and 30.^{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 2006, approximately 92% of the samples that were scheduled were collected. Samples were not collected because of dry wells, dry surface water locations, or equipment failures. 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 factors⁸ and were compared with the annual dose limits for uncontrolled areas. The CEDEs were calculated from the DOE Derived Concentration Guides (DCGs)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 4.24). Occasionally, other standards are used, and their sources are identified in the text.

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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. Particle samplers are placed at 12 locations around the Argonne perimeter and at 4 off-site locations approximately 8 km (5 mi) from Argonne, to determine the ambient or background concentrations. Samples were 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 12 perimeter locations and at 4 off-site locations on glass fiber filter media. Average flow rates on the air samplers are about 70 m³/h (2,472 ft³/h). Filters are changed weekly. Argonne staff change the filters on perimeter samplers, and the filters on off-site samplers are changed and mailed to Argonne by cooperating local agencies. The sampling units are serviced every six months, and the flow meters are recalibrated annually.

At the time of sample collection, the date and time when sampling was begun and the date and time when sample collection was completed are recorded on a label attached to the sample container. The samples are then transported to Argonne, where this information is then transferred to the Environmental Protection Data Management System.

Each air filter sample collected for alpha, beta, and gamma-ray analyses is cut in half. Half of each sample for any calendar week is combined with all other perimeter samples from that week and packaged for gamma-ray spectrometry. A similar package is prepared for the off-site filters for each week. A 5-cm (2-in.) circle is cut from the other half of the filter, mounted in a 5-cm (2-in.) low-lip stainless-steel planchet, and counted to determine alpha and beta activity. The remainder of the filter is saved.

Stack monitoring is conducted continuously at four locations (see Section 4.8.1), at those emission points that have a probability of releasing measurable concentrations of radionuclides. 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.

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Table 4.1 summarizes the monthly total alpha and beta activities for the individual weekly 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 composite weekly samples, are given in Table 4.2. The gamma-ray detector is a shielded germanium diode calibrated for each gamma-ray-emitting nuclide measured.

Comparison of perimeter to off-site alpha and beta concentrations over the past several years shows that the perimeter results are consistently lower. This was most pronounced this year, particularly during the summer months. An investigation of this difference showed that there was significantly less particulate material collected on the perimeter air filters. In addition, the off-site samples would occasionally not be changed on the weekly schedule and ran for two weeks. These samples would have a significant amount of particulate material on the filter. The differences in concentration appear to be a function of the mass of material on the filter, which is probably related to the location of the air sampler. The perimeter samplers are sited in grassy, open areas, away from buildings, roads, and other sources of airborne particulate material. The off-site samplers are located within municipal complexes, within secured locations, and are typically exposed to higher levels of airborne particulate material, especially resuspended soil, which contains naturally occurring radionuclides.

The perimeter beta activity averaged 14 fCi/m³, which is similar to the average value for the past 5 years. The gamma-ray emitters listed in Table 4.2 are those that have been present in the air for past years and are of natural origin. The beryllium-7 concentration 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 last year. The annual average radiation measurements for the on-site samples were less than the off-site samples, as discussed above.

The annual average alpha and beta activities since 1985 are displayed in Figure 4.1. The elevated beta activity in 1986 was due to fallout from the Chernobyl incident. If the radionuclides attributed to the Chernobyl incident are subtracted from the annual beta average of 40 fCi/m³, the net would be 27 fCi/m³, very similar to the averages of the other years. Figure 4.2 presents the annual average concentrations of the two major gamma-ray-emitting radionuclides in air. The annual average beryllium-7 concentrations have decreased regularly since 1987, reached a minimum in 1991, increased until 1996, and have now decreased. 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

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TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 2006
(Concentrations in fCi/m³)

Month	Location	No. of Samples	Alpha Activity			Beta Activity		
			Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	48	0.70	< 0.1	1.53	13.04	3.5	26.3
	Off-Site	8	1.46	1.1	1.78	14.54	10.3	18.3
February	Perimeter	48	1.15	0.3	2.51	15.57	6.2	34.5
	Off-Site	13	1.73	0.7	3.58	17.31	7.9	37.8
March	Perimeter	60	1.00	0.3	1.99	11.98	5.1	26.0
	Off-Site	16	1.74	0.4	3.29	16.11	6.2	36.4
April	Perimeter	48	1.22	0.1	2.74	12.69	2.1	27.2
	Off-Site	11	1.69	0.7	3.24	14.73	7.4	26.8
May	Perimeter	58	0.94	0.2	2.27	11.13	2.3	23.2
	Off-Site	12	1.01	0.4	2.20	11.24	1.8	20.1
June	Perimeter	48	0.98	< 0.1	2.43	11.44	4.8	20.4
	Off-Site	12	1.77	0.4	4.37	14.16	6.9	24.4
July	Perimeter	48	1.14	< 0.1	3.08	14.83	1.4	30.9
	Off-Site	14	1.59	0.5	2.96	18.77	7.9	30.0
August	Perimeter	60	1.35	0.2	2.57	18.37	3.1	35.3
	Off-Site	18	1.74	0.6	3.76	19.65	8.4	34.3
September	Perimeter	48	1.08	0.5	1.85	13.78	4.5	25.7
	Off-Site	9	1.13	0.3	2.36	11.98	4.2	21.4
October	Perimeter	48	0.97	0.2	1.89	12.33	4.5	22.9
	Off-Site	9	1.06	0.4	2.74	9.39	2.6	16.6
November	Perimeter	60	1.30	0.2	3.57	15.64	4.0	35.9
	Off-Site	11	2.12	1.3	2.93	22.31	12.1	37.8
December	Perimeter	35	1.32	0.3	1.96	20.2	5.7	35.2
	Off-Site	10	2.66	1.7	3.56	30.7	24.2	36.8
Annual Summary	Perimeter	609	1.10 ± 0.3	< 0.1	3.57	14.13 ± 4.1	1.4	35.9
	Off-Site	143	1.66 ± 0.5	0.3	4.37	17.00 ± 6.5	1.8	37.8

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TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 2006
(Concentrations in fCi/m³)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	34	12
	Off-Site	24	10
February	Perimeter	74	13
	Off-Site	62	11
March	Perimeter	71	10
	Off-Site	49	11
April	Perimeter	96	9
	Off-Site	80	9
May	Perimeter	81	8
	Off-Site	55	5
June	Perimeter	90	8
	Off-Site	90	9
July	Perimeter	91	13
	Off-Site	74	12
August	Perimeter	96	15
	Off-Site	79	14
September	Perimeter	62	11
	Off-Site	40	9
October	Perimeter	68	12
	Off-Site	48	8
November	Perimeter	51	12
	Off-Site	59	17
December	Perimeter	60	20
	Off-Site	69	25
Annual Summary	Perimeter	73 ± 2	12 ± 1
	Off-Site	61 ± 8	12 ± 2
Dose (mrem)	Perimeter	(0.00018)	(1.37)
	Off-Site	(0.00015)	(1.37)

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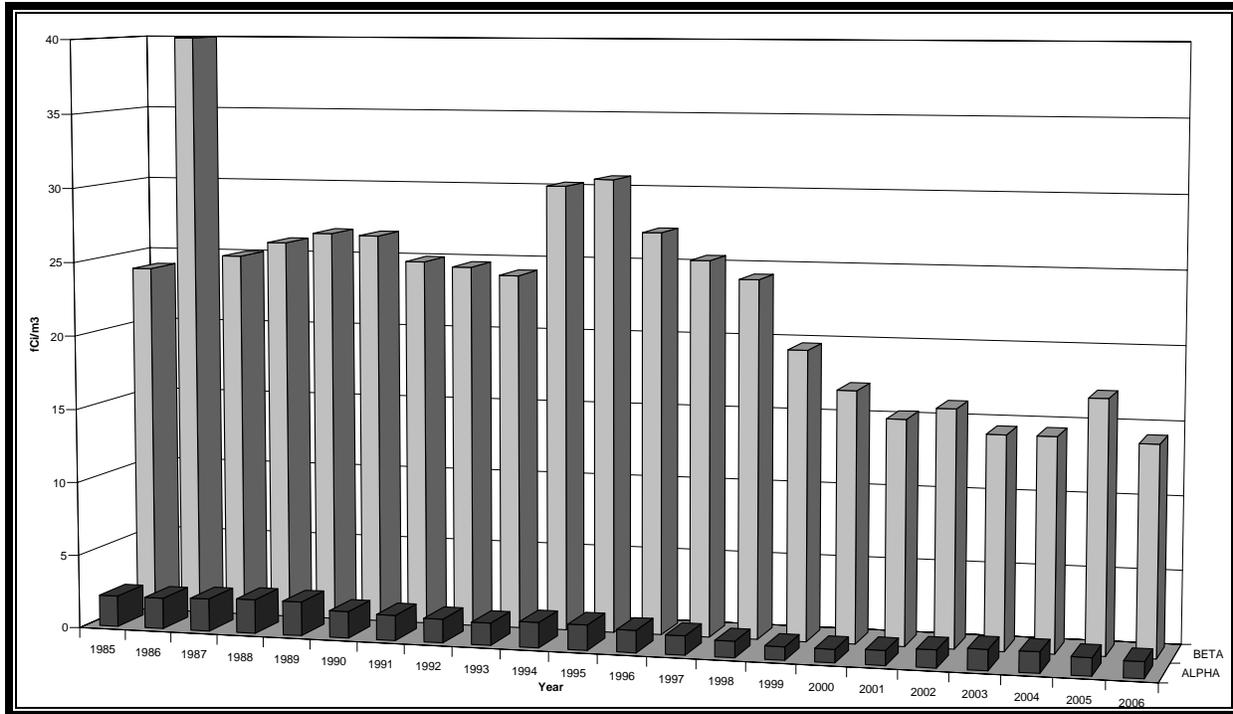


FIGURE 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples

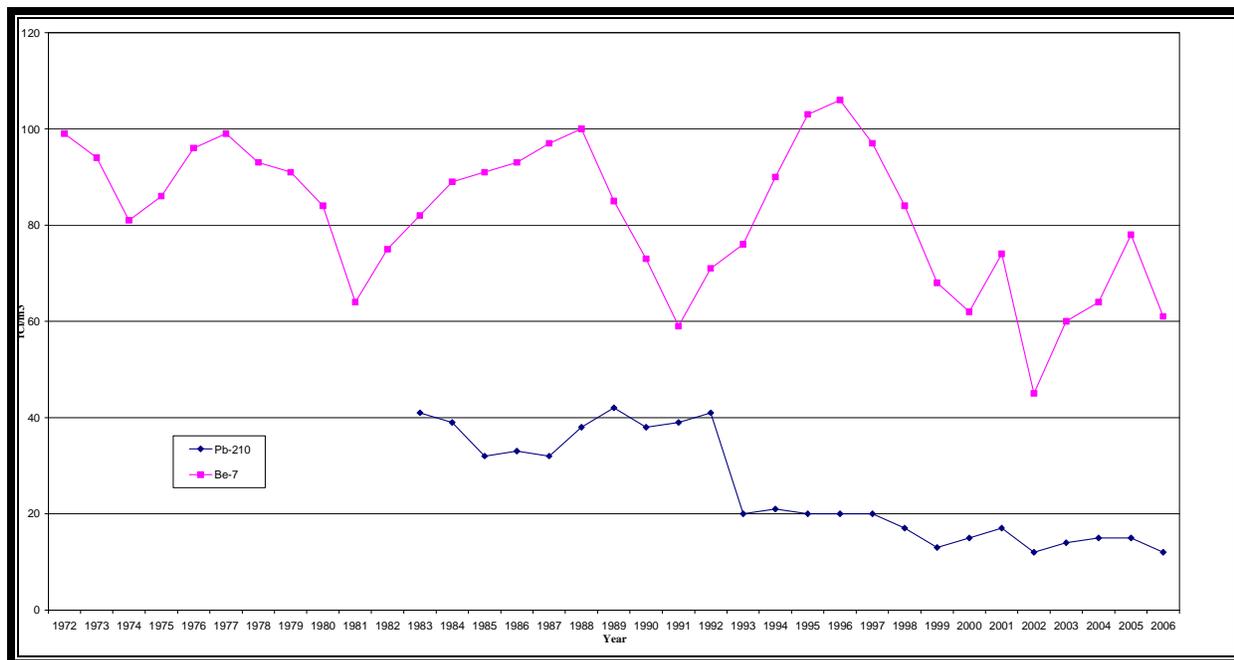


FIGURE 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples

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The major airborne effluents released at Argonne during 2006 are listed by location in Table 4.3. The radon-220 releases from Building 200, due to radioactive contamination from the “proof-of-breeding” program conducted in the mid-1980s, have been greatly reduced. The hydrogen-3 emitted from Building 212 is from hydrogen-3 recovery studies, while short-lived neutron activation products are emitted from the IPNS and APS. In addition to the radionuclides listed in Table 4.3, several other fission products also were released in millicurie or smaller amounts. The quantities listed in Table 4.3 were measured by on-line stack monitors in the exhaust systems of the buildings, except those for Buildings 350 and 411.

Phytoremediation is being applied to 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 the 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 planting shallow-rooted willow and special deep-rooted poplar trees. Approximately 800 poplar trees were planted in the fall of 1999.

One of the major groundwater contaminants in the 317/319 Area is hydrogen-3, as tritiated water. The phytoremediation process will translocate 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 consumption 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.

Quarterly monitoring is conducted at the 18 wells that are within the phytoremediation plantation. The average hydrogen-3 concentration for 2006 for all the wells was 444 pCi/L. The annual amount of hydrogen-3 released is then the product of the annual volume of water released for all 800 trees multiplied by the hydrogen-3 concentration in the groundwater. For 2006, the total hydrogen-3 released was 0.008 Ci. Applying the CAP-88 code,⁹ an estimate of the annual dose to the maximally exposed individual was 0.0000001 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 monitoring program were acidified to 0.1N with nitric acid and filtered immediately after collection. 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

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TABLE 4.3

Summary of Airborne Radioactive Emissions from Argonne Facilities, 2006

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	30	1.1×10^{12}
212 (Alpha-Gamma Hot Cell Facility)	Hydrogen-3 (tritiated water vapor [HTO])	12.3 yr	6.0	2.2×10^{11}
	Hydrogen-3 (tritiated hydrogen gas [HT])	12.3 yr	20.3	7.5×10^{11}
	Krypton-85	10.7 yr	0.4	1.5×10^{10}
	Radon-220	56 s	0.2	7.4×10^9
350 (NBL)	Uranium-234	2.4×10^5 yr	1.8×10^{-10}	6.7
	Uranium-238	4.5×10^9 yr	1.8×10^{-10}	6.7
375 (IPNS)	Carbon-11	20 min	1,264.9	4.7×10^{13}
	Argon-41	1.8 h	42.8	1.6×10^{11}
411/415 (APS)	Carbon-11	20 min	1.3	4.8×10^{10}
	Nitrogen-13	10 min	60.3	2.2×10^{12}
	Oxygen-15	122 s	6.5	2.4×10^{11}

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 or uranium-236 as an isotopic tracer.

Liquid 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. The release limits are based on the DCGs 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 to waste storage tanks. At the influent to the WTP, all effluent wastewater is screened for gamma-ray radioactivity. The effluent monitoring program documents that no liquid releases

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above the DCGs have occurred and reinforces demonstration of compliance with the use of best available technology (BAT) as required by DOE Order 5400.5.⁵

Another component of the radiological effluent monitoring program is the radiological analysis of the main water treatment plant discharge (Outfall 001). Metals have been analyzed at this location for a number of years (see Table 5.6). The same radiological constituents that are determined in Sawmill Creek are also analyzed at this location. Samples are collected daily, and equal portions are combined for each week and analyzed to obtain an average weekly concentration. Table 4.4 gives the results for 2006. The results show that the radionuclides hydrogen-3 and possibly strontium-90 detected in the effluent water can be attributed to Argonne operations. However, analysis of the Argonne domestic water, which is obtained from Lake Michigan, indicates strontium-90 at about 0.4 pCi/L. This was confirmed by the direct

TABLE 4.4

Radionuclides in Effluents from the Argonne Wastewater Treatment Plant, 2006

Activity	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
		Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	52	0.86	<0.1	2.64	— ^a	—	—
Beta	52	11.32	4.36	20.35	—	—	—
Hydrogen-3	52	<100	<100	223	<0.0046	<0.0046	0.0103
Strontium-90	52	0.35	0.27	0.43	0.034	0.026	0.041
Cesium-137	52	<2.0	<2.0	<2.0	<0.07	<0.07	<0.07
Uranium-234	52	0.33	0.13	0.86	0.062	0.025	0.164
Uranium-238	52	0.30	0.11	0.80	0.049	0.018	0.133
Neptunium-237	52	<0.0010	<0.0010	<0.0010	<0.0028	<0.0028	<0.0028
Plutonium-238	52	0.0024	<0.0010	0.0124	0.0067	< 0.0028	0.0347
Plutonium-239	52	0.0014	<0.0010	0.0288	0.0043	< 0.0031	0.089
Americium-241	52	<0.0010	<0.0010	0.0026	<0.0033	<0.0033	0.0086
Curium-242 and/or Californium-252	52	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
Curium-244 and/or Californium-249	52	<0.0010	<0.0010	<0.0010	<0.0034	<0.0034	<0.0034

^a A dash indicates no CEDEs for alpha and beta.

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analysis of Lake Michigan water. The concentrations are very low and a small fraction of the DOE limits. These findings reinforce Argonne compliance with DOE Order 5400.5 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 (1.02×10^9 L) is computed. These results are given in Table 4.5.

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. Daily samples were collected below the wastewater outfall. Equal portions of the daily samples collected each week were combined and analyzed to obtain an average weekly concentration. Samples were collected upstream of the site once a month and were analyzed for the same radionuclides measured in the below-outfall samples.

Table 4.6 gives the annual summaries of the results obtained for Sawmill Creek. Comparison of the results and 95% confidence levels of the averages for the two sampling locations shows that the following radionuclides found in the creek water can be attributed to Argonne operations: hydrogen-3, strontium-90, neptunium-237, plutonium-238, plutonium-239, americium-241, and curium-244 and/or californium-249. The concentrations of all these nuclides are low and at a small fraction of DOE concentration limits. In Sawmill Creek, below the Argonne outfall, the annual average concentrations of most measured radionuclides were similar to recent annual averages. All annual averages were well below the applicable DOE standards.

On the basis of the results of the Stormwater Characterization Study, two perimeter surface water locations were identified that contained measurable levels of radionuclides. They were south of the 319 Area, Location 7J, and south of the 800 Area Landfill, Location 11D (see 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.

The source of the radionuclides at Location 7J appears to be 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. Since the construction and operation of the leachate collection system, radionuclide concentrations in surface water at Location 7J have decreased substantially. The hydrogen-3 at Location 11D is probably also from the leachate; the decrease in the concentration from earlier years is due to the completion of the clay cap on the 800 Area Landfill in the fall of 1993.

TABLE 4.5

Total Radioactivity Released, 2006	
Radionuclide	WTP Outfall (Ci)
Hydrogen-3	0.07
Strontium-90	0.0004
Uranium-234	0.0008
Uranium-238	0.0008
Plutonium-239	<0.0001
Other transuranics	<0.0001
Total	0.07

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TABLE 4.6

Radionuclides in Sawmill Creek Water, 2006

Activity	Location ^a	No. of Samples	Concentrations (pCi/L)			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (nonvolatile)	16K	12	1.0	0.42	1.60	– ^b	–	–
	7M	52	0.8	<0.1	2.18	–	–	–
Beta (nonvolatile)	16K	12	5.3	4.0	7.7	–	–	–
	7M	52	9.8	5.4	14.3	–	–	–
Hydrogen-3	16K	12	<100	<100	<100	<0.0046	<0.0046	<0.0046
	7M	52	<100	<100	434	<0.0046	<0.0046	0.0120
Strontium-90	16K	12	<0.25	<0.25	<0.25	<0.024	<0.024	<0.024
	7M	51	0.31 ± 0.04	<0.25	0.50	0.030	<0.024	0.048
Cesium-137	16K	12	<2.0	<2.0	<2.0	<0.07	<0.07	<0.07
	7M	52	<2.0	<2.0	<2.0	<0.07	<0.07	<0.07
Uranium-234	16K	12	0.77 ± 0.08	0.32	1.17	0.147	0.117	0.223
	7M	52	0.43 ± 0.05	0.17	0.79	0.082	0.032	0.151
Uranium-238	16K	12	0.70 ± 0.08	0.33	1.14	0.116	0.054	0.189
	7M	52	0.38 ± 0.05	0.12	0.76	0.063	0.020	0.126
Neptunium-237	16K	12	<0.0010	<0.0010	<0.0010	<0.0028	<0.0028	<0.0028
	7M	52	<0.0010	<0.0010	<0.0010	<0.0028	<0.0028	<0.0028
Plutonium-238	16K	12	0.0028	<0.0010	0.0069	0.0078	<0.0028	0.0193
	7M	52	0.0028	<0.0010	0.0473	0.0078	<0.0028	0.1324
Plutonium-239	16K	12	0.0017	<0.0010	0.0182	0.0053	<0.0031	0.0564
	7M	52	0.0031	<0.0010	0.1373	0.0096	<0.0031	0.4256
Americium-241	16K	12	0.0014	<0.0010	0.0149	0.0046	<0.0033	0.0492
	7M	50	0.0037	<0.0010	0.1683	0.0122	<0.0033	0.5554
Curium-242 and/or Californium-252	16K	12	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
	7M	50	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
Curium-244 and/or Californium-249	16K	12	<0.0010	<0.0010	<0.0010	<0.0034	<0.0034	<0.0034
	7M	50	<0.0010	<0.0010	0.0042	<0.0034	<0.0034	0.0143

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

^b A dash indicates no CEDEs for alpha and beta.

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TABLE 4.7

Radionuclides in Stormwater Outfalls, 2006
(concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
January 13	<100	0.34	<2	Dry
April	Dry	Dry	Dry	Dry
August 3	<100	0.72	<2	<100
October 3	<100	0.91	<2	Dry

One of the Argonne waste management locations is within the 398A Area fenced area (Location 8J in Figure 1.1). Surface water drainage from this area is collected in a small pond at the south (downgradient) 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 did not detect any radionuclides associated with Argonne activities above the detection limit of 2 pCi/L.

Because Sawmill Creek empties into the Des Plaines River, data on the radioactivity in this river is important in assessing the contribution of Argonne wastewater to environmental radioactivity. The Des Plaines River was sampled twice a month below and once a month above 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. Results were similar above and below the creek for all radionuclides, because the activity in Sawmill Creek was reduced by dilution to the point that it was not detectable in the Des Plaines River.

4.4. Bottom Sediment

The radioactive content of bottom sediment was measured in Sawmill Creek. A grab sample technique was used to obtain bottom sediments. After drying, grinding, and mixing portions of each of the bottom sediment samples, the samples were analyzed by the methods previously described 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.

A set of sediment samples was collected on September 27, 2006, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which Argonne discharges its treated wastewater (Location 7M in Figure 1.1). 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

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TABLE 4.8

Radionuclides in Des Plaines River Water, 2006

Activity	Location ^a	No. of Samples	Concentrations (pCi/L)			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (nonvolatile)	A	12	1.0 ± 0.5	0.15	1.7	_b	–	–
	B	24	1.0 ± 0.5	<0.1	2.3	–	–	–
Beta (nonvolatile)	A	12	10 ± 1	6	14	–	–	–
	B	24	11 ± 1	5	16	–	–	–
Hydrogen-3	A	12	<100	<100	152	<0.0046	<0.0046	0.0070
	B	24	<100	<100	<100	<0.0046	<0.0046	<0.0046
Strontium-90	A	12	<0.25	<0.25	0.27	<0.024	<0.024	0.026
	B	24	<0.25	<0.25	<0.25	<0.024	<0.024	<0.024
Uranium-234	A	12	0.512 ± 0.065	0.189	0.867	0.098	0.036	0.166
	B	24	0.520 ± 0.066	0.232	0.816	0.099	0.044	0.156
Uranium-238	A	12	0.424 ± 0.058	0.156	0.758	0.070	0.026	0.126
	B	24	0.443 ± 0.060	0.172	0.744	0.074	0.029	0.124
Neptunium-237	A	12	<0.0010	<0.0010	<0.0010	<0.0028	<0.0028	<0.0028
	B	12	<0.0010	<0.0010	<0.0010	<0.0028	<0.0028	<0.0028
Plutonium-238	A	12	0.0020	<0.0010	0.0051	0.0056	<0.0028	0.0143
	B	12	0.0020	<0.0010	0.0042	0.0056	<0.0028	0.0118
Plutonium-239	A	12	<0.0010	<0.0010	<0.0010	<0.0031	<0.0031	<0.0031
	B	12	<0.0010	<0.0010	<0.0010	<0.0031	<0.0031	<0.0031
Americium-241	A	12	<0.0010	<0.0010	<0.0010	<0.0033	<0.0033	<0.0033
	B	12	<0.0010	<0.0010	<0.0010	<0.0033	<0.0033	<0.0033
Curium-242 and/or Californium-252	A	12	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
	B	12	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
Curium-244 and/or Californium-249	A	12	<0.0010	<0.0010	<0.0010	<0.0034	<0.0034	<0.0034
	B	12	<0.0010	<0.0010	<0.0010	<0.0034	<0.0034	<0.0034

^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 dash indicates no CEDEs for alpha and beta.

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TABLE 4.9
Radionuclides in Bottom Sediment, 2006

Location	Concentration (pCi/g)							Concentration (fCi/g)		
	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241		
Sawmill Creek 25 m above outfall	10.64 ± 0.46	0.05 ± 0.02	0.92 ± 0.05	0.59 ± 0.03	0.50 ± 0.06	0.14 ± 0.18	2.16 ± 0.71	0.77 ± 0.44		
Sawmill Creek at outfall	9.33 ± 0.37	0.13 ± 0.02	0.83 ± 0.05	0.47 ± 0.03	0.45 ± 0.06	0.77 ± 0.35	37.40 ± 3.35	7.29 ± 1.50		
Sawmill Creek 50 m below outfall	9.27 ± 0.37	0.06 ± 0.01	0.65 ± 0.04	0.40 ± 0.03	0.33 ± 0.05	0.05 ± 0.09	4.14 ± 0.97	1.04 ± 0.53		
Sawmill Creek 100 m below outfall	13.80 ± 0.57	0.05 ± 0.02	0.72 ± 0.05	0.46 ± 0.03	0.44 ± 0.06	0.05 ± 0.09	10.10 ± 1.50	2.75 ± 1.06		
Sawmill Creek at Des Plaines River	15.30 ± 0.53	1.15 ± 0.04	1.53 ± 0.06	0.92 ± 0.04	0.77 ± 0.07	2.03 ± 0.62	64.30 ± 4.76	23.50 ± 3.00		

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of the off-site samples collected in past years.¹¹ The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, which indicates that their origin is in Argonne wastewater. Plutonium results varied widely among locations and were strongly dependent on the retentiveness of the sediment material. The changes in concentrations of these nuclides with time and location indicate that the sediment material in this area has a dynamic nature.

4.5. External Penetrating Gamma Radiation

Levels of external penetrating gamma radiation at and in the vicinity of the Argonne site were measured with aluminum oxide thermoluminescent dosimeter (TLD) chips provided and read by a commercial vendor. Each measurement reported represents the average of two chips exposed in the same packet. Dosimeters were exposed at 17 locations at the site boundary and on the site. Readings were also taken at five off-site locations (Figure 1.2) for comparative purposes. Three locations were added to the network in 1999 to monitor radioactive waste management activities. They are east of Building 306 (Location 9/10I), south of Building 331 (Location 9H/I), and next to the 398A radioactive waste storage area (Location 9J).

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 101 ± 6 mrem/yr and were higher than last year's off-site average of 87 ± 3 mrem/yr.¹² The elevated off-site results in 2006 were primarily due to unusually high readings for all the results during the third quarter. No explanation could be found. To compare boundary results for individual sampling periods, the standard deviation of

TABLE 4.10

Environmental Penetrating Radiation at Off-Site Locations, 2006

Location	Dose Rate (mrem/yr)				Average
	Period of Measurement				
	Jan. 2–April 3	April 3–July 3	July 3–Oct. 2	Oct. 2–Jan. 2	
Lemont	96	100	123	89	102 ± 15
Oak Brook	83	105	133	95	104 ± 22
Orland Park	102	124	113	94	108 ± 13
Woodridge	80	99	122	97	99 ± 18
Willow Springs	79	100	111	85	93 ± 15
Average	88 ± 16	106 ± 11	120 ± 9	92 ± 5	101 ± 6

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TABLE 4.11

Environmental Penetrating Radiation at Argonne, 2006

Location ^a	Dose Rate (mrem/yr) Period of Measurement				Average
	Jan. 2–April 3	April 3–July 3	July 3–Oct. 2	Oct. 2–Jan. 2	
14G – Boundary	101	115	129	96	110 ± 15
14I – Boundary	77	92	111	81	90 ± 15
14L – Boundary	87	106	121	91	101 ± 15
6I – 200 m N of Quarry Road	88	106	118	81	98 ± 17
7I – Center, Waste Storage Area Facility 317	167	173	186	136	165 ± 21
7I – Boundary	75	_b	113	88	92 ± 19
8H – Boundary	94	108	118	85	101 ± 15
8H – 65 m S of Building 316	85	104	117	82	97 ± 16
8H – 200 m NW of Waste Storage Area (Heliport)	92	106	112	95	101 ± 9
8H – Boundary, Center, St. Patrick Cemetary	96	116	119	94	106 ± 13
9H – 50 m SE of CP-5	90	102	101	82	94 ± 10
9H/I – 50 m E of Building 331	259	335	259	383	300 ± 61
9/10I – E of D306	380	633	493	360	467 ± 125
9/10I – 65 m NE of Building 350 230 m NE of Building 316	85	115	114	77	98 ± 19
9/10E/F – Boundary	71	78	127	93	92 ± 25
9J – 50 m W of 398A Area	661	727	689	517	648 ± 91
10/11K – Lodging Facilities	80	100	106	75	96 ± 15

^a See Figure 4.3.

^b The dash indicates that the sample was lost.

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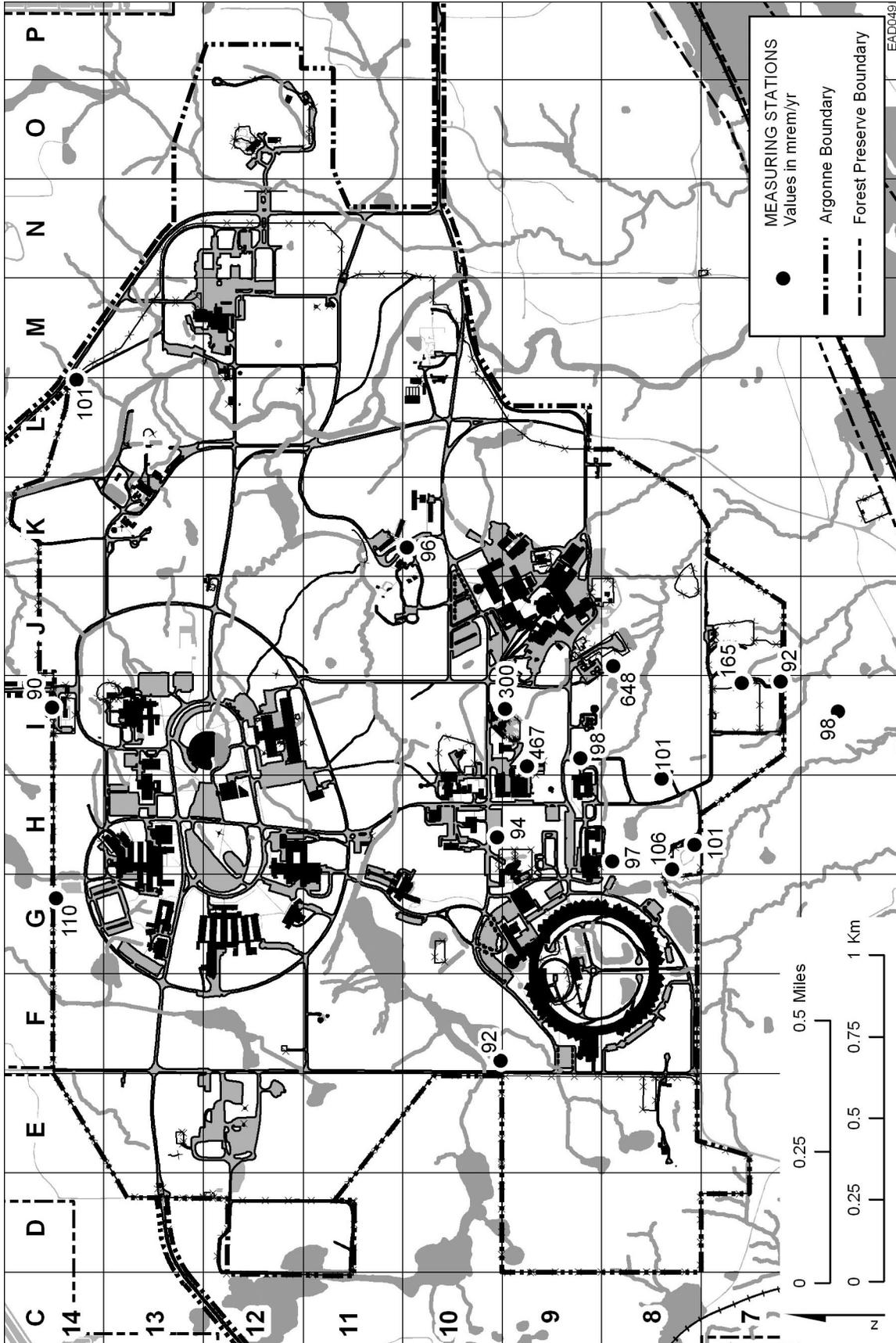


FIGURE 4.3 Penetrating Radiation Measurements at the Argonne Site, 2006

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the 20 individual off-site results is useful. This value is 9 mrem/yr; thus, individual results in the range of 101 ± 18 mrem/yr may be considered to be the average natural background with a 95% probability.

The site boundary at Location 7I had past dose rates above the average background. This was the result of radiation from Argonne's 317 Area in the northern half of grid 7I. In the past, waste was packaged and temporarily stored in this area before removal for permanent disposal off-site. In 2006, the dose at this perimeter fence location was 92 ± 19 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose is 98 ± 17 mrem/yr, which is within the normal background range.

In the past, an elevated on-site dose had been measured at Location 9H, next to the CP-5 reactor, where irradiated hardware from the reactor was stored. During the past few years, considerable cleanup of the CP-5 reactor yard has occurred as part of the CP-5 reactor D&D project. The dose at Location 9H decreased from about 1,200 mrem/yr in 1989 to 94 mrem/yr in 2006.

Three locations were added to monitor radioactive waste facilities and areas. Significant movement of radioactive waste took place, principally waste from the D&D activities and the relocation of radioactive waste from the 317 Area to the 398A Area. Some waste is repacked in Building 306 (Location 9/10I). The dose from these operations was above normal background levels. The elevated dose levels in the 398A Area (Location 9J) are from waste relocated from the 317 Area, historic waste, and D&D waste temporarily stored pending shipment. The Building 331 yard (Location 9H/I) is being used as a staging area to load trucks for shipment off-site. A number of radioactive waste shipments were made during 2006, as reflected by the elevated dose rates. The 398A Area was also used as a staging area to load trucks for shipment off-site. Depending on the number of shipments, the dose rates will vary from quarter to quarter.

4.6. Neutron Monitoring

An environmental fast neutron monitoring program was first established in 2002 at the IPNS. Although Argonne does not have any operating nuclear reactors, several facilities produce fast neutrons and have the potential to release these to the environment. To estimate the dose to the environment during normal operation of these facilities, one of the facilities, the IPNS, was selected for monitoring.

The IPNS produces up to several hundred MeV neutrons for experimental work. Pulses of high-energy protons from an accelerator system are directed by magnets contained in a heavily shielded beamline enclosure into the target area. The target consists of depleted uranium discs contained within stainless-steel housing. The target is cooled by water. The neutron-generating facilities and target support systems are encased within a biological shield that provides structural support and shielding of steel and concrete. Air emissions from this facility are discussed in Section 4.8.1.

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Beginning in January 2002, four environmental neutron monitors were obtained from a commercial vendor and placed at locations that were most likely to result in neutron dose. A fifth dosimeter was placed at an off-site location to monitor background neutron dose in areas unaffected by Argonne operations. The neutron dosimeters were changed quarterly. The results are given in Table 4.12 and shown in Figure 4.4.

The results are expressed in units of dose (mrem) for the time the dosimeter was in the field. Therefore, the annual dose is the sum of the individual measurements. Because the IPNS does not operate continuously, there may be time periods of up to a month when the system is not generating neutrons. The monitored locations are outside but near the facility. Although these areas are not continuously occupied, measurements in 2006 indicated the potential for neutron dose. Any nearby workers would receive a significantly lower dose, and the dose to the fence line is estimated to be less than 0.01 mrem.

Beginning in January 2003, a set of four fast neutron dosimeters was placed around the ATLAS facility (location 13H in Figure 1.1). ATLAS is the world's first superconducting accelerator for projectiles heavier than electrons. It has the capability of producing heavy-ion beams from hydrogen to uranium, to energies as high as 17 MeV per nucleon. Because of the many and varied types of experiments that are conducted at ATLAS, the potential exists for the production of fast neutrons.

TABLE 4.12

Fast Neutron Dose at Argonne, 2006
(dose equivalent for measurement period in mrem)

Location	Period of Measurement				Total
	Jan. 3–April 3	April 3–July 3	July 3–Oct. 2	Oct 2.–Jan. 2	
<i>On-Site</i>					
60 m NE of Bldg. 375 (IPNS)	50	50	– ^a	33	133
30 m NW of Bldg. 375 (IPNS)	<1	<1	<1	<1	<1
45 m SW of Bldg. 375 (IPNS)	<1	<1	<1	<1	<1
60 m S of Bldg. 375 (IPNS)	<1	<1	<1	<1	<1
50 m ENE of ATLAS	<1	<1	<1	<1	<1
60 m NNE of ATLAS	<1	<1	<1	<1	<1
80 m NW of ATLAS	<1	<1	<1	<1	<1
120 m WNW of ATLAS	<1	<1	<1	<1	<1
<i>Off-Site</i>					
Woodridge	<1	<1	<1	<1	<1

^a The dash indicates that the sample was lost.

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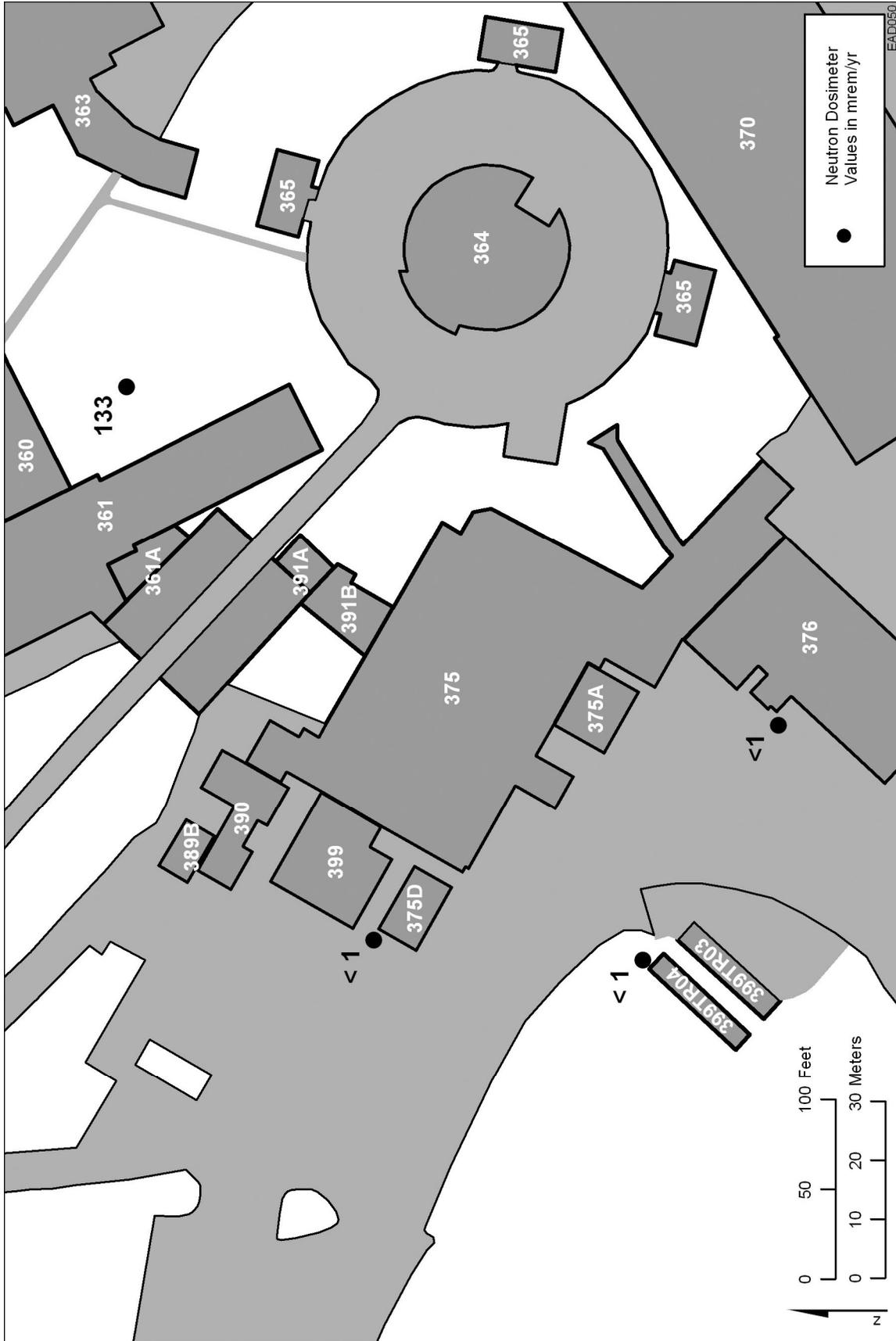


FIGURE 4.4 Neutron Dose Measurements, 2006

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The four neutron dosimeters were placed at various distances east, north, and west of the ATLAS facility. The dosimeters were changed on the same schedule as the IPNS dosimeters. The results are shown in Table 4.12. No fast neutron dose was measurable at any of the ATLAS dosimeter locations. This program will be continued.

4.7. Compliance with DOE Order 435.1

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 sitewide monitoring and surveillance program. Waste management operations in general are covered by relying on the perimeter air monitoring network and monitoring of the liquid effluent streams and Sawmill Creek.

Of particular interest is monitoring of the waste management activities conducted in the 317 Area. These include air particulate monitoring for total alpha, total beta, and gamma-ray emitters; direct radiation measurements with TLDs; surface water discharges for hydrogen-3 and gamma-ray emitters; and subsurface water samples at all monitoring wells with analyses for hydrogen-3, strontium-90, and gamma-ray emitters, plus selected monitoring for VOCs. Direct radiation measurements are also conducted at other waste management areas: Building 306, Building 331, and the 398A Area. The results are presented here and in Chapter 6 of this report.

During 2006, Argonne did not release any property containing residual radioactive material for recycle or reuse. All property that contained residual radioactivity was disposed of in an off-site low-level radioactive disposal facility.

4.8. Estimates of Potential Radiation Doses

The radiation doses at the site boundary and off the site that could have been received by the public from radioactive materials and radiation leaving the site were calculated. Calculations were performed for three exposure pathways — airborne, water, and direct radiation from external sources.

4.8.1. 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 code⁹ to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2006 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 2006, doses were calculated for hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85,

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radon-220 plus daughters, and a number of actinide radionuclides. The annual releases are those listed in Table 4.3. Separate calculations were performed for each of the five release points. The wind speed and direction data shown in Figure 1.3 were used for these calculations. In the past, the wind stability classes had been determined by the temperature differences between the 10-m (33-ft) and 60-m (197-ft) levels. To improve the determination of stability levels, the categories were obtained from daytime measurements of solar radiation and nighttime measurements of the standard deviation of the horizontal wind speed. 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 (see 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, and immersion — 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 Buildings 200 (Tables 4.13 and 4.14), Building 212 (Tables 4.15 and 4.16), Building 350 (Tables 4.17 and 4.18), Building 375 (Tables 4.19 and 4.20), and Building 411/415 (APS) (Tables 4.21 and 4.22). The doses given in these tables are the committed whole body effective dose equivalents.

A significant D&D program was completed in 1995 for the M-Wing hot cells in Building 200, which constituted the source of the radon-220 emissions. Cleanup of the major source of the radon-220, cell M-1, resulted in a decrease of radon-220 emissions from 3,000 Ci in 1992 to 193 Ci in 1999. The radon-220 emissions were reduced further in 1999, to the present 30 Ci, because of the termination of the nuclear medical program that separates radium-224 from the thorium-228 parent and continued D&D of other cells. Also, the hydrogen-3 recovery program in Building 205 was terminated, and final cleanup of the area was completed in July 2003.

The doses from each of the CAP-88 dose assessments were combined on the basis of the assumption that the IPNS is the central emission point for the site. The 16 compass directions from the IPNS were established for each perimeter and actual resident location. The five 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 southwest direction, with a maximum value of 0.26 mrem/yr (Location 9L in Figure 1.1). Essentially all of this dose can be attributed to air immersion of carbon-11 from the IPNS facility. The maximum perimeter dose is lower than last year due to reduced carbon-11 emissions from the IPNS. The programmatic need for continued operation of the facility will result in continued releases of carbon-11.

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TABLE 4.13

Radiological Airborne Releases from Building 200, 2006

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	500	8.0×10^{-3}	1,000	2.1×10^{-3}
NNE	600	6.0×10^{-3}	1,100	1.9×10^{-3}
NE	750	3.1×10^{-3}	2,600	3.0×10^{-4}
ENE	1,700	5.8×10^{-4}	3,100	2.0×10^{-4}
E	2,400	3.4×10^{-4}	3,500	1.8×10^{-4}
ESE	2,200	3.5×10^{-4}	3,600	1.5×10^{-4}
SE	2,100	3.5×10^{-4}	4,000	1.2×10^{-4}
SSE	2,000	3.8×10^{-4}	4,000	1.2×10^{-4}
S	1,500	3.1×10^{-4}	4,000	6.2×10^{-5}
SSW	1,000	1.7×10^{-3}	2,500	3.3×10^{-4}
SW	800	3.6×10^{-3}	2,200	7.0×10^{-4}
WSW	1,100	1.3×10^{-3}	1,500	7.2×10^{-4}
W	750	1.6×10^{-3}	1,500	4.4×10^{-4}
WNW	800	1.2×10^{-3}	1,300	4.8×10^{-4}
NW	600	2.0×10^{-3}	1,100	6.2×10^{-4}
NNW	600	3.7×10^{-3}	800	2.2×10^{-3}

^a Source term: radon-220 = 30 Ci (plus daughters).

The full-time resident who would receive the largest annual dose (0.029 mrem/yr), if he or she were outdoors during the entire year, is located approximately 2.2 km (1.3 mi) north-northwest (NNW) of the IPNS facility. The major contributor to the whole body dose is the air immersion dose from carbon-11 (0.027 mrem/yr). Releases of radon-220 plus daughters contribute less than 1% of the resident dose. If radon-220 plus daughters were excluded from the calculation, the NESHAP reportable dose to the maximally exposed individual would be 0.029 mrem/yr.

The individual doses to the maximally exposed member of the public and the maximum fence line dose are shown in Figure 4.5. The decreases in individual and population doses from 1988 to 1999 are due in part to the decrease of radon-220 emissions as a result of the cleanup of the Building 200 M-Wing hot cells. The increase from 1999 to 2004 is principally due to increased emissions from the IPNS as a result of increased operating time.

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 4.23, 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 300 mrem/yr.¹⁴ It is assumed that

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TABLE 4.14

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 2006
(dose in mrem/yr)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	1.2×10^{-14}	3.9×10^{-15}
Inhalation	7.9×10^{-3}	2.2×10^{-3}
Air immersion	5.3×10^{-5}	1.3×10^{-5}
Ground surface	3.9×10^{-6}	1.3×10^{-6}
Total	8.0×10^{-3}	2.2×10^{-3}
<i>Radionuclide</i>		
Thallium-208	4.6×10^{-5}	1.1×10^{-5}
Bismuth-212	9.5×10^{-4}	3.0×10^{-4}
Lead-212	4.8×10^{-3}	1.6×10^{-3}
Radon-220	2.2×10^{-3}	3.1×10^{-4}
Total	8.0×10^{-3}	2.2×10^{-3}

this dose is representative of the entire area within an 80-km (50-mi) radius. The population dose resulting from Argonne operations since 1987 is shown in Figure 4.6.

The significant increase in population dose in 2006 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.

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.⁵ 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 $8,400 \text{ m}^3/\text{yr}$.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 $\text{rem}/\mu\text{Ci}$, and this calculation gives the 50-year CEDE. Table 4.24 lists the applicable CEDE factors.

An evaluation was conducted of potential sensitive receptors of Argonne airborne releases, including children at the Argonne Child Development Center (Location 120 in

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TABLE 4.15

Radiological Airborne Releases from Building 212, 2006

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	800	6.6×10^{-5}	2,000	1.5×10^{-5}
NNE	1,000	4.6×10^{-5}	2,500	1.0×10^{-5}
NE	1,300	2.4×10^{-5}	2,000	1.1×10^{-5}
ENE	1,500	1.7×10^{-5}	2,500	7.2×10^{-6}
E	1,600	1.6×10^{-5}	2,800	6.4×10^{-6}
ESE	1,200	2.4×10^{-5}	2,500	6.9×10^{-6}
SE	1,400	1.7×10^{-5}	3,500	3.7×10^{-6}
SSE	1,400	1.7×10^{-5}	4,500	2.5×10^{-6}
S	1,500	7.2×10^{-6}	5,000	1.1×10^{-6}
SSW	1,600	1.7×10^{-5}	5,000	2.7×10^{-6}
SW	1,400	3.2×10^{-5}	2,400	1.5×10^{-5}
WSW	1,300	2.1×10^{-5}	2,300	8.3×10^{-6}
W	1,700	8.6×10^{-6}	2,200	5.6×10^{-6}
WNW	1,500	9.0×10^{-6}	2,000	5.6×10^{-6}
NW	1,300	1.1×10^{-5}	2,000	5.2×10^{-6}
NNW	1,000	3.1×10^{-5}	2,000	1.0×10^{-5}

^a Source terms: hydrogen-3 = 20.3 Ci (HT = gaseous tritium)
hydrogen-3 = 6.0 Ci (HTO = tritiated water vapor)
krypton-85 = 0.4 Ci
antimony-125 = 3.0×10^{-8} Ci
iodine-125 = 7.0×10^{-8} Ci
iodine-129 = 1.6×10^{-6} Ci
radon-220 = 0.2 Ci

Figure 1.1). The airborne dose from Argonne is estimated to be about 0.10 mrem/yr at this location. This assumes full-time, outdoor exposure. Assuming that the children are present about 8 hours per day, 5 days per week, the actual dose is closer to 0.03 mrem/yr. Additional potential sensitive receptors are located at the Darien school on 91st Street, west of Route 83. The estimated full-time outdoor dose at this location is about 0.01 mrem/yr. Again, assuming that the children are only present at this location 6 hours per day, 5 days per week, and for 35 weeks a year, the actual dose is closer to 0.001 mrem/yr.

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TABLE 4.16

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 2006
(dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,400 m SW)
Ingestion	5.5×10^{-6}	8.6×10^{-7}
Inhalation	5.7×10^{-5}	1.3×10^{-5}
Air immersion	4.4×10^{-7}	1.1×10^{-7}
Ground surface	3.0×10^{-6}	4.1×10^{-7}
Total	6.6×10^{-5}	1.5×10^{-5}
<i>Radionuclide</i>		
Hydrogen-3	1.0×10^{-6}	2.4×10^{-7}
Krypton-85	4.3×10^{-7}	1.0×10^{-7}
Antimony-125	1.7×10^{-10}	3.8×10^{-11}
Iodine-125	3.6×10^{-10}	5.0×10^{-11}
Iodine-129	7.6×10^{-6}	1.0×10^{-6}
Radon-220	5.6×10^{-5}	1.3×10^{-5}
Total	6.6×10^{-5}	1.5×10^{-5}

4.8.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5,⁵ the annual intake of radionuclides (in μCi) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter ($\mu\text{Ci/mL}$) by the average annual water consumption of a member of the general public (7.3×10^5 mL). This annual intake is then multiplied by the CEDE conversion factor for ingestion (Table 4.24) to obtain the dose received in that year. This procedure was carried out for all radionuclides, and the individual results were summed to obtain the total ingestion dose.

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. Those 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 4.25. 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 4.7 is a plot since 1986 showing the estimated dose a hypothetical individual would receive if ingesting Sawmill Creek water.

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TABLE 4.17

Radiological Airborne Releases from Building 350, 2006

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,700	9.3×10^{-10}	2,200	6.4×10^{-10}
NNE	1,800	8.6×10^{-10}	3,200	3.6×10^{-10}
NE	2,200	5.1×10^{-10}	3,100	3.0×10^{-10}
ENE	2,000	5.3×10^{-10}	3,100	2.7×10^{-10}
E	1,700	7.1×10^{-10}	2,500	3.0×10^{-10}
ESE	900	1.5×10^{-9}	3,000	2.7×10^{-10}
SE	900	1.4×10^{-9}	3,000	3.0×10^{-10}
SSE	700	1.8×10^{-9}	2,700	2.9×10^{-10}
S	600	7.3×10^{-10}	2,700	1.4×10^{-10}
SSW	400	2.6×10^{-9}	2,500	4.2×10^{-10}
SW	600	2.9×10^{-9}	2,700	5.4×10^{-10}
WSW	800	1.7×10^{-9}	2,100	4.8×10^{-10}
W	900	8.9×10^{-10}	2,200	2.8×10^{-10}
WNW	1,000	6.6×10^{-10}	2,100	2.5×10^{-10}
NW	1,900	2.9×10^{-10}	2,400	2.0×10^{-10}
NNW	1,900	5.4×10^{-10}	2,200	4.3×10^{-10}

^a Source terms: uranium-234 = 1.8×10^{-10} Ci
uranium-238 = 1.8×10^{-10} Ci

As indicated in Table 4.6, occasional Sawmill Creek samples (fewer than 10%) contained traces of cesium-137, plutonium-238, curium-242 and 244, or californium-249 and 252; 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 averaging, however, probably overestimates the true concentration. Annual doses range from 3×10^{-4} to 6×10^{-6} mrem/yr for these radionuclides.

Sawmill Creek flows into the Des Plaines River. The flow rate of Sawmill Creek (see Section 1.6) is about $0.28 \text{ m}^3/\text{s}$ ($10 \text{ ft}^3/\text{s}$). The flow rate of the Des Plaines River in the vicinity of Argonne is about $25 \text{ m}^3/\text{s}$ ($900 \text{ ft}^3/\text{s}$). Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.25, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.0002 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.

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TABLE 4.18

Maximum Perimeter and Individual Doses
from Building 350 Air Emissions, 2006
(dose in mrem/yr)

Pathway	Perimeter (600 m SW)	Individual (2,200 m N)
Ingestion	1.5×10^{-11}	3.4×10^{-12}
Inhalation	2.7×10^{-9}	6.0×10^{-10}
Air immersion	5.3×10^{-18}	1.2×10^{-18}
Ground surface	1.3×10^{-10}	3.1×10^{-11}
Total	2.8×10^{-9}	6.4×10^{-10}
<i>Radionuclide</i>		
Uranium-234	1.5×10^{-9}	3.3×10^{-10}
Uranium-238	1.3×10^{-9}	2.8×10^{-10}
Total	2.8×10^{-9}	6.4×10^{-10}

4.8.3. Biota Dose Assessment

DOE Order 5400.5⁵ 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 (about 100 g [4 oz] each). 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 with biota concentration guides (BCGs). Maximum water concentrations for hydrogen-3, strontium-90, plutonium-239, and americium-241 were obtained from Table 4.6, while maximum sediment concentrations for cesium-137, 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 0.0029 to aquatic biota. This is well below a ratio of one and demonstrates compliance with the limit in DOE Order 5400.5.

4.8.4. External Direct Radiation Pathway

The TLD measurements given in Section 4.5 were used to calculate the radiation dose from external sources. Above-background doses attributable to Argonne operations were found at the southern boundary near the Waste Storage Facility (Location 7I).

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TABLE 4.19

Radiological Airborne Releases from Building 375 (IPNS), 2006

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,600	6.8×10^{-2}	3,200	2.2×10^{-2}
NNE	1,700	6.9×10^{-2}	3,100	2.3×10^{-2}
NE	1,700	5.3×10^{-2}	2,700	2.2×10^{-2}
ENE	1,500	5.4×10^{-2}	2,500	2.3×10^{-2}
E	600	2.5×10^{-1}	2,500	2.7×10^{-2}
ESE	600	2.3×10^{-1}	2,500	2.2×10^{-2}
SE	600	2.1×10^{-1}	2,500	2.1×10^{-2}
SSE	600	2.1×10^{-1}	3,000	1.5×10^{-2}
S	800	6.0×10^{-2}	3,000	7.9×10^{-3}
SSW	800	1.7×10^{-1}	3,500	1.6×10^{-2}
SW	800	2.4×10^{-1}	4,000	2.6×10^{-2}
WSW	1,500	5.4×10^{-2}	2,700	2.1×10^{-2}
W	2,200	2.0×10^{-2}	2,700	1.3×10^{-2}
WNW	1,500	2.9×10^{-2}	2,600	1.2×10^{-2}
NW	2,200	1.4×10^{-2}	2,500	1.2×10^{-2}
NNW	1,800	3.9×10^{-2}	2,200	2.8×10^{-2}

^a Source terms: carbon-11 = 1,264.9 Ci
argon-41 = 42.8 Ci

At Location 7I, the fence-line dose from Argonne was 92 ± 19 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 98 ± 17 mrem/yr, essentially the same as the off-site average (101 ± 6 mrem/yr). No individuals live in this area. The closest residents are about 1.6 km (1 mi) south of the fence line. At this distance, the calculated dose rate from the Waste Storage Facility would be 0.001 mrem/yr, if the energy of the radiation was that of a 0.66-MeV cesium-137 gamma ray, and approximately 0.003 mrem/yr, if the energy was that of a 1.33-MeV cobalt-60 gamma ray.

At the fence line, where higher doses were measured in the past, the land is wooded and unoccupied. All of these dose calculations are based on full-time, outdoor exposure. Actual exposures to individuals would be substantially less because some of the individuals are indoors (which provides shielding) or away from their dwellings for part of the time. In addition to the permanent resident in the area, occasionally visitors may conduct activities around Argonne that could result in exposure to radiation from this site. Examples of these activities could be cross-country skiing, horseback riding, or running in the fire lane next to the perimeter fence. If the individual spent 10 minutes per week adjacent to the 317 Area, the dose would be 0.001 mrem/yr at the 317 Area fence (Location 7I) from Argonne operations.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.20

Maximum Perimeter and Individual Doses from
Building 375 (IPNS) Air Emissions, 2006
(dose in mrem/yr)

Pathway	Perimeter (600 m E)	Individual (2,200 m NNW)
Ingestion	— ^a	—
Inhalation	—	—
Air immersion	2.5×10^{-1}	2.8×10^{-2}
Ground surface	—	—
Total	2.5×10^{-1}	2.8×10^{-2}
<i>Radionuclide</i>		
Carbon-11	2.4×10^{-1}	2.7×10^{-2}
Argon-41	1.4×10^{-2}	1.6×10^{-3}
Total	2.5×10^{-1}	2.8×10^{-2}

^a A dash indicates no exposure by this pathway.

4.8.5. Dose Summary

The total effective dose equivalent received by off-site residents during 2006 was a combination of the individual doses received through the separate pathways. Radionuclides that contributed through the air pathway are hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 (plus daughters), and actinides. The highest dose was approximately 0.029 mrem/yr to individuals living north northwest 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 7.60 person-rem. The dose pathways are presented in Table 4.26 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 0.046 mrem/yr attributable to Argonne operations into perspective, comparisons can be made with annual average doses (360 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 4.27. These site-related doses are in addition to the background doses. The magnitude of the doses received from Argonne operations is insignificant compared with 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.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.21

Radiological Airborne Releases from Building 411/415 (APS), 2006

Direction	Distance to Perimeter (m)	Dose ^a (mrem/yr)	Distance to Nearest Resident (m)	Dose ^a (mrem/yr)
N	1,500	2.6×10^{-3}	2,000	1.6×10^{-3}
NNE	1,600	2.4×10^{-3}	2,100	1.5×10^{-3}
NE	2,200	1.1×10^{-3}	3,100	6.1×10^{-4}
ENE	2,500	8.0×10^{-4}	3,300	5.1×10^{-4}
E	1,600	1.8×10^{-3}	3,400	5.3×10^{-4}
ESE	1,500	1.8×10^{-3}	3,500	4.5×10^{-4}
SE	400	1.3×10^{-2}	3,000	5.3×10^{-4}
SSE	400	1.2×10^{-2}	3,000	5.3×10^{-4}
S	350	5.6×10^{-3}	2,500	3.6×10^{-4}
SSW	400	1.5×10^{-2}	2,800	7.6×10^{-4}
SW	550	1.4×10^{-2}	3,000	1.3×10^{-3}
WSW	800	5.1×10^{-3}	1,400	2.1×10^{-3}
W	800	3.2×10^{-3}	1,500	1.2×10^{-3}
WNW	500	5.2×10^{-3}	1,400	1.1×10^{-3}
NW	350	8.9×10^{-3}	1,600	8.5×10^{-4}
NNW	1,500	1.8×10^{-3}	2,000	1.1×10^{-3}

^a Source terms: carbon-11 = 1.3 Ci
nitrogen-13 = 60.3 Ci
oxygen-15 = 6.5 Ci

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.22

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 2006
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	— ^a	—
Inhalation	—	—
Air immersion	1.5×10^{-2}	2.1×10^{-3}
Ground surface	—	—
Total	1.5×10^{-2}	2.1×10^{-3}
<i>Radionuclide</i>		
Carbon-11	4.2×10^{-4}	5.8×10^{-5}
Nitrogen-13	1.4×10^{-2}	2.0×10^{-3}
Oxygen-15	1.6×10^{-4}	2.3×10^{-5}
Total	1.5×10^{-2}	2.1×10^{-3}

^a A dash indicates no exposure by this pathway.

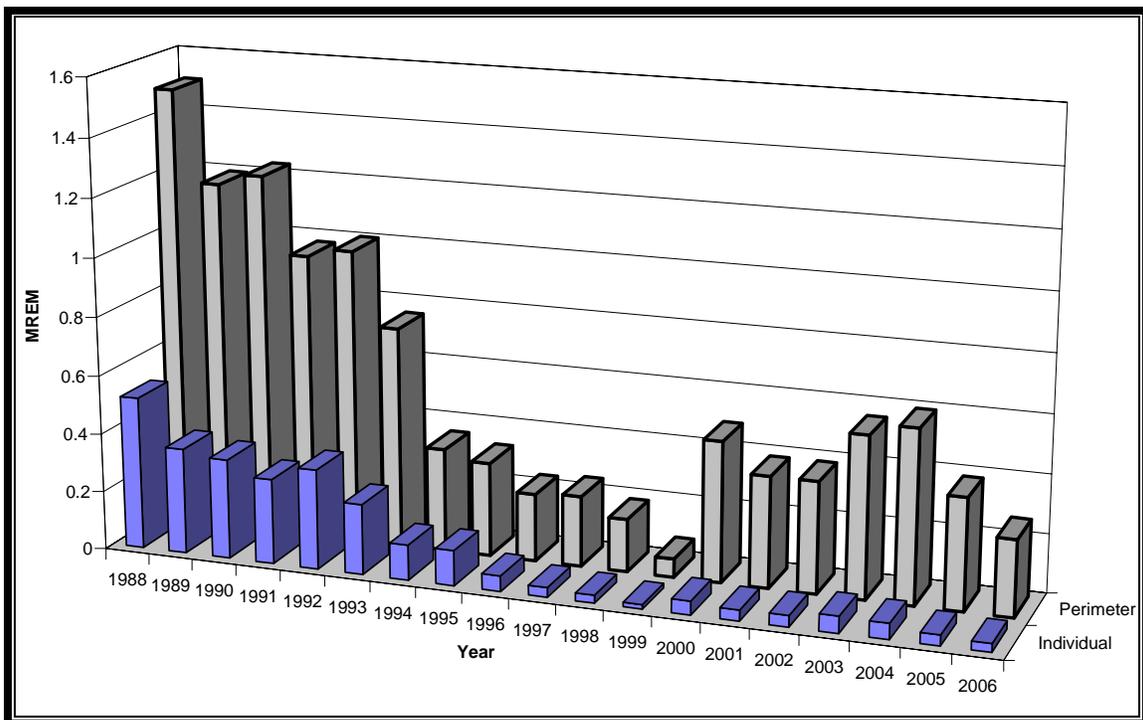


FIGURE 4.5 Individual and Perimeter Doses from Airborne Radioactive Emissions

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.23

Population Dose within 80 km
(50 mi), 2006

Radionuclide	Person-rem
Hydrogen-3	<0.01
Carbon-11	6.94
Nitrogen-13	0.24
Oxygen-15	<0.01
Argon-41	0.42
Krypton-85	<0.01
Antimony-125	<0.01
Iodine-125	<0.01
Iodine-129	<0.01
Uranium-234	<0.01
Uranium-238	<0.01
Total	7.60
Natural	2.7×10^6

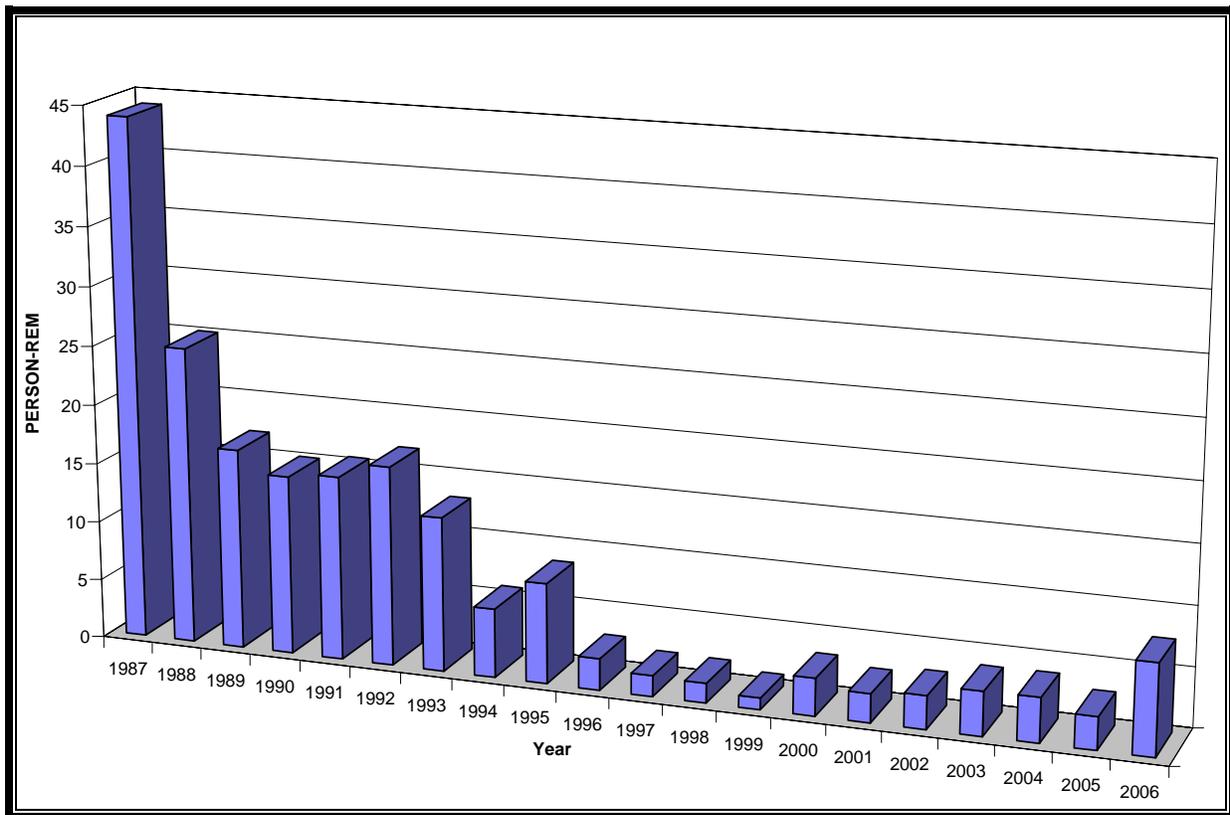


FIGURE 4.6 Population Dose from Airborne Radioactive Emissions

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.24

50-Year Committed Effective Dose
Equivalent (CEDE) Conversion Factors
(rem/ μ Ci)

Nuclide	Ingestion	Inhalation
Hydrogen-3	6.3×10^{-5}	9.6×10^{-5}
Beryllium-7	– ^a	2.7×10^{-4}
Carbon-11	–	8.0×10^{-6}
Strontium-90	0.13	1.32
Cesium-137	0.05	0.032
Lead-210	–	13.2
Radium-226	1.1	–
Thorium-228	–	310
Thorium-230	–	260
Thorium-232	–	1,100
Uranium-234	0.26	130
Uranium-235	0.25	120
Uranium-238	0.23	120
Neptunium-237	3.9	–
Plutonium-238	3.8	–
Plutonium-239	4.3	330
Americium-241	4.5	–
Curium-242	0.11	–
Curium-244	2.3	–
Californium-249	4.6	–
Californium-252	0.94	–

^a A dash indicates that a value is not required.

TABLE 4.25

Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 2006

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.07	26	0.0012
Strontium-90	0.0004	0.15	0.014
Plutonium-239	<0.0001	0.0003	0.0009
Americium-241	<0.0001	0.0004	0.00012
Total	0.07		0.016

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

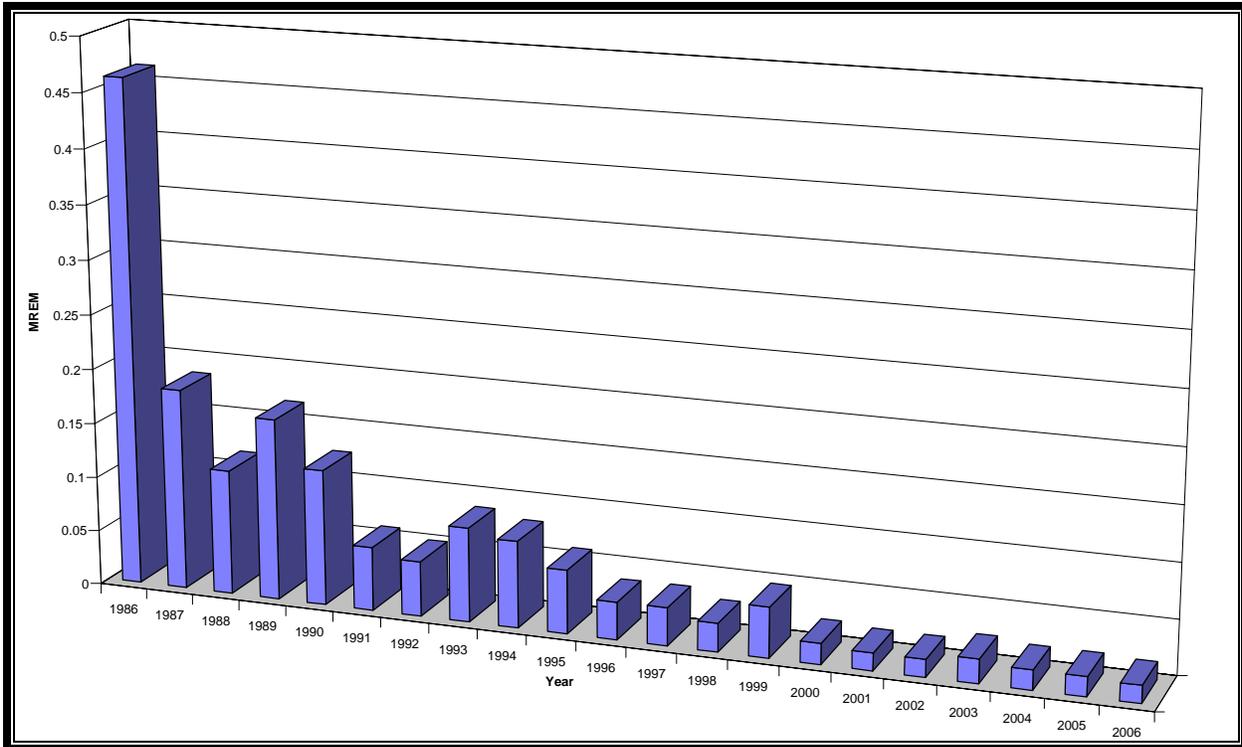


FIGURE 4.7 Comparison of Dose Estimate from Ingestion of Sawmill Creek Water

TABLE 4.26

Summary of the Estimated Dose to a Hypothetical Individual, 2006 (mrem/yr)

Pathway	Argonne Estimate	Applicable Standard
Air total	0.029	10 (EPA)
Water	0.016	4 (EPA) ^a
Direct radiation	0.001	25 (NRC)
Maximum dose	0.046	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.

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TABLE 4.27

Annual Average Dose Equivalent
in the U.S. Population^a

Source	Dose (mrem)
Natural	
Radon	200
Internal (potassium-40 and radium-226)	39
Cosmic	28
Terrestrial	28
Medical/dental	
Diagnostic x-rays	39
Nuclear medicine	14
Consumer products	
Domestic water supplies, building materials, etc.	10
Occupational (medical radiology, industrial radiography, research, etc.)	1
Nuclear fuel cycle	<1
Fallout	<1
Other miscellaneous sources	<1
Total	360

^a National Council on Radiation Protection and
Measurements Report No. 93.¹⁴

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION



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5.1. INTRODUCTION

The nonradiological monitoring program primarily involves the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. Argonne's extensive groundwater monitoring program is discussed separately in Chapter 6. This chapter discusses the monitoring of releases to the air and surface water.

5.1.1. Chapter Highlights

Air Releases: Monitoring of releases of nonradiological contaminants to the air from Argonne operations is limited to compliance monitoring of combustion products from the on-site coal-fired boiler. During 2006, there were no exceedances of the air permit limits for this facility during 3,672 hours of operation.

Surface Water: Releases to surface water are monitored by sampling discharges from numerous NPDES-permitted wastewater outfalls around the site. During 2006, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits. The only significant ongoing issue is the exceedance of TDS limits at three outfalls, 001, J03 and H03, resulting from the seasonal use of road salt during the winter. Actions continued in 2006 to determine the nature of the problem and to identify solutions to reduce the number of exceedances. With the exception of two exceedances of TDS limits in January of 2006, the discharges from the two on-site wastewater treatment plants were all within the discharge limits. No toxicity was observed in any of the five outfalls that were tested for aquatic toxicity. Samples are also collected from Sawmill Creek, upstream and downstream of Argonne. The combined wastewater discharge and Sawmill Creek downstream of the outfall were found to meet the IEPA's criteria for effluent quality and general use water quality. Thus, it appears that, with the exception of the elevated levels of TDS from road salt, the Argonne site is not adversely impacting surface water quality.

5.2. MONITORING AIR DISCHARGES

Argonne operations utilize a wide variety of nonradioactive chemicals and fuels that have the potential to adversely impact the environment if released in sufficient quantities. However, because of the nature of the research conducted at Argonne, most chemicals are used in small quantities within laboratories, and the potential for a significant release is very small. These discharges are not monitored. A few exhaust points are significant enough to require monitoring to ensure compliance with applicable regulations and permits.

The most significant air pollutants at Argonne are combustion products discharged from Boiler No. 5 while it is burning coal. Most of the time all of the boilers burn natural gas, which emits few regulated pollutants, and do not require monitoring. Boiler No. 5 is equipped to burn either natural gas or coal. Coal is used primarily during the peak heating demand periods in the winter. It is equipped with dedicated monitoring equipment for sulfur dioxide and opacity to be

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

used while burning coal. No exceedances were noted during 2006 over a period of 3,672 hours of coal-burning operation (see Section 2.1.2). The lack of exceedances for 2006 indicates that the boiler house is operating within its allowable discharge constraints. Other significant sources of air discharges include a number of backup power generators that are operated periodically for maintenance reasons and a transportation research facility that evaluates internal combustion engines. Chapter 2 (Table 2.3) contains a summary of estimated air discharges (estimated based on run time and typical emission factors for each type of equipment) from the major air point-source discharges at Argonne.

Another 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 gas migration into structures around landfills. Gas composition is measured quarterly at 4 wells located in the waste mound, at 10 gas monitoring wells adjacent to the landfill but outside of the buried waste, and in two nearby structures. Monitoring in 2006 indicated that the gas within the landfill waste mound contained up to 68% methane, but no methane was found in the gas monitoring wells surrounding the landfill except for two samples from gas well G-8 (0.5% and 0.3% methane). The quantity of gas generated is not measured, but observations during sampling indicated that the flow is very small.

Small amounts of research-related chemicals are released to the air as laboratory wastewater is treated in the LWTP. The release of volatile organic materials and HAPs from the LWTP is calculated each month on the basis of an analysis of a single sample of wastewater flowing into the plant and the flow rate of wastewater through the plant by using the EPA's WATER9 model for determining emissions from such facilities. Section 5.3.1 discusses the results of the wastewater analysis. The concentrations are typically very low, and most constituents routinely detected are the result of water disinfection by-products present in the potable water Argonne purchases from the DuPage Water Commission that is produced by the Chicago Water Department. In early 2006, one sample contained a relatively high concentration of ethanol, which resulted in an unusually high estimate of the amount discharged to the air during treatment. No specific reason for the high levels of ethanol could be found, although it was determined that ethanol is used in many locations throughout Argonne and is occasionally found in the wastewater, though at much lower levels than the January sample.

5.3. MONITORING SURFACE WATER DISCHARGES

Surface water samples for nonradiological chemical analyses are collected from 26 NPDES-permitted outfalls. Sampling frequency and analyses conducted on the samples from the NPDES outfalls vary, depending on the 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. In addition to being published in this report, the NPDES monitoring results are transmitted monthly to the IEPA in a DMR.¹⁸

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

In addition to the permit-required monitoring, other analyses are voluntarily conducted on samples collected from the laboratory wastewater treatment plant inlet and the combined wastewater outfall (NPDES Outfall 001) to provide a more complete evaluation of contaminants discharged to the environment. Water samples from Sawmill Creek are also collected and analyzed for a number of inorganic constituents. The results of these additional analyses are then compared with the IEPA's General Effluent Standards and Stream Quality Standards listed in IAC, Title 35, Subtitle C, Chapter I.¹⁹ 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 quality and stream quality downstream of Argonne can be compared.

Surface water discharges from the closed 800 Area Landfill are sampled quarterly at two locations to monitor for potential leachate seepage from the waste mound. This sampling is required by the landfill's postclosure care plan.

5.3.1. Wastewater Treatment Influent Monitoring

Untreated wastewater entering the laboratory wastewater treatment plant is sampled once per month and analyzed for VOCs. This monitoring is a requirement of Argonne's Title V air permit and is performed to document the amount of volatile organic matter that could be released to the air during treatment of the wastewater. It also provides evidence of the success of Argonne's effort to eliminate the discharge of chemicals to the sewer system.

Table 5.1 gives the results of the analysis of laboratory wastewater influent in 2006. Figures 5.1 and 5.2 present comparisons of the 1992 through 2006 results for the VOCs most commonly found, acetone and chloroform. The 2006 results are similar to those from previous years with the exception of one sample with unusually high levels of ethanol.

Low concentrations of chloroform, bromodichloromethane, bromoform, and dibromochloromethane were found in nearly all of the samples. These compounds are halogenated organic chemicals that are produced when chlorine is added to the water supply during treatment by the Chicago Water Department, which provides the water that Argonne purchases from the DuPage Water Commission. The chlorine interacts with naturally occurring organic chemicals in the water and produces low concentrations of a number of chlorinated or brominated chemicals collectively known as trihalomethanes (THMs). Some of these materials remain in the wastewater and are detected in the influent samples. The decrease in chloroform shown in Figure 5.2 in 1997 is likely the result of the switch from well water to Lake Michigan water, which occurred in 1997. The drinking water limit for the sum of all the THM compounds is 80 µg/L.

In addition to the THMs, six other chemicals were detected in more than one sample. The chemicals consistently detected in the highest concentrations were acetone and ethanol. Acetone was found in 9 of 12 samples and is likely the result of equipment cleaning. Ethanol was detected in only 3 samples, with 1 sample containing 32,592 µg/L. The source of the ethanol in this and the other samples is not known, but ethanol is used in many locations throughout Argonne and is

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TABLE 5.1

Laboratory Influent Wastewater, 2006
(concentrations in µg/L)

Month	Acetaldehyde	Acetone	2-Butanone	Chloroform	Bromodichloro- methane	Bromoform	Dibromochloro- methane	Ethanol	Methylene Chloride	2-Propanol
January	43	23	- ^a	7	3	-	3	32,592	-	540
February	-	27	-	20	1	-	-	-	32	-
March	-	9	0.4	17	3	2	2	-	-	-
April	-	-	-	5	2	-	1	-	-	-
May	43	65	-	10	1	-	-	-	6	350
June	47	51	4	4	3	1	2	-	-	-
July	-	-	-	3	2	-	2	-	-	-
August	24	99	0.7	2	2	-	2	649	1	-
September	13	302	2	8	3	6	5	653	6	-
October	15	10	-	2	2	5	4	-	-	-
November	-	-	-	1	1	5	2	-	-	-
December	-	28	-	4	2	-	-	-	-	-
Average ^b	31	68	2	7	2	4	3	11,298	11	445

^a A dash indicates that the concentration was less than the detection limit.

^b Average calculated from values above detection limits only.

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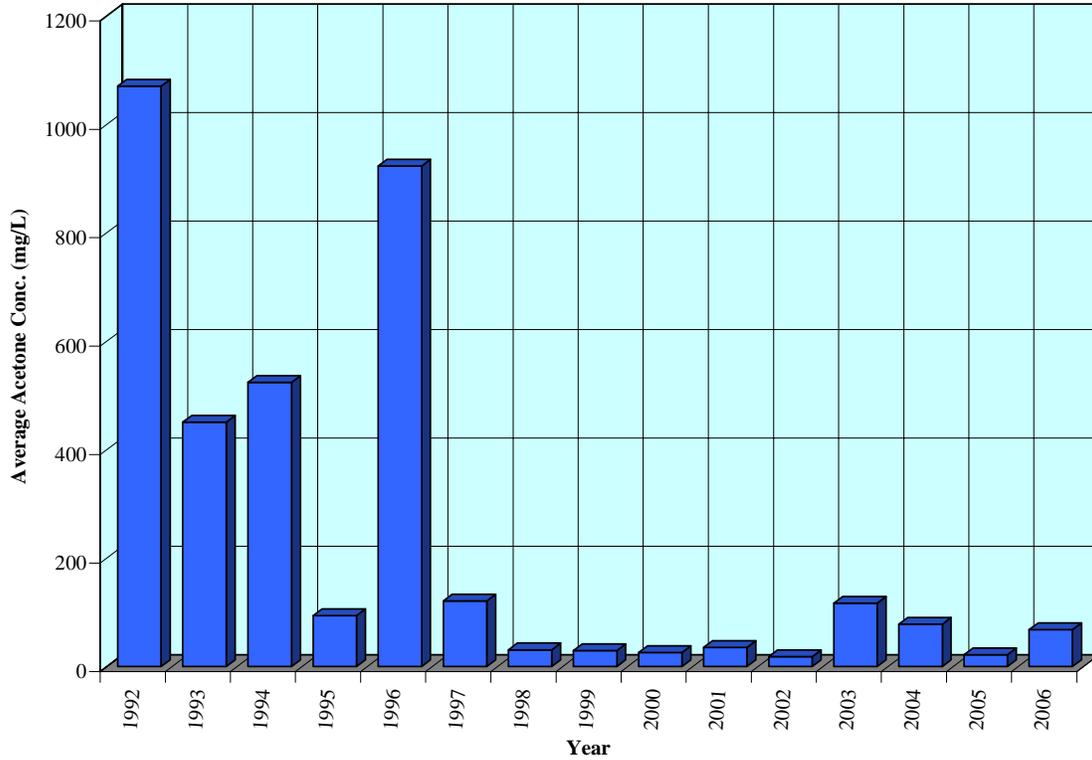


FIGURE 5.1 Average Acetone Levels in Laboratory Influent Wastewater, 1992 to 2006

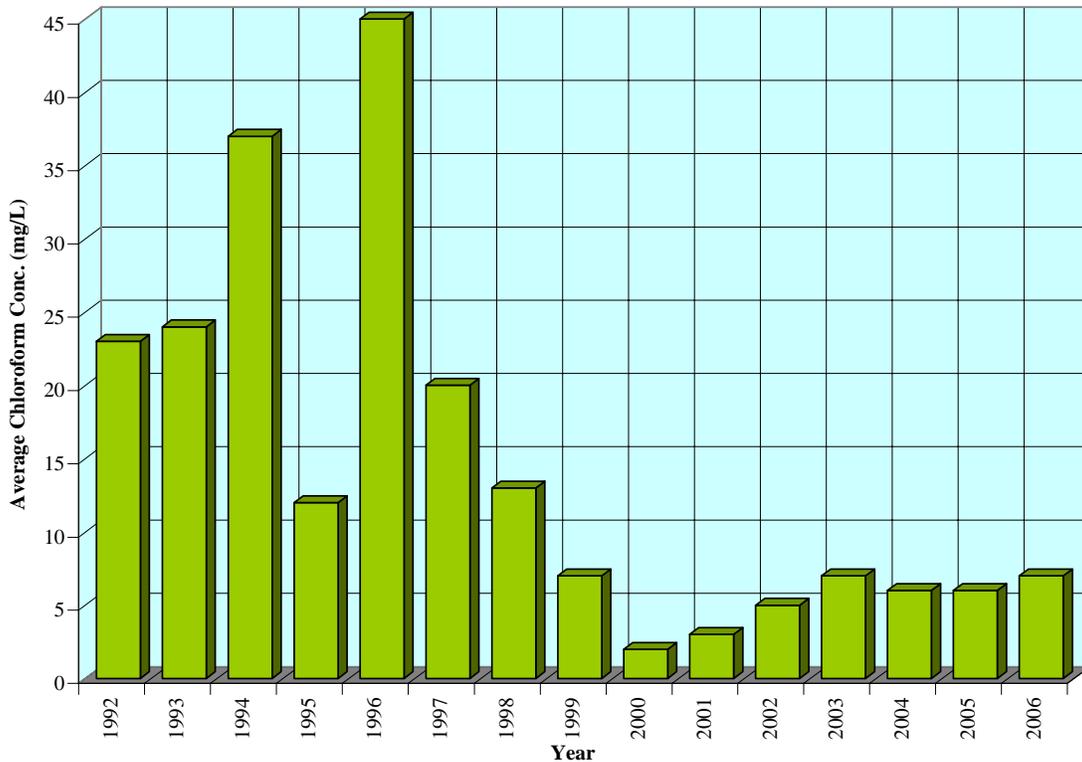


FIGURE 5.2 Average Chloroform Levels in Laboratory Influent Wastewater, 1992 to 2006

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often used to clean glassware. 2-Propanol (also known as isopropyl alcohol), which was present in only 2 samples, is also a common cleaning solvent. Acetaldehyde was also found in a number of samples at low concentrations. This is an organic molecule that can also be used in various chemical processes. The exact source is unknown. Infrequent trace levels of 2-butanone and methylene chloride were also noted, as shown in Table 5.1. Six other chemicals not shown in this table (tetrachlorethene at 1 µg/L, ethyl ether at 36 µg/L, 4-methyl-2-pentanone at 1 µg/L, tetrahydrofuran at 4 µg/L, 1-propanol at 377 µg/L, and octanol at 1 µg/L) were present above detection limits in only one sample. Research activities at Argonne utilize a wide variety of chemicals for a variety of purposes and discharge small amounts of such chemicals into the sewer from time to time. As discussed later in this chapter, very few of these chemicals were detected in the effluent from the treatment plant.

As part of Argonne's ongoing pollution prevention efforts, it conducts a waste generator education program in which proper handling and disposal of chemicals are explained. However, normal laboratory activities, such as cleaning laboratory equipment, result in the discharge of small amounts of chemicals into the sewer. The decrease in influent concentrations of acetone since the late 1990s can in part be attributed to educational efforts related to waste disposal and pollution prevention. In addition to laboratory activities, VOCs are discharged into the laboratory sewer from the 317/319 Area lift station, which pumps contaminated groundwater generated by Argonne's groundwater extraction systems in this area. The chemicals in the groundwater discharged to the treatment plant are organic solvents, including acetone, 1,1-dichloroethane, trichloroethene, 1,4-dioxane, and chloroform. Several of these types of chemicals were detected in influent samples during 2006; however, the concentrations were very low.

5.3.2. Wastewater Treatment Effluent Monitoring

Wastewater at Argonne is treated, if necessary, to meet disclosure limits, and discharged through a series of point-source wastewater discharges (outfalls) permitted by the IEPA under the NPDES program. Section 2.2 of Chapter 2 describes the 42 current outfalls on the Argonne site. In July 2005, effective September 2005, the current NPDES permit was issued. This permit modified the list of outfalls, changed the monitoring requirements for the outfalls, and used a different outfall naming scheme than the previous permit issued in 1995 had used. The new NPDES outfall designations are shown in Figure 5.3.

In general, the outfalls fall into three groups; the treated wastewater discharges, direct discharges that contain some type of process wastewater in addition to stormwater and groundwater discharges, and those that contain only stormwater runoff and groundwater following a rain event.

Wastewater treatment occurs in two separate treatment systems. In general, wastewater from non-research-related activities (bathrooms, cafeterias, mop sinks, etc.) is treated in the SWTP, while wastewater from laboratories and other research facilities is treated in the LWTP, although some minor industrial discharges are routed to the SWTP when necessary. Both systems are located in the same part of the site known as the WTP. Outfalls A01 (formerly 001A) and

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B01 (formally 001B), are internal monitoring points consisting of effluent from the SWTP and LWTP, respectively. Their flows combine to form Outfall 001, which also is located at the WTP. The combined wastewater stream 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 at 7M in Figure 1.1.

In addition to the main wastewater outfalls, a small amount of process wastewater consisting of cooling tower blowdown or noncontact cooling water is discharged directly to small streams and ditches throughout the site. This wastewater does not contain significant amounts of contaminants and does not require treatment before discharge. These 12 discharge points are included in Argonne's NPDES permit as regulated outfalls. Only the dry weather process discharges are subject to discharge limits and monitoring requirements in the permit. In recent years, most of the cooling tower and cooling water discharges have been rerouted to the Argonne sewer system, resulting in a reduction in the number of outfalls of this type. Twenty seven other outfalls contain only stormwater runoff or groundwater. Eleven of these outfalls are included in the permit because the IEPA required routine monitoring or other studies of the flow from these outfalls. The remaining stormwater outfalls are listed in the permit, but monitoring is not normally required.

5.3.2.1. Sample Collection and Analysis

Effluent samples are collected from Argonne outfalls as specified by the NPDES permit, which lists the frequency of sample collection and the parameters to be monitored for each individual outfall. The sampling requirements of the outfalls depend on the nature of the activity generating the wastewater. They range from weekly sampling of the main treated wastewater to semiannual sampling of certain stormwater outfalls. Certain parameters have permit limits associated with them, while others are collected for information only (monitor-only parameters) and have no discharge limits. This section discusses those requirements and the results of the monitoring.

All samples are collected in specially cleaned and labeled bottles with appropriate preservatives added. Custody seals and chain-of-custody sheets also are used as needed. Samples are submitted to the appropriate laboratory for analysis within the required holding time.

Sample collection, preservation, holding times, and analytical methods are specified by the EPA as codified in 40 CFR Part 136, Tables 1B and 2,²⁰ as well as Standard Methods.²¹ Table 5.2 provides a summary of the analytical methods used for the NPDES monitoring programs. These analyses are conducted by the Argonne EQO Analytical Services (EQO-AS) laboratory as well as commercial laboratories. Commercial laboratories are used for a select set of analyses that the Argonne laboratory does not perform.

NPDES sample analyses conducted by Argonne were performed in accordance with standard operating procedures (SOPs) that are issued and updated periodically as controlled documents. These SOPs cite protocols that can be found in 40 CFR Part 136, "Test Procedures

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TABLE 5.2

Analytical Procedures

Analyte	Description	Analytical Lab
Wastewater properties		
pH	Electrochemical pH electrode method	Field
Temperature	Electronic probe method	Field
Inorganic constituents		
Ammonia nitrogen	Ion-selective electrode measurement	Commercial
Chloride	Turbidimetric method	Argonne
Hexavalent/trivalent chromium	Inductively coupled plasma (ICP) emission spectroscopy	Argonne
Iron/dissolved iron	ICP emission spectroscopy	Argonne
Low-level mercury	Cold-vapor atomic fluorescence spectrometry	Commercial
Nitrate-nitrite	Colorimetric/cadmium	Commercial
Total organic halogen (TOX)	Carbon adsorption with a microcoulometric titration detector	Commercial
Total organic carbon (TOC)	Carbonaceous analysis	Commercial
Sulfate	Ultraviolet/visible absorption spectrometry	Argonne
Total dissolved solids (TDS)	Drying and gravimetric method	Argonne
Total residual chlorine (TRC)	<i>n, n</i> -Diethyl- <i>p</i> -phenylene diamine (DPD) colorimetric method	Argonne/Field
Total suspended solids (TSS)	Gravimetric method	Argonne
Organic constituents		
Oil and grease	Solvent partition-gravimetric method	Argonne
Biological oxygen demand (BOD ₅)	Fermentation and dissolved oxygen depletion method (5-day)	Commercial
Chemical oxygen demand (COD)	Closed reflux, colorimetric method	Argonne
Carbon tetrachloride	Purge and trap gas chromatograph and mass spectrometer (GC/MS) method	Argonne
Phenols	Distillation followed by colorimetric measurement	Commercial
Tetrachloroethene	Purge and trap capillary-column GC/MS method	Argonne
Priority pollutant list analyses		
Cyanide (total)	Distillation and colorimetric method	Commercial
Herbicides/pesticides	Liquid/liquid extraction followed by GC/MS	Commercial
PCBs	Liquid/liquid extraction followed by GC/MS	Argonne
Semivolatile organics	Liquid/liquid extraction followed by GC/MS	Argonne
Volatile organics	Purge and GC/MS method	Argonne
Metals (except mercury) antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc	Metals and trace elements by ICP/atomic emission spectrometry	Argonne
Mercury	Mercury by cold vapor atomic absorption spectrometry	Argonne

for the Analysis of Pollutants under the Clean Water Act.”²⁰ and Standard Methods. Commercial laboratories utilize their own SOPs based on the same protocols.

5.3.3. Outfall Monitoring Requirements and Results

This section discusses the monitoring requirements and summarizes the results of monitoring at the outfalls covered by the NPDES permit.

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5.3.3.1. Wastewater Treatment Facility Outfalls

Outfall A01. This outfall consists of treated sanitary wastewater from throughout the site. The effectiveness of the sanitary wastewater treatment systems is evaluated by monitoring the constituents shown in Table 5.3 at the frequency shown. The results are then compared with the concentration limits shown in this table. Two sets of limits are listed; one is a maximum limit for any single weekly sample, and the other is for the average of all weekly samples collected during the month. Table 5.3 also contains a summary of the monitoring results from 2006. No limits were exceeded during 2006.

The NPDES permit requires that Argonne conduct a study to determine the effects of stormwater infiltration into the sanitary sewer system. Because of the age of the sewers at Argonne, rainwater and shallow groundwater can enter the sewer system and significantly increase the flow into the treatment plant after a major rain event. To determine if this increased flow adversely impacts the operation of the plant, the permit requires the collection of samples immediately after 12 significant rain storms (greater than 0.3 cm [0.1 in.] of precipitation). Both a grab sample, collected within the first 30 minutes of storm-flow out of the plant, and a flow-weighted composite are collected and analyzed for the same parameters as the normal monitoring. During 2006, 6 of these 12 samples were collected. The results of these 6 samples were submitted to the IEPA on the DMR forms. None of these special samples exceeded the permit limits, and they confirm that the plant operation is not hindered by stormwater infiltration.

TABLE 5.3

Outfall A01 Effluent Limits and Monitoring Results, 2006
(concentrations in mg/L)

Constituent	NPDES Permit Requirements			Monitoring Results			Exceedances in 2006
	Monitoring Frequency	Average Limit	Maximum Limit	Minimum	Average	Maximum	
Flow	Weekly	NA ^a	NA	0.108	0.277	1.399	NA
pH	Weekly	NA	6.0–9.0	6.2	NA	8.7	0
BOD ₅	Weekly	10.0	20.0	1	2.5	10	0
TSS	Weekly	12.0	24.0	1	2.2	8	0
Copper	Weekly	0.5	1	<0.025 ^b	<0.025	<0.025	0
Iron	Weekly	2	4	<0.5	<0.5	<0.5	0
Manganese	Weekly	1	2	<0.075	<0.075	<0.075	0
Zinc	Weekly	1	2	<0.5	<0.5	<0.5	0

^a NA indicates that there is no limit or value of the type shown.

^b A 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.

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Outfall B01. This outfall consists of treated wastewater from the laboratory wastewater collection system. Table 5.4 gives the monitoring requirements and effluent limits and summarizes the monitoring results for this outfall. This outfall is subject to both concentration limits and mass discharge limits. The mass discharge limit represents the maximum weight of material that can be discharged per day. The mass discharge amount that is compared with the limit is calculated by using the constituent concentration and the flow rate measured the day that the sample was collected. There were no exceedances of either the concentration or mass limits for this outfall in 2006.

Iron and chemical oxygen demand (COD) are included in the permit as monitor-only constituents. The COD results provide a rough indication of the oxygen-consuming potential of this effluent on the receiving stream. None of the samples in 2006 had iron or COD concentrations above their respective analytical detection limits of 0.5 and 20 mg/L.

Outfall B01 is also monitored semiannually (June and December) for priority pollutant compounds. Priority pollutants are a list of 124 organic and inorganic constituents the EPA has determined deserve special attention in monitoring programs. The June sampling is to be conducted at the same time that aquatic toxicity testing of Outfall 001 is conducted. Samples were collected on June 13, 2006, and December 13, 2006, and analyzed within the required holding times. Multiple sample bottles were collected and submitted to the Argonne laboratory and commercial laboratories for priority pollutants using the methods analyses listed in Table 5.2. Table 5.5 gives the results for those constituents that were found above the analytical detection limits. The results for most of the metals and VOCs, and all of the semivolatile organic compounds (SVOCs), PCBs, pesticides, and cyanide were less than the detection limits. Low levels of copper (0.07 mg/L), lead (0.014 mg/L), and zinc (0.63 mg/L) were noted in the June sample, but none of these were found in the December sample. The samples contained very low concentrations of several THMs, which result from the chlorination of drinking water. The December sample contained 0.0075 mg/L of phenol; the June sample, however, did not have measurable amounts of phenol. In general, these results indicate that the treated wastewater is free of most of the toxic chemicals on this list, and the few that were detected are only occasionally present at extremely low concentrations.

Outfall 001. This outfall represents the combined wastewater from both treatment plants. The combined effluent flows through a 1,100-m (3,500-ft) outfall pipe where it is eventually discharged into Sawmill Creek at the main outfall south of the Argonne site (Location 7M).

Composite and grab samples of the combined effluent are collected weekly or monthly, as required by the permit. Table 5.6 lists the monitoring requirements and limits, summarizes the results, and lists the number of exceedances of the limits during 2006.

Two permit exceedance occurred at this outfall in 2006. The TDS limit was exceeded in January and February during periods of heavy snowmelt. The TDS exceedances are believed to be related to increases in TDS concentrations in the wastewater caused by infiltration of salt-laden snowmelt into the sewer system. The role of road salt in the TDS exceedances was

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.4

Outfall B01 Effluent Limits and Monitoring Results, 2006
(concentrations in mg/L)

Constituent	NPDES Permit Requirements			Monitoring Results			2006 Exceedances
	Monitoring Frequency	Average Limit	Maximum Limit	Minimum	Average	Maximum	
Flow (MGD) ^a	Weekly	NA ^b	NA	0.157	0.461	1.149	NA
pH	Weekly	NA	6.0–9.0	6.9	NA	8.4	0
BOD ₅ concentration	Weekly	10	20	1	2	6	0
BOD ₅ mass (lb/day)	Weekly	38	77	1	8	31	0
TSS concentration	Weekly	12	24	1	4	16	0
TSS mass (lb/day)	Weekly	46	92	3	16	84	0
Zinc concentration	Weekly	1	2	<0.5	<0.5	<0.5	0
Zinc mass (lb/day)	Weekly	3.8	7.6	<1.2	<1.84	<3.80	0
Mercury concentration	Weekly	0.003	0.006	<0.0002 ^c	<0.0002	<0.0002	0
Mercury mass (lb/day)	Weekly	0.0115	0.023	<0.0005 ^d	<0.00079	<0.00093	0
Oil and grease concentration	Weekly	15	30	<5	<5	<5	0
Oil and grease mass limit (lb/day)	Weekly	57.5	115.1	<12.4	<18.1	<38.2	0
Iron ^e	Weekly	NA	NA	<0.5	<0.5	<0.5	NA
COD ^e	Weekly	NA	NA	<20	<20	<20	NA
Priority pollutants ^f	Semiannual	NA	NA	– ^b	–	–	NA

^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.

^d A mass value shown with a “less than” (<) sign indicates that the concentration values used to calculate the mass were less than the detection limits of the analytical method; thus, the mass amount is shown as a “less than” quantity as well.

^e Monitor only parameter.

^f Priority pollutant results are presented in Table 5.5.

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TABLE 5.5

Compound ^a	Concentration in June Sample	Concentration in December Sample
Copper (mg/L)	0.07	<0.025
Lead (mg/L)	0.014	<0.09
Zinc (mg/L)	0.63	<0.5
Bromodichloromethane (µg/L)	2	2
Bromoform (µg/L)	1	<1
Chloroform (µg/L)	3	3
Dibromochloromethane (µg/L)	2	<1
Phenol (total) (mg/L)	<0.005	0.0075

^a All 124 priority pollutants were analyzed. Only those found above the analytical detection limits are shown in this table.

confirmed by examining the chloride concentrations for the same time period. High chloride levels indicate that the source is probably salt (sodium chloride). Figure 5.4 shows the results of TDS and chloride analyses for 2000 through 2006. This figure shows the seasonal nature of TDS levels in the outfall (i.e., the seasonal use of road salt) and the close correlation between TDS and chloride.

This outfall is also sampled and analyzed annually during June for acute aquatic toxicity. The testing is performed by creating samples with various ratios of Argonne effluent and Sawmill Creek receiving water, into which two types of organisms are introduced, water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*). Survival is measured over 2 to 4 days, and statistically significant mortality is reported as a function of effluent concentration. An off-site contract laboratory performs the sample collection and analyses.

The December 8, 2005, IEPA-approved biomonitoring plan also calls for acute toxicity testing of the effluent from direct discharge Outfalls H03, J03, 006, and 025. Prior to 2006, toxicity testing had been required at Outfalls I03 and 004 as well; however, prior testing confirmed that no more testing was needed at these outfalls and they were removed from the list. The same testing protocol as that used for Outfall 001 is used for these outfalls. The testing is performed during the months of July and August. These outfalls were sampled during the periods of July 24 to 28, and August 21 to 25, 2006.

Table 5.7 summarizes the results of the toxicity tests from 2000 to 2006. No toxicity was observed to the fathead minnow or to the water flea in any of the 2006 samples. These tables show the concentration of wastewater that produces 50% mortality in the test population (i.e., the median lethal concentration [LC₅₀]). A value of >100 shown in this table means that undiluted effluent is not toxic to these species.

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TABLE 5.6

Outfall 001 Monitoring Results and Effluent Limits, 2006
(concentrations in mg/L)

Constituent	NPDES Permit Requirements			Monitoring Results			
	Monitoring Frequency	Average Limit	Maximum Limit	Minimum	Average	Maximum	2006 Exceedances
Flow	Daily	NA ^a	NA	0.37	0.73	2.09	0
pH	Weekly grab	NA	6.0–9.0	6.8	b	8.3	0
TDS	Weekly composite	NA	1,000	467	720	1,192	2
Chloride	Weekly composite	NA	500	115	206	390	0
Sulfate	Weekly composite	NA	500	67	109	136	0
Dissolved iron	Weekly composite	NA	1	<0.5	<0.5	<0.5	0
Ammonia nitrogen (Nov.–March)	Weekly composite	2.4	10.8	0.05	0.44	2.6	0
Ammonia nitrogen (Apr.–Oct.)	Weekly composite	1.2	3.8	0.007	0.5	2.6	0
Copper	Weekly composite	0.031	0.051	<0.025	<0.025	<0.025	0
Manganese	Weekly composite	NA	1	<0.075	<0.075	<0.075	0
Zinc	Weekly composite	NA	1	<0.5	<0.5	<0.5	0
Lead	Monthly composite	NA	NA	<0.5	<0.5	<0.5	0
Hexavalent chromium	Monthly composite	NA	NA	<0.05	<0.05	<0.05	0
Trivalent chromium	Monthly composite	NA	NA	<0.05	<0.05	<0.05	0
Beta radioactivity	Monthly grab	NA	NA	4.68	5.67	7.20	0
Low-level mercury ^c	Monthly grab	NA	NA	0.000011	0.000023	0.000053	0

^a NA = not applicable.

^b Since pH is a log function of hydrogen ion concentrations, average values are not mathematically correct. Only minimum and maximum values are listed.

^c Effective September 2005, low-level mercury is sampled once per month until 12 samples have been collected; after which the IEPA will make a determination on the need for further sampling and discharge limits, if appropriate.

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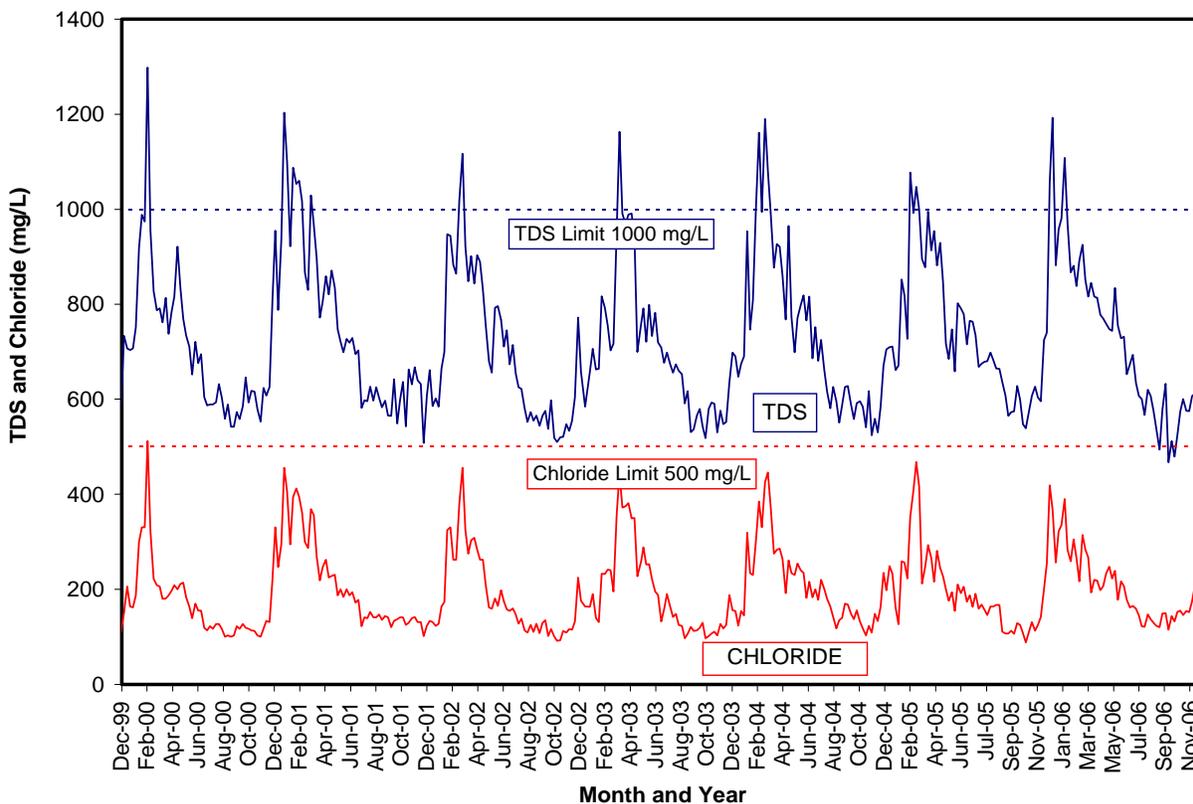


FIGURE 5.4 Total Dissolved Solids and Chloride in Outfall 001 Water, 2000 to 2006

5.3.3.2. Direct Discharge Outfalls

In addition to the three outfalls at the wastewater treatment facilities, 21 other outfalls are monitored. Some outfalls discharge a combination of process wastewater that does not require treatment prior to release, and stormwater. Some outfalls discharge only stormwater. The sampling requirements and effluent limits for these outfalls are described in Table 5.8.

Three of the 21 direct discharge outfalls monitored in 2006 experienced permit exceedances. Outfalls H03 and J03 experienced repeated exceedance of the TDS limit of 1,000 mg/L. Figure 5.5 shows the TDS concentrations for these two outfalls since January of 2004. This chart shows that the TDS levels in Outfall J03 fluctuate seasonally with the highest levels occurring in winter and early spring, which corresponds with the time when road salt is used on Argonne roads and parking areas, though elevated concentrations often occur into the summer. The TDS levels at Outfall H03 do not fluctuate as much, but the 2006 results do show a seasonal trend. Since these outfalls discharge stormwater mixed with process discharges, the high TDS levels in the winter and spring are thought to result from road salt dissolved in snowmelt and residual salt in the soil contaminating stormwater runoff. An investigation into the source of the TDS in these outfalls during warm weather began in 2006. Preliminary results indicated that residual road salt contamination is present in the soil and shallow groundwater

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TABLE 5.7
Toxicity Testing Results, 2000 to 2006
 (% of effluent producing toxicity)

NPDES Outfall	2000		2001		2002		2003		2004		2005		2006	
	June/ July ^c	August	June/July	August	June/July	August	June/July	August	June/July	August	June/July	August	June/July	August
Water Flea, 48-Hour Acute Toxicity Results														
001	100	NA ^a	>100	NA	>100	NA	>100	NA	>100	NA	>100	NA	>100	NA
H03	100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
I03	>100	>100	71b	>100	88^b	>100	82	>100	>100	>100	>100	>100	- ^c	-
J03	>100	<20	<20	>100	<20	>100	>100	>100	>100	>100	>100	>100	>100	>100
004	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	-	-
006	>100	30	40	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
025	29	<20	64	>100	>100	>100	>100	57	34	20	62	47	>100	>100
Fathead Minnow, 96-Hour Acute Toxicity Results														
001	>100	NA ^a	>100	NA	>100	NA	>100	NA	>100	NA	>100	NA	>100	NA
H03	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
I03	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	-	-
J03	>100	40	<20	>100	30	45	>100	>100	>100	>100	>100	>100	>100	>100
004	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	88	>100	-	-
006	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
025	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100

^a Outfall 001 was sampled in June; the rest were sampled in July and August.

^b Bold type indicates acute toxicity was detected.

^c A dash indicates that toxicity testing is no longer required for these two outfalls.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.8

Summary of Monitored Direct Discharge NPDES Outfalls, 2006

Outfall	Constituent	Permit Limit	Sample Results		
			Average for 2006	No. of Samples	2006 Exceedances
B03	Flow (MGD)	None	0.015	12	NA ^a
	pH	6–9	7.4	12	0
	Temperature	<2.8°C rise	13.8	12	0
	TSS	Monitor only	<1	12	NA
C03	Flow (MGD)	None	0.029	12	NA
	pH	6–9	7.64	12	0
D03	Flow (MGD)	None	0.012	12	NA
	pH	6–9	7.36	12	0
	Temperature	<2.8°C rise	24.7	12	0
	TSS	Monitor only	<1	12	NA
E03	Flow (MGD)	None	No Flow	0	NA
	pH	6–9	No Flow	0	NA
	Temperature	<2.8°C rise	No Flow	0	NA
	TSS	Monitor only	No Flow	0	NA
G03	Flow (MGD)	None	0.028	12	NA
	pH	6–9	7.7	12	0
	Temperature	<2.8°C rise	19.5	12	0
H03	Flow (MGD)	None	<0.001	12	NA
	pH	6–9	7.41	12	0
	Temperature	<2.8°C rise	12.7	12	0
	TDS	1,000	1,115	12	7
	TSS	15 Avg.; 30 Max.	3.1	12	0
	TRC ^b	0.011 Avg.; 0.019 Max.	<0.05	48	2
J03	Flow (MGD)	None	0.005	12	NA
	pH	6–9	8.05	12	0
	Temperature	<2.8°C rise	12.6	12	0
	TDS	1,000	1,509	12	10
	TRC ^b	0.011 Avg.; 0.019 Max.	<0.05	50	0
004	Flow (MGD)	None	0.036	12	NA
	pH	6–9	7.77	12	0
	TSS	15 Avg.; 30 Max.	7	12	0
	TRC ^b	0.011 Avg.; 0.019 Max.	<0.05	50	0
A05 ^{c,d}	Flow (MGD)	None	0.147	4	NA
	Iron (total)	Monitor only	2.07	4	NA
	Iron (dissolved)	Monitor only	1.44	4	NA

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TABLE 5.8 (Cont.)

Outfall	Constituent	Permit Limit	Sample Results		
			Average for 2006	No. of Samples	2006 Exceedances
B05 ^{c,d}	Flow (MGD)	None	0.357	4	NA
	Iron (total)	Monitor only	3.85	4	NA
	Iron (dissolved)	Monitor only	1.41	4	NA
	Oil and grease	Monitor only	4.82	4	NA
C05	Flow (MGD)	None	0.03	12	NA
	pH	6-9	8.03	12	0
	Temperature	<2.8°C rise	13.4	12	0
E05	Flow (MGD)	None	0.004	12	NA
	pH	6-9	7.73	12	0
	Temperature	<2.8°C rise	15	12	0
	TRC	0.011 Avg.; 0.019 Max.	<0.05	49	0
006	Flow (MGD)	None	0.059	12	NA
	pH	6-9	8.04	12	0
	Temperature	<2.8°C rise	11.6	12	0
	TSS	15 Avg.; 30 Max.	5	12	0
	TDS	1,000	606	12	0
	TRC	0.011 Avg.; 0.019 Max.	<0.05	50	0
	Phenols	0.01	<0.016 ^e	12	1
007	Flow (MGD)	None	0.02	11	NA
	pH	6-9	7.81	11	0
	Temperature	<2.8°C rise	11	11	0
008 ^c	Flow (MGD)	None	0.28	5	NA
	pH	6-9	8.0	5	0
	Tetrachloroethene	Monitor only	<0.001	5	NA
	Carbon tetrachloride	Monitor only	<0.001	5	NA
	bis(2-ethylhexyl) phthalate	Monitor only	<0.01	5	NA
020 ^{c,d}	Flow (MGD)	None	No Flow	0	NA
	COD	Monitor only	No Flow	0	NA
021 ^d	Flow (MGD)	None	0.044	8	NA
	Hydrogen-3	Monitor only	<100	8	NA
	Iron	Monitor only	0.812	8	NA
	Priority pollutants	Monitor only	- ^f	1	NA
A22 ^d	Flow (MGD)	None	0.0015	2	NA
	Hydrogen-3	Monitor only	<100	2	NA

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.8 (Cont.)

Outfall	Constituent	Permit Limit	Sample Results		
			Average for 2006	No. of Samples	2006 Exceedances
B22 ^d	Flow (MGD)	None	0.0115	2	NA
	Hydrogen-3	Monitor only	<100	2	NA
023 ^d	Flow (MGD)	None	0.033	5	NA
	Hydrogen-3	Monitor only	191	5	NA
	Copper	Monitor only	<0.025	5	NA
025	Flow (MGD)	None	0.004	12	NA
	pH	6–9	7.72	12	0
	Temperature	<2.8°C rise	14	12	0
	TDS	1,000	351	12	0
	TRC ^b	0.011 Avg.; 0.019 Max.	<0.05	12	0

^a NA = not applicable; the parameter is a monitor-only constituent and limit exceedance is not applicable.

^b Analytical detection limit is 0.05 mg/L. Values less than 0.05 mg/L are considered in compliance with the discharge limits.

^c One time study of stormwater runoff quality at this outfall required. Monitoring of outfall required immediately after a rain storm, six events total.

^d Stormwater only outfall.

^e All but two samples were less than the detection limit of 0.005 mg/L. The October sample was 0.13 mg/L and exceeded the limit. The December sample was 0.011. The yearly average was calculated by using the detection limit of 0.005 for 10 months.

^f A dash indicates that priority pollutant results are presented elsewhere in Section 5.3.3.2.

around and under the parking lots near these outfalls. Additional studies will be conducted in 2007 to confirm this observation and to identify options to reduce TDS exceedances.

Outfall H03 also experienced exceedances of the total residual chlorine limits in January and March of 2006. Investigation of these exceedances revealed that they were the result of the overflow of a cooling tower caused by heavy rains that flowed to this outfall. The cooling tower water contains chlorine to prevent fouling of the heat exchangers. To prevent further exceedances, the overflow drain was rerouted to the sewer system rather than the stormwater outfall.

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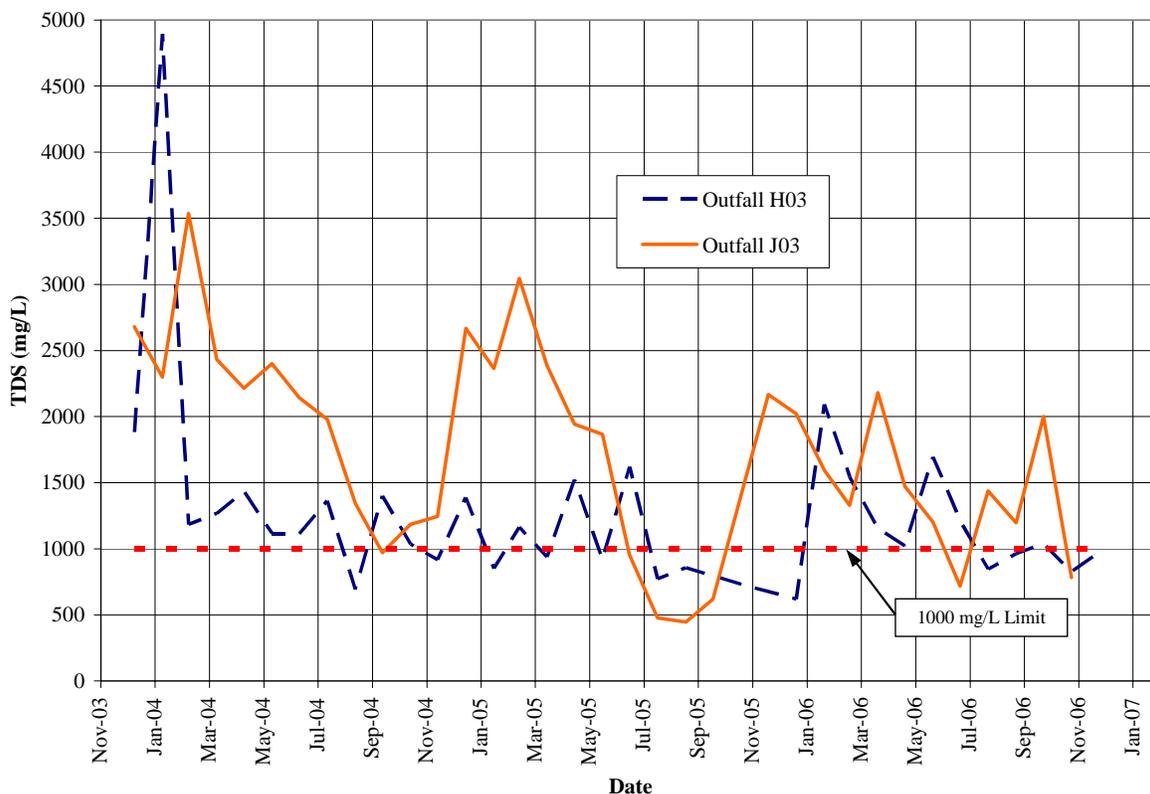


FIGURE 5.5 TDS Concentrations at Outfalls J03 and H03

Outfall 006 experienced one exceedance of the total phenol limit of 0.1 mg/L. The sample contained 0.13 mg/L phenol. The nine samples prior to this and the next monthly sample after this sample did not have phenol above the detection limit of 0.005 mg/L. An investigation did not identify any potential source of phenol in this watershed, and this one detection is considered an anomaly at this point. Continued monitoring will determine if a source of phenol exists in this area.

Outfall 021 is sampled once per year and analyzed for the priority pollutant list of constituents. Because of ongoing remedial actions in the 317 and 319 Areas, the potential for release of toxic organic chemicals into stormwater runoff exists. The 2006 sample was collected on January 30, 2006. Only 2 compounds out of the 124 compounds measured by this test were detected above the analytical detection limits. 1,1-Dichloroethane and 1,1,1-trichloroethane were found at 0.2 and 0.3 $\mu\text{g/L}$, respectively (estimated values less than the detection limits of the analytical method used). These VOCs are present in the soil and groundwater within the 317 Area. Such low levels of these chemicals do not represent a hazard to potential uses of this water. The concentration of 1,1,1-trichloroethane found is well below the standard of 200 $\mu\text{g/L}$ for this chemical in drinking water. No drinking water standard exists for 1,1-dichloroethane.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5.4. Additional Effluent Monitoring

In addition to surface water monitoring required by the NPDES permit, Argonne monitors other surface water bodies on the site and conducts additional analyses at outfalls not required by the permit. To characterize the wastewater from the Argonne site more fully, composite samples of the combined WTP effluent were collected each week and analyzed for the constituents shown in Table 5.9. The results were then compared with IEPA General Effluent Limits found in 35 IAC, Subtitle C, Part 304.²² While Argonne is not required to comply with these limits, they do provide a pertinent point of reference to compare the results of this additional monitoring.

5.4.1. Sample Collection and Analysis

Outfall 001. Samples for analysis of inorganic constituents were collected daily from Outfall 001 with a refrigerated time-proportional sampler. A portion of the sample was transferred to a clean bottle, a security seal was affixed, and chain of custody was maintained. Five daily samples were composited on an equal-volume basis to produce a weekly sample that was then analyzed for the constituents shown in Table 5.9 by using the analytical procedures previously discussed. Table 5.9 also gives the results for 2006. The pH was within the acceptable range, and none of the results exceeded the General Effluent Limits.²² Only one metal was present above analytical detection limits in any of the 52 weekly samples collected.

Sawmill Creek. Sawmill Creek is a small natural stream that is fed primarily by stormwater runoff. During extended periods of low precipitation, the creek above Argonne has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of Argonne wastewater and process wastewater discharged to storm drains. To determine the impact Argonne wastewaters have on Sawmill Creek, samples of the creek downstream of all Argonne discharge points were collected and analyzed. The results were then compared with IEPA General Use Water Quality Standards found in 35 IAC, Subtitle C, Part 302.²³

A time-proportional sampler was used to collect a daily sample at a point well downstream of the combined wastewater discharge point to allow mixing of the Argonne effluent with Sawmill Creek. After the pH was measured, the daily samples were acidified and then combined into equal-volume weekly composites and analyzed for the inorganic constituents in Table 5.10. The results obtained for 2006 are shown in Table 5.10. The pH was in the appropriate range throughout the year, and none of the metals results exceeded General Use Water Quality Standards.²³ Only fluoride was present in high enough concentration to be detected in any of the samples.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.9

Chemical Constituents in Effluents from the Argonne
Wastewater Treatment Plant, 2006

Constituent	No. of Samples	Concentration (mg/L)			Limit
		Average	Minimum	Maximum	
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	1.041	0.745	1.357	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			<0.5	1.0
pH	52	NA ^c	6.83	7.63	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.

5.4.2. 800 Area Stormwater Sampling

The Post Closure Care Plan²⁴ 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, 113 and 114. Outfall 113 (new outfall number 023) is also included in the NPDES program. These two outfalls are monitored for TDS, TSS and pH. No limits are included in the plan. The average monitoring results for 2006 are shown in Table 5.11. Comparing these values with other NPDES discharges in 2006 suggests that there is no indication of stormwater contamination from landfill operations.

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.10

Chemical Constituents in Sawmill Creek, Location 7M, ^a 2006					
Constituent	No. of Samples	Concentration (mg/L)			
		Average	Minimum	Maximum	Limit
Arsenic	52			<0.025 ^b	0.36 ^c
Barium	52			<0.5	5.0
Beryllium	52			<0.0025	– ^d
Cadmium	52			<0.0025	0.03
Chromium	52			<0.05	3.6
Cobalt	52			<0.25	–
Copper	52			<0.025	0.041 ^c
Fluoride	52	0.804	0.362	1.244	1.4
Iron	52			<0.5	1.0
Lead	52			<0.09	0.3 ^c
Manganese	52			<0.075	1.0
Mercury	52			<0.0002	0.0026 ^c
Nickel	52			<0.05	1.0
Silver	52			<0.0025	0.005
Thallium	52			<0.002	–
Vanadium	52			<0.075	–
Zinc	52			<0.5	1.0
pH	52	NA ^e	7.00	7.98	6.5–9.0

^a Location 7M is 15 m (50 ft) downstream from the Argonne wastewater outfall.

^b If all values were less than the detection limit for a constituent, only the detection limit is given.

^c The acute standard for the chemical constituent is listed.

^d A dash indicates that there is no effluent limit for this constituent.

^e NA = not applicable.

TABLE 5.11

Average Monitoring Results for 800 Area Landfill Stormwater, 2006			
Outfall Number	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	pH
113	404	3.3	7.62
114	359	4.8	7.61

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION

6. GROUNDWATER PROTECTION

Groundwater is present beneath the Argonne site in several different geologic units. Above the bedrock is glacial drift, which is a mixture of clay, silt, sand, and gravel. Layers of drift with high proportions of sand and gravel may contain groundwater. Some of these layers are interconnected and 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 zone contains the uppermost aquifer used 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 the dolomite. The sandstone aquifer is too deep to be affected by Argonne operations.

The groundwater below the Argonne site is monitored through the collection and analysis of samples obtained from the formerly used on-site water supply wells, from a series of groundwater monitoring wells located near several sites that have the potential for affecting groundwater, and from other monitoring wells on and off the Argonne site. General regulatory requirements intended to protect groundwater resources are contained in IEPA Groundwater Quality Standards (GQSs), 35 IAC, Subtitle F, Part 620.²⁵ Argonne groundwater is considered Class I (highest quality) groundwater under these regulations. In addition, DOE Order 450.1 contains groundwater protection requirements for DOE sites, including the need for sitewide characterization studies and monitoring well networks. This chapter documents Argonne's compliance with these requirements.

In addition to general groundwater quality protection requirements, Argonne is subject to specific groundwater monitoring requirements at several waste management units. Various permits discussed in Chapter 2 require groundwater monitoring programs for the 800 Area Landfill, the 317/319 Area remedial action site, and the ENE former landfill. Argonne is also voluntarily conducting groundwater monitoring at the former CP-5 reactor. This section summarizes the results from these monitoring programs.

6.1. Monitoring of the Former Potable Water System

6.1.1. Overview

Starting in the early years of the laboratory, domestic water was supplied by four potable water supply wells (described in Table 6.1). The well locations are shown in Figure 1.1. Use of these wells was discontinued in 1997 when the water supply was switched to Lake Michigan water, obtained from DuPage County. Lake Michigan water was selected over well water because of its higher quality, lower levels of TDS, and lower corrosivity. Lake Michigan water is treated by the City of Chicago and distributed by DuPage County. Three of the four former potable wells are maintained as a backup in the case of a loss of Lake Michigan water. Well 2 is

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TABLE 6.1

Argonne Former Water Supply Wells						
Well No.	Location	Well Elevation (m AMSL) ^a	Bedrock Elevation (m AMSL)	Well Depth (m BGS) ^b	Inner Diameter (m)	Year Drilled
1	Building 31	204.5	184.4	86.6	0.30	1948
2 ^c	Building 32	202.4	183.2	91.4	0.30	1948
3	Building 163	210.0	182.9	96.9	0.30	1955
4	Building 264	218.2	181.4	103.6	0.36	1959

^a AMSL = above mean sea level.

^b bgs = below ground surface.

^c Well no longer operational.

no longer operational. The three remaining wells are all constructed in the dolomite bedrock aquifer.

6.1.2. Former Supply Well Monitoring Program and Results

Samples were collected quarterly at the wellheads of the three active wells. The existing pumps were used to purge the wells of stagnant water after which samples of the pump discharge were collected. The samples were analyzed to determine the presence of several types of radioactive constituents and VOCs. Samples from each well were tested for total alpha radioactivity, total beta radioactivity, hydrogen-3, and strontium-90. Samples also were analyzed annually for isotopic uranium and radium. VOCs were determined by purge and trap sample preparation followed by gas chromatography/mass spectroscopy (GC/MS) in accordance with EPA Method 524.2.²⁶ Alpha and beta radioactivity were determined by using a gas-flow-proportional counting technique. Hydrogen-3 was determined by means of distillation followed by a beta liquid scintillation counting technique. Strontium-90 was determined by means of ion-exchange and chromatographic separations followed by proportional counting. Uranium was analyzed by using chromatographic separations followed by alpha spectrometry. Radium was analyzed by trapping it on a special resin, then using gamma spectrometry to measure radium-226 and radium-228. The results are summarized in Table 6.2.

All radiological results were similar to previous year's results. Only one of four samples from Well 1 contained hydrogen-3 above the detection limit of 100 pCi/L. All other results are consistent with normal background levels. No VOCs were detected in any of the samples. The detection limits for VOCs were 1 to 10 µg/L.

6.2. Dolomite Aquifer Monitoring

Groundwater in the dolomite aquifer is monitored at several locations across the site. Most of the monitoring is conducted in response to permit conditions for waste management

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TABLE 6.2

Radioactivity in Argonne Former Water Supply Wells, 2006
(concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Average	Minimum	Maximum
Alpha	Well 1	4	2.7	2.0	3.4
	Well 3	4	2.8	2.4	4.0
	Well 4	3	4.4	3.5	5.1
Beta	Well 1	4	6.8	6.4	7.1
	Well 3	4	10.1	9.6	10.8
	Well 4	3	11.6	11.4	12.0
Hydrogen-3	Well 1	4	<100	<100	207
	Well 3	4	<100	<100	<100
	Well 4	3	<100	<100	<100
Strontium-90	Well 1	4	<0.25	<0.25	<0.25
	Well 3	4	<0.25	<0.25	<0.25
	Well 4	3	<0.25	<0.25	<0.25
Uranium-234	Well 1	1	— ^a	—	0.49
	Well 3	1	—	—	0.18
	Well 4	1	—	—	0.19
Uranium-235	Well 1	1	—	—	0.02
	Well 3	1	—	—	<0.01
	Well 4	1	—	—	<0.01
Uranium-238	Well 1	1	—	—	0.26
	Well 3	1	—	—	0.11
	Well 4	1	—	—	0.05
Radium-226	Well 1	1	—	—	1.33
	Well 3	1	—	—	0.660
	Well 4	1	—	—	0.165
Radium-228	Well 1	1	—	—	1.64
	Well 3	1	—	—	1.57
	Well 4	1	—	—	1.25

^a A dash indicates that for a single result, the value is placed in the maximum column.

6. GROUNDWATER PROTECTION

units, and these results are discussed elsewhere in this chapter. However, in the East Area of the Argonne site, a set of dolomite wells has been monitored since 1998 to track the amount of hydrogen-3 present in the dolomite aquifer in that part of the site. Analytical data from the late 1990s identified the presence of low levels of hydrogen-3 (less than 300 pCi/L) in the former domestic supply Well 1. Natural background levels of tritium are less than 100 pCi/L. As noted above, low levels of hydrogen-3 are still occasionally found in this well. It was speculated at the time, that the source of the hydrogen-3 may have been wastewater occasionally stored in an unlined earthen basin at the wastewater treatment area (located northwest of the existing equalization pond shown in Figure 1.1) in the 1950s. The hydrogen-3, as tritiated water, could have migrated through the glacial drift to the dolomite aquifer in this part of the site. To determine if a significant release of hydrogen-3 had occurred, groundwater monitoring in this area was begun. Because of uncertainty regarding groundwater flow direction in the dolomite, particularly after the water supply wells were shut down in 1997, a monitoring well network was established throughout the eastern end of the site, and sampling of this network continued in 2006. The network consists of three wells on Argonne property and seven wells in the Waterfall Glen Forest Preserve. The well locations are shown in Figure 6.1. Well 570091D is located immediately adjacent to the former holding basin. During 2006, samples were collected quarterly and analyzed for hydrogen-3. Table 6.3 shows the results for 2006. Hydrogen-3 was noted at very low levels in only two samples from any of the wells. One of the wells where hydrogen-3 was found was 570091D, near the possible source of hydrogen-3. The other well, HP10, is southeast of the treatment plant. None of the wells had consistently measurable hydrogen-3 levels. These results are similar to past results, though the concentrations detected in 2006 were significantly lower than those during the first few years of monitoring. It appears that dilution and radioactive decay are slowly eliminating the hydrogen-3 in this part of the dolomite aquifer. In any case, the highest concentration is far below the drinking water limit of 20,000 pCi/L.

6.3. Groundwater Monitoring at Former Waste Management Areas

Argonne has occupied its current site since 1948. Over the years of operation, various wastes generated by Argonne were placed in a number of on-site disposal units. These ranged from ditches filled with construction and demolition debris constructed in the 1950s to a former sanitary landfill used for nonhazardous solid waste disposal, which operated until September 1992. No radioactive waste was knowingly placed in any of these units for disposal; however, contaminated equipment and debris were disposed of. Several contain significant amounts of chemically hazardous materials and, therefore, represented a potential threat to the environment. Extensive site characterization and remediation of these units occurred under the Argonne remediation program that was completed in September 2003. 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 could not be remediated by complete removal of the waste and continue to be maintained and monitored as part of the LTS Program. LTS areas that require ongoing remedial actions, including routine monitoring of groundwater, include the 317 and 319 Areas, the 800 and ENE Landfill Areas, three off-site groundwater seeps, and the Groundwater Management Zone (GMZ). Groundwater below the sites with waste in place is monitored routinely to determine if hazardous materials have migrated from the units. Where

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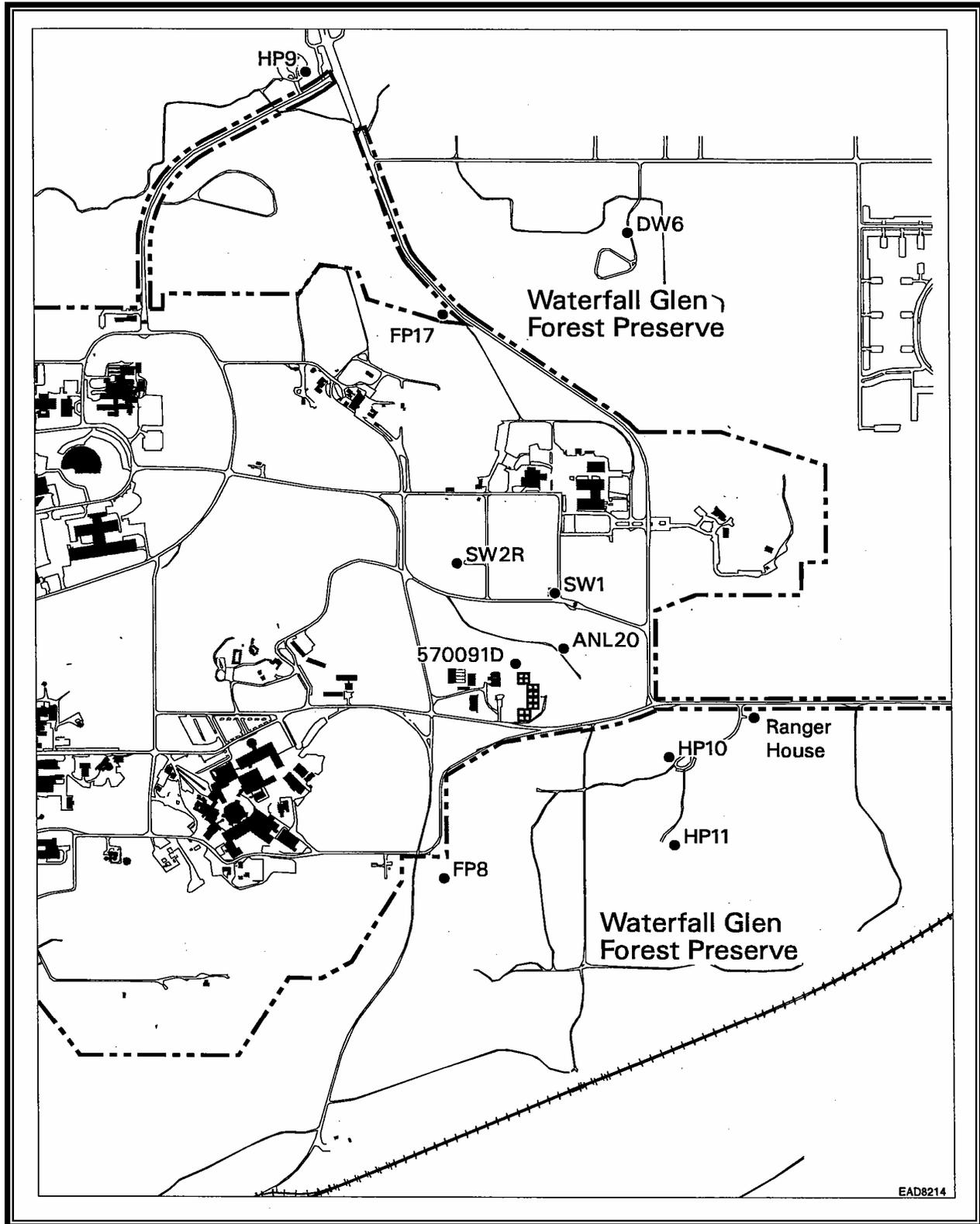


FIGURE 6.1 East Area/Forest Preserve Monitoring Wells

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TABLE 6.3

Hydrogen-3 in Dolomite Wells, 2006
(concentrations in pCi/L)

Well	Month Collected			
	Jan.–Feb.	Jun.	Aug.	Oct.
Waterfall Glen				
DW 6	<100	<100	<100	<100
HP 9	<100	<100	<100	<100
HP 10	122	<100	<100	<100
HP 11	<100	<100	<100	<100
FP 8	<100	<100	<100	<100
FP 17	<100	<100	<100	<100
Ranger house	<100	<100	<100	<100
Argonne				
570091D	<100	<100	<100	194
ANL-20	<100	<100	<100	<100
SW2R	<100	<100	<100	<100
Trip blank	<100	<100	<100	<100

contaminants have already been released to the environment, the monitoring is carried out to assess the effectiveness of the remedial actions underway and to monitor for changes in the nature and extent of contamination. The LTS Program and related groundwater monitoring are part of the Argonne Environmental Monitoring and Surveillance Program.

6.3.1. 317/319 Area

The 317/319 Area contains seven separate current or former units that have been used for handling or disposal of various types of waste. The 317 Area currently contains an active radioactive waste container storage area. It includes aboveground storage of containers of radioactive waste as well as the North Vault, an in-ground radioactive material container storage vault that was refurbished in 2003 but is currently empty. Four similar vaults located in this area were cleaned and demolished in place during remedial actions in this area. A small aboveground waste processing building, the Baler Building, was also demolished. Low levels of hydrogen-3 are present in this area as a result of past waste management practices.

In the past, the 317 Area was used for disposal of various liquid chemical wastes in a unit known as a French drain. The drain consisted of a shallow trench filled with gravel into which an unknown quantity of liquid wastes was poured. The wastes were primarily VOCs, including cleaning solvents. This unit operated during the late 1950s. Because of these past disposal practices, there is a region of contaminated soil in the northern half of the 317 Area. The most

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highly contaminated sections of the French Drain area were treated by using a deep soil mixing and metallic iron treatment technique during 1998. However, the groundwater below and downgradient of this area contains significant amounts of these chemicals. General features of the 317 and 319 Areas are shown in Figure 6.2.

The 319 Area contains an inactive 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 soil and leachate during site characterization activities completed in the early 1990s. 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 mostly 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 groundwater below the 317/319 Area exists in several 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. There are no known consumers of this groundwater downgradient of the Argonne site. The presence of liquid chemical wastes from the 317 and 319 French drains, as well as 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). Two separate plumes from the 317 Area and the 319 Area Landfill mingle and together come to the surface approximately 360 m (1200 ft) south of the mound, visible as three small groundwater seeps located at the base of a ravine directly south of the waste mound in the Waterfall Glen Forest Preserve. Since their discovery, these seeps have been monitored on a regular basis (see Section 6.4.4). Two of these seeps contain low levels of several VOCs. All three seeps have at one time contained hydrogen-3 at concentrations below all applicable standards.

Cleanup of the 317/319 Area has been under way since the late 1980s. The cleanup has been carried out in a series of interrelated actions designed to remove or contain the waste and chemical contaminants so that they will not migrate away from the waste disposal units. To prevent migration of contaminated groundwater from the 317 French Drain area, an underground footing drain pipe around the vaults was sealed and a groundwater collection system was installed in the southern end of the 317 Area. This system consists of a set of 15 groundwater extraction wells with screens located in shallow porous layers where contaminated groundwater was found during site characterization activities. This system removes contaminated groundwater and discharges it to the on-site wastewater treatment plant

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

To address the comingled groundwater plumes south of the 317 and 319 Areas, a phytoremediation system was installed in 1999. Phytoremediation involves the use of green plants to remove contaminated groundwater by evapotranspiration and to facilitate the

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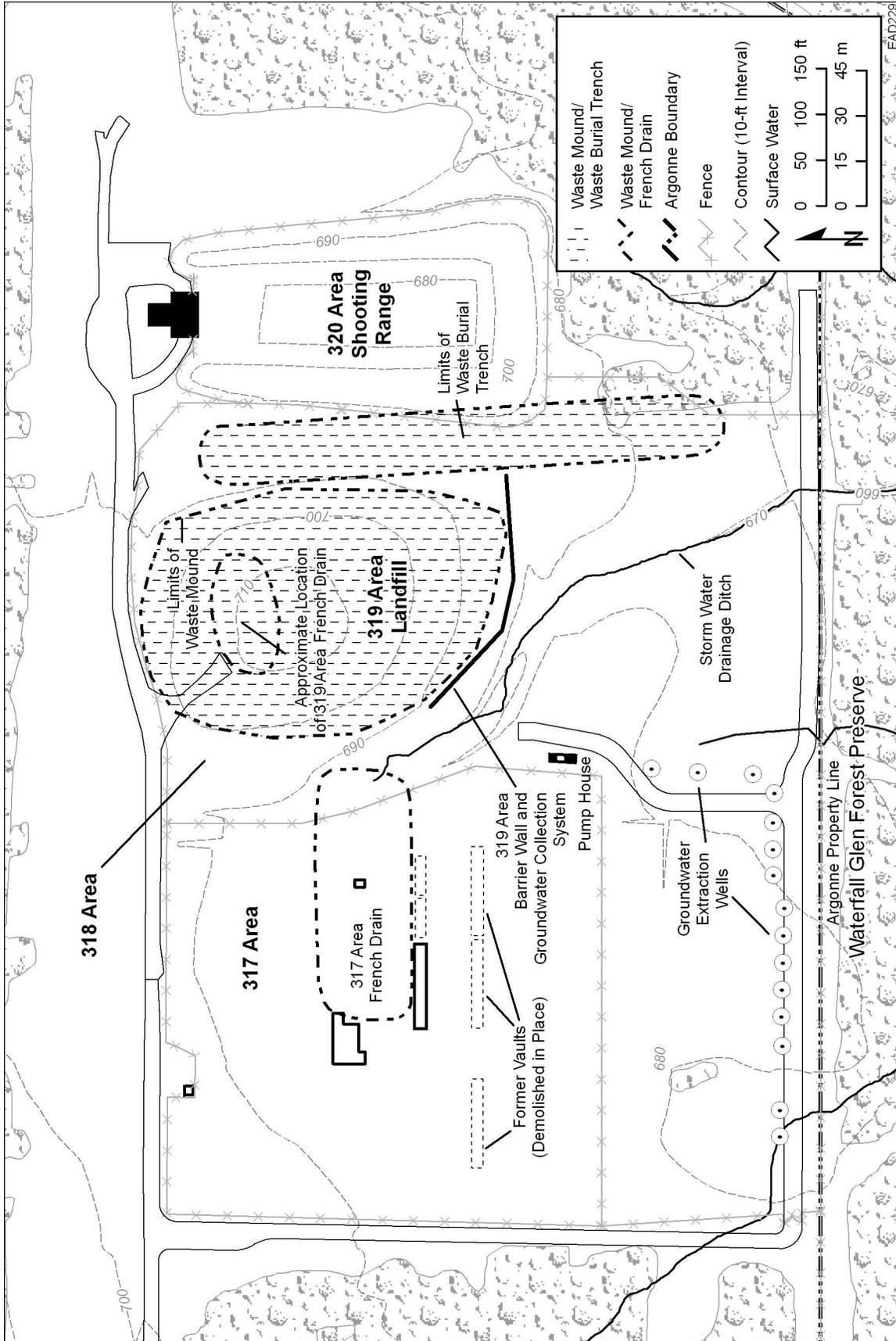


FIGURE 6.2 Locations of Components within the 317/319/ENE Area

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biodegradation of contaminants in soil and groundwater. This system consists of a dense planting of willow trees in the vicinity of the 317 French Drain and a larger planting of hybrid poplar trees downgradient of the 317 Area and the former 319 Area Landfill. Approximately 950 poplar and willow trees were planted. Most of the poplar trees were installed in special lined boreholes to force the tree roots to grow toward the contaminated zones. This system is monitored to document its ability to control groundwater flow and remove contaminants.

The landfill caps, leachate and groundwater extraction systems, and phytoremediation system require ongoing operation and maintenance, which is conducted as part of the LTS Program. Sampling and analysis of groundwater and surface water are conducted as part of the LTS Program as well as the routine Environmental Monitoring and Surveillance Program.

The results of the required monitoring of the groundwater collection systems in the 317 and 319 Areas, the phytoremediation system, and the monitoring of the off-site groundwater seeps are transmitted to the IEPA on a quarterly basis through the submittal of Quarterly Progress Reports. The data from all of these monitoring activities are too voluminous to include in this report; however, the results are summarized and general conclusions are discussed below (see Section 6.4).

In addition to the permit-required monitoring, Argonne has voluntarily conducted groundwater sampling from a network of wells installed starting in 1986. This groundwater surveillance network was established during the early years of the site remediation program and has provided valuable insight into changes in the contaminant levels as remedial actions have progressed in the area. Section 6.3.2 discusses the results of the voluntary surveillance program.

6.3.2. Voluntary Groundwater Surveillance at the 317/319 Area

Groundwater sampling in the 317/319 Area became a part of the sitewide monitoring and surveillance program in 1986, prior to any remedial actions. The original wells were installed during a series of campaigns from 1986 through 1989. As time progressed wells were added, replaced, or removed. The surveillance system currently consists of 10 wells shown in Figure 6.3 and described in Table 6.4. Eight of the wells are completed in various sand lenses less than 13 m (41 ft) deep in the glacial drift. Wells 317121D and 319131D are placed in the dolomite aquifer about 20 m (64 ft) below the surface. In this area, groundwater in both the glacial drift and the dolomite flows southeast, toward the Des Plaines River. Wells 317101 and 317111 are upgradient of the 317 Area, and Well 319011 is upgradient of the 319 Area Landfill. Wells 317021, 317052, 317061, 319031, and 319032, are downgradient of the 317 and 319 Areas. Wells 317121D, and 319131D make up a well cluster intended to determine the vertical distribution of contaminants. These wells are independent of wells installed as part of remedial actions and are not LTS wells used to directly monitor the progress of the remediation systems, but are used for general groundwater surveillance for the 317 and 319 Areas as a whole.

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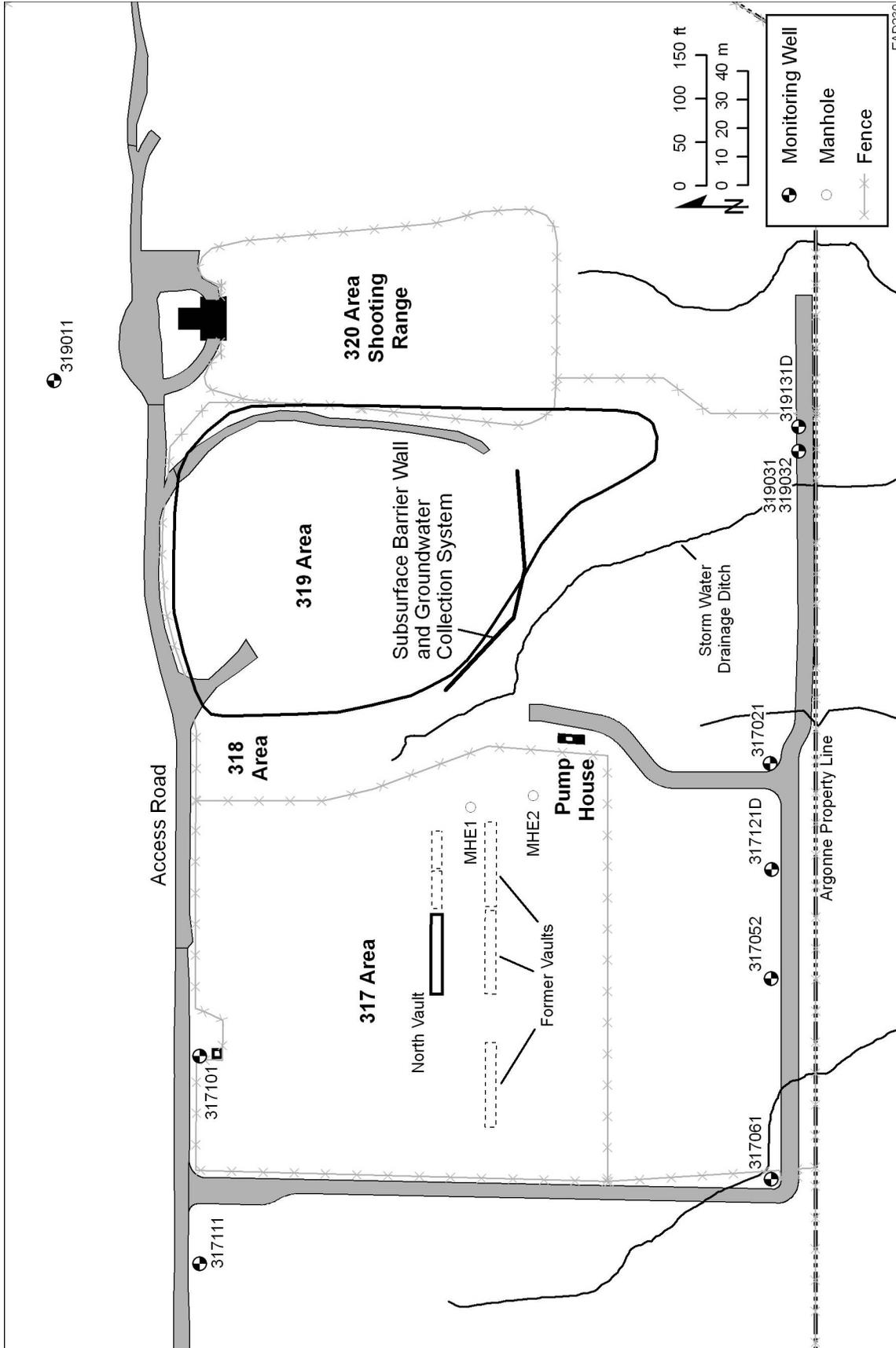


FIGURE 6.3 Groundwater Surveillance Wells in the 317/319 Area, 2006

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TABLE 6.4

Groundwater Monitoring Wells: 317/319 Area

ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type ^a	Date Drilled
319011	12.19	209.8	199.1–197.6	0.05/PVC	9/1986
317021	12.19	209.2	198.5–197.0	0.05/PVC	9/1986
319031	12.50	204.3	194.8–191.8	0.05/PVC	9/1986
319032	7.62	204.3	198.2–196.7	0.05/PVC	6/1989
317052	4.27	208.3	207.1–204.0	0.05/PVC	6/1989
317061 ^b	10.36	207.6	197.3–199.7	0.05/PVC	5/2000
317101	11.89	211.0	202.2–199.1	0.05/PVC	9/1988
317111	11.89	210.3	201.4–198.4	0.05/PVC	9/1988
317121D ^c	24.08	207.6	185.0–183.5	0.15/CS	11/1989
319131D	21.03	203.5	184.0–182.5	0.15/CS	11/1989

^a Inner diameter (m)/well material (PVC = polyvinyl chloride; CS = carbon steel).

^b Well was replaced when original well was damaged and became inoperable.

^c Wells identified by a “D” are deeper wells monitoring the dolomite bedrock aquifer.

6.3.2.1. Sample Collection

The monitoring wells are sampled according to the EPA protocol described in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.²⁷ Prior to collecting any samples, stagnant water is removed from the well. The volume of water to remove from the casing is determined by measuring the water depth from the surface and the depth to the bottom of the well. The latter measurement also determines whether siltation has occurred, which might restrict water movement through the well screen. For those wells that recharge rapidly, at least three well volumes are purged by using dedicated submersible pumps or balers. During well purging, the field parameters (pH, specific conductivity, redox potential, and temperature) are measured. For the wells reported in this study, temperature, pH, redox potential, and specific conductivity remained fairly constant after two well volumes were removed. Sampling is conducted after three well volumes are removed. For those wells in the glacial drift that do not recharge rapidly, the well is emptied completely and allowed to refill. Wells 319011, 317021, 317061, 317111, 319031, and 319032 usually dry up after one well volume is removed. Therefore, field parameters were measured on the one well volume removed. After the well refills, samples are collected using a dedicated Teflon[®] bailer for the shallow wells or an electronic pump for the dolomite wells. Samples for VOCs, SVOCs, PCBs and pesticides, metals, nonmetals, and radionuclide analysis are collected in that order. The samples are placed in precleaned bottles, labeled, and preserved in accordance with EPA guidance.

During each sampling event, one well is selected for replicate sampling. An effort is made to vary this selection so that replicates are obtained at every well over time. In addition, a field blank is also prepared. The field blank consists of a sample bottle filled with ultra-pure

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water in the laboratory that is submitted for the same analysis as the field samples. This is done to verify the cleanliness of the sample bottles.

6.3.2.2. Sample Analyses — 317/319 Area Surveillance

Groundwater samples from these wells are analyzed quarterly for tritium, strontium-90, gamma-emitting radionuclides, soluble (filtered) metals, chloride, and VOCs. Once per year each well is also analyzed for semivolatile organics and PCBs and pesticides. Chemical analyses were performed in accordance with SOPs that were written, reviewed, and issued as controlled documents by members of EQO-AS. These SOPs reference protocols in EPA-SW-846²⁸ or Standard Methods.²¹ Fifteen metals in filtered samples were routinely measured using inductively coupled plasma (ICP) atomic emission spectrometry. Mercury was determined by using cold vapor atomic absorption (AA) spectroscopy. Chloride (filtered samples) was determined by means of ultraviolet (UV) visible spectrometry. VOCs were determined by using a purge and trap sample pretreatment followed by GC/MS detection. SVOCs were determined by means of solvent extraction followed by GC/MS detection. PCBs and pesticides were determined by using solvent extraction followed by gas chromatography-electron capture detection.

Groundwater radiological analyses for the 317/319 Area were performed by using SOPs that were written, reviewed, and issued as controlled documents by members of EQO-AS. Cesium-137 was determined by using gamma-ray spectrometry. Hydrogen-3 was determined by using distillation followed by a beta liquid scintillation counting technique. Strontium-90 was determined by means of ion-exchange separation followed by a proportional counting technique.

6.3.2.3. Results of Analyses

To determine if groundwater quality in the 317/319 Area has been impacted, the analysis results were compared with the appropriate GQSs found in 35 IAC, Section 620.410. Standards for the most conservative groundwater classification, Class I, Potable Resource Groundwater, were used. The groundwater under this site has not been formally designated by the IEPA; however, it fits the technical criteria for Class I groundwater, even though it is not used as a potable water supply. The current standards for inorganic and radioactive constituents are shown in Table 6.5. When used to officially document compliance with state standards, these standards are to be compared with analysis results from unfiltered groundwater samples. However, for environmental surveillance purposes, filtered samples were used. This was done to reduce the interference from suspended soil particle in the samples caused by the use of a bailer to collect water samples. The introduction of soil solids into a sample causes significantly higher metals results that do not reflect the true character of the in-situ groundwater. The standards for organic compounds are presented in Table 6.6. Results that exceed these standards are shown in bold in the following data tables.

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TABLE 6.5

Illinois Class I Groundwater
Quality Standards: Inorganics
(concentrations in mg/L, except
radionuclides and pH)

Constituent	Standard
Antimony	0.006
Arsenic	0.05
Barium	2.0
Beryllium	0.004
Boron	2.0
Cadmium	0.005
Chloride	200.0
Chromium	0.1
Cobalt	1.0
Copper	0.65
Cyanide	0.2
Fluoride	4.0
Iron	5.0
Lead	0.0075
Manganese	0.15
Mercury	0.002
Nickel	0.1
Nitrate, as N	10.0
pH	6.5–9.0
Radium-226	20 pCi/L
Radium-228	20 pCi/L
Selenium	0.05
Silver	0.05
Strontium-90	8.0 pCi/L
Sulfate	400
TDS	1,200
Thallium	0.002
Tritium	20,000 pCi/L
Zinc	5.0

The results of field parameter measurement and the results of chemical and radiological analyses of samples from the surveillance wells in the 317/319 Area are contained in Tables 6.7 through 6.16. Well 319031 was dry throughout 2006, thus no data were generated and no data table was prepared. All radiological and inorganic analytical results are provided in these tables. The analytical methods used for organic compounds could identify and quantify all compounds contained in the Contract Laboratory Program (CLP) Target Compound List at concentrations as low as the detection limits, typically 1 to 10 µg/L. However, only a few of these compounds were detected in the samples. These results are listed toward the bottom of the data tables. To simplify the format of these tables, compounds that were not detected above the detection limit are not included.

Field Parameters. The field parameter results listed in the tables are the final readings obtained at the time of sampling. Wells 317021, 317052, 319011, and 319032 were dry during sampling for one or more quarters. The only parameter with a GQS is pH. The only pH values that were outside of the acceptable pH range were reported in the last two quarters in dolomite Well 317121D, which exceeded the range. This well has a history of high

pH. As in past years, the conductivity in background wells 317101 and 317111 was higher than the other wells. Chloride levels in these two wells are also elevated, in most cases above the GQS. It is likely that the elevated conductivity and chloride are related to the fact that both wells are located near a road that is salted during the winter.

Inorganic Parameters. In 2006, all samples for metals analyses were filtered prior to preservation with acid. Background values for this area have not yet been developed; however, Wells 317111, 317101, and 319011 are upgradient of the 317/319 Area and represent background conditions. In these wells only one sample contained any metals above the detection limits. Manganese was found in Well 317111 at a concentration below the GQS. Manganese was found in three of the four shallow downgradient wells (Well 319031 was dry all during 2006).

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TABLE 6.6

Illinois Class I Groundwater Quality Standards: Organics
(concentrations in µg/L)

Constituent	Standard	Constituent	Standard
Alachlor	2	Ethylene dibromide	0.05
Aldicarb	3	Heptachlor	0.4
Atrazine	3	Heptachlor epoxide	0.2
Benzene	5	Hexachlorocyclopentadiene	50
Benzo(a)pyrene	0.2	Lindane	0.2
Carbofuran	40	Methoxychlor	40
Carbon tetrachloride	5	Monochlorobenzene	100
Chlordane	2	PCBs (decachlorobiphenyl)	0.5
2,4-D	70	Pentachlorophenol	1
Dalapon	200	Phenols	100
1,2-Dibromo-3-chloropropane	0.2	Picloram	500
<i>o</i> -Dichlorobenzene	600	2,4,5-TP (Silvex)	50
<i>p</i> -Dichlorobenzene	75	Simazine	4
1,2-Dichloroethane	5	Styrene	100
Dichloromethane	5	Tetrachloroethylene	5
1,1-Dichloroethene	7	Toluene	1,000
<i>cis</i> -1,2-Dichloroethylene	70	Toxaphene	3
<i>trans</i> -1,2-Dichloroethylene	100	1,1,1-Trichloroethane	200
1,2-Dichloropropane	5	1,1,2-Trichloroethane	0.5
Di(2-ethylhexyl)phthalate	6	1,2,4-Trichlorobenzene	70
Dinoseb	7	Trichloroethylene	5
Endothall	100	Vinyl chloride	2
Endrin	2	Xylenes	10,000
Ethylbenzene	700		

Well 317052 exceeded the GQS for manganese all three quarters it was sampled. Iron was detected in the same three downgradient wells, at levels below the GQS. The presence of manganese in one of the upgradient wells indicates that manganese is naturally present in the 317/319 Area groundwater. Many other wells discussed in this chapter exhibit elevated manganese and iron concentrations, indicating that they are naturally present. The two dolomite wells did not contain any metals above detection limits.

Organic Parameters. Low levels of several VOCs were noted in all four downgradient wells. Well 317021 contained very low levels of TCA and DCA, as it has for years. DCA is often found along with TCA since it is a biodegradation product of TCA. Lower levels of TCA were also noted one quarter in Well 319032. TCA levels ranged from less than 1.0 to 7 µg/L, significantly lower than in previous years. 1,4 Dioxane was found in two wells. This is a highly soluble chemical that moves easily in groundwater but is difficult to analyze. It was not detected in the other samples from these wells. Tetrahydrofuran was detected in one sample from Well 317061. No organics were found in the three background wells or either of the dolomite wells. None of the organics in any of the wells were above GQSs.

6. GROUNDWATER PROTECTION

TABLE 6.7

Groundwater Surveillance Results, 300 Area Well 317021, 2006

Parameter	Unit	Date of Sampling				
		February	6/12/2006	8/22/2006	8/22/2006 (Duplicate)	11/7/2006
Field Parameters						
Water elevation ^a	m	Dry	198.80	198.15	198.15	199.06
Temperature	°C	Dry	12.9	14.2	14.2	11.4
pH	pH	Dry	6.89	7.00	7.00	6.99
Redox	mV	Dry	0	-5	-5	-1
Conductivity	µS/cm	Dry	1,178	952	952	875
Filtered Samples						
Chloride	mg/L	Dry	340^b	29	29	10
Arsenic	mg/L	Dry	0.003	< 0.025	< 0.025	< 0.025
Barium	mg/L	Dry	0.103	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	Dry	- ^c	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	Dry	< 0.0002	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	2.254	< 0.5	< 0.5	< 0.5
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	0.081	< 0.075	< 0.075	< 0.075
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	Dry	< 0.001	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	Dry	-	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	Dry	-	< 0.075	< 0.075	< 0.075
Zinc	mg/L	Dry	< 0.02	< 0.5	< 0.5	< 0.5
Radioactive Materials						
Cesium-137	pCi/L	Dry	-	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	Dry	< 100	< 100	< 100	< 100
Strontium-90	pCi/L	Dry	-	< 0.25	< 0.25	< 0.25
VOCs Found above Quantitation Limits^d						
1,1,1-Trichloroethane	µg/L	Dry	7	5	7	4
1,1-Dichloroethane	µg/L	Dry	3	1	2	< 1

^a Well point elevation = 197.44 m (MSL); ground surface elevation = 209.16 m (MSL); casing material = PVC.

^b Bold type indicates that the value exceeds applicable standards.

^c A dash indicates that an analysis was not conducted.

^d Only VOCs detected in at least one sample above detection limits are shown.

6. GROUNDWATER PROTECTION

TABLE 6.8

Groundwater Monitoring Results, 300 Area Well 317052, 2006

Parameter	Unit	Date of Sampling			
		February	6/12/2006	8/22/2006	11/1/2006
Field Parameters					
Water elevation ^a	m	Dry	205.08	204.58	206.01
Temperature	°C	Dry	13.0	14.8	13.5
pH	pH	Dry	6.62	6.74	7.01
Redox	mV	Dry	17	10	0
Conductivity	µS/cm	Dry	1,140	1,489	965
Filtered Samples					
Chloride	mg/L	Dry	52	43	30
Arsenic	mg/L	Dry	< 0.025	< 0.025	< 0.025
Barium	mg/L	Dry	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	Dry	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	Dry	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	2.5522	1.748	< 0.5
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	0.541	0.773	0.196
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05
Silver	mg/L	Dry	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	Dry	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	Dry	< 0.075	< 0.075	< 0.075
Zinc	mg/L	Dry	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	Dry	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	Dry	118	< 100	137
Strontium-90	pCi/L	Dry	< 0.25	< 0.25	< 0.25
VOCs Found above Quantitation Limits^b					
1,4-Dioxane ^c	µg/L	Dry	< 1	< 1	15

^a Well point elevation = 204.53 m (MSL); ground surface elevation = 208.18 m (MSL); casing material = PVC.

^b Only VOCs detected in at least one sample above detection limits are shown.

^c No GQS exists for 1,4 dioxane.

6. GROUNDWATER PROTECTION

TABLE 6.9

Groundwater Monitoring Results, 300 Area Well 317061, 2006

Parameter	Unit	Date of Sampling			
		2/28/2006	6/13/2006	8/16/2006	10/31/2006
<i>Field Parameters</i>					
Water elevation ^a	m	198.51	198.51	198.24	198.76
Temperature	°C	10.9	15.1	11.5	10.8
pH	pH	7.05	6.80	7.03	7.03
Redox	mV	-2	6	-7	-5
Conductivity	µS/cm	1,169	1,204	1,168	1,161
<i>Filtered Samples</i>					
Chloride	mg/L	46	53	68	104
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.367	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.130	0.076	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	0.214
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	194	178	531	481
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
<i>VOCs Found above Quantitation Limits^b</i>					
Tetrahydrofuran ^c	µg/L	< 1	11	< 1	< 1

^a Well point elevation = 197.68 m (MSL); ground surface elevation = 207.57 m (MSL); casing material = PVC.

^b Only VOCs detected in at least one sample above detection limits are shown.

^c No GQS exists for tetrahydrofuran.

6. GROUNDWATER PROTECTION

TABLE 6.10

Groundwater Monitoring Results, 300 Area Well 317101, 2006

Parameter ^a	Unit	Date of Sampling			
		2/6/2006	6/13/2006	8/16/2006	10/31/2006
<i>Field Parameters</i>					
Water elevation ^b	m	201.74	202.05	201.82	202.23
Temperature	°C	10.5	14.8	13.6	11.7
pH	pH	7.10	6.99	6.84	6.86
Redox	mV	-8	-6	4	5
Conductivity	µS/cm	2,530	2,800	2,580	2,800
<i>Filtered Samples</i>					
Chloride	mg/L	607^c	750	479	816
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a No VOCs above analytical detection limits were found in this well.

^b Well point elevation = 198.66 m(MSL); ground surface elevation = 211.01 m (MSL); casing material = PVC.

^c Bold type indicates that the value exceeds applicable standards.

6. GROUNDWATER PROTECTION

TABLE 6.11

Groundwater Monitoring Results, 300 Area Well 317111, 2006

Parameter ^a	Unit	Date of Sampling			
		2/27/2006	6/13/2006	8/16/2006	10/31/2006
<i>Field Parameters</i>					
Water elevation ^b	m	202.08	202.05	201.84	202.22
Temperature	°C	9.0	13.2	12.3	10.5
pH	pH	7.25	7.27	6.90	7.03
Redox	mV	-15	-17	1	-2
Conductivity	µS/cm	2,060	1,246	1,490	1,288
<i>Filtered Samples</i>					
Chloride	mg/L	433^c	228	230	199
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.089	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a No VOCs above analytical detection limits were found in this well

^b Well point elevation = 198.37 m (MSL); ground surface elevation = 210.25 m (MSL); casing material = PVC.

^c Bold type indicates that the value exceeds applicable standards.

6. GROUNDWATER PROTECTION

TABLE 6.12

Groundwater Monitoring Results, 300 Area Well 317121D, 2006

Parameter ^a	Unit	Date of Sampling				
		2/6/2006	6/12/2006	8/22/2006	11/6/2006	11/6/2006 (Duplicate)
<i>Field Parameters</i>						
Water elevation ^b	m	186.52	186.57	186.54	186.60	186.60
Temperature	°C	10.1	13.2	12.7	11.3	11.3
pH	pH	7.24	6.94	9.56^c	9.51	9.51
Redox	mV	-32	-2	-147	-139	-139
Conductivity	µS/cm	546	1,013	493	648	648
<i>Filtered Samples</i>						
Chloride	mg/L	95	101	67	87	78
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>						
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	123	116
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

^a No VOCs above analytical detection limits were found in this well.

^b Well point elevation = 183.49 m (MSL); ground surface elevation = 207.57 m (MSL); casing material = steel.

^c Bold type indicates that the value exceeds applicable standards.

6. GROUNDWATER PROTECTION

TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 319011, 2006

Parameter ^a	Unit	Date of Sampling			
		February	May	8/22/2006	11/7/2006
<i>Field Parameters</i>					
Water elevation ^b	m	Dry	Dry	198.27	200.46
Temperature	°C	Dry	Dry	13.8	11.4
pH	pH	Dry	Dry	6.92	6.98
Redox	mV	Dry	Dry	0	-1
Conductivity	µS/cm	Dry	Dry	985	960
<i>Filtered Samples</i>					
Chloride	mg/L	Dry	Dry	39	44
Arsenic	mg/L	Dry	Dry	< 0.025	< 0.025
Barium	mg/L	Dry	Dry	< 0.5	< 0.5
Beryllium	mg/L	Dry	Dry	< 0.0025	< 0.0025
Cadmium	mg/L	Dry	Dry	< 0.0025	< 0.0025
Chromium	mg/L	Dry	Dry	< 0.05	< 0.05
Cobalt	mg/L	Dry	Dry	< 0.25	< 0.25
Copper	mg/L	Dry	Dry	< 0.025	< 0.025
Iron	mg/L	Dry	Dry	< 0.5	< 0.5
Lead	mg/L	Dry	Dry	< 0.004	< 0.004
Manganese	mg/L	Dry	Dry	< 0.075	< 0.075
Mercury	mg/L	Dry	Dry	< 0.0002	< 0.0002
Nickel	mg/L	Dry	Dry	< 0.05	< 0.05
Silver	mg/L	Dry	Dry	< 0.0025	< 0.0025
Thallium	mg/L	Dry	Dry	< 0.002	< 0.002
Vanadium	mg/L	Dry	Dry	< 0.075	< 0.075
Zinc	mg/L	Dry	Dry	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	Dry	Dry	< 2.0	< 2.0
Hydrogen-3	pCi/L	Dry	Dry	< 100	< 100
Strontium-90	pCi/L	Dry	Dry	< 0.25	< 0.25

^a No VOCs above analytical detection limits were found in this well.

^b Well point elevation = 197.51 m (MSL); ground surface elevation = 209.80 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319032, 2006

Parameter	Unit	Date of Sampling			
		February	6/12/2006	8/22/2006	11/1/2006
Field Parameters					
Water elevation ^a	m	Dry	197.50	197.42	197.29
Temperature	°C	Dry	14.5	11.4	10.8
pH	pH	Dry	6.94	6.99	7.06
Redox	mV	Dry	-3	-4	-4
Conductivity	µS/cm	Dry	1,433	1,085	1,065
Filtered Samples					
Chloride	mg/L	Dry	15	13	11
Arsenic	mg/L	Dry	< 0.025	< 0.025	< 0.025
Barium	mg/L	Dry	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	Dry	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	Dry	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.5	< 0.5	< 0.5
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	< 0.075	< 0.075	< 0.075
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05
Silver	mg/L	Dry	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	Dry	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	Dry	< 0.075	< 0.075	< 0.075
Zinc	mg/L	Dry	< 0.5	< 0.5	< 0.5
Radioactive Materials					
Cesium-137	pCi/L	Dry	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	Dry	174	176	212
Strontium-90	pCi/L	Dry	< 0.25	< 0.25	< 0.25
VOCs Found above Quantitation limits^b					
1,1,1-Trichloroethane	µg/L	Dry	1	< 1	< 1
1,4-Dioxane ^c	µg/L	Dry	< 1	18	< 1

^a Well point elevation = 196.66 m (MSL); ground surface elevation = 204.28 m (MSL); casing material = PVC.

^b Only VOCs detected in at least one sample above detection limits are shown.

^c No GQS exists for 1,4-dioxane.

6. GROUNDWATER PROTECTION

TABLE 6.15

Groundwater Monitoring Results, 300 Area Well 319131D, 2006

Parameter ^a	Unit	Date of Sampling				
		2/27/2006	2/27/2006 (Duplicate)	6/12/2006	8/22/2006	11/7/2006
Field Parameters						
Water elevation ^b	m	184.57	184.57	185.89	184.55	184.73
Temperature	°C	10.1	10.1	11.8	13.9	11.8
pH	pH	7.09	7.09	6.98	7.04	7.09
Redox	mV	-7	-7	-5	-7	-7
Conductivity	µS/cm	1,068	1,068	1,097	1,060	1,021
Filtered Samples						
Chloride	mg/L	63	63	70	57	66
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Radioactive Materials						
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	765	862	782	619	572
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

^a No VOCs above analytical detection limits were found in this well.

^b Well point elevation = 182.77 m (MSL); ground surface elevation = 203.55 m (MSL); casing material = steel.

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Figure 6.4 shows the TCA and DCA concentrations in Well 310021 since 1988, a period that spans all of the remediation activities completed in this area. As shown in the figure, the concentrations of these two compounds roughly parallel each other. The levels were low and relatively consistent until 1991, at which time a trend of increasing concentrations continues until 1995 when a rapid decrease in concentrations begins. This period represents the time when active remediation of the 317 French drain was underway. This well is immediately adjacent to a former footing drain discharge line that was known to transport contaminated groundwater to the south. This drain line was sealed in 1997. A groundwater collection system was installed in the vicinity of this well in late 1997, and contaminated soil in the 317 French drain area was treated in 1998. A phytoremediation system was installed in 1999. All of these remedial actions may be responsible for the rapid decrease in VOC concentrations in this well since 1994. Since 1999, only very low residual amounts of VOCs have been present at this well.

Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, pesticides, and herbicides. None of these types of compounds was found in any of the wells during 2006.

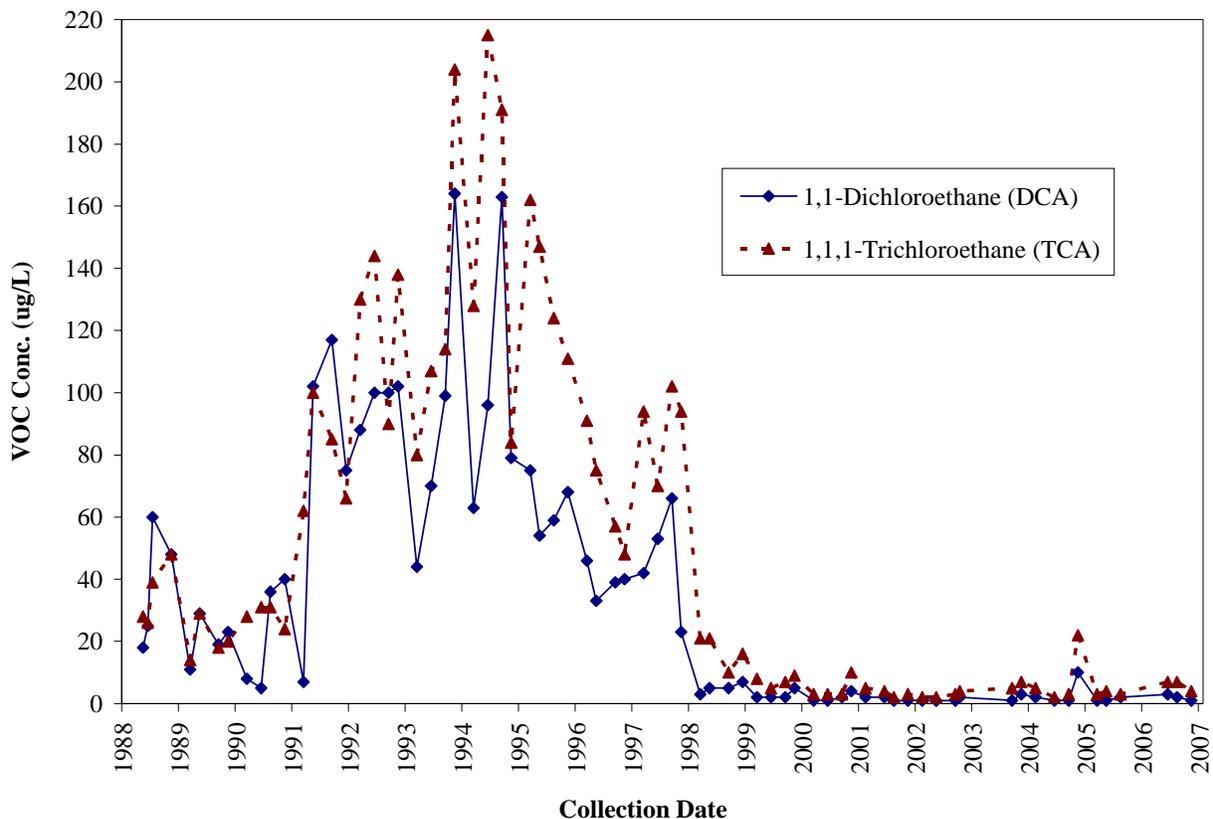


FIGURE 6.4 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

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These results imply that only a low level of groundwater contamination exists in the 317/319 Area, outside of the remedial action zones. However, it should be noted that monitoring conducted within the remediation areas as part of the LTS Program, described in Section 6.4, routinely detects orders of magnitude higher concentrations of VOCs than those described above (see Table 6.19); and many results are well in excess of GQSs. These samples are collected closer to the French drains and landfill areas and within shallow saturated soil layers known to be contaminated. Higher concentrations of contaminants at these targeted zones are expected at this point in the remediation process.

Radiological Parameters. Because the 317 and 319 Areas were used to process radioactive materials and contaminated equipment, three isotopes were monitored in these wells — cesium-137, hydrogen-3, and strontium-90. The only isotope detected in the wells was hydrogen-3, which was present in all of the downgradient wells except 317021, at very low concentrations. None of the wells contained strontium-90. None of the background wells contained measurable amounts of any of these isotopes. The well with the highest hydrogen-3 value was the dolomite well 319131D, which is downgradient of the 319 Area Landfill, near the Argonne fence line. The highest concentration, 862 pCi/L, is still well below the GQS of 20,000 pCi/L. The source is thought to be hydrogen-3 in leachate from the 319 Area Landfill that had migrated away from the landfill prior to the start of remedial actions. Figure 6.5 shows the annual average hydrogen-3 concentrations since 1995. This figure shows that there is a slight downward trend, particularly since 2001 (except for 2005, which had one sample with an unusually high tritium result), compared with relatively stable concentrations prior to 2001.

6.3.3 317 Area Manhole Sampling

In addition to the wells in this area, two manholes associated with the waste storage vault footing drain sewer system are also monitored on a monthly basis. Figure 6.3 shows the locations of these two manholes. These manholes convey contaminated groundwater from footing drains around the North Vault and 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. There it is treated and discharged to Sawmill Creek. Since 1997, water collected by the 317 and 319 leachate and groundwater collection systems has also been discharged to Manhole E2 where it is pumped to the treatment plant. Thus, the water in these manholes, particularly Manhole E2, is a mixture of groundwater from vaults in the 317 Area, leachate and groundwater from the 319 Area landfill system, and groundwater from the 317 Area groundwater collection system. Changes in contaminant concentrations of the water in these manholes are a general indication of the effectiveness of remedial actions in the 317 French drain area.

Manholes E1 and E2 in the 317 Area were sampled monthly and analyzed for VOCs, as discussed previously. The results are presented in Table 6.16. No record of the total volume of water pumped from Manhole E2 is maintained; however, contributions of groundwater into Manhole E2 during 2006 included an average of 1,408 L/day (372 gal/day) from the 319 Area

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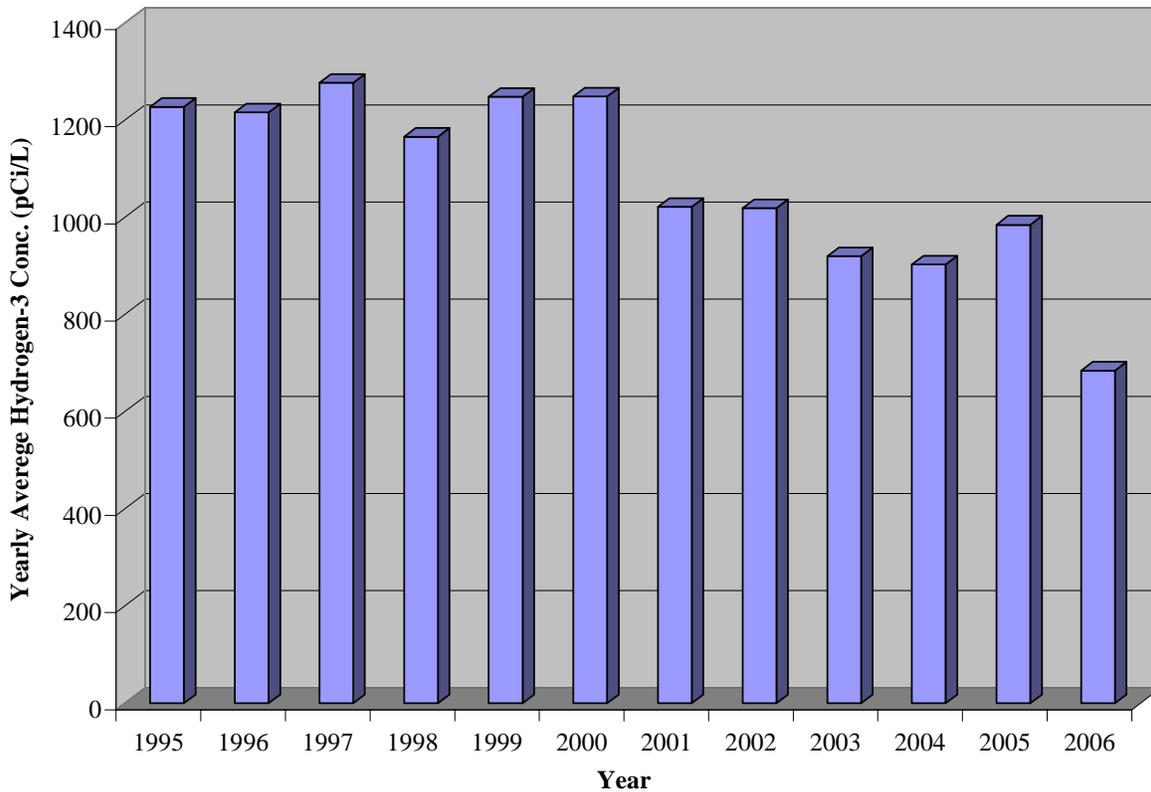


FIGURE 6.5 Hydrogen-3 in Dolomite Well 319131D

TABLE 6.16

Volatile Organic Compounds in the 317 Area: Manholes E1 and E2, 2006
(concentrations in $\mu\text{g/L}$)

Month Collected	Chloroform		Tetra-chloroethene		Trichloro-ethene		<i>cis</i> -1,2-Dichloro-ethane		1,1-Dichloro-ethane		Carbon Tetrachloride		1,1,1-Trichloro-ethane	
	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
Jan.	174	112	13	50	77	45	34	21	3	2	105	198	2	2
Feb.	186	73	11	18	71	27	29	12	3	1	117	93	4	3
March	420	171	22	28	141	50	33	16	4	2	378	224	5	3
April	475	139	24	24	188	51	47	17	5	3	469	170	4	4
May	490	490	18	18	245	245	55	55	3	3	452	452	2	2
June	348	29	36	14	170	10	56	4	7	4	315	36	4	3
July	280	9	14	19	172	4	40	3	2	1	159	19	2	<1
Aug.	235	48	19	25	161	19	38	10	3	1	175	93	3	<1
Sept.	310	137	22	43	147	62	32	14	3	2	235	169	4	3
Oct.	174	115	13	26	108	55	15	9	<1	1	144	134	2	2
Nov.	186	48	17	16	137	13	30	4	2	9	404	95	2	5
Dec.	420	76	14	24	108	38	17	9	2	<1	224	86	2	1

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groundwater collection system, an average of 3,176 L/day (839 gal/day) from the 317 Area groundwater collection system, in addition to an unknown amount of groundwater originating in the 317 Area footing drains around the vaults. The relatively low flow from the 319 Area is the result of the impermeable cap installed over the waste mound during the summer of 1999.

Figures 6.6 and 6.7 show plots of selected annual average VOC results for these manholes since monitoring was begun in 1995, with VOC values from both manholes shown on the same vertical scale to highlight the difference in concentration. Pumping of groundwater from the 319 Area was begun in early 1996 and from the 317 Area in late 1997. The introduction of these additional flows, as well as a number of separate remedial actions completed in this area during the monitoring period, makes it difficult to interpret the changes in VOC concentrations since the measured values represent an unknown mixture of water from three distinctly different and changing sources. The much lower levels of VOCs in Manhole E2 are likely due to the introduction of the two other discharges, which have less contamination than the groundwater in the footing drain. In general, annual average VOC concentrations in Manholes E1 and E2 decreased from unusually high levels noted in 2005, but most of the average values were still significantly higher than the typical values seen from 1999 through 2004. During this period, a trend of decreasing VOC concentrations was observed. The higher values during the last two years may be due to below normal precipitation in 2005, which affects groundwater depth and the flow path of contaminated groundwater from the 317 French drain area. Such changes may have exposed the groundwater to pockets of VOCs that were not previously exposed to groundwater movement. The higher concentrations may also be due to reduced low-VOC inflow from the 317 Area groundwater extraction system because of the maturing phytoremediation plantation, which extracts groundwater before it can be removed by the extraction wells.

Figures 6.8 to 6.14 compare the major VOC concentrations in Manholes E1 and E2. The TCA and DCA levels in both manholes parallel each other (see Figures 6.11 and 6.12) and show a steady decreasing trend. DCA is a degradation product of TCA biodegradation, which could account for the similarity in trends. Carbon tetrachloride and chloroform also exhibited similar trend patterns, with both compounds experiencing a peak concentration in the late spring of 2005. Levels returned to nearly normal levels in 2006. The 2005 spike may be related to lower than normal precipitation during that part of 2005. VOC concentrations in this area are thought to be precipitation-dependent; that is, increased concentrations are often found during drier periods. The concentrations of perchloroethylene (PCE), trichloroethylene (TCE), and dichloroethylene (DCE) were relatively stable until late 2005 and 2006, when a significant increase in TCE and DCE concentrations was observed, while PCE was seen to decrease slightly. Since TCE and DCE are breakdown products of PCE, it is possible that the increase observed in 2006 is the result of increased rate of degradation PCE. However, it is also known that TCE and DCE are present in the French drain area, and their increased concentrations could also be related to the dry weather in 2005. With the return of more normal rainfall patterns in late 2006, the concentrations of these compounds were observed to decrease. In most cases, the VOC concentrations in Manhole E2 are much less than those in Manhole E1, which demonstrates the effect of the discharge of the relatively clean water from the 319 and 317 groundwater extraction systems into Manhole E2.

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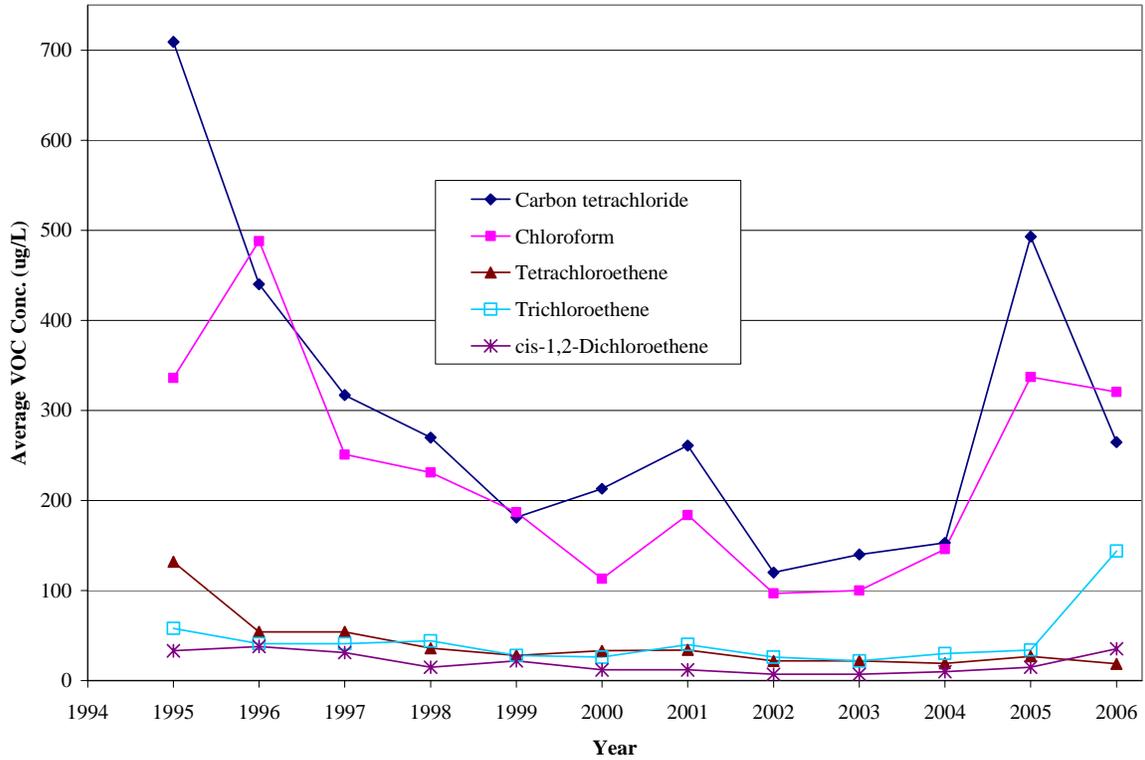


FIGURE 6.6 VOCs in Manhole E1

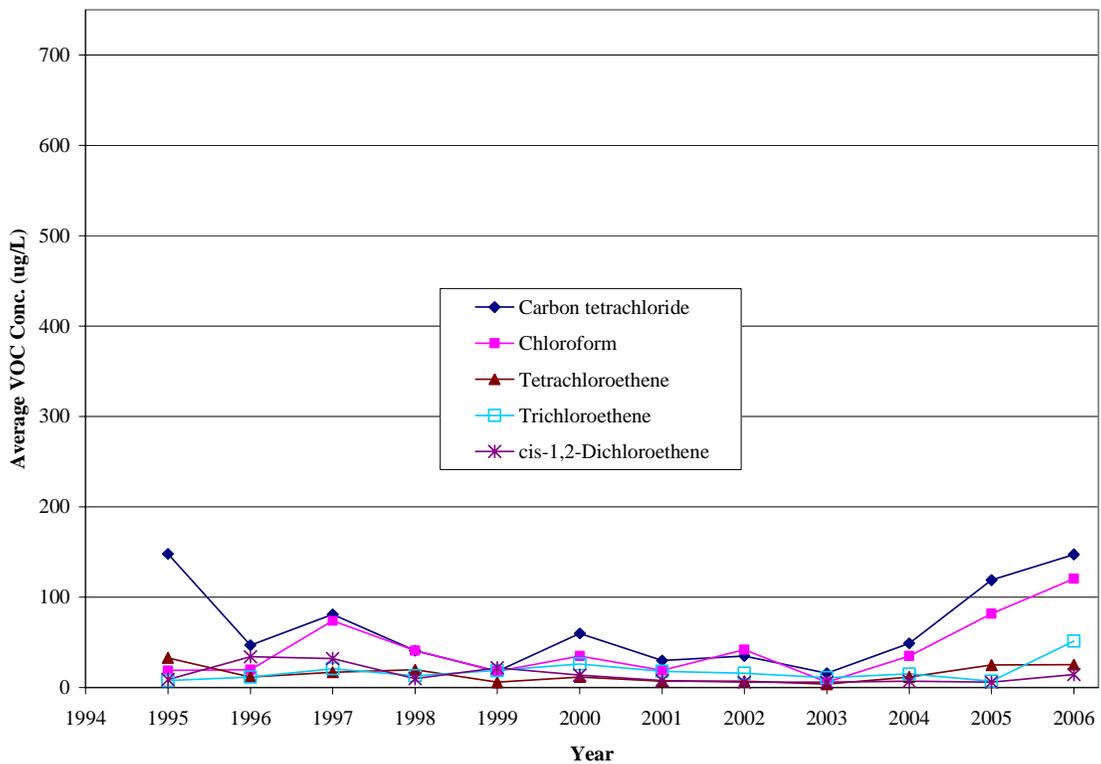


FIGURE 6.7 VOCs in Manhole E2

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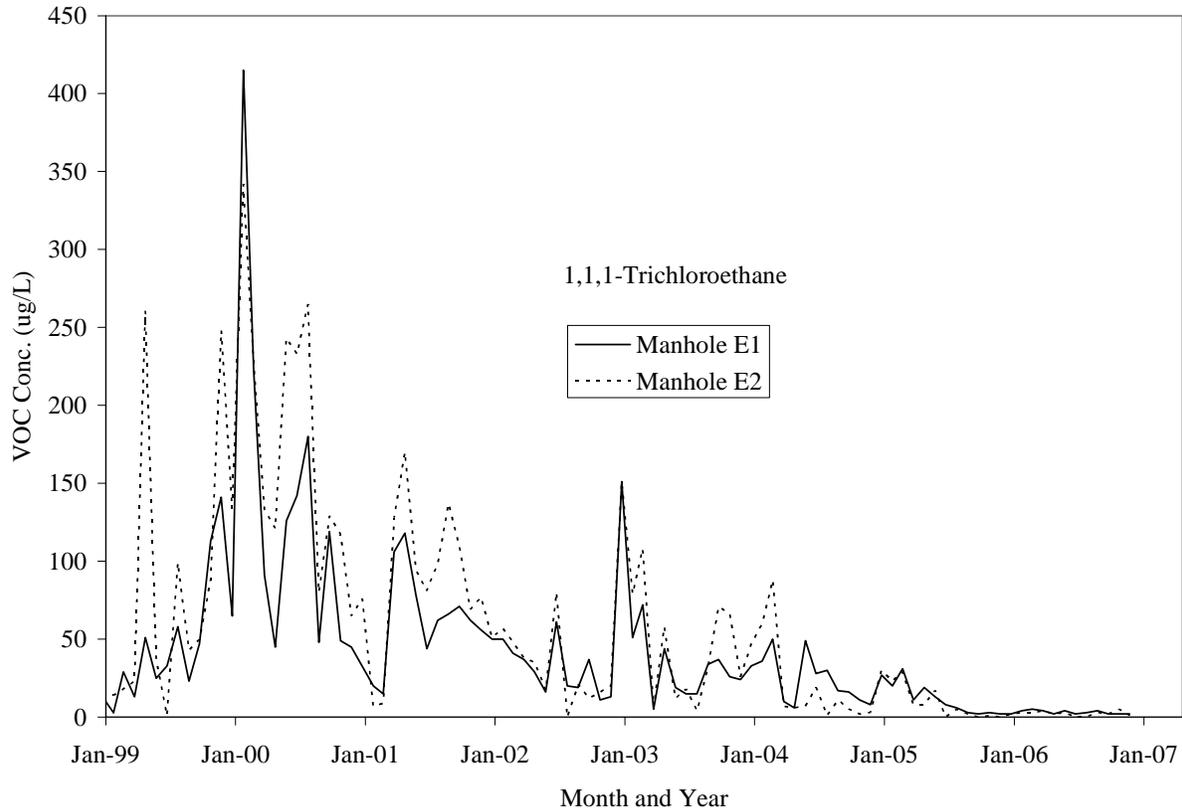


FIGURE 6.8 Manholes E1 and E2 1,1,1-Trichloroethane Levels, 1999 through 2006

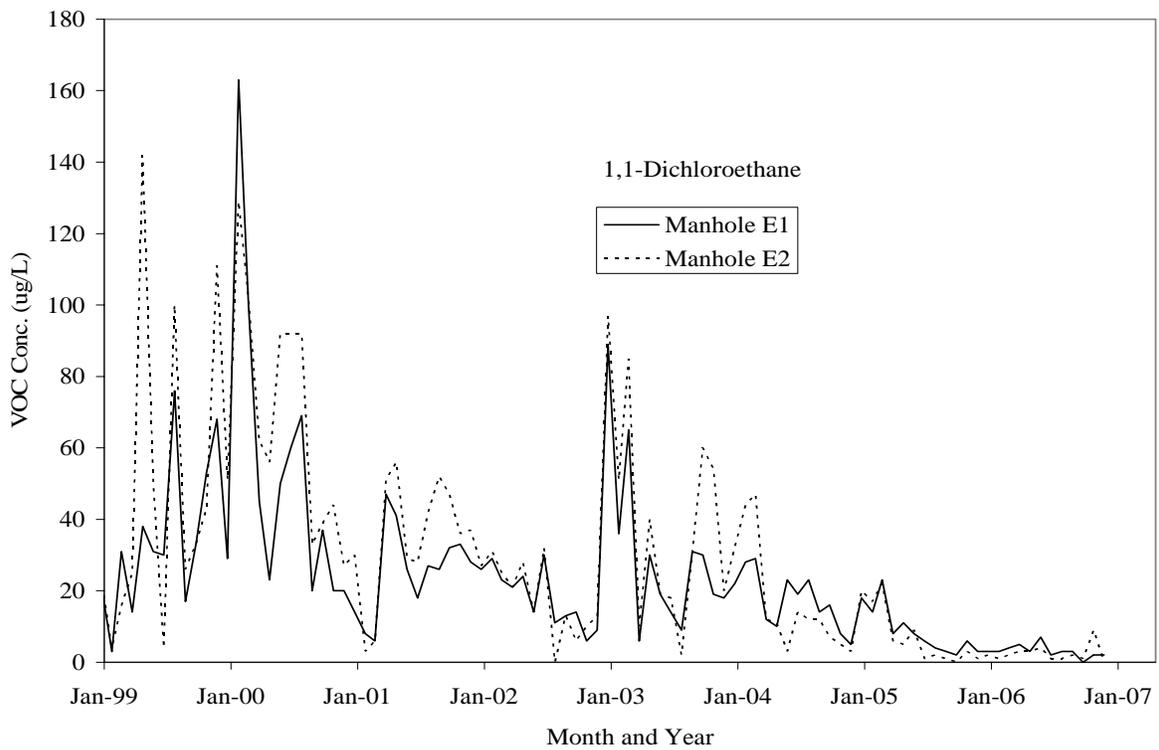


FIGURE 6.9 Manholes E1 and E2 1,1-Dichloroethane Levels, 1999 through 2006

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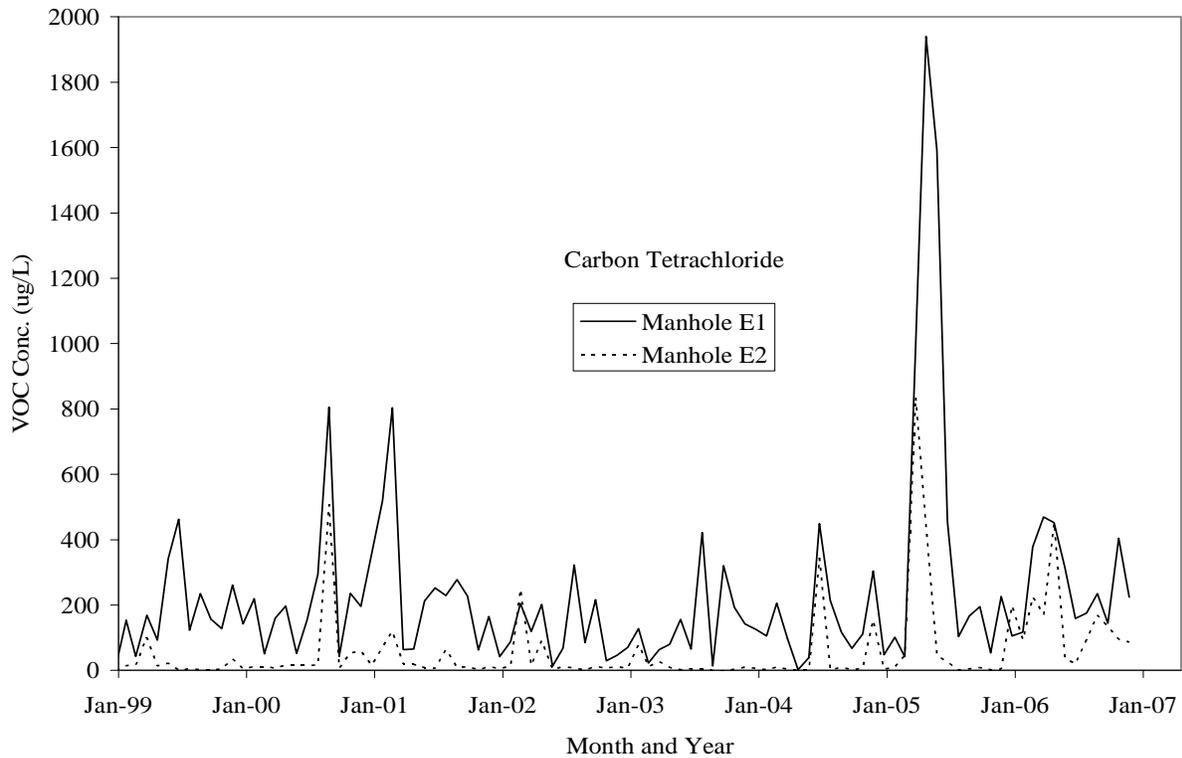


FIGURE 6.10 Manholes E1 and E2 Carbon Tetrachloride Levels, 1999 through 2006

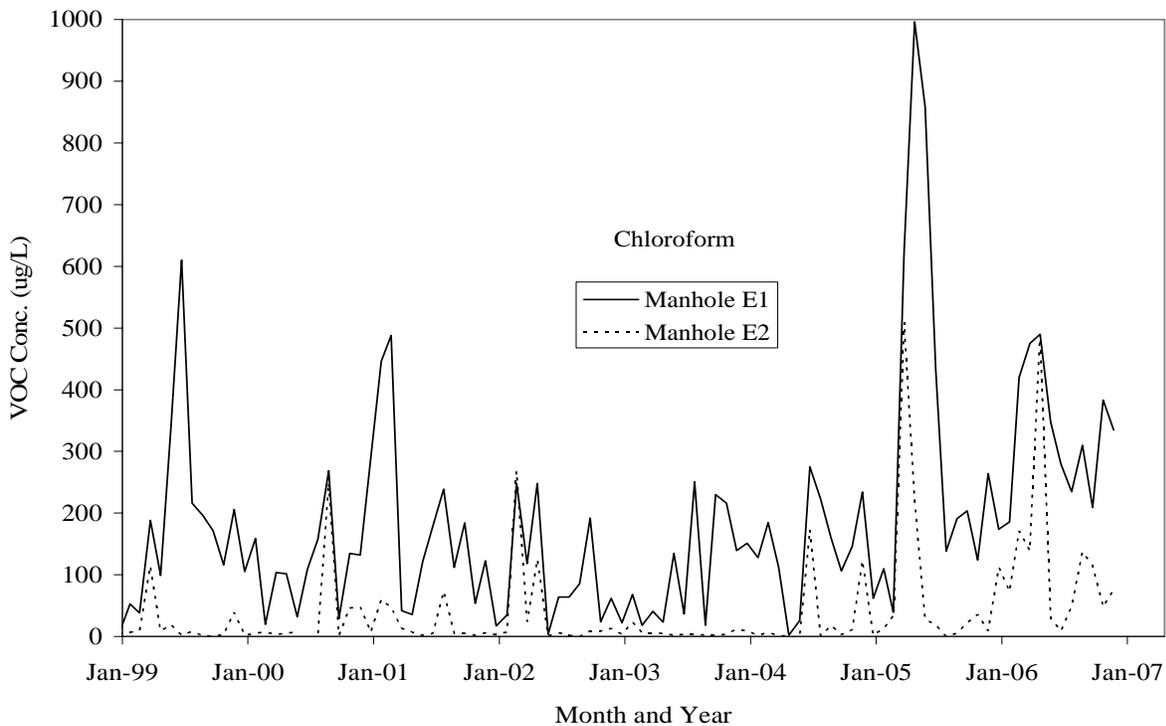


FIGURE 6.11 Manholes E1 and E2 Chloroform Levels, 1999 through 2006

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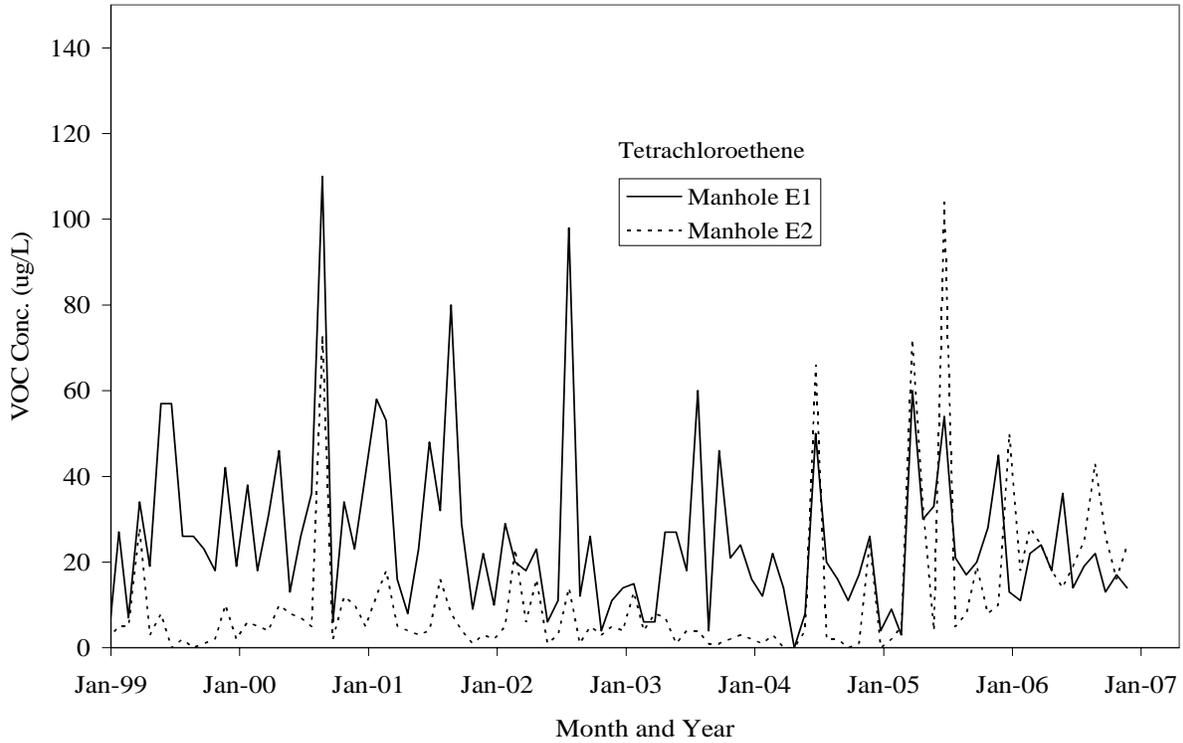


FIGURE 6.12 Manholes E1 and E2 Tetrachloroethene Levels, 1999 through 2006

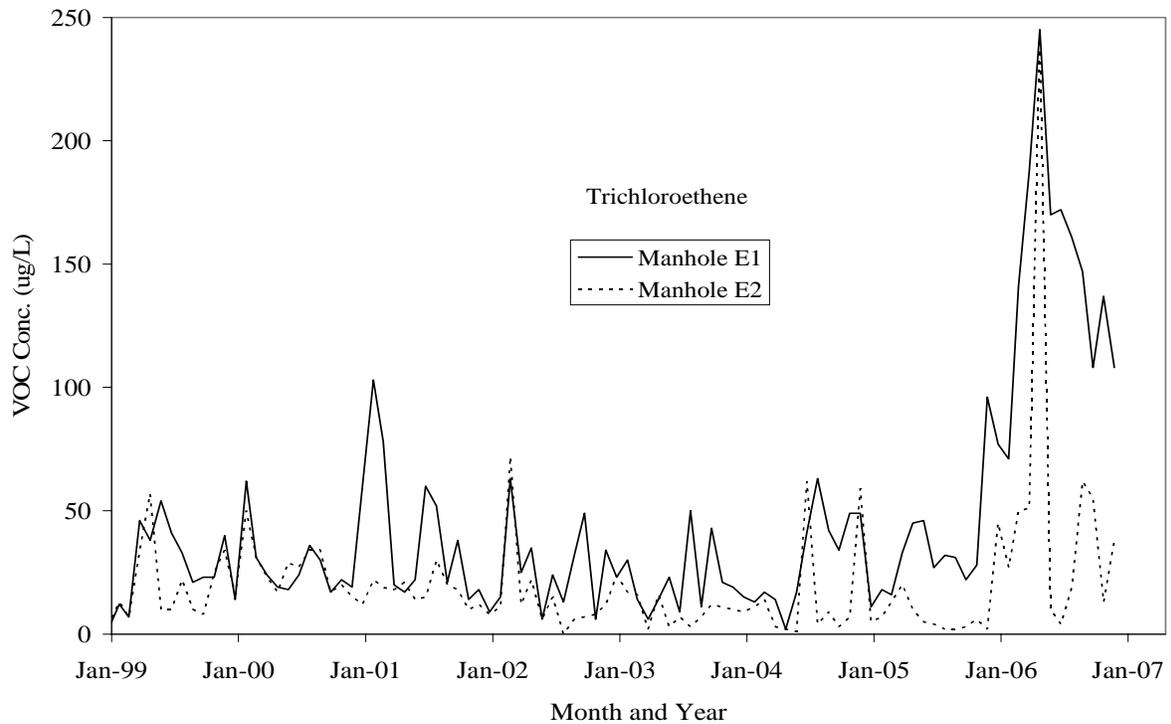


FIGURE 6.13 Manholes E1 and E2 Trichloroethene Levels, 1999 through 2006

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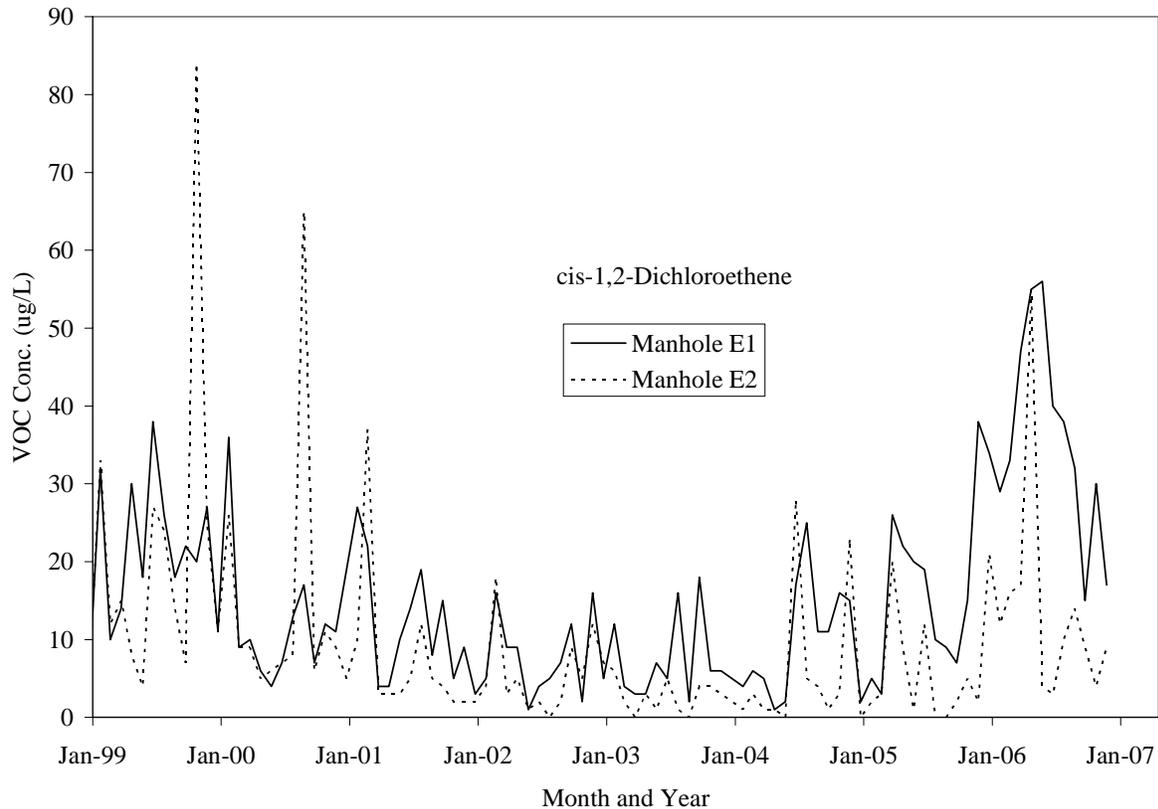


FIGURE 6.14 Manholes E1 and E2 *cis*-1,2-Dichloroethene Levels, 1999 through 2006

In addition to VOCs, the manhole water is analyzed for hydrogen-3 and gamma-ray-emitting radionuclides. Table 6.17 gives the hydrogen-3 results. All values were well below the GQS of 20,000 pCi/L. Unlike the VOCs, Manhole E2 typically exhibits higher hydrogen-3 concentrations than Manhole E1. The primary source of the hydrogen-3 is the 319 Area groundwater extraction system. Analysis of water from this system, discussed elsewhere in this document, shows that the hydrogen-3 levels can range up to 10,000 pCi/L, while the water from the 317 Area extraction system contains less than 1,700 pCi/L of hydrogen-3. No gamma-ray-emitting radionuclides were detected above the detection limits of 2.0 pCi/L in any samples.

Figure 6.15 shows changes in hydrogen-3 concentrations in the manholes

TABLE 6.17

Hydrogen-3 Concentrations in Manhole Water Samples, 2006
(concentrations in pCi/L)

Month Collected	Manhole E1	Manhole E2
Jan.	1,863	2,722
Feb.	1,043	1,432
March	744	1,721
April	627	1,017
May	833	833
June	934	1,236
July	1,214	1,536
Aug.	840	3,995
Sept.	356	375
Oct.	383	669
Nov.	575	272
Dec.	568	835

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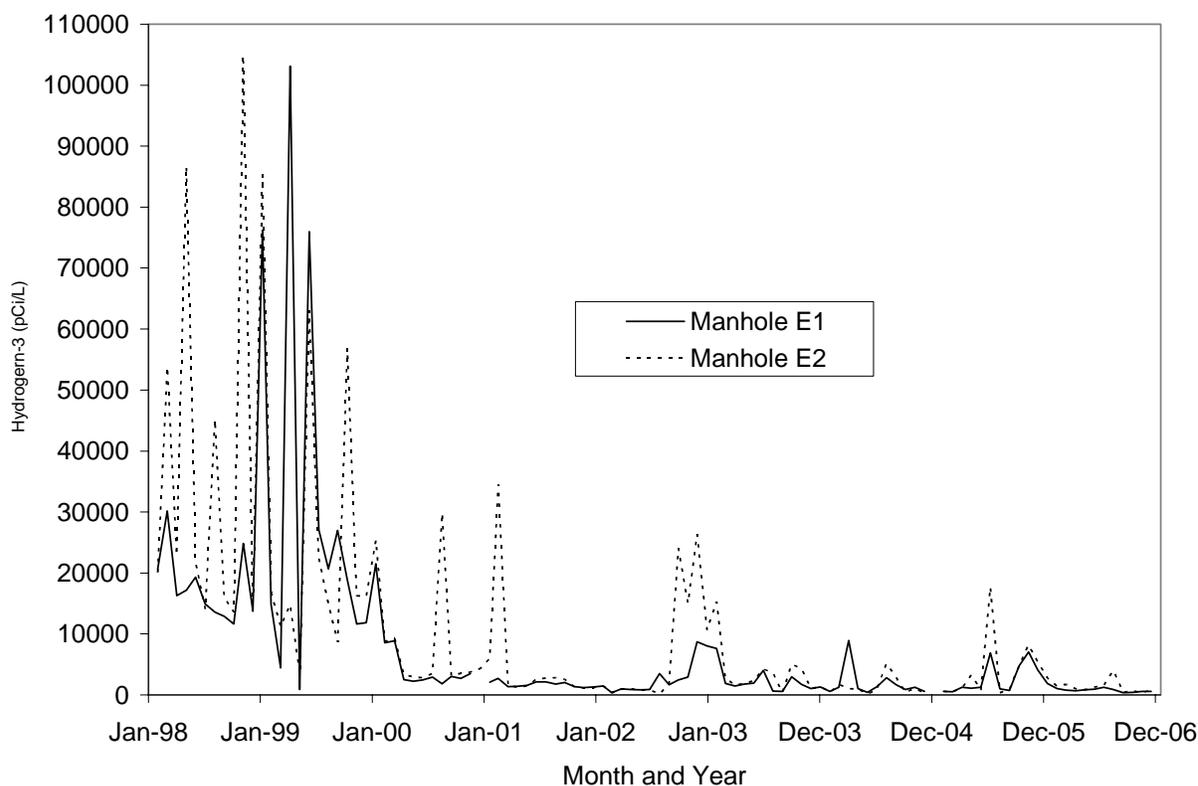


FIGURE 6.15 Hydrogen-3 in the 317 Manholes

since 1998. Since 2000, hydrogen-3 concentrations have been relatively steady. The reduction in hydrogen-3 concentrations since 1999 may be the result of the impervious cap placed over the 319 Area landfill, which was completed in 1999. From 1996 to 1999, significant amounts of leachate containing hydrogen-3 were pumped to the manholes prior to being pumped to the LWTP.

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

The LTS Program includes the collection of groundwater quality data from an extensive network of monitoring wells and other sampling points located throughout the 317/319 Area. The purpose of this monitoring 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. Most samples are collected on a quarterly basis and analyzed for VOCs and hydrogen-3 by using methods discussed elsewhere in this chapter. Once per year samples of groundwater from several of these wells are also analyzed for metals, SVOCs, PCBs, pesticides, and radionuclides other than hydrogen-3. These data are transmitted to the IEPA quarterly and are summarized in this section.

Because of the number of wells and other sampling points sampled in this area, the volume of analytical data generated is quite large. To simplify the presentation of the data in this

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report, only a summary of the most significant results is presented. No organics other than VOCs were detected, and no metals other than naturally occurring metals resulting from soil solids in the samples were detected. Only normal background levels of other radionuclides were detected. To simplify this report, none of these results are discussed in this chapter.

Overall, the monitoring results generated during 2006 indicate that the two groundwater collection systems south of the 319 Area Landfill and the 317 Area are effectively preventing off-site migration of contaminated groundwater that moves south toward the Des Plaines River. High concentrations of a number of VOCs are still present in groundwater in the immediate vicinity of the former 317 Area French Drain. VOC concentrations as high as 599,000 µg/L for carbon tetrachloride were detected in this area. However, downgradient (south) of the French drain the levels are much lower than in the French drain area itself, though still in excess of GQSs.

6.4.1. Phytoremediation Groundwater Monitoring

The 317 Area French drain soil treatment completed in 1998 resulted in the removal of approximately 80% of the subsurface contaminants. The final corrective action in the 317/319 Area was the deployment of phytoremediation in 1999. Phytoremediation (phyto) is a process that relies on woody and herbaceous plants to extract pore water and dissolved contaminants from subsurface soils, degrade and/or sequester them, and transpire water vapor and some volatile constituents into the atmosphere. To monitor the effectiveness of the process, monitoring wells were installed in the phyto plantation area. The wells are shown in Figure 6.16.

Samples are collected quarterly from the phyto wells and analyzed for VOCs and hydrogen-3. Table 6.18 shows the maximum and minimum of the four 2006 quarterly results for four wells in the French drain area. Organics that were below the quantitation limit in all the wells were not shown on this table. Values that exceed the applicable IEPA-approved Groundwater Remediation Objective (GRO) are indicated in bold type. Comparing maximum and minimum results shows how the concentrations vary during the year. Some of the variability noted has been linked to seasonal variability in precipitation and infiltration, compounded by seasonal groundwater uptake by the trees.

The data in Table 6.19 indicate that small pockets of elevated VOCs remain in the French drain area. The phyto plantation installed in this area is expected to slowly reduce residual VOC concentrations. These values are consistent with results found in past sampling events and no consistent trend in concentrations has yet been observed, indicating that the phytoremediation process has not yet resulted in significant reduction in VOCs in the French drain area.

Plant tissue monitoring conducted in the phytoremediation system during the last few years indicates that the trees are indeed taking up the organic contaminants from the soil and transpiring them to the air or degrading them within the plant. Because of the difficulty of measuring VOCs in sap and tree tissue, it has not yet been possible to measure the rate at which the trees are removing VOCs or how quickly they will reduce residual contaminant levels.

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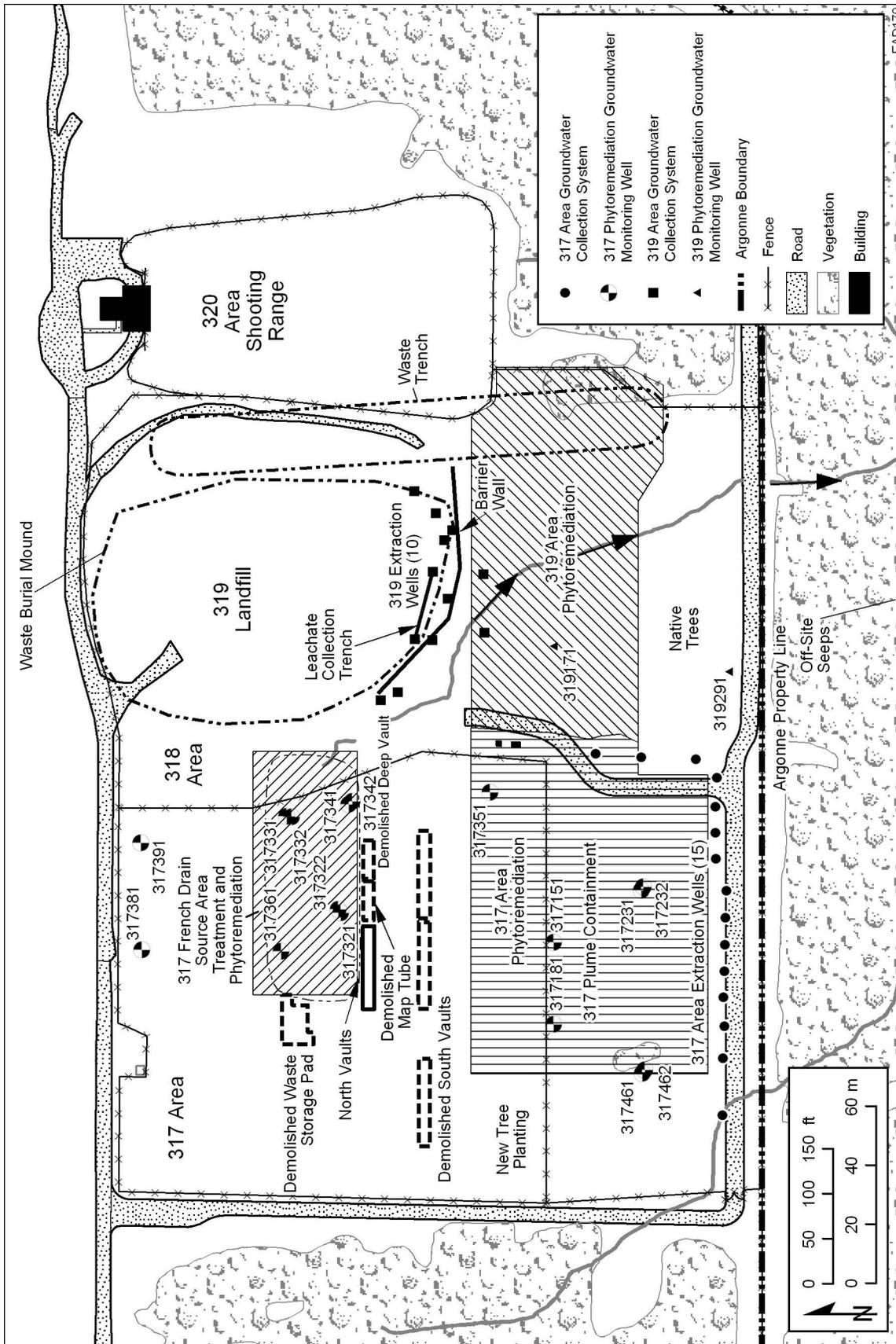


FIGURE 6.16 Phytoremediation Monitoring Wells

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TABLE 6.18

Annual Maximum and Minimum Concentrations of French Drain Well Water Constituents, 2006

Parameter VOC (µg/L)	Well No.								Remediation Objective
	317321		317322		317331		317332		
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Acetone	<1.0	6,620^a	<1.0	2,484	< 1.0	< 1.0	< 1.0	< 1.0	700
Benzene	<1.0	17,598	352	1,324	486	611	< 1.0	< 1.0	5
Carbon tetrachloride	274,000	598,541	260	2,062	< 1.0	< 1.0	< 1.0	< 1.0	5
Chloroform	66,000	121,868	2,916	9,990	863	1,067	< 1.0	< 1.0	0.2
1,1-Dichloroethane	<1.0	<1.0	950	4,024	3,815	15,365	1,175	2,476	700
1,1-Dichloroethene	<1.0	<1.0	<1.0	49	3,220	9,885	31	396	7
1,2-Dichloroethane	182	402	<1.0	70	1,982	4,070	105	176	5
<i>cis</i> -1,2-Dichloroethene	286	598	6,605	47,375	18,400	30,105	426	821	70
Dichlorodifluoromethane	<5.0	<5.0	<1.0	594	< 1.0	180	< 1.0	15	1,400
1,4-Dioxane	<1.0	<1.0	<1.0	2,420	< 1.0	5,063	< 1.0	1,387	1
Ethylbenzene	<1.0	81	<1.0	<1.0	< 1.0	< 1.0	< 1.0	< 1.0	700
Ethylether	313	502	<1.0	106	< 1.0	< 1.0	< 1.0	< 1.0	1,400
Methylene chloride	<1.0	1,890	1,360	3,297	< 1.0	< 1.0	< 1.0	< 1.0	5
Tetrachloroethene	769	1,297	88	1,194	< 1.0	< 1.0	< 1.0	< 1.0	5
Toluene	912	1,599	<1.0	69	< 1.0	< 1.0	< 1.0	< 1.0	1,000
<i>trans</i> -1,2-Dichloroethene	<1.0	<1.0	260	364	1,069	1,511	15	57	100
1,1,1-Trichloroethane	<1.0	<1.0	<1.0	<1.0	149,000	185,298	2,162	7,270	200
Trichloroethene	25,900	45,389	326	1,074	44,300	57,846	220	760	5
1,2,4 Trimethylbenzene	<1.0	136	<1.0	<1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.5
Vinyl chloride	<2.0	<2.0	121	2,152	153	401	<2.0	14	2
Xylene (total)	<1.0	347	<1.0	<1.0	< 1.0	< 1.0	< 1.0	< 1.0	10,000
Total VOCs	471,446	831,244	28,647	65,468	240,075	285,890	4,134	10,834	
Hydrogen-3 (pCi/L)	1,205	1,420	602	814	133	217	168	598	20,000

^a Bold type indicates that the value exceeds applicable standards.

Long-term monitoring of this system will determine its effectiveness at achieving the remediation objectives for this area.

Table 6.19 contains results for the same constituents listed in Table 6.18 for four downgradient wells south of the French drain. Two wells (317151 and 317351) are approximately mid-way between the French drain and the southern fence line, and two (317232 and 317462) are near the fence line. The concentrations found in these wells are much lower than in the French drain area; however, quite a few of the constituents are present above applicable standards. Apparently, the highly contaminated groundwater in the French drain area is not migrating downgradient. The phyto plantation in this part of the 317 Area is intended to accelerate the removal of this part of the groundwater plume.

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TABLE 6.19

Annual Maximum and Minimum Concentrations of Downgradient French Drain
Well Water Constituents, 2006

Parameter VOC (µg/L)	Well No.								Remediation Objective
	Wells midway to fence				Wells near fence line				
	317151		317351		317232		317462		
	Min	Max	Min	Max	Min	Max	Min	Max	
Acetone	<1	<1	<1	25	<1	<1	<1	<1	700
Benzene	<1	<1	<1	<1	<1	<1	<1	<1	5
Carbon tetrachloride	<1	<1	14^a	564	2	10	<1	<1	5
Chloroform	<1	19	85	240	<1	3	<1	<1	0.2
1,1-Dichloroethane	260	737	<1	<1	<1	1	2,173	2,989	700
1,1-Dichloroethene	40	146	<1	<1	<1	<1	24	44	7
1,2-Dichloroethane	20	38	<1	<1	<1	<1	92	121	5
<i>cis</i> -1,2-Dichloroethene	<1	26	4	11	<1	<1	44	53	70
<i>trans</i> -1,2-Dichloroethene	<1	<1	<1	<1	<1	<1	<1	<1	100
Dichlorodifluoromethane	<5	<5	<5	<5	<5	<5	<5	<5	1,400
1,4-Dioxane	<1	<1	<1	<1	<1	<1	<1	<1	1
Ethylbenzene	<1	<1	<1	<1	<1	<1	<1	<1	700
Ethylether	<1	<1	<1	<1	<1	<1	<1	<1	1,400
Methylene chloride	<1	<1	<1	<1	<1	<1	<1	<1	5
Tetrachloroethene	23	450	167	818	<1	<1	<1	<1	5
Toluene	<1	<1	<1	<1	<1	<1	<1	<1	1,000
1,1,1-Trichloroethane	2,212^a	3,436	<1	<1	<1	<1	124	168	200
Trichloroethene	599	734	4	7	<1	<1	30	43	5
1,2,4-Trimethylbenzene	<1	<1	<1	<1	<1	<1	<1	<1	0.5
Vinyl chloride	<2	<2	<2	<2	<2	<2	<2	<2	2
Xylene (total)	<1	<1	<1	<1	<1	<1	<1	<1	10,000
Total VOCs	3,154	5,586	274	1,665	2	14	2,487	3,418	
Hydrogen-3 (pCi/L)	1,420	1,205	814	602	217	133	598	168	20,000

^a Bold type indicates that the value exceeds applicable standards.

6.4.2. Extraction Well Monitoring

Two groundwater management systems in the 317/319 Area remove contaminated groundwater to prevent further migration. A line of 15 groundwater extraction wells was installed near the 317 Area south fence, and 10 wells (8 groundwater and 2 leachate collection wells) were installed south of the 319 Area landfill. The groundwater extraction wells were installed at approximately 10-m (30-ft) intervals at a depth of 10 to 15 m (30 to 50 ft) in the shallow porous zones. The discharge from the extraction wells is routed to the lift station in the 317 Area where the combined wastewater is pumped to the LWTP. The locations of the extraction wells are shown in Figure 6.17.

The flow from the 317 Area wells is influenced by the amount of precipitation as well as the uptake of groundwater by the phyto trees during the warm months. The long-term average flow from this system through 2006 was 15,367 L/day (4060 gal/day), with the flow prior to

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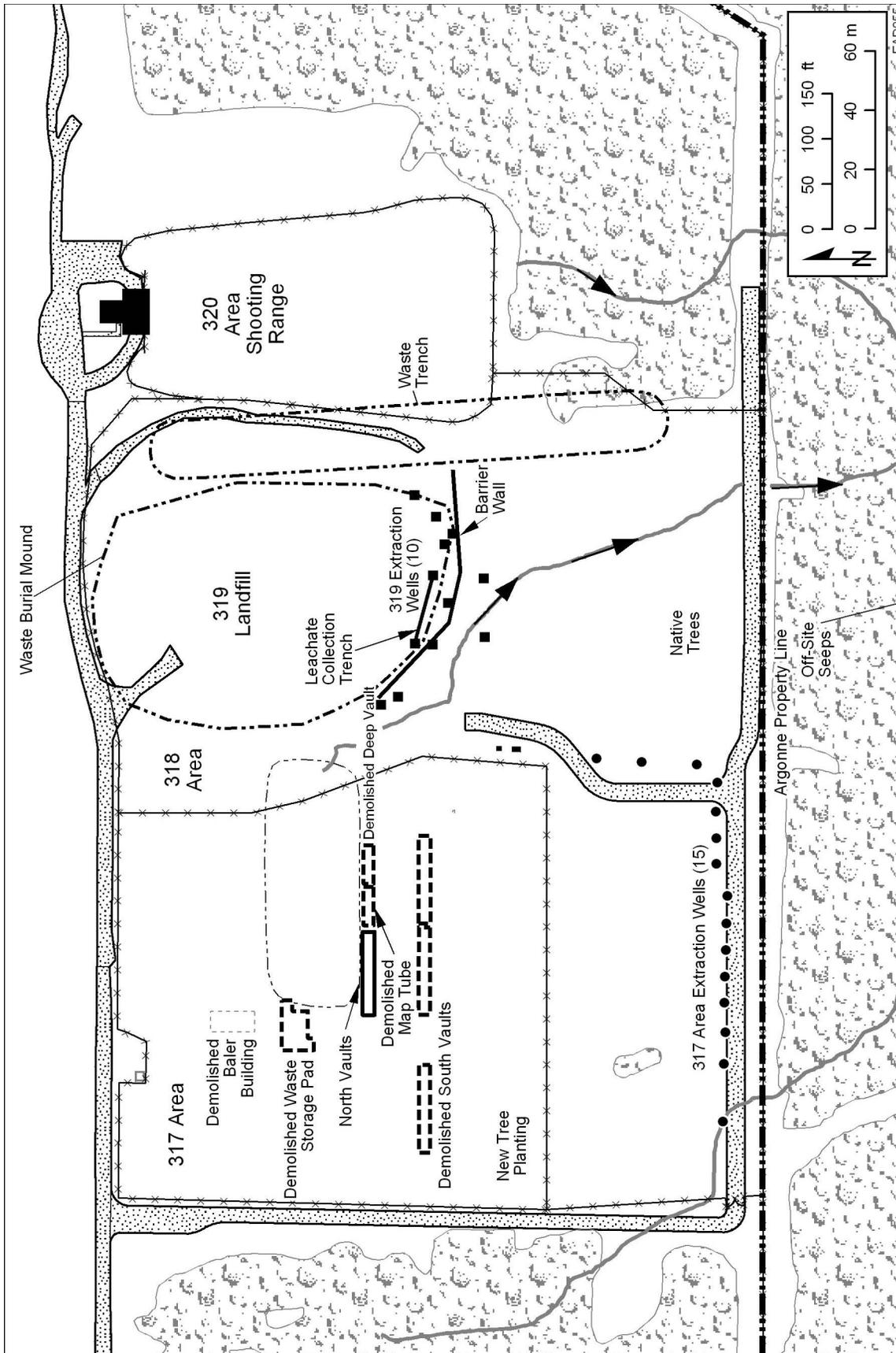


FIGURE 6.17 Extraction Wells

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2002 often exceeding 30,000 L (8,000 gal) per day. The flow rate decreased significantly starting in late 2002, possibly because of the trees removing groundwater from the shallow aquifers. The average flow rate during 2006 was only 3,180 L (839 gal) per day. The flow rate from the 319 Area collection system is much lower than the 317 Area system because the size of the system is much smaller and an impermeable clay cap was installed over the 319 Area Landfill, greatly reducing the amount of groundwater generated. Prior to installation of the cap, flows averaged approximately 5,680 L (1,500 gal) per day. During 2006, the average flow was less than 1,510 L (400 gal) per day.

Monitoring of groundwater removed by the individual groundwater and leachate extraction wells is conducted annually. During 2006, one 317 Area extraction well and one 319 Area well were completely dry, preventing sample collection entirely, and eight wells did not contain sufficient water to collect all of the samples desired. Samples are analyzed for VOCs and various radiological parameters. All but the two dry wells generated results for at least VOCs and hydrogen-3. The concentrations of most of the parameters were below laboratory detection limits. Table 6.20 summarizes the range of selected contaminant concentrations in the two extraction well systems.

TABLE 6.20

Range of VOC and Hydrogen-3 Concentrations in the
317/319 Extraction Wells, 2006

Parameter	Range (µg/L)	Remediation Objective
Acetone	<1- 952^a	700
Benzene	<1	5
Carbon tetrachloride	<1	5
Chloroethane	<5-6	NA ^b
Chloroform	<1- 2	0.2
1,1-Dichloroethane	<1-637	700
1,2-Dichloroethane	<1- 33	5
1,1-Dichloroethene	<1-2	7
<i>cis</i> -1,2-Dichloroethene	<1-18	70
1,4-Dioxane	<1- 22	1
Methylene chloride	<1	5
Tetrachloroethene	<1-3	5
1,1,1-Trichloroethane	<1-64	200
Trichloroethene	<1- 16	5
Xylene (total)	<1	5
Vinyl chloride	<1	2
Hydrogen-3 (pCi/L)	<100-9,680	20,000

^a Bold type indicates that the value exceeds applicable standards.

^b NA = not applicable.

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Examination of Table 6.20 shows that several extraction wells contained VOCs at concentrations that exceeded the GROs (cleanup levels). The groundwater from the 319 Area extraction wells is less contaminated than that from the 317 Area wells; all of the highest VOC values reported in Table 6.20 were found in the 317 Area wells. However, even the highest concentrations in the 317 Area extraction wells are orders of magnitude lower than the highest concentrations in groundwater under the French drain (see Section 6.4.1.). This indicates that the groundwater in the French drain area, which is in contact with untreated contaminated soil, is not migrating and only a relatively small amount of this contamination had migrated south of this area prior to the start of remediation. The remaining contamination south of the French drain should slowly decrease because of dilution from rainwater, natural biodegradation, and the effects of the phytoremediation plantation.

In addition to the VOCs, the extraction well water was also analyzed for gross alpha and gross beta radioactivity, cesium-137, isotopic uranium, and hydrogen-3. In the wells sampled in 2006, all radiological constituents, except hydrogen-3, were not detected or were within the range of normal ambient concentrations. The highest hydrogen-3 value in Table 6.20 was from one of the two leachate collection wells in the 319 Area Landfill. Other 319 Area monitoring wells and extraction wells also exhibit elevated hydrogen-3 levels, compared with the 317 Area. Leachate from the landfill has been known to contain hydrogen-3 since the site was first characterized. Since the landfill cap was installed, the amount of leachate produced has been very small, and most sampling attempts do not yield a sample. The highest value for hydrogen-3 in 2006 was less than the GQS of 20,000 pCi/L.

Each quarter the groundwater elevations around the extraction wells are analyzed to determine the effectiveness of the extraction systems. On the basis of this analysis and estimations of groundwater flow directions, the extraction wells appear to be effectively preventing migration of contaminated groundwater from the Argonne site.

Each quarter an attempt is made to collect a sample of surface water from the stormwater ditch south of the 317 and 319 Areas, at the point where the ditch passes under the Argonne fence line. The samples are analyzed for VOCs and hydrogen-3. During 2006, three samples were collected during the last three quarters of the year. The results of the analysis are shown in Table 6.21. Very small amounts of VOCs, at or slightly above the analytical detection limits, were detected in some of these samples, but no hydrogen-3 was detected in any of the samples. From the types of the compounds detected, and from the lack of hydrogen-3, it is believed that the contamination noted results from rainwater contacting contaminated soil in the 317 French drain area.

6.4.3 ENE Landfill Groundwater Monitoring

In September 2001, Argonne completed the remediation of a small solid waste disposal area used in the early years of the Laboratory, known as the ENE Landfill. Waste material was consolidated and a clay cap was constructed over the waste mound. Five monitoring wells were installed to facilitate monitoring of the groundwater around the landfill. Two of the wells (ENE061 and ENE071) were installed upgradient of the landfill, and the other three wells

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TABLE 6.21

VOC and Hydrogen-3 Concentrations in the 317/319
Surface Water Runoff, 2006

Parameter	Quarter Sampled			
	First	Second	Third	Fourth
Carbon tetrachloride (µg/L)	Dry	<1.0	3.0	2.0
Chloroform (µg/L)	Dry	<1.0	1.0	2.0
1,1-Dichloroethane (µg/L)	Dry	<1.0	<1.0	1.0
1,1,1-Trichloroethane (µg/L)	Dry	1.0	1.0	2.0
Trichloroethylene (µg/L)	Dry	3.0	<1.0	<1.0
Hydrogen-3 (pCi/L)	Dry	<100	<100	<100

(ENE031, ENE041, and ENE051) were installed immediately downgradient of the landfill. Four other wells southeast of the mound (ENE011, ENE012, ENE013D, and ENE021D), which had been installed earlier as part of the 317/319/ENE RCRA Facility Investigation (RFI) in 1996, were incorporated into the sampling network. Figure 6.18 shows the well locations.

In April 2003, the IEPA issued a RCRA corrective action permit covering postclosure care and groundwater monitoring for the ENE Landfill. The purpose of groundwater monitoring at the ENE Landfill is to verify that contaminants found in the landfill contents, including metals (chromium, lead, and selenium), the PCB Aroclor 1254, as well as hydrogen-3 and other radionuclides, which were all above their respective Tier 1 soil remediation objectives (as found in 35 IAC Part 742 [i.e., Tiered Approach to Corrective Action Objectives]), are not of concern with regard to shallow groundwater.²⁹ The contaminants in the landfill were only of concern because of their potential ingestion risk and not their migration-to-groundwater risk. The cap placed over the landfill contents was designed to prevent exposure to future site workers to eliminate the ingestion pathway and not to prevent the generation of contaminated groundwater or leachate. Nonetheless, the groundwater sampling program is in place to detect any future releases of waste constituents from the former landfill. Monitoring at the ENE Landfill will be conducted for a minimum of 15 years starting in December 2002, as required by the IEPA.

All wells shown in Figure 6.18 are included in the quarterly monitoring program. Parameters analyzed on a quarterly basis include total PCBs and filtered and unfiltered arsenic, chromium, lead, manganese, nickel, and selenium. Beginning in 2006, most of the wells have been 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, occasionally groundwater levels are too low to allow this type of sampler to operate. At times, site conditions prevented a vehicle from accessing the wells, which prevents the use of the low flow sampler since the vehicle is needed to operate the pumps. In such a situation, the pump is removed from the well and the samples are collected by hand with a baler.

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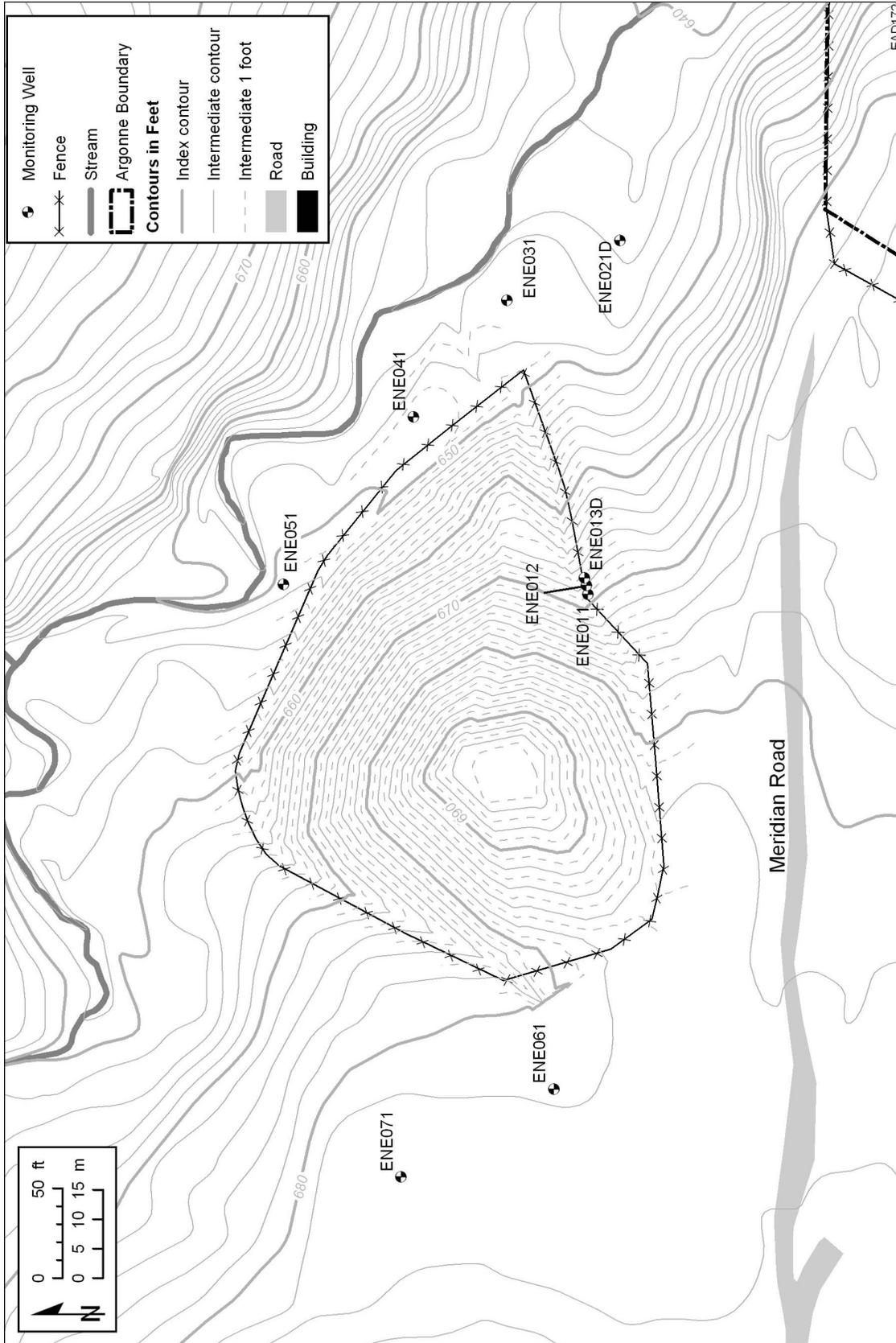


FIGURE 6.18 ENE Area Groundwater Monitoring Wells

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The 2006 results of this program are summarized in Table 6.22. The averages of the four 2006 quarterly results from each well are shown (the individual values were submitted to the IEPA with the required quarterly LTS report). As shown in this table, a number of average results exceed the GROs for lead, manganese, and nickel in six of the eight wells sampled (Well ENE061 was dry throughout 2006). The data show that total (unfiltered) metals results were much higher than dissolved (filtered) metals results. Only 2 of the 14 exceedances were from filtered samples, and these two were for manganese, which is a relatively soluble and abundant naturally occurring metal. The higher total metals concentrations results found in unfiltered samples indicate that soil solids in the sample contributed to the elevated metals. The effects of the low flow sampling process on total metals concentrations will be evaluated after several more quarters of data are obtained. PCBs were not detected above the analytical detection limit of 0.5 µg/L in any of the eight wells.

Argonne is currently gathering data on normal background levels of naturally occurring groundwater constituents, such as iron, manganese, and nickel. Once a sufficient number of samples are obtained from the two upgradient wells, a statistical analysis of the results will be completed and a set of IEPA-approved background values established. The monitoring results will then be compared with these background values as well as the GROs. It is anticipated that many of the sample results that currently appear elevated will be shown to be consistent with natural background levels.

6.4.4. Monitoring of the Seeps South of the 300 Area

In 1996, during the RFI of the 317/319 Area, a series of groundwater seeps was discovered in a network of steeply eroded ravines in the Waterfall Glen Forest Preserve south and southeast of the 317 and 319 Areas. Shallow monitoring wells were installed in five locations in these groundwater seeps. Three of these seep sampling wells (SP01, SP02, and SP04) are located about 200 m (600 ft) south of the 319 Area. SP04 is located adjacent to an old hand dug well. The locations are shown in Figure 6.19. The seeps are in a ravine network that is located in a pristine, heavily wooded section of the forest preserve. The ravines carry stormwater drainage from the 317 and 319 Areas. Stormwater flow has eroded the soil deep enough to expose a shallow sandy layer containing groundwater. Water emanating from the exposed sandy layer flows to the nearby ravine, where it forms a small rivulet in the bottom of the ravine. Approximately 30 m (100 ft) downstream of the seep area, the water from the seeps is no longer visible because it drains back into the soil in the bed of the ravine or evaporates. During extended dry-weather conditions, the seeps disappear completely. Two other seeps (SP03 and SP05) were discovered about 360 m (1,200 ft) south of the 317 Area in an unrelated ravine system and were used as clean background seeps. These background seeps are no longer sampled.

During the RFI, samples were collected from these seeps and analyzed for metals, VOCs, and selected radionuclides. Two groundwater seeps (SP01 and SP04) contained measurable levels of three VOCs: carbon tetrachloride, chloroform, and tetrachloroethene. The other three seeps, including the two background seeps, did not contain any quantifiable VOCs. Three of the five seeps, including the two containing the VOCs, were found to contain hydrogen-3 at measurable concentrations. Since the initial samples were collected, monthly samples were

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TABLE 6.22
Annual Average Concentrations of ENE Landfill Well Water Constituents, 2006^a

Metal	Well No.											Standard	
	ENE-011	ENE-012	ENE-013D	ENE-021D	ENE-031	ENE-041	ENE-051	ENE-061	ENE-071	ENE-071	Standard		
Arsenic-filtered	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	50
Arsenic-unfiltered	<25	<25	33	<25	34	<25	<25	<25	<25	<25	<25	<25	50
Chromium-filtered	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	100
Chromium-unfiltered	<50	<50	<50	72.7	65.4	<50	<50	<50	<50	<50	<50	66.7	100
Lead-filtered	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	7.5
Lead-unfiltered	5.0	8.0^b	<4.0	<4.0	43	6.8	61	<4.0	<4.0	62	<4.0	62	7.5
Manganese-filtered	<75	<75	<75	86.9	665	<75	<75	<75	<75	277	<75	277	150
Manganese-unfiltered	145	227	30.0	152	2,028	1,105	1,729	<75	<75	3,858	<75	3,858	150
Nickel-filtered	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	100
Nickel-unfiltered	<50	<50	<50	<50	102	<50	61	<50	<50	128	<50	128	100
Selenium-filtered	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	50
Selenium-unfiltered	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	50
PCB-total	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.0

^a Concentrations in µg/L.

^b Bold type indicates that the value exceeds the GRO.

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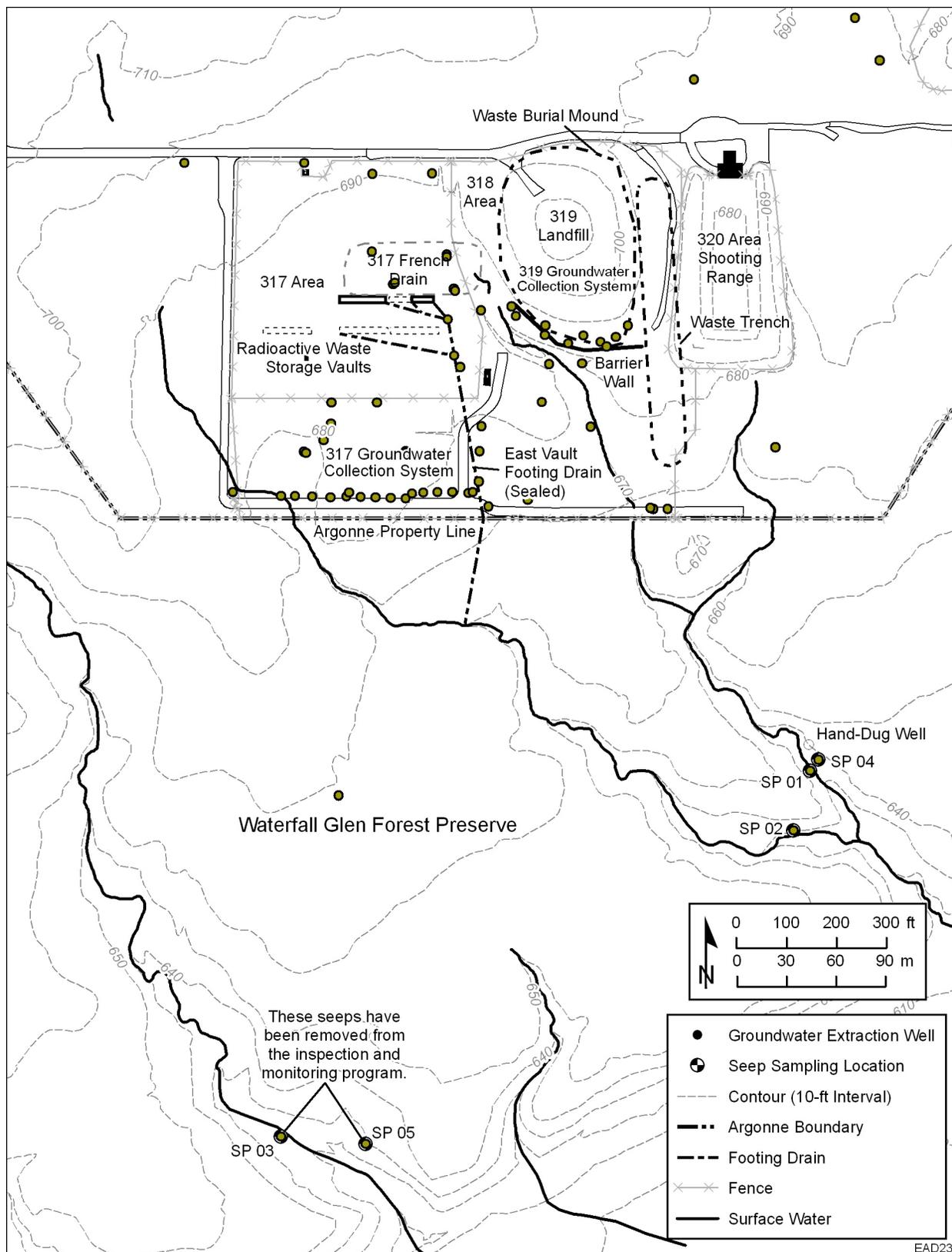


FIGURE 6.19 Seep Locations South of the 317/319 Area

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obtained through the end of 1997, and quarterly samples have been collected since. Initial sampling results are summarized in previous SERs.

During 2006, Seeps SP01, SP02, and SP04 were sampled quarterly for VOCs and hydrogen-3. Table 6.23 contains the results of this and past monitoring since early 2000. VOCs were noted in each seep during each quarter of 2006. The levels of VOCs in SP01 and SP02 were very low and no clear trend can be seen. As in previous years, Seep SP04 showed the highest levels of all three VOCs (carbon tetrachloride, chloroform, and tetrachloroethene). Figure 6.20 contains a trend plot of carbon tetrachloride and chloroform in this seep. As seen in this figure, the concentrations have remained relatively constant since the start of monitoring, except for several extended dry periods when the seep completely dries up. The concentrations of carbon tetrachloride and chloroform decreased significantly immediately after such dry periods, increasing to previous levels once normal precipitation returned. The 2006 sample results show slowly increasing concentrations following a dry period in 2005.

The hydrogen-3 results for the seeps show a clear decline in hydrogen-3 concentrations since monitoring began. Figure 6.21 shows the tritium results in all three seeps since 2000. The decline in tritium could be related to the installation of the cap over the 319 Area Landfill, which is the likely source of the hydrogen-3 at the seeps. The decline in hydrogen-3 is much more rapid than radioactive decay alone would account for. In recent years most of the hydrogen-3 results have been at or below the analytical detection limits.

Monitoring was also conducted quarterly in the forest preserve at an artesian well located about 2,000 m (6,000 ft) southwest of the 317 Area (grid location 3E in Figure 1.1). All hydrogen-3 concentrations were below the detection limit of 100 pCi/L. This finding suggests that any subsurface hydrogen-3 contaminant movement has not extended to this location and indicates a western limit to the migration.

6.4.5. Groundwater Monitoring at the GMZ Area

Remedial investigations and remedial actions have been underway in the 317/319 Area since 1994. Many of these actions have been discussed elsewhere in this chapter. These actions were focused on identifying, removing, or containing sources of contamination. The final such action was the installation of the phytoremediation system in 1999. Because of the nature, extent, and depth of contamination, it was not feasible to remove all contaminated soil or groundwater during the active remediation phase. The phytoremediation system, as well as the groundwater extraction systems, were intended to contain residual contamination and slowly reduce contaminant levels until the GRO levels are attained. The regulatory tool the IEPA utilizes to oversee such a remedial process is a GMZ. 35 Ill. Adm. Code Part 620.250 allows for the establishment of a GMZ as a three-dimensional region containing groundwater being actively remediated to clean up contamination caused by past releases. For a GMZ to be established, the groundwater within the proposed GMZ must be managed to ensure that cleanup of the contaminants continues until GRO levels are achieved. Because of the proximity of the 317 and 319 Areas and the fact that the groundwater plumes have intermingled and emerged to the surface in the seeps, the entire area encompassing the 317 Area, 319 Area, and the area

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TABLE 6.23

Contaminant Concentrations in Seep Water, 2000 to 2006

Site	Date Collected	Hydrogen-3 (pCi/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)
SP01	03/21/00	706	5	2	<1
	06/07/00	1,425	6	2	<1
	08/21/00	1,178	8	2	<1
	11/03/00	1,120	7	2	<1
	01/31/01	640	5	1	<1
	05/15/01	633	7	1	<1
	09/07/01	555	4	1	<1
	11/02/01	645	6	2	<1
	01/28/02	614	2	<1	<1
	04/18/02	383	2	1	<1
	07/30/02	242	4	2	<1
	11/13/02	250	7	4	<1
	03/25/03	203	<1	<1	<1
	05/13/03	128	3	1	<1
	08/14/03	187	<1	1	<1
	12/08/03	198	<1	1	<1
	02/11/04	161	9	3	<1
	05/03/04	178	7	2	<1
	08/03/04	114	7	2	<1
	10/25/04	114	8	2	<1
	01/24/05	160	9	2	<1
	05/02/05	<100	5	1	<1
	09/27/05	<100	6	<1	1
	12/05/05	<100	5	2	1
	03/13/06	<100	2	<1	<1
	05/04/06	137	3	1	<1
08/31/06	<100	2	<1	<1	
10/12/06	<100	4	2	<1	
SP02	03/21/00	1,998	1	<1	<1
	06/07/00	1,124	1	<1	<1
	08/21/00	625	3	<1	<1
	11/03/00	1,348	2	<1	<1
	01/31/01	1,383	2	<1	<1
	05/15/01	340	2	<1	<1
	09/07/01	619	2	<1	<1
	11/02/01	626	2	<1	<1
	01/28/02	572	7	2	<1
	04/18/02	274	<1	<1	<1
	07/30/02	188	1	<1	<1
	11/13/02	326	1	<1	<1
	03/25/03	361	<1	<1	<1
	05/13/03	256	1	<1	<1
	08/14/03	273	<1	<1	<1
	12/08/03	248	1	1	<1
	02/11/04	394	3	1	<1
	05/03/04	228	3	1	<1
	08/03/04	175	2	<1	<1
	10/25/04	111	2	<1	<1
	01/24/05	192	2	<1	<1
	05/02/05	146	2	<1	<1
	09/27/05	120	2	<1	<1
	12/05/05	Dry	Dry	Dry	Dry
	03/13/06	100	<1	<1	<1
	05/04/06	123	2	<1	<1
08/31/06	<100	3	1	<1	
10/12/06	114	2	1	<1	

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TABLE 6.23 (Cont.)

Site	Date Collected	Hydrogen-3 (pCi/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)
SP04	03/21/00	Dry	Dry	Dry	Dry
	06/07/00	1,043	179^a	18	7
	08/21/00	435	301	28	9
	11/03/00	323	194	23	6
	01/31/01	418	221	22	6
	05/15/01	124	208	25	7
	09/07/01	117	145	54	7
	11/02/01	183	148	23	6
	01/28/02	409	152	20	5
	04/18/02	<100	143	20	7
	07/30/02	<100	180	26	6
	11/13/02	116	118	43	6
	03/25/03	Dry	Dry	Dry	Dry
	05/13/03	<100	39	10	2
	08/14/03	<100	137	33	4
	12/08/03	Dry	Dry	Dry	Dry
	02/11/04	164	188	23	6
	05/03/04	185	192	20	5
	08/03/04	<100	214	25	6
	10/25/04	<100	229	32	6
	01/24/05	101	235	26	5
	05/02/05	110	243	28	6
	09/27/05	<100	204	30	7
12/05/05	Dry	Dry	Dry	Dry	
03/13/06	<100	10	6	1	
05/04/06	<100	64	17	3	
08/31/06	<100	102	56	5	
10/12/06	<100	125	26	5	

^a Bold type indicates that the value exceeds the State of Illinois Groundwater Quality Standard.

extending down to the seeps was included within the GMZ. The GMZ measures approximately 8.9 ha (22 acres) in extent. The GMZ was approved by the IEPA on November 22, 2000.

The boundaries of the GMZ are delineated by a set of monitoring wells that are located on the outer boundary of the region of contaminated groundwater, both laterally and vertically. Figure 6.22 shows the locations of these boundary wells. These wells are screened in the glacial drift (Wells 317971, 317941, 319781, and 319801) and the upper dolomite bedrock (Wells 317012D, 317951D, 319961D, and 319013D). They include three mini-monitoring wells (MMW06D, MMW013, and MMW011) installed in the shallow glacial drift in the forest preserve between the Argonne site and the seeps. Because of the inaccessibility of this area, a different well installation technique was used that required the installation of small diameter wells, termed mini-monitoring wells. Well 317941 had shown contamination above GROs and was replaced by Well 317971 in 2002. Well 317941 continues to be sampled but is no longer considered a perimeter GMZ well. Wells 317951 and 319961 were installed in 2002 to replace existing dolomite wells 317121D and 319131D, which were installed in 1988 by using

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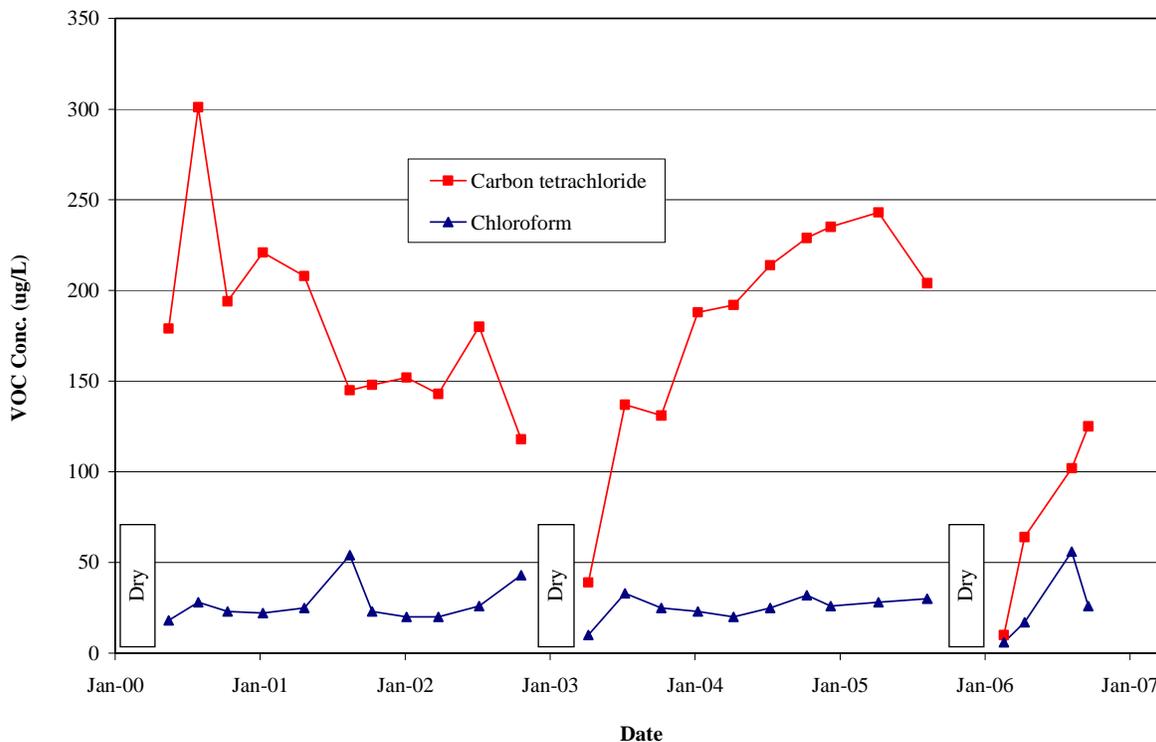


FIGURE 6.20 Carbon Tetrachloride and Chloroform in Seep 04, 2000 to 2006

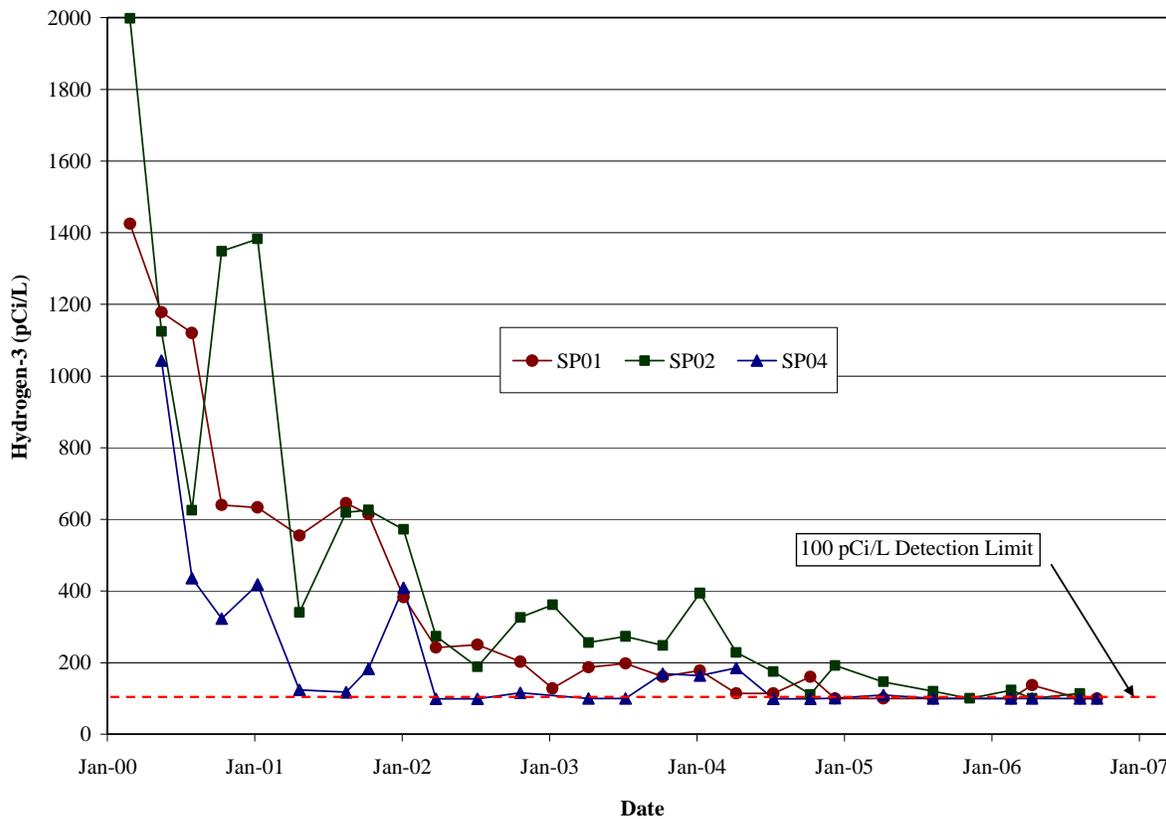


FIGURE 6.21 Hydrogen-3 Concentrations in Seep Water, 2000 to 2006

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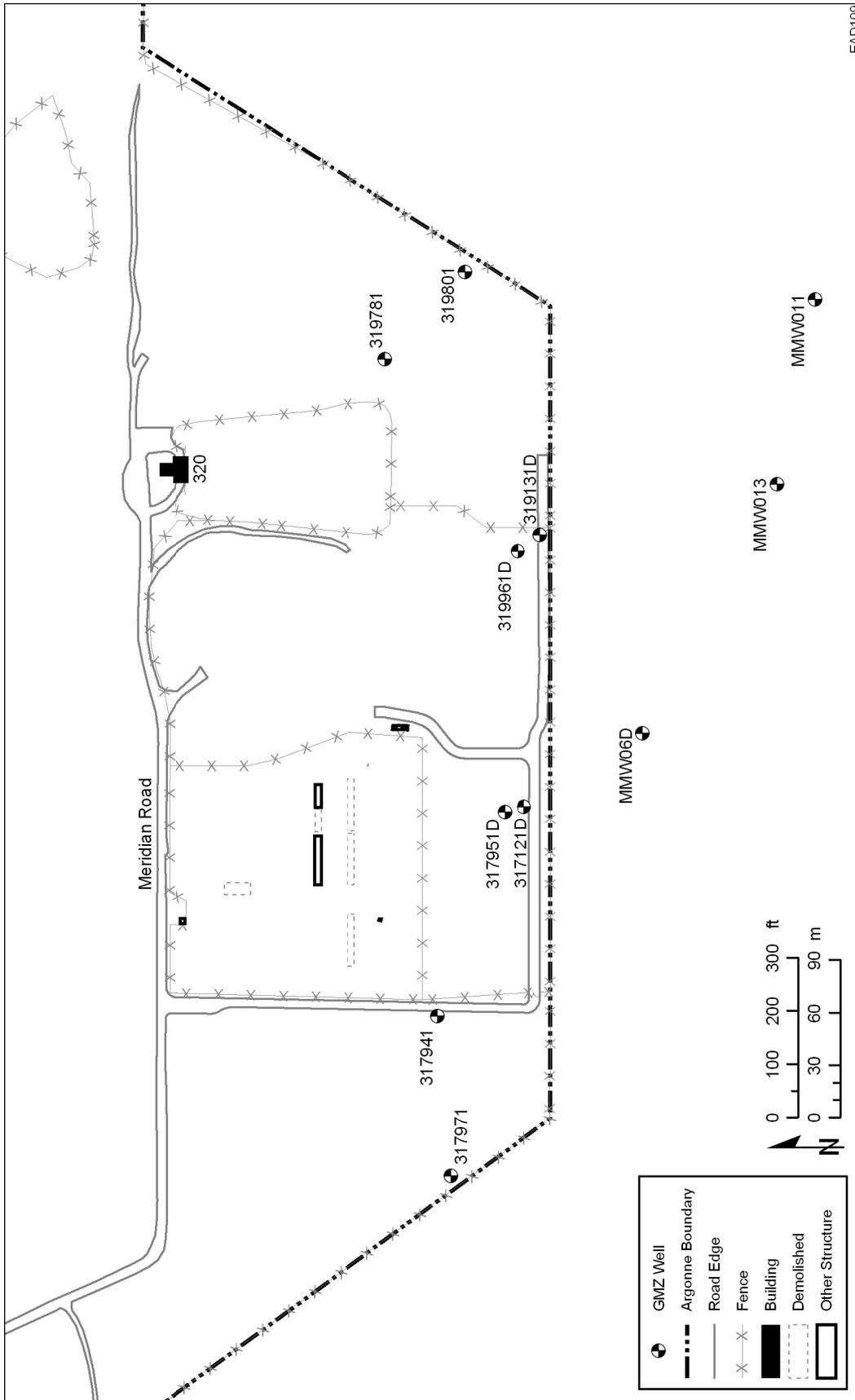


FIGURE 6.22 Locations of Monitoring Wells in the GMZ within the 317/319 Area and Adjacent Forest Preserve Property

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techniques that are no longer used to install groundwater monitoring wells. Both the original and replacement wells will be sampled for several years to compare result.

Sample collection at the GMZ area was initiated in 2000 and is conducted semiannually from the 11 wells mentioned previously. The purpose of this monitoring is to determine if contamination has migrated beyond the perimeter of the approved GMZ. The averages of the two semiannual samples collected in 2006 are shown in Table 6.24. Well 319781 was dry both quarters of 2006 so no data are shown. The individual results were transmitted to the IEPA in the quarterly LTS report.

Monitoring results from 2006 indicate that no contamination above GROs extends laterally beyond the current GMZ perimeter wells. Results from Well 317941 do exceed the GROs; however, this well does not represent the western boundary of the GMZ. 1,4-Dioxane was detected in Well MMW013 just at the GRO of 1.0 µg/L, that were also the analytical detection limit for this compound. 1,4-Dioxane is present above its detection limits and GRO value in two adjacent bedrock monitoring wells (317121D and 317951D that were installed to replace 317121D). The average 1,4-dioxane concentration in Well 317951D was 16 µg/L and in 317121D it was 2.4 µg/L. The fact that both the original and replacement well contained 1,4-dioxane above GROs tends to indicate that its presence is likely the result of migration through the glacial till overlying the bedrock, and not the result of outdated or deteriorating well construction at Well 317121D, as previously believed. Monitoring Wells 317951D and 319961D were not included in the original GMZ proposal but were installed to evaluate the adequacy of the existing dolomite wells and confirm the presence of contamination above GROs. They will continue to be monitored with data reported in subsequent quarterly reports.

The presence of 1,4-dioxane in the deepest of the GMZ wells indicates that the vertical extent of the contaminated region may not yet be defined. If subsequent monitoring of the replacement well continues to confirm the presence of contamination above GROs, it may be necessary to install a deeper well to better delineate the bottom of the contaminated region.

6.5. Sanitary Landfill

The former Argonne sanitary landfill is located in the 800 Area on the western edge of the site (see Figure 1.1). The 8.8-ha (21.8-acre) former landfill received miscellaneous solid waste from 1966 until September 1992 and was operated under IEPA Permit No. 1981-29-OP, which was issued on September 18, 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 liquid wastes from 1969 to 1978. The wastes were placed into the landfill through a French drain, which consisted of a pipe inserted into the waste mound. The liquid waste was poured into the pipe and allowed to permeate into the waste. Historic documentation indicates that 109,000 L (29,000 gal) of liquid waste was placed in this drain. Most of this material was used oil or used machining coolant (an oil-water emulsion), though small quantities of toxic wastes were also placed in the landfill.

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TABLE 6.24

Annual Average Results from the GMZ Monitoring Wells, 2006
(concentrations in µg/L, except hydrogen-3)

Parameter	Monitoring Well No.						
	319781	317951D	319961D	317121D	319131D	319801	GRO
Alpha-BHC	Dry	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
Benzene	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Carbon tetrachloride	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Chloroform	Dry	<0.2	<0.2	<0.2	<0.2	<0.2	0.2
1,1-Dichloroethane	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	700
1,2-Dichloroethane	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1-Dichloroethene	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	7.0
<i>cis</i> -1,2-Dichloroethene	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	70
1,4-Dioxane	Dry	16^a	<1.0	2.4	<1.0	<1.0	1.0
<i>bis</i> (2-ethylhexyl)phthalate	Dry	<3.0	<3.0	<3.0	<3.0	<3.0	6.0
Hydrogen-3 (pCi/L)	Dry	217	780	142	668	<100	20,000
Methylene chloride	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Nitrobenzene	Dry	<2.0	<2.0	<2.0	<2.0	<2.0	3.5
Tetrachloroethene	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1,1-Trichloroethane	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	200
1,1,2-Trichloroethane	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	0.5
Trichloroethene	Dry	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Vinyl chloride	Dry	<2.0	<1.0	<1.0	<1.0	<2.0	2.0

Parameter	Monitoring Well No.						
	317941	317971	MMW06	MMW011	MMW013	Blank	GRO
Alpha-BHC	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
Benzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Carbon tetrachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Chloroform	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2
1,1-Dichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	700
1,2-Dichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	7.0
<i>cis</i> -1,2-Dichloroethene	2.5	<1.0	<1.0	<1.0	<1.0	<1.0	70
1,4-Dioxane	4.5	<1.0	<1.0	<1.0	1.0	<1.0	1.0
<i>bis</i> (2-ethylhexyl)phthalate	<3.0	<3.0	<3.0	Dry	Dry	<3.0	6.0
Hydrogen-3 (pCi/L)	1,127	<100	490	<100	151	<100	20,000
Methylene chloride	4.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Nitrobenzene	<3.5	<3.5	<3.5	Dry	Dry	<3.5	3.5
Tetrachloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
1,1,1-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	200
1,1,2-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.5
Trichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.0
Vinyl chloride	29.8	<2.0	<2.0	<2.0	<2.0	<2.0	2.0

^a Bold type indicates that the value exceeds the GRO.

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The landfill was closed in 1992 pursuant to Permit No. 1992-002-SP and Supplemental Permit Nos. 1994-506-SP, 1997-295-SP, 1998-017-SP, 1999-107-SP, 1999-476-SP, and 2002-194-SP. Closure of the landfill and associated areas was also subject to the RCRA Corrective Action process since the landfill area included SWMU No. 4 (landfill mound), No. 20 (the French drain), No. 744 (a small area of buried waste adjacent to the main waste mound), AOC-B (wetlands immediately adjacent to the landfill), and AOC-C (leachate seeps from the waste mound). Closure included the installation of a 0.6-m (2-ft) thick compacted clay cap over the waste mounds. An RFI was required under the RCRA Corrective Action program. This RFI was conducted to determine if any hazardous materials had migrated from the landfill. It consisted of an extensive characterization program that was completed in 1997. Measurable amounts of several hazardous materials were identified in leachate in the waste mound itself and a small amount in the adjacent wetlands, but none were found in groundwater near the landfill. The study determined that no further remedial actions were required. An NFA was received from the IEPA on March 25, 2003. This letter also specified that postclosure care and all future groundwater monitoring activities at the 800 Area Landfill would be carried out under the corrective action provisions (Section V) of Argonne's RCRA Part B permit.

The 15-year postclosure care period for the landfill began in 1999. The primary requirements during postclosure are groundwater monitoring and maintenance and inspection of the landfill cap. This section discusses the groundwater monitoring results for 2006.

On October 25, 2005, the IEPA modified the RCRA corrective action permit for the 800 Area Landfill to include a set of background values for groundwater constituents upgradient of the landfill. The background values were developed from five years of monitoring results from two upgradient monitoring wells, one in the shallow glacial drift and one in the dolomite bedrock. These background levels, along with IEPA groundwater quality standards for unfiltered samples, are compared with the analytical results from landfill perimeter wells to determine if a release has occurred from the landfill. The background values are discussed in Section 6.5.1.3.

6.5.1. Sanitary Landfill Groundwater Monitoring

The current groundwater monitoring well network is shown in Figure 6.23. Table 6.25 contains a description of each active well. All wells are specially designed groundwater monitoring wells consisting of 0.05-m (2-in.) diameter stainless-steel casings and screens installed in boreholes sealed with bentonite grout, a concrete cap, and locking steel protective cover. The networks consist of three groups of wells. Fifteen shallow wells are screened in shallow glacial till between 4 and 14 m (13 and 46 ft) deep. These wells are in a series of thin porous sandy zones within the glacial drift under the 800 Area. They provide samples of the uppermost layers of groundwater under and adjacent to the landfill. Five deep wells are screened in the top of the dolomite limestone bedrock underlying the glacial till. The upper part of the dolomite bedrock represents the uppermost true aquifer under the landfill that has the potential for off-site migration of groundwater. These five wells are situated near five of the shallow wells, forming five well clusters. Two background wells (800271 and 800273D) are located in a

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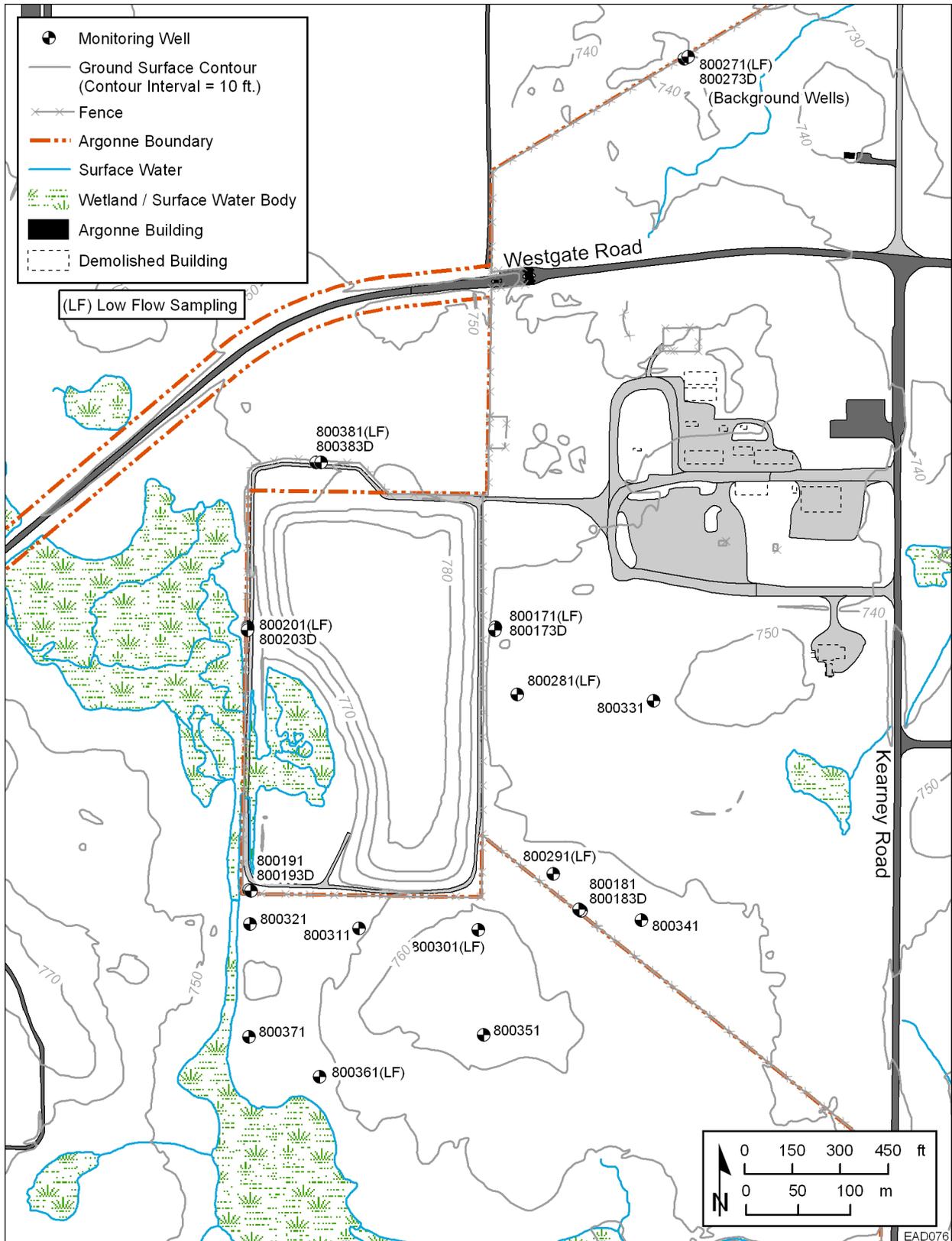


FIGURE 6.23 800 Area Landfill Monitoring Wells

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TABLE 6.25

Groundwater Monitoring Wells: 800 Area Landfill

Argonne ID Number	IEPA Well Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Date Drilled	Sampling Device
Background Wells						
800271	G16S	4.57	225.62	223.18–221.65	Aug. 1999	Low flow pump
800273D ^a	D16D	37.49	225.61	191.78–188.12	Aug. 1999	Submersible pump
Shallow Monitoring Wells						
800171	G06S	7.62	228.42	222.32–220.80	Oct. 1992	Low flow pump
800181	G08S	10.67	230.52	221.37–219.85	Oct. 1992	Bailer
800191R ^b	G11S	4.63	227.38	224.43–222.90	Sept. 2005	Bailer
800201	G14S	10.67	227.93	218.78–217.26	Oct. 1992	Low flow pump
800281	G17S	3.96	227.66	225.52–224.00	Sept. 1999	Low flow pump
800291	G18S	7.01	230.49	225.00–223.48	Sept. 1999	Low flow pump
800301	G19S	7.62	232.53	226.51–224.91	Sept. 1999	Low flow pump (Bailed Jan. and Oct.)
800321	G21S	4.27	227.93	225.26–223.66	Sept. 1999	Bailer
800331	G22S	5.18	227.93	224.27–222.75	Sept. 1999	Bailer
800341	G23S	3.96	229.97	227.53–226.01	Sept. 1999	Bailer
800351	G24S	11.89	232.75	223.91–220.86	Sept. 1999	Bailer
800361	G25S	7.01	227.24	222.12–220.52	Sept. 1999	Low flow pump (Bailed Jan. and Oct.)
800371	G26S	9.75	227.50	219.27–217.44	Sept. 1999	Bailer
800381 ^c	G03S	7.31	231.11	227.44–224.40	June 1999	Low flow pump
Dolomite Bedrock Monitoring Wells						
800173D	G06D	39.62	228.40	192.13–189.09	Oct. 2001	Submersible pump
800183D	G08D	49.99	230.37	183.43–180.38	Oct. 2001	Submersible pump
800193D	G11D	46.02	227.34	184.40–181.35	Oct. 2001	Submersible pump
800203D	G14D	38.40	227.92	192.63–189.47	Sept. 2001	Submersible pump
800383D ^c	G03D	44.50	231.24	190.39–187.35	June 2001	Submersible pump

^a Wells identified by a “D” are deeper wells monitoring the dolomite bedrock aquifer.

^b Replacement for original Well 800191.

^c Replacement wells used after July 1, 1999.

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cluster approximately 670 m (2,200 ft) to the northeast of the landfill mound. These wells are located out of the influence of the landfill and provide information on the normal background level of groundwater constituents.

Prior to 2005, the network also included four intermediate wells (800382, 800192, 800202, and 800272) that were part of three-well clusters with shallow and deep dolomite wells. These wells were usually dry and were not situated at a depth that yielded meaningful results for the monitoring program. They were removed from the network by the October 2005 RCRA permit modification. Thus, these wells are no longer included in the program and no data from them are included in this report.

The wells were installed in stages and a number of wells have been installed, monitored, and removed from the network over the last 20 years. Only the currently active wells are described in this report. The oldest set of active wells was installed in 1992 as part of the closure process. Additional wells were installed in 1999 to enhance the effectiveness of the network. Well 800191R, installed in 2005, is a replacement for the original 800191 well, which was removed because its sampling pump failed and could not be removed from the well. Well 800311, installed in 1999, has been dry since installation.

6.5.1.1. Sample Collection

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

During the early years of monitoring the landfill, it was noted that high levels of unfiltered metals were detected in samples with high levels of turbidity. The turbidity resulted from the resuspension of soil solids in the sample during the collection of samples using a baler. The baler agitates the water in the well as it is lowered into the well. It was thought that many of the high metals concentrations in shallow wells were artifacts of this type of sampling and not a result of landfill operations. To reduce this source of interference, a different type of sampling procedure was implemented. Starting in 2003, IEPA-approved low-flow sampling devices were installed in Wells 800171, 800201, 800281, 800291, 800301, 800361, and 800381 and the shallow background well 800271. This low flow sampling system allows samples to be collected at a steady, low flow rate that does not disturb the sediment in the well. The remaining wells are sampled using a baler. The wells with low flow samplers in Figure 6.26 have “(LF)” next to the well number.

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Samples from the deeper 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 samplers are not required in these wells.

Wells that are equipped with a bailer or submersible pumps are sampled after stagnant water is purged from the well by removing 3 to 5 well volumes of water out of the well. The temperature, pH, conductivity, and redox potential are measured periodically as the purging process progresses. Samples are collected after the water quality parameters have stabilized.

Wells equipped with low flow samplers are sampled once water quality parameters stabilize, regardless of the amount of water removed. The low flow sampling system pumping rate is controlled by monitoring the field parameters while pumping at a rate low enough to prevent significant drawdown of water in the well. Turbidity of the groundwater is also monitored during this process. For these wells, samples are collected after the field parameters have stabilized and turbidity has reached its target level. Field parameter values reported are those measured after purging is complete.

6.5.1.2. Sample Analyses — 800 Area

The analysis of 800 Area groundwater samples is conducted by EQO-AS as well as several commercial laboratories. The 800 Area sample analyses were performed in accordance with SOPs written, reviewed, and issued as controlled documents by members of EQO-AS. These SOPs reference protocols in EPA-SW-846²⁸ and Standard Methods.²¹ Analyses performed by commercial contractor laboratories also followed EPA-SW-846²⁸ or other EPA-approved procedures.

Fifteen metals were analyzed by using ICP atomic emission spectroscopy and graphite furnace AA spectroscopy. Mercury was determined by means of cold vapor AA spectroscopy. VOCs were determined by using purge and trap sample pretreatment, followed by GC/MS detection. SVOCs were determined by using solvent extraction followed by GC/MS detection. PCBs and pesticides were determined by means of solvent extraction followed by gas chromatography-electron capture detection. TDS were determined gravimetrically. Sulfate determination was performed by using a turbidimetric technique, while chloride was determined by UV/visible light spectrometry. Ammonia nitrogen was determined by using distillation followed by an ion-selective electrode technique. Cyanide and phenol were determined by distillation followed by a spectrophotometric measurement. TOC and TOX were determined by using combustion techniques followed by infrared detection and coulometric titration, respectively. Chlorinated organic compounds and pesticides were analyzed by extractions followed by gas and liquid chromatography techniques, respectively.

The 800 Area groundwater radiological analyses were performed by EQO-AS in accordance with approved SOPs. Hydrogen-3 was determined by means of distillation followed by a beta liquid scintillation counting technique.

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6.5.1.3. Basis for Evaluation of Analytical Results

The monitoring results are evaluated by comparing the results with applicable background values and permit limits for each constituent, where such limits exist. For routine indicator parameters (List 1 and 2), the permit requires the comparison of the individual results with a background data set (from samples collected from Wells 800271 and 800273D) that represents 21 quarters of data. These values were determined in several ways, based on the results of the 21 sets of analytical data from the background wells. For constituents that had less than 15% of the results below detection limits, the background value represents the upper 95% confidence limit for the set of data. These statistical evaluations were conducted by using the procedures outlined in the permit. For constituents where more than 15% but less than 100% of the results were below detection limits, a nonparametric technique was used to identify the background value. Where all measured concentrations were below the detection limits, the practical quantitation limits (PQLs) provided by the IEPA were used as the background value. For unfiltered metals and organic analyses, the results are compared with the GQSs for Class I Potable Resource Groundwater (35 IAC Part 620.410) where such standards exist. Otherwise, they are compared with the PQL for that compound. Table 6.26 lists all of the applicable permit limits. A number of filtered metals results do not have permit limits. These results are collected for informational purposes only and are not reported to the IEPA. In the data tables that follow, values that exceed these background values or permit limits are shown in bold print.

6.5.1.4. Results of Analyses

For each well monitored, field parameters measured during sample collection, and the results of chemical and radiological analysis of the two background wells are presented in Tables 6.27 and 6.28, the shallow landfill wells are presented in Tables 6.29 through 6.42, and the dolomite wells in Tables 6.43 through 6.47. The results for all inorganic species measured are shown in these tables. In addition to the inorganics, each well was analyzed quarterly for VOCs. The analytical method used for these compounds is able to identify and quantify all of the compounds contained in the CLP Target Compound List to concentrations of 1 to 10 µg/L. However, none were detected above the detection limits in any of the wells. These constituents are not shown in the following tables for clarity.

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TABLE 6.26

Permits Limits for 800 Area Groundwater

Parameter	Unit	Permit Limit – Shallow Wells	Source ^a	Permit Limit – Deep Wells	Source ^a
<i>Field Parameters</i>					
Conductivity	μS/cm	703	4	1,306	1
Oxid./Red. Potential	mV	NA ^b	– ^c	NA	–
pH	pH	6.57–7.88	1	6.48–7.74	1
Temperature	° C	NA	–	NA	–
Water elevation	m	NA	–	NA	–
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.90	4	1.0	4
Chloride	mg/L	20	4	137	1
Sulfate	mg/L	58.54	1	152	1
TDS	mg/L	428.45	1	880	1
Arsenic	mg/L	0.010	2	0.0048	4
Barium	mg/L	NA	–	NA	–
Boron	mg/L	NA	–	NA	–
Cadmium	mg/L	0.001	2	0.001	2
Chromium	mg/L	NA	–	NA	–
Cobalt	mg/L	NA	–	NA	–
Copper	mg/L	NA	–	NA	–
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
Nickel	mg/L	NA	–	NA	–
Selenium	mg/L	NA	–	NA	–
Silver	mg/L	NA	–	NA	–
Zinc	mg/L	NA	–	NA	–
<i>Unfiltered Samples</i>					
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
Hydrogen-3	pCi/L	NA	–	NA	–
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	5.00	3

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TABLE 6.26 (Cont.)

Parameter	Unit	Permit Limit – Shallow Wells	Source ^a	Permit Limit – Deep Wells	Source ^a
<i>Unfiltered Samples (Cont.)</i>					
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 data set, less than 15% below detection limits. Calculation uses one-half the detection limits for values less than the detection limits.

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

3 = IEPA's Class 1 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.

^b NA indicates that no permit limit exists for this constituent. The data are collected for informational purposes only.

^c A dash indicates that no limit exists and thus listing a source is not necessary.

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TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Background Well 800271, 2006

Parameter	Unit	Date of Sampling			
		1/25/2006	5/2/2006	7/18/2006	10/17/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	742^a	523	683	579
Oxid./Red. Potential	mV	-24	-72	-7	-7
pH	pH	7.36	8.23	7.09	7.1
Temperature	° C	7.2	10.6	18.6	13.9
Water elevation ^b	m	223.00	224.86	223.64	225.27
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	< 0.05	< 0.05	< 0.05	0.05
Chloride	mg/L	3.0	3.0	3.0	5.0
Sulfate	mg/L	88	40	57	33
TDS	mg/L	481	327	416	256
Arsenic	mg/L	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	0.014	0.019	0.018
Boron	mg/L	< 0.5	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	2	3	3	4
Cyanide (Total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	- ^c	0.266	-	-
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	1.9	-	-
Phenols	mg/L	< 0.005	0.005	< 0.005	< 0.005
Sulfate	mg/L	100	41	57	31
TOCs (max. of 4 samples)	mg/L	1.3	1.6	1.2	2.2
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.020	< 0.020
Arsenic	mg/L	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	< 0.012	0.02	0.019
Boron	mg/L	< 0.5	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	0.103	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 221.65 m (MSL); ground surface elevation = 225.62 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

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TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Background Well 800273D, 2006

Parameter	Unit	Date of Sampling				
		1/10/2006	4/10/2006	7/18/2006	10/17/2006	10/17/2006 (Duplicate)
<i>Field Parameters</i>						
Conductivity	µS/cm	1,020	1,048	1,044	1,081	1,081
Oxid./Red. Potential	mV	8	-23	-7	-5	-5
pH	pH	6.72	7.38	7.08	7.07	7.07
Temperature	°C	10.0	13.2	12.8	11.6	11.6
Water elevation ^a	m	192.27	192.45	192.53	192.84	192.84
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.81	0.76	0.93	0.85	0.80
Chloride	mg/L	85	90	94	106	103
Sulfate	mg/L	106	116	115	132	127
TDS	mg/L	813^{b,c}	679	703	584	609
Arsenic	mg/L	< 0.025^c	< 0.003	0.008	0.006	0.006
Barium	mg/L	< 0.5	0.044	0.048	0.048	0.048
Boron	mg/L	< 0.5	0.155	0.152	0.147	0.143
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	0.70	0.56	1.58	1.16	1.25
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	0.011	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>						
Chloride	mg/L	– ^d	96	–	–	–
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.457	–	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	–	–	–
Phenols	mg/L	< 0.005	< 0.005	0.0093	0.018	< 0.005
Sulfate	mg/L	–	116	–	–	–
TOCs (max. of 4 samples)	mg/L	1.3	1.3	1.3	1.8	1.5
TOXs (max. of 2 samples)	mg/L	0.022	< 0.02	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	–	0.004	–	–	–
Barium	mg/L	–	0.046	–	–	–
Boron	mg/L	–	0.178	–	–	–
Cadmium	mg/L	–	< 0.0002	–	–	–
Chromium	mg/L	–	< 0.05	–	–	–
Cobalt	mg/L	–	< 0.25	–	–	–
Copper	mg/L	–	< 0.025	–	–	–
Iron	mg/L	–	1.14	–	–	–
Lead	mg/L	–	< 0.004	–	–	–
Manganese	mg/L	–	0.017	–	–	–
Mercury	mg/L	–	< 0.0002	–	–	–
Nickel	mg/L	–	< 0.05	–	–	–
Selenium	mg/L	–	< 0.015	–	–	–
Silver	mg/L	–	< 0.001	–	–	–
Zinc	mg/L	–	< 0.02	–	–	–

^a Well point elevation = 188.12 m (MSL); ground surface elevation = 225.61 m (MSL); casing material = stainless steel.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^c Preliminary values of 937 mg/L for TDS and 0.00117 mg/L for arsenic were reported as exceedances in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 2006

Parameter	Unit	Date of Sampling			
		1/25/2006	5/1/2006	7/25/2006	10/25/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	1,366^a	1,090	1,138	1,072
Oxid./Red. Potential	mV	3	-3	7	14
pH	pH	6.92	6.89	6.85	6.72
Temperature	° C	8.9	10.4	17.2	12.6
Water elevation ^b	m	224.80	227.12	224.61	226.98
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.06	< 0.05	< 0.05	0.15
Chloride	mg/L	114	110	79	94
Sulfate	mg/L	99	76	94	73
TDS	mg/L	864	674	793	616
Arsenic	mg/L	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.50	0.057	0.058	0.058
Boron	mg/L	< 0.50	0.114	0.131	0.151
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	<0.50^c	< 0.021	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.01	< 0.01	< 0.01
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.50	< 0.020	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	114	110	86	94
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	- ^d	0.258	-	-
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	2.7	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	91	72	85	72
TOCs (max. of 4 samples)	mg/L	4.3	3.2	2.6	3.3
TOXs (max. of 2 samples)	mg/L	0.041	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.50	0.061	0.061	0.063
Boron	mg/L	< 0.50	0.124	0.158	0.184
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	0.680	0.751	0.037	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	0.063	< 0.01	0.011
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.050	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.50	< 0.020	< 0.02	< 0.02

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 220.80 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

^c A preliminary value of 0.68 was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 2006

Parameter	Unit	Date of Sampling				
		2/6/2006	4/25/2006	7/25/2006	7/25/2006 (Duplicate)	10/24/2006
<i>Field Parameters</i>						
Conductivity	µS/cm	Dry	894^a	1,427	1,427	1,270
Oxid./Red. Potential	mV	Dry	-43	-22	-22	-23
pH	pH	Dry	7.68	7.36	7.36	7.38
Temperature	°C	Dry	9.3	11.9	11.9	9.8
Water elevation ^b	m	Dry	227.56	223.60	223.60	227.66
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	Dry	< 0.05	< 0.05	<0.05	0.09
Chloride	mg/L	Dry	8	10	9	8
Sulfate	mg/L	Dry	106	181	171	107
TDS	mg/L	Dry	620	962	918	595
Arsenic	mg/L	Dry	< 0.008	0.006	0.005	0.008
Barium	mg/L	Dry	0.023	0.044	0.046	0.032
Boron	mg/L	Dry	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.021	< 0.021	< 0.021	< 0.021
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	< 0.010	< 0.01	< 0.01	< 0.01
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	Dry	< 0.003	< 0.015	< 0.015	< 0.003
Silver	mg/L	Dry	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	Dry	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>						
Chloride	mg/L	Dry	8	- ^c	-	-
Cyanide (total)	mg/L	Dry	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	Dry	1.158	-	-	-
Hydrogen-3	pCi/L	Dry	< 100	< 100	< 100	< 100
Nitrate	mg/L	Dry	< 0.1	-	-	-
Phenols	mg/L	Dry	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	Dry	101	-	-	-
TOCs (max. of 4 samples)	mg/L	Dry	3.2	3.0	3.7	3.2
TOXs (max. of 2 samples)	mg/L	Dry	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	Dry	0.008	-	-	-
Barium	mg/L	Dry	0.023	-	-	-
Boron	mg/L	Dry	< 0.1	-	-	-
Cadmium	mg/L	Dry	< 0.0002	-	-	-
Chromium	mg/L	Dry	<0.05	-	-	-
Cobalt	mg/L	Dry	< 0.25	-	-	-
Copper	mg/L	Dry	< 0.025	-	-	-
Iron	mg/L	Dry	0.703	-	-	-
Lead	mg/L	Dry	< 0.004	-	-	-
Manganese	mg/L	Dry	0.013	-	-	-
Mercury	mg/L	Dry	< 0.0002	-	-	-
Nickel	mg/L	Dry	< 0.05	-	-	-
Selenium	mg/L	Dry	< 0.003	-	-	-
Silver	mg/L	Dry	< 0.001	-	-	-
Zinc	mg/L	Dry	< 0.02	-	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 219.85 m (MSL); ground surface elevation = 230.52 m; casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800191R, 2006

Parameter	Unit	Date of Sampling			
		1/9/2006	4/4/2006	7/12/2006	10/9/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	2,240^a	2,330	2,160	1,981
Oxid./Red. Potential	mV	6	-7	22	22
pH	pH	6.62	6.74	6.58	6.58
Temperature	° C	9.0	9.2	12.2	14.3
Water elevation ^b	m	225.40	226.03	225.65	225.80
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.31	0.25	<0.05	0.08
Chloride	mg/L	73	92	96	86
Sulfate	mg/L	924	696	745	692
TDS	mg/L	1,908	1,645	1,800	1,536
Arsenic	mg/L	<0.025^c	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	0.04	0.036	0.031
Boron	mg/L	< 0.5	< 0.10	< 0.1	< 0.1
Cadmium	mg/L	0.0027	< 0.0002	0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	0.058	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	1.48	0.173	0.466
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.533	1.49	1.25	1.4
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.03	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.020	< 0.020	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	– ^d	119	–	–
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.714	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	103
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	713	–	–
TOCs (max. of 4 samples)	mg/L	5.7	5.3	4.6	4.6
TOXs (max. of 2 samples)	mg/L	0.037	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	0.0275	< 0.003	–	–
Barium	mg/L	< 0.5	0.054	–	–
Boron	mg/L	< 0.5	< 0.10	–	–
Cadmium	mg/L	0.0025	0.0007	–	–
Chromium	mg/L	0.07	< 0.05	–	–
Cobalt	mg/L	< 0.25	< 0.25	–	–
Copper	mg/L	0.068	< 0.025	–	–
Iron	mg/L	16.78	3.791	–	–
Lead	mg/L	0.004	< 0.004	–	–
Manganese	mg/L	0.625	1.683	–	–
Mercury	mg/L	< 0.0002	< 0.0002	–	–
Nickel	mg/L	0.052	< 0.05	–	–
Selenium	mg/L	< 0.01	< 0.03	–	–
Silver	mg/L	< 0.0025	< 0.001	–	–
Zinc	mg/L	< 0.5	< 0.020	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 222.90 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

^c A preliminary value of 0.021 mg/L for filtered arsenic was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 2006

Parameter	Unit	Date of Sampling				
		2/1/2006	5/2/2006	7/26/2006	7/26/2006 (Duplicate)	10/16/2006
<i>Field Parameters</i>						
Conductivity	µS/cm	1,110^a	1,088	1,103	1,103	1,089
Oxid./Red. Potential	mV	1	-35	8	8	7
pH	pH	6.97	7.51	6.84	6.84	6.86
Temperature	°C	10.0	12.5	16.1	16.1	11.2
Water elevation ^b	m	223.13	224.01	224.03	224.03	224.42
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	3.0	2.2	3.9	3.9	3.3
Chloride	mg/L	15	18	20	21	34
Sulfate	mg/L	73	71	82	78	70
TDS	mg/L	761	746	755	756	630
Arsenic	mg/L	<0.025	0.004	0.009	0.009	0.007
Barium	mg/L	<0.5	0.244	0.267	0.269	0.243
Boron	mg/L	<0.5	<0.1	<0.1	<0.1	<0.1
Cadmium	mg/L	<0.0025	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25
Copper	mg/L	<0.025	<0.025	<0.025	<0.025	<0.025
Iron	mg/L	2.20	0.176	2.96	3.41	1.77
Lead	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Manganese	mg/L	0.224	0.117	0.148	0.145	0.140
Mercury	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	mg/L	<0.01	<0.015	<0.015	<0.015	<0.003
Silver	mg/L	<0.0025	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	<0.5	<0.02	<0.02	<0.02	<0.02
<i>Unfiltered Samples</i>						
Chloride	mg/L	16	18	20	20	35
Cyanide (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride	mg/L	- ^c	0.407	-	-	-
Hydrogen-3	pCi/L	103	<100	<100	<100	<100
Nitrate	mg/L	-	0.54	-	-	-
Phenols	mg/L	<0.005	<0.005	<0.005	<0.005	0.012
Sulfate	mg/L	84	78	77	75	83
TOCs (max. of 4 samples)	mg/L	31	27	29	29	30
TOXs (max. of 2 samples)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020
Arsenic	mg/L	<0.025	0.005	0.008	0.009	0.007
Barium	mg/L	<0.5	0.24	0.271	0.28	0.262
Boron	mg/L	<0.5	<0.1	<0.1	<0.1	<0.1
Cadmium	mg/L	<0.0025	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Cobalt	mg/L	<0.25	<0.25	<0.25	<0.25	<0.25
Copper	mg/L	<0.025	<0.025	<0.025	<0.025	<0.025
Iron	mg/L	2.19	0.89	3.21	3.69	2.94
Lead	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004
Manganese	mg/L	0.232	0.097	0.164	0.161	0.164
Mercury	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	mg/L	<0.01	<0.015	<0.015	<0.015	<0.003
Silver	mg/L	<0.0025	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	<0.5	<0.02	<0.02	<0.02	<0.02

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 217.26 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800281, 2006

Parameter	Unit	Date of Sampling			
		2/6/2006	4/18/2006	7/19/2006	10/18/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	Dry	1,685^a	1,549	1,413
Oxid./Red. Potential	mV	Dry	32	24	21
pH	pH	Dry	6.55	6.54	6.59
Temperature	° C	Dry	10.1	17.8	13.6
Water elevation ^b	m	Dry	225.88	225.06	226.13
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	Dry	< 0.05	< 0.05	0.13
Chloride	mg/L	Dry	77	104	88
Sulfate	mg/L	Dry	244	111	108
TDS	mg/L	Dry	1,167	1,089	870
Arsenic	mg/L	Dry	< 0.003	< 0.003	< 0.003
Barium	mg/L	Dry	0.051	0.068	0.082
Boron	mg/L	Dry	0.262	0.296	0.309
Cadmium	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.021	< 0.021	0.061
Lead	mg/L	Dry	< 0.004	0.004	0.004
Manganese	mg/L	Dry	0.017	0.425	0.700
Mercury	mg/L	Dry	< 0.0002	0.0002	0.0002
Nickel	mg/L	Dry	< 0.05	0.05	0.197
Selenium	mg/L	Dry	< 0.015	0.015	0.003
Silver	mg/L	Dry	< 0.001	0.001	0.001
Zinc	mg/L	Dry	< 0.02	0.02	0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	Dry	78	102	89
Cyanide (total)	mg/L	Dry	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	Dry	0.338	- ^c	-
Hydrogen-3	pCi/L	Dry	262	282	238
Nitrate	mg/L	Dry	< 0.1	-	-
Phenols	mg/L	Dry	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	Dry	250	144	104
TOCs	mg/L	Dry	3.7	4.1	4.5
TOXs	mg/L	Dry	0.021	0.037	0.056
Arsenic	mg/L	Dry	< 0.003	< 0.003	< 0.003
Barium	mg/L	Dry	0.056	0.071	0.088
Boron	mg/L	Dry	0.293	0.309	0.352
Cadmium	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.021	0.117	0.246
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	0.020	0.444	0.759
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	0.234
Selenium	mg/L	Dry	< 0.015	< 0.015	< 0.003
Silver	mg/L	Dry	< 0.001	< 0.001	< 0.001
Zinc	mg/L	Dry	< 0.02	< 0.02	< 0.02

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 224.00 m (MSL); ground surface elevation = 227.66 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800291, 2006

Parameter	Unit	Date of Sampling			
		1/17/2006	4/11/2006	7/19/2006	10/18/2006
<i>Field Parameters</i>					
Conductivity	μS/cm	1,132^a	1,172	1,164	1,113
Oxid./red. potential	mV	-12	0	-1	-2
pH	pH	6.95	7.12	7.00	7.01
Temperature	°C	8.0	10.9	15.0	12.5
Water elevation ^b	m	225.04	227.58	227.19	228.00
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.09	< 0.05	< 0.05	0.15
Chloride	mg/L	7	12	10	9
Sulfate	mg/L	191	183	237	211
TDS	mg/L	755	753	800	675
Arsenic	mg/L	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	0.024	0.023	0.022
Boron	mg/L	< 0.5	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	0.095	< 0.021	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.133	0.084	0.047	0.094
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02
<i>Unfiltered Sample</i>					
Chloride	mg/L	7	11	10	9
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	- ^c	0.457	-	-
Hydrogen-3	pCi/L	233	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	195	185	218	207
TOCs (max. of 4 samples)	mg/L	2.1	2.2	2.1	2.4
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.020	< 0.020
Arsenic	mg/L	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	0.025	0.024	0.024
Boron	mg/L	< 0.5	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	0.812	0.221	0.082	0.088
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.141	0.086	0.057	0.118
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 223.48 m (MSL); ground surface elevation = 230.49 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800301, 2006

Parameter	Unit	Date of Sampling			
		1/16/2006	4/10/2006	8/2/2006	10/31/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	1,067^a	Dry	1,027	1,029
Oxid./Red. Potential	mV	-10	Dry	5	5
pH	pH	6.91	Dry	6.89	6.89
Temperature	°C	10.4	Dry	19.3	9.9
Water elevation ^b	m	226.35	Dry	226.36	225.90
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.12	Dry	0.18	0.14
Chloride	mg/L	7	Dry	9	7
Sulfate	mg/L	174	Dry	153	150
TDS	mg/L	724	Dry	698	595
Arsenic	mg/L	< 0.025	Dry	< 0.003	< 0.003
Barium	mg/L	< 0.5	Dry	0.022	< 0.02
Boron	mg/L	< 0.5	Dry	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	Dry	< 0.0002	0.0006
Chromium	mg/L	< 0.05	Dry	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	Dry	< 0.25	< 0.25
Copper	mg/L	< 0.025	Dry	< 0.025	< 0.025
Iron	mg/L	< 0.5^c	Dry	0.604	0.173
Lead	mg/L	< 0.004	Dry	< 0.004	< 0.004
Manganese	mg/L	0.166	Dry	0.116	0.138
Mercury	mg/L	< 0.0002	Dry	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	Dry	< 0.05	< 0.05
Selenium	mg/L	< 0.01	Dry	< 0.015	< 0.003
Silver	mg/L	< 0.0025	Dry	< 0.001	< 0.001
Zinc	mg/L	< 0.5	Dry	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	7	Dry	14	8
Cyanide (total)	mg/L	< 0.01	Dry	< 0.01	< 0.01
Fluoride	mg/L	- ^d	Dry	-	-
Hydrogen-3	pCi/L	< 100	Dry	< 100	< 100
Nitrate	mg/L	-	Dry	-	-
Phenols	mg/L	< 0.005	Dry	0.0051	< 0.005
Sulfate	mg/L	181	Dry	140	142
TOCs (max. of 4 samples)	mg/L	1.9	Dry	1.5	1.7
TOXs (max. of 2 samples)	mg/L	< 0.02	Dry	< 0.02	< 0.02
Arsenic	mg/L	< 0.025	Dry	< 0.003	0.027
Barium	mg/L	< 0.5	Dry	0.022	0.115
Boron	mg/L	< 0.5	Dry	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	Dry	< 0.0002	0.0019
Chromium	mg/L	< 0.05	Dry	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	Dry	< 0.25	< 0.25
Copper	mg/L	< 0.025	Dry	< 0.025	0.045
Iron	mg/L	1.10	Dry	0.578	39.8
Lead	mg/L	< 0.004	Dry	< 0.004	0.041
Manganese	mg/L	0.176	Dry	0.125	0.889
Mercury	mg/L	< 0.0002	Dry	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	Dry	< 0.05	< 0.05
Selenium	mg/L	< 0.01	Dry	< 0.015	< 0.003
Silver	mg/L	< 0.0025	Dry	< 0.001	< 0.001
Zinc	mg/L	< 0.5	Dry	< 0.02	0.039

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 224.91 m (MSL); ground surface elevation = 232.53 m (MSL); casing material = stainless steel.

^c A preliminary filtered iron value of 0.217 mg/L was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800321, 2006

Parameter	Unit	Date of Sampling			
		2/6/2006	4/17/2006	8/1/2006	10/24/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	Dry	1,184^a	1,998	2,080
Oxid./red. potential	mV	Dry	11	12	12
pH	pH	Dry	6.92	6.75	6.77
Temperature	°C	Dry	9.1	13.1	12.8
Water elevation ^b	m	Dry	226.43	224.23	225.35
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	Dry	0.14	< 0.05	0.36
Chloride	mg/L	Dry	18	35	35
Sulfate	mg/L	Dry	282	992	1,119
TDS	mg/L	Dry	787	1,972	2,025
Arsenic	mg/L	Dry	< 0.003	< 0.003	< 0.003
Barium	mg/L	Dry	0.018	0.013	0.015
Boron	mg/L	Dry	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	Dry	< 0.0002	0.0025	< 0.0002
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.021	< 0.021	< 0.021
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	< 0.01	0.041	< 0.01
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05
Selenium	mg/L	Dry	< 0.015	< 0.015	< 0.003
Silver	mg/L	Dry	< 0.001	< 0.001	< 0.001
Zinc	mg/L	Dry	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	Dry	22	- ^c	-
Cyanide (total)	mg/L	Dry	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	Dry	0.471	-	-
Hydrogen-3	pCi/L	Dry	< 100	< 100	< 100
Nitrate	mg/L	Dry	< 0.1	-	-
Phenols	mg/L	Dry	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	Dry	371	-	-
TOCs (max. of 4 samples)	mg/L	Dry	3.3	2.2	2.5
TOXs (max. of 2 samples)	mg/L	Dry	< 0.02	< 0.02	0.02
Arsenic	mg/L	Dry	< 0.003	-	-
Barium	mg/L	Dry	0.03	-	-
Boron	mg/L	Dry	< 0.1	-	-
Cadmium	mg/L	Dry	< 0.0002	-	-
Chromium	mg/L	Dry	< 0.05	-	-
Cobalt	mg/L	Dry	< 0.25	-	-
Copper	mg/L	Dry	< 0.025	-	-
Iron	mg/L	Dry	4.78	-	-
Lead	mg/L	Dry	< 0.004	-	-
Manganese	mg/L	Dry	0.092	-	-
Mercury	mg/L	Dry	< 0.0002	-	-
Nickel	mg/L	Dry	< 0.05	-	-
Selenium	mg/L	Dry	< 0.015	-	-
Silver	mg/L	Dry	< 0.001	-	-
Zinc	mg/L	Dry	< 0.02	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 223.66 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800331, 2006

Parameter	Unit	Date of Sampling			
		2/6/2006	4/10/2006	7/11/2006	10/10/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	Dry	1,026^a	993	967
Oxid./red. potential	mV	Dry	-1	-8	-18
pH	pH	Dry	7.16	7.13	7.29
Temperature	°C	Dry	9.5	11.3	12.4
Water elevation ^b	m	Dry	226.25	225.86	226.39
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	Dry	0.07	< 0.05	0.08
Chloride	mg/L	Dry	6	12	6
Sulfate	mg/L	Dry	188	170	189
TDS	mg/L	Dry	655	659	537
Arsenic	mg/L	Dry	< 0.003	< 0.003	< 0.003
Barium	mg/L	Dry	0.047	0.036	0.03
Boron	mg/L	Dry	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.021	< 0.021	< 0.021
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	< 0.010	< 0.010	0.090
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05
Selenium	mg/L	Dry	< 0.015	< 0.015	< 0.003
Silver	mg/L	Dry	< 0.001	< 0.001	< 0.001
Zinc	mg/L	Dry	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	Dry	6	– ^c	–
Cyanide (total)	mg/L	Dry	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	Dry	0.448	–	–
Hydrogen-3	pCi/L	Dry	< 100	< 100	< 100
Nitrate	mg/L	Dry	< 0.1	–	–
Phenols	mg/L	Dry	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	Dry	192	–	–
TOCs (max. of 4 samples)	mg/L	Dry	1.6	1.6	1.9
TOXs (max. of 2 samples)	mg/L	Dry	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	Dry	< 0.003	–	–
Barium	mg/L	Dry	0.052	–	–
Boron	mg/L	Dry	< 0.1	–	–
Cadmium	mg/L	Dry	< 0.0002	–	–
Chromium	mg/L	Dry	< 0.05	–	–
Cobalt	mg/L	Dry	< 0.25	–	–
Copper	mg/L	Dry	< 0.025	–	–
Iron	mg/L	Dry	1.828	–	–
Lead	mg/L	Dry	< 0.004	–	–
Manganese	mg/L	Dry	0.048	–	–
Mercury	mg/L	Dry	< 0.0002	–	–
Nickel	mg/L	Dry	< 0.05	–	–
Selenium	mg/L	Dry	< 0.015	–	–
Silver	mg/L	Dry	< 0.001	–	–
Zinc	mg/L	Dry	< 0.02	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 222.75 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well 800341, 2006

Parameter	Unit	Date of Sampling			
		2/6/2006	4/24/2006	7/11/2006	10/10/2006
<i>Field Parameters</i>					
Conductivity	μS/cm	Dry	822^a	910	984
Oxid./red. potential	mV	Dry	-29	-22	-14
pH	pH	Dry	7.41	7.36	7.23
Temperature	°C	Dry	7.9	11.9	13.2
Water elevation ^b	m	Dry	229.45	228.58	229.32
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	Dry	< 0.05	< 0.05	0.05
Chloride	mg/L	Dry	10	12	12
Sulfate	mg/L	Dry	172	196	254
TDS	mg/L	Dry	522	633	579
Arsenic	mg/L	Dry	< 0.003	< 0.003	< 0.003
Barium	mg/L	Dry	0.023	0.028	0.032
Boron	mg/L	Dry	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	< 0.021	< 0.021	< 0.021
Lead	mg/L	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	< 0.01	< 0.01	0.042
Mercury	mg/L	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	< 0.05	< 0.05	< 0.05
Selenium	mg/L	Dry	< 0.015	< 0.015	< 0.003
Silver	mg/L	Dry	< 0.001	< 0.001	< 0.001
Zinc	mg/L	Dry	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	Dry	10	- ^c	-
Cyanide (total)	mg/L	Dry	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	Dry	0.446	-	-
Hydrogen-3	pCi/L	Dry	< 100	< 100	< 100
Nitrate	mg/L	Dry	0.9	-	-
Phenols	mg/L	Dry	< 0.005	< 0.005	0.0051
Sulfate	mg/L	Dry	177	-	-
TOCs (max. of 4 samples)	mg/L	Dry	3.8	3.1	2.5
TOXs (max. of 2 samples)	mg/L	Dry	0.031	< 0.02	< 0.02
Arsenic	mg/L	Dry	< 0.003	-	-
Barium	mg/L	Dry	0.026	-	-
Boron	mg/L	Dry	< 0.1	-	-
Cadmium	mg/L	Dry	< 0.0002	-	-
Chromium	mg/L	Dry	< 0.05	-	-
Cobalt	mg/L	Dry	< 0.25	-	-
Copper	mg/L	Dry	< 0.025	-	-
Iron	mg/L	Dry	1.36	-	-
Lead	mg/L	Dry	< 0.004	-	-
Manganese	mg/L	Dry	0.021	-	-
Mercury	mg/L	Dry	< 0.0002	-	-
Nickel	mg/L	Dry	< 0.05	-	-
Selenium	mg/L	Dry	< 0.015	-	-
Silver	mg/L	Dry	< 0.001	-	-
Zinc	mg/L	Dry	< 0.02	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 226.01 m (MSL); ground surface elevation = 229.97 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well 800351, 2006

Parameter	Unit	Date of Sampling				
		1/16/2006	4/4/2006	4/4/2006 (Duplicate)	7/12/2006	10/11/2006
<i>Field Parameters</i>						
Conductivity	µS/cm	918^a	909	909	907	901
Oxid./red. potential	mV	-21	-36	-36	-13	-7
pH	pH	7.12	7.27	7.27	7.21	7.08
Temperature	°C	10.3	13.3	13.3	12.7	10.3
Water elevation ^b	m	224.72	224.47	224.47	224.42	224.56
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.35	0.36	0.42	0.33	0.29
Chloride	mg/L	4	5	4	5	4
Sulfate	mg/L	55	54	53	50	52
TDS	mg/L	566	553	553	555	450
Arsenic	mg/L	< 0.025	0.003	0.004	0.004	0.004
Barium	mg/L	< 0.5	0.089	0.09	0.088	0.085
Boron	mg/L	< 0.5	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.021	< 0.021	0.056	0.154
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075^c	0.025	0.025	0.024	0.022
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>						
Chloride	mg/L	– ^d	5	5	–	–
Cyanide (total)	mg/L	< 0.01	0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.317	0.347	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	57	56	–	–
TOCs (max. of 4 samples)	mg/L	3.3	2.4	2.4	2.2	2.0
TOXs (max. of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	–	0.023	0.020	–	–
Barium	mg/L	–	0.194	0.187	–	–
Boron	mg/L	–	0.142	0.128	–	–
Cadmium	mg/L	–	0.0003	0.0005	–	–
Chromium	mg/L	–	0.051	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	< 0.25	–	–
Copper	mg/L	–	0.04	0.039	–	–
Iron	mg/L	–	45.02	43.05	–	–
Lead	mg/L	–	0.035	0.021	–	–
Manganese	mg/L	–	0.888	0.868	–	–
Mercury	mg/L	–	< 0.0002	< 0.0002	–	–
Nickel	mg/L	–	0.058	0.052	–	–
Selenium	mg/L	–	< 0.015	< 0.015	–	–
Silver	mg/L	–	< 0.001	< 0.001	–	–
Zinc	mg/L	–	0.023	0.023	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 220.86 m (MSL); ground surface elevation = 232.75 m (MSL); casing material = stainless steel.

^c A preliminary value of 0.166 mg/L for manganese was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well 800361, 2006

Parameter	Unit	Date of Sampling			
		1/10/2006	5/5/2006	8/1/2006	10/30/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	912^a	Dry	2,320	1,902
Oxid./Red. Potential	mV	-20	Dry	12	10
pH	pH	7.09	Dry	6.75	6.80
Temperature	° C	8.4	Dry	20.4	11.8
Water elevation ^b	m	221.31	Dry	221.40	221.30
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.07	Dry	< 0.05	0.17
Chloride	mg/L	14	Dry	19	12
Sulfate	mg/L	147	Dry	1,508	1,010
TDS	mg/L	610	Dry	2,376	1,787
Arsenic	mg/L	< 0.025	Dry	< 0.003	< 0.003
Barium	mg/L	< 0.5	Dry	0.015	0.013
Boron	mg/L	< 0.5	Dry	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	Dry	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	Dry	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	Dry	< 0.25	< 0.25
Copper	mg/L	< 0.025	Dry	< 0.025	< 0.025
Iron	mg/L	< 0.5	Dry	< 0.021	< 0.021
Lead	mg/L	< 0.004	Dry	< 0.004	< 0.004
Manganese	mg/L	0.123	Dry	0.226	0.314
Mercury	mg/L	< 0.0002	Dry	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	Dry	< 0.05	< 0.05
Selenium	mg/L	< 0.01	Dry	< 0.015	< 0.015
Silver	mg/L	< 0.0025	Dry	< 0.001	< 0.001
Zinc	mg/L	< 0.5	Dry	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	15	Dry	18	14
Cyanide (total)	mg/L	< 0.01	Dry	< 0.01	< 0.01
Fluoride	mg/L	- ^c	Dry	-	-
Hydrogen-3	pCi/L	< 100	Dry	< 100	< 100
Nitrate	mg/L	-	Dry	-	-
Phenols	mg/L	< 0.005	Dry	< 0.005	< 0.005
Sulfate	mg/L	159	Dry	1473	986
TOCs (max. of 4 samples)	mg/L	1.7	Dry	2.4	1.8
TOXs (max. of 2 samples)	mg/L	< 0.02	Dry	< 0.02	< 0.02
Arsenic	mg/L	< 0.025	Dry	< 0.003	0.04
Barium	mg/L	< 0.5	Dry	< 0.017	0.15
Boron	mg/L	< 0.5	Dry	< 0.1	0.109
Cadmium	mg/L	< 0.0025	Dry	< 0.0002	0.0008
Chromium	mg/L	0.0586	Dry	< 0.05	0.057
Cobalt	mg/L	< 0.25	Dry	< 0.25	< 0.25
Copper	mg/L	0.0684	Dry	< 0.025	0.075
Iron	mg/L	46.19	Dry	0.276	73.7
Lead	mg/L	0.028	Dry	< 0.004	0.044
Manganese	mg/L	0.9162	Dry	0.363	2.39
Mercury	mg/L	< 0.0002	Dry	< 0.0002	0.0002
Nickel	mg/L	< 0.05	Dry	< 0.05	0.076
Selenium	mg/L	< 0.01	Dry	< 0.015	< 0.015
Silver	mg/L	< 0.0025	Dry	< 0.001	< 0.001
Zinc	mg/L	< 0.5	Dry	< 0.02	< 0.02

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 220.52 m (MSL); ground surface elevation = 227.24 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well 800371, 2006

Parameter	Unit	Date of Sampling				
		2/6/2006	5/5/2006	8/1/2006	10/30/2006	10/30/2006 (Duplicate)
Field Parameters						
Conductivity	µS/cm	Dry	Dry	2,180^a	2,160	2,160
Oxid./red. potential	mV	Dry	Dry	11	13	13
pH	pH	Dry	Dry	6.77	6.73	6.73
Temperature	° C	Dry	Dry	12.7	11.0	11.0
Water elevation ^b	m	Dry	Dry	218.07	218.40	218.40
Filtered Samples						
Ammonia nitrogen	mg/L	Dry	Dry	0.23	0.14	0.13
Chloride	mg/L	Dry	Dry	3	3	3
Sulfate	mg/L	Dry	Dry	1,045	1,098	955
TDS	mg/L	Dry	Dry	2,065	2,234	1,812
Arsenic	mg/L	Dry	Dry	< 0.003	< 0.003	0.004
Barium	mg/L	Dry	Dry	0.024	0.018	0.018
Boron	mg/L	Dry	Dry	0.114	0.116	0.116
Cadmium	mg/L	Dry	Dry	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	Dry	Dry	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	Dry	Dry	< 0.25	< 0.25	< 0.25
Copper	mg/L	Dry	Dry	< 0.025	< 0.025	< 0.025
Iron	mg/L	Dry	Dry	0.290	0.501	1.27
Lead	mg/L	Dry	Dry	< 0.004	< 0.004	< 0.004
Manganese	mg/L	Dry	Dry	0.292	0.357	0.258
Mercury	mg/L	Dry	Dry	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	Dry	Dry	< 0.05	< 0.05	< 0.05
Selenium	mg/L	Dry	Dry	< 0.015	< 0.015	< 0.015
Silver	mg/L	Dry	Dry	< 0.001	< 0.001	< 0.001
Zinc	mg/L	Dry	Dry	< 0.02	< 0.02	< 0.02
Unfiltered Samples						
Chloride	mg/L	Dry	Dry	– ^c	–	–
Cyanide (total)	mg/L	Dry	Dry	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	Dry	Dry	–	–	–
Hydrogen-3	pCi/L	Dry	Dry	< 100	240	< 100
Nitrate	mg/L	Dry	Dry	–	–	–
Phenols	mg/L	Dry	Dry	0.0051	< 0.005	< 0.005
Sulfate	mg/L	Dry	Dry	–	–	–
TOCs (max. of 4 samples)	mg/L	Dry	Dry	2.5	1.8	2.1
TOXs (max. of 2 samples)	mg/L	Dry	Dry	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	Dry	Dry	–	–	–
Barium	mg/L	Dry	Dry	–	–	–
Boron	mg/L	Dry	Dry	–	–	–
Cadmium	mg/L	Dry	Dry	–	–	–
Chromium	mg/L	Dry	Dry	–	–	–
Cobalt	mg/L	Dry	Dry	–	–	–
Copper	mg/L	Dry	Dry	–	–	–
Iron	mg/L	Dry	Dry	–	–	–
Lead	mg/L	Dry	Dry	–	–	–
Manganese	mg/L	Dry	Dry	–	–	–
Mercury	mg/L	Dry	Dry	–	–	–
Nickel	mg/L	Dry	Dry	–	–	–
Selenium	mg/L	Dry	Dry	–	–	–
Silver	mg/L	Dry	Dry	–	–	–
Zinc	mg/L	Dry	Dry	–	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 217.44 m (MSL); ground surface elevation = 227.50 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill Well 800381, 2006

Parameter	Unit	Date of Sampling				
		1/26/2006	1/26/2006 (Duplicate)	5/2/2006	7/18/2006	10/23/2006
<i>Field Parameters</i>						
Conductivity	µS/cm	1,267^a	1,267	1,659	1,591	1,526
Oxid./Red. Potential	mV	0	0	-28	16	19
pH	pH	6.93	6.93	7.36	6.69	6.62
Temperature	°C	10.3	10.3	12.8	18.5	10.8
Water elevation ^b	m	225.98	225.98	227.23	227.32	228.33
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.09	0.1	< 0.05	0.38	0.21
Chloride	mg/L	33	33	24	36	18
Sulfate	mg/L	150	161	448	430	411
TDS	mg/L	840	840	1,248	1,278	1,119
Arsenic	mg/L	< 0.025	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	< 0.5	0.029	0.035	0.03
Boron	mg/L	< 0.5	< 0.5	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.96	2.008	< 0.021	2.78	< 0.021
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.117	0.124	0.115	0.519	0.13
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.5	< 0.2	< 0.2	< 0.2
<i>Unfiltered Samples</i>						
Chloride	mg/L	32	32	31	40	- ^c
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	-	-	0.452	-	20
Hydrogen-3	pCi/L	114	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	-	3.3	-	-
Phenols	mg/L	< 0.005	< 0.005	0.011	< 0.005	< 0.005
Sulfate	mg/L	160	157	416	395	425
TOCs (max of 4 samples)	mg/L	2.8	2.8	3.5	3.6	4.0
TOXs (max of 2 samples)	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	< 0.025	< 0.025	< 0.003	< 0.003	< 0.003
Barium	mg/L	< 0.5	< 0.5	0.032	0.037	0.032
Boron	mg/L	< 0.5	< 0.5	< 0.1	< 0.1	< 0.1
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	2.25	2.28	0.469	3.72	< 0.021
Lead	mg/L	< 0.004	< 0.004	0.035	< 0.004	< 0.004
Manganese	mg/L	0.121	0.121	0.108	0.532	0.141
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.5	< 0.2	< 0.2	< 0.2

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 224.40 m (MSL); ground surface elevation = 231.21 m (MSL); casing material = stainless steel.

^c A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 2006

Parameter	Unit	Date of Sampling			
		1/10/2006	4/10/2006	7/25/2006	10/25/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	1,494^a	1,602	1,780	1,752
Oxid./red. potential	mV	-14	-6	-2	-2
pH	pH	7.22	7.07	7.00	7.01
Temperature	° C	10.4	13.4	13.9	13.0
Water elevation ^b	m	192.36	192.51	192.65	192.75
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	1.3	1.0	1.1	1.1
Chloride	mg/L	210	340	355	289
Sulfate	mg/L	110	105	75	66
TDS	mg/L	937	1,029	1,120	969
Arsenic	mg/L	<0.025 ^c	0.003	0.004	< 0.003
Barium	mg/L	< 0.5	0.103	0.105	0.095
Boron	mg/L	< 0.5	0.123	0.131	0.123
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.86	2.25	1.84	0.498
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	<0.075 ^c	0.081	0.069	0.070
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	_d	316	-	-
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	-	0.506	-	-
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	0.005	0.0086
Sulfate	mg/L	-	106	-	-
TOCs (max. of 4 samples)	mg/L	3.8	4.8	4.3	5.3
TOXs (max. of 2 samples)	mg/L	0.027	0.051	0.029	< 0.020
Arsenic	mg/L	-	0.004	-	-
Barium	mg/L	-	0.113	-	-
Boron	mg/L	-	0.155	-	-
Cadmium	mg/L	-	< 0.0002	-	-
Chromium	mg/L	-	< 0.05	-	-
Cobalt	mg/L	-	< 0.25	-	-
Copper	mg/L	-	< 0.025	-	-
Iron	mg/L	-	3.99	-	-
Lead	mg/L	-	< 0.004	-	-
Manganese	mg/L	-	0.183	-	-
Mercury	mg/L	-	< 0.0002	-	-
Nickel	mg/L	-	< 0.05	-	-
Selenium	mg/L	-	< 0.015	-	-
Silver	mg/L	-	< 0.001	-	-
Zinc	mg/L	-	< 0.02	-	-

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 189.09 m (MSL); ground surface elevation = 228.40 m (MSL); casing material = stainless steel.

^c Preliminary values of 0.0077 mg/L for arsenic and 0.0688 mg/L for manganese were reported as exceedances in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.44

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 2006

Parameter	Unit	Date of Sampling				
		1/17/2006	1/17/2006 (Duplicate)	4/25/2006	7/25/2006	10/24/2006
<i>Field Parameters</i>						
Conductivity	µS/cm	1,273	1,273	1,241	1,216	1,216
Oxid./red. potential	mV	24	24	-32	-1	-2
pH	pH	6.51	6.51	7.45	6.98	7.01
Temperature	° C	7.5	7.5	10.4	14.9	12.0
Water elevation ^a	m	192.55	192.55	194.17	192.68	192.76
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	1.1	1.2	0.87	1.0	1.2
Chloride	mg/L	119	132	111	144	130
Sulfate	mg/L	170^b	154	150	146	115
TDS	mg/L	858	817	800	918	700
Arsenic	mg/L	<0.025^c	<0.025	< 0.003	< 0.003	0.004
Barium	mg/L	< 0.5	< 0.5	0.044	0.045	0.038
Boron	mg/L	< 0.5	< 0.5	0.149	0.173	0.144
Cadmium	mg/L	<0.0025	0.00045	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.49	0.946	1.07	0.925	0.561
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	<0.075	<0.075	0.018	0.013	0.019
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.5	< 0.020	< 0.020	< 0.020
<i>Unfiltered Samples</i>						
Chloride	mg/L	_d	–	80	–	–
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	–	0.486	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	–	133	–	–
TOCs (max. of 4 samples)	mg/L	2.4	2.5	2.4	2.5	2.7
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	0.025	< 0.020
Arsenic	mg/L	–	–	< 0.003	–	–
Barium	mg/L	–	–	0.056	–	–
Boron	mg/L	–	–	0.193	–	–
Cadmium	mg/L	–	–	0.0002	–	–
Chromium	mg/L	–	–	< 0.05	–	–
Cobalt	mg/L	–	–	< 0.25	–	–
Copper	mg/L	–	–	< 0.025	–	–
Iron	mg/L	–	–	2.28 ^c	–	–
Lead	mg/L	–	–	< 0.004	–	–
Manganese	mg/L	–	–	0.028	–	–
Mercury	mg/L	–	–	< 0.0002	–	–
Nickel	mg/L	–	–	< 0.05	–	–
Selenium	mg/L	–	–	< 0.015	–	–
Silver	mg/L	–	–	< 0.001	–	–
Zinc	mg/L	–	–	< 0.020	–	–

^a Well point elevation = 180.38 m (MSL); ground surface elevation = 230.37 m (MSL); casing material = stainless steel.

^b Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^c A preliminary value for filtered arsenic of 0.0062 was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

6. GROUNDWATER PROTECTION

TABLE 6.45

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 2006

Parameter	Unit	Date of Sampling				
		1/9/2006	4/10/2006	4/10/2006 (Duplicate)	7/12/2006	10/10/2006
<i>Field Parameters</i>						
Conductivity	µS/cm	1,295	1,369^a	1,369	1,578	1,646
Oxid./red. potential	mV	-12	2	2	0	2
pH	pH	6.96	7.06	7.06	6.96	6.95
Temperature	°C	10.3	14.4	14.4	13.1	11.8
Water elevation ^b	m	192.28	192.48	192.48	192.63	192.76
<i>Filtered Samples</i>						
Ammonia nitrogen	mg/L	0.86	0.88	0.86	0.96	1.0
Chloride	mg/L	128	184	165	252	243
Sulfate	mg/L	192	174	179	163	161
TDS	mg/L	1,109	949	968	995	997
Arsenic	mg/L	<0.025 ^c	0.004	0.003	0.003	< 0.003
Barium	mg/L	< 0.5	0.069	0.069	0.077	0.08
Boron	mg/L	< 0.5	0.16	0.59	0.156	0.15
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.28	1.20	1.21	1.39	1.06
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	<0.075	0.023	0.022	0.025	0.022
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02	< 0.02
<i>Unfiltered samples</i>						
Chloride	mg/L	– ^d	183	160	–	–
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.456	0.463	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	176	177	–	–
TOCs (max of 4 samples)	mg/L	2.5	2.8	2.8	2.9	4.4
TOXs (max of 2 samples)	mg/L	0.022	< 0.020	0.03	0.026	0.021
Arsenic	mg/L	–	0.006	0.004	–	–
Barium	mg/L	–	0.073	0.072	–	–
Boron	mg/L	–	0.19	0.179	–	–
Cadmium	mg/L	–	< 0.0002	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	< 0.25	–	–
Copper	mg/L	–	< 0.025	< 0.025	–	–
Iron	mg/L	–	2.07	2.08	–	–
Lead	mg/L	–	< 0.004	< 0.004	–	–
Manganese	mg/L	–	0.030	0.029	–	–
Mercury	mg/L	–	< 0.0002	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	< 0.05	–	–
Selenium	mg/L	–	< 0.015	< 0.015	–	–
Silver	mg/L	–	< 0.001	< 0.001	–	–
Zinc	mg/L	–	< 0.02	< 0.02	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 181.35 m (MSL); ground surface elevation = 227.34 m (MSL); casing material = stainless steel.

^c A preliminary value of 0.0064 mg/L for arsenic was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

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TABLE 6.46

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 2006

Parameter	Unit	Date of Sampling			
		1/24/2006	4/12/2006	7/26/2006	10/16/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	977	971	1,366^a	1,286
Oxid./red. potential	mV	-3	-12	0	2
pH	pH	7.00	7.07	6.97	6.93
Temperature	°C	9.5	13.7	12.7	11.2
Water elevation ^b	m	192.52	192.57	192.72	192.84
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.48	1.3	1.9	2.1
Chloride	mg/L	29	81	216	193
Sulfate	mg/L	32	35	54	41
TDS	mg/L	616	628	919	692
Arsenic	mg/L	< 0.025	< 0.003	0.005	0.004
Barium	mg/L	< 0.5	0.139	0.148	0.132
Boron	mg/L	< 0.5	0.168	0.139	0.138
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	0.2638	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	0.216	1.81	1.19
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075^c	0.040	0.046	0.044
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.01	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	– ^d	96	–	–
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.375	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Sulfate	mg/L	–	37	–	–
TOCs (max. of 4 samples)	mg/L	4.6	4.4	5.0	6.1
TOXs (max. of 2 samples)	mg/L	< 0.020	< 0.020	< 0.020	< 0.020
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.143	–	–
Boron	mg/L	–	0.192	–	–
Cadmium	mg/L	–	0.0004	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	0.058	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.045	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.01	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 189.47 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

^c A preliminary value of 0.026 mg/L for manganese was reported as an exceedance in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

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TABLE 6.47

Groundwater Monitoring Results, Sanitary Landfill Well 800383D, 2006

Parameter	Unit	Date of Sampling			
		1/11/2006	4/25/2006	7/18/2006	10/23/2006
<i>Field Parameters</i>					
Conductivity	µS/cm	1,318^a	1,545	1,658	1,737
Oxid./red. potential	mV	1	-24	0	0
pH	pH	6.87	7.38	6.96	6.99
Temperature	° C	10.0	10.9	13.1	10.8
Water elevation ^b	m	192.00	192.05	192.13	192.33
<i>Filtered Samples</i>					
Ammonia nitrogen	mg/L	0.85	0.89	0.93	0.94
Chloride	mg/L	177	224	243	353
Sulfate	mg/L	141	127	121	99
TDS	mg/L	845	966	1,053	960
Arsenic	mg/L	<0.025 ^c	< 0.003	< 0.003	0.003
Barium	mg/L	< 0.5	0.088	0.093	0.091
Boron	mg/L	< 0.5	0.146	0.145	0.138
Cadmium	mg/L	< 0.0025	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	1.23	1.03	1.29	1.43
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	<0.075 ^c	0.053	0.060	0.052
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Selenium	mg/L	< 0.01	< 0.015	< 0.015	< 0.003
Silver	mg/L	< 0.0025	< 0.001	< 0.001	< 0.001
Zinc	mg/L	< 0.5	< 0.02	< 0.02	< 0.02
<i>Unfiltered Samples</i>					
Chloride	mg/L	_d	236	–	–
Cyanide (total)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride	mg/L	–	0.463	–	–
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Nitrate	mg/L	–	< 0.1	–	–
Phenols	mg/L	< 0.005	< 0.005	0.0059	0.0074
Sulfate	mg/L	–	127	–	–
TOCs (max. of 4 samples)	mg/L	1.8	2.6	2.4	3.4
TOXs (max. of 2 samples)	mg/L	< 0.02	0.022	0.02	< 0.02
Arsenic	mg/L	–	< 0.003	–	–
Barium	mg/L	–	0.088	–	–
Boron	mg/L	–	0.152	–	–
Cadmium	mg/L	–	< 0.0002	–	–
Chromium	mg/L	–	< 0.05	–	–
Cobalt	mg/L	–	< 0.25	–	–
Copper	mg/L	–	< 0.025	–	–
Iron	mg/L	–	1.834	–	–
Lead	mg/L	–	< 0.004	–	–
Manganese	mg/L	–	0.058	–	–
Mercury	mg/L	–	< 0.0002	–	–
Nickel	mg/L	–	< 0.05	–	–
Selenium	mg/L	–	< 0.015	–	–
Silver	mg/L	–	< 0.001	–	–
Zinc	mg/L	–	< 0.02	–	–

^a Bold type indicates that the value exceeds the applicable limits shown in Table 6.26.

^b Well point elevation = 187.35 m (MSL); ground surface elevation = 231.24 m (MSL); casing material = stainless steel.

^c Preliminary values of 0.0073 mg/L for arsenic and 0.047 for manganese were reported as exceedances in the Quarterly Report submitted to the IEPA.

^d A dash indicates that no samples were collected.

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6.5.2. Discussion of Results — Shallow Wells

The shallow wells produce groundwater samples from the uppermost saturated zones underlying the landfill. As such, they should be the first to show evidence of migration of hazardous materials from the landfill. The soil in these saturated zones is a highly heterogeneous mix of clay, silt, sand, and gravel, with somewhat different geochemistry in each saturated region. As a result, the concentrations of naturally occurring constituents will vary considerably from zone to zone.

The RFI of the 800 Landfill identified several potential contaminants of concern in the leachate from the waste. The most significant contaminants were low levels of organic constituents, PCBs and pesticides (Aroclor 1260, DDE, and DDT), several VOCs (toluene, acetone, and methylene chloride), and SVOCs (several phthalates). Several metals were detected above background in soil, but these were attributed to natural variation in soil composition. Thus, the detection of VOCs or SVOCs would indicate the potential release of waste products from the landfill. As the data tables demonstrate, there were no detections of these materials in any of the groundwater samples collected in 2006. Thus, there is no indication of a release of hazardous materials from the landfill. However, the data are useful in understanding the hydrogeology and geochemistry of the area surrounding the landfill.

A discussion of groundwater flow direction and all analytical results for 2006 are summarized in the 2006 Annual Summary Assessment of the groundwater monitoring program for the 800 Area Landfill, which was sent to the IEPA in July 2007.

Field Parameters. Field parameters include well and water depth information, pH, specific conductivity, oxidation/reduction potential, and water temperature. These parameters are measured at the time the samples are collected each quarter. The specific conductivity results are discussed in the next section. Two instances of unusually low pH were noted in 2006; however, they were only slightly less than the low end of the pH range in the background well. In general, the results are consistent from quarter to quarter and are similar to results obtained in previous years.

Filtered Inorganic Constituents. Several inorganic constituents were detected above their respective permit limits. The most common exceedances were TDS, specific conductivity, and sulfate, which are all measures of the amount of dissolved material in the groundwater. All of the wells sampled exhibited TDS and conductivity results above the background values of 428 and 703 mg/L, respectively. The wells with the highest TDS/conductivity values also exhibited the highest sulfate concentrations. The highest concentrations were found in the wells closest to the wetland west of the landfill (Wells 800371, 800191R, and 800321). These wells also generally exhibit the highest concentrations of dissolved iron and manganese. The lowest TDS/conductivity concentrations were on the southeast side of the landfill, the farthest away from the wetland. None of these elevated results appeared to correlate with the proximity of the well to the landfill. It is likely that the elevated concentrations of dissolved inorganic matter are related to the proximity of the large wetland that contains thick deposits of high organic-content

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soil. This type of soil produces slightly acidic anaerobic conditions that can increase the solubility of many naturally occurring materials that could migrate to the shallow groundwater near the wetlands. It could also be related to dissolved material in stormwater runoff (including road salt) that originates in a nearby intersection between a large highway and major surface roadway. This runoff flows through the wetlands.

The fact that all of the wells had higher levels of TDS/conductivity than the background well may be an indication that the background well is located in a region with different geochemistry than the 800 Area wells. Because of the heterogeneous nature of the glacial drift under the landfill, groundwater geochemistry could vary significantly over short distances.

Chloride levels were elevated in a number of wells, particularly 800171 and 800281, which are located east of the landfill. These wells are near roadways in the 800 Area and near a former road salt storage area that had been located in the 800 Area for a number of years. It is possible that chloride from the sodium chloride in road salt has migrated to the shallow wells in this area. The other wells with elevated chloride levels are generally near the wetlands and could be affected by road salt in runoff that flows through the wetlands.

All other inorganic results were generally consistent with background values. One well (800201) contained ammonia results well above background in all samples from 2006. This well is immediately adjacent to the waste mound as well as the wetland. The source of the ammonia is unclear.

Metals. Metals results were obtained for both filtered and unfiltered samples and from samples collected using balers and low-flow sampling techniques. Filtered results are compared with background concentrations and unfiltered results are compared with the GQS. Filtered samples contained many values above background for soluble iron and soluble manganese. These results may be related to the proximity of the wetland west of the wells, as discussed in the previous section. Only one instance of elevated arsenic and two of elevated cadmium were noted; elevated results were not present in any other samples from those wells, however, and these results are considered anomalies.

Unfiltered samples contained a larger number of detectable levels of several metals; however, only a few were above the GQS. The most common exceedances were iron and manganese. In addition to iron and manganese, there was one instance of elevated nickel and four of elevated lead. These elevated nickel and lead results generally occurred in samples with high levels of iron and manganese as well. The highest unfiltered metals results were generally found in samples collected using a bailer rather than the low flow sampler. The added turbulence caused by the bailer suspends sediment in the well, which increases the metals results in these samples since the suspended soil particles are digested and the natural metal contained in the soil adds to the metals present in solution. The low flow sampling technique greatly reduces the amount of suspended soil in the sample. For example Well 800361 was sampled the first and fourth quarters by using a bailer, and the third quarter by using the low flow sampler (it was dry the second quarter). Total iron results were 46.2 and 73.7 mg/L with the use of the bailer, and 0.276 with the use of the low flow sampler. Thus, the presence of elevated metals levels in

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groundwater is likely to be a function of the sampling method and is probably not an indication of contaminants migrating from the landfill.

Organics. Groundwater samples are measured each quarter for VOCs and annually for the set of SVOCs and PCBs and pesticides listed in the permit. None of the samples contained any measurable organic constituents in 2006. These results are not shown in the data tables to simplify the tables.

Unfiltered Miscellaneous Constituents. These parameters include cyanide, phenols (total recoverable), TOC, and TOX and are measured each quarter. The results are compared with background levels. Except for TOC, all values were consistent with background concentrations. During 2006, elevated TOC results were found in 8 of 14 wells sampled. Only one well was significantly higher than the background concentration of 2.7 mg/L. This well, 800201, is immediately adjacent to the landfill mound as well as the wetland. The elevated organic matter content could be organic materials leaching from the waste or it could be naturally occurring organics coming from the wetland soil. This well also contained the highest concentration of ammonia.

Radioactive Constituents. Samples collected from the 800 Area Landfill monitoring wells were also analyzed for hydrogen-3. Although the disposal of radioactive materials was prohibited in the sanitary landfill, concentrations of hydrogen-3 were detected during the RFI. Hydrogen-3 was found above the 100-pCi/L detection limit only in Wells 800191R, 800201, 800281, and 800291. Only Well 800281 consistently had measurable amounts of hydrogen-3 each quarter. The GQS for hydrogen-3 is 20,000 pCi/L. All results were well below this limit.

6.5.3. Discussion of Results — Bedrock Monitoring Wells

The monitoring wells installed in the dolomite bedrock are situated in the uppermost region of the bedrock, the layer in contact with the glacial drift above. It is a zone containing many cracks, fissures, and solution cavities. Groundwater flow in this formation moves generally to the southeast. Because of the different mineral structures of this formation, the geochemistry is significantly different from the shallow wells, which is reflected in the different values for background levels of the various constituents.

Field Parameters. Except for specific conductivity, which is discussed in the next section, all of the field parameters were consistent with the background values.

Filtered Inorganic Constituents. The amount of dissolved matter in three of the five dolomite wells was higher than background levels, as evidenced by elevated

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TDS/conductivity values. All five wells had at least one chloride value greater than background. The higher chloride levels correlated closely with higher TDS/conductivity levels. Sulfate, on the other hand, was not consistent with the chloride or TDS/conductivity levels. Only one well had consistently elevated sulfate levels with the highest value of 192 mg/L being only marginally higher than the background value of 152 mg/L. Ammonia was found to be higher than background in one or more samples from three of the five wells, with the highest value being 2.1 mg/L, compared with a background value of 1.0 mg/L. The ammonia concentrations varied considerably from quarter to quarter. All of these constituents are naturally occurring materials and are not considered a hazard at the concentrations found. While some constituents such as TDS, chloride, and sulfate could originate in the landfill leachate, it is likely that the elevated levels detected reflect natural variation in the soil composition around and above the monitoring wells rather than past releases of materials from the landfill.

Metals. The only metals detected consistently above background levels in filtered samples were iron and manganese. Because of the difference in geochemistry between the two aquifers sampled, the background levels of these two metals vary considerably. Iron is much higher in the dolomite, with a background value of 1.9 mg/L compared with 0.099 mg/L in the shallow well. Manganese, on the other hand, is lower in the dolomite, with a background value of 0.021 compared with 0.097 in the shallow well. Two of the five dolomite wells had elevated iron concentrations. Three wells were consistently elevated in manganese, with the highest concentration being 0.081 mg/L. Interestingly, three of the four samples from the background well exceeded the calculated background levels for arsenic, which illustrates the natural variability in metals composition of groundwater samples.

Unfiltered metals samples were analyzed once per year for each well (one duplicate sample was analyzed in well 800193D). One manganese result was the only unfiltered metal result that exceeded any of the GQSS. The manganese result was 0.183 mg/L compared with the standard of 0.15 mg/L.

Unfiltered Miscellaneous Constituents. The exceedance of groundwater quality criteria for these parameters was limited to chloride, which was elevated in two samples, and TOC and TOX in one well each. Fluoride was detected in all the wells, but all results were well below the criterion of 4.0 mg/L. No cyanide or nitrate was detected. Phenol was detected in two wells, but significantly below the criterion of 0.033 mg/L. TOC and TOX were elevated in one of four samples from two different wells, the remainder of the samples from these wells were consistent with background values.

Organics. As with the shallow wells, no organic constituents were found above the analytical detection limits.

Radioactive Constituents. All samples were at or below the hydrogen-3 analytical detection limit of 100 pCi/L.

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6.5.4. Summary of 800 Area Groundwater Monitoring Results

While a number of the constituents monitored in the wells exceeded their respective background values or the GQS, these constituents were naturally occurring materials present in the soil and groundwater. The elevated concentrations are likely the result of sampling activity disturbing sediment or natural variation in geochemistry in the highly heterogeneous soil underlying the landfill. The use of road salt in the 800 Area could also contribute to some exceedances. None of the contaminants detected in the landfill leachate, including one PCB, two pesticides, and several VOCs and SVOCs, have been found in the groundwater, thus there is no indication that the landfill is releasing hazardous materials into the environment.

6.6. CP-5 Reactor Area

In addition to the required sampling of former waste sites, Argonne is voluntarily monitoring the condition of groundwater beneath the former CP-5 reactor. The CP-5 reactor was a 5-MW research reactor that was used from 1954 until operations ceased in 1979. In addition to the reactor vessel inside its containment dome, the CP-5 complex contained several cooling towers and an outdoor equipment yard for storing equipment and supplies. The reactor and associated yard area have been decommissioned by removal of the reactor and internal components and removal of material from the yard. The yard area surrounding the CP-5 reactor structure was classified as a SWMU and was, therefore, investigated for chemically hazardous groundwater releases under the RCRA Part B permit. Radioactive contamination was cleaned up in 2001 under DOE supervision. The RFI and corrective actions were completed in 2002, and the IEPA issued a notice of NFA in 2003.

Groundwater under and adjacent to the reactor complex has been monitored through a series of groundwater monitoring wells installed in stages beginning in 1989. Figure 6.24 shows the current monitoring well network. Table 6.48 provides information on the current set of wells. The first exploratory monitoring well (330011) was installed in 1989 behind the reactor building, just outside the reactor fuel storage area of the complex. Additional wells were added from 1992 through 2001 to support the various characterization studies. Argonne expanded the monitoring well network to its current configuration in 2003 and replaced two existing shallow wells, 330021 and 330031, with new wells with a shorter screen targeting the saturated zone within the drift. One well, 330012D, is screened in the dolomite bedrock; the remainder are screened in the glacial drift. Because of the small size of this site and complex glacial geology, it is difficult to identify the shallow groundwater flow direction or to identify which wells are upgradient and which are downgradient. All wells are treated as downgradient wells in this discussion. The current network of wells is sampled quarterly and analyzed for soluble metals and chloride (filtered samples) and radioactive materials (cesium-137, hydrogen-3, and strontium-90). Field parameters are measured at the time samples are collected.

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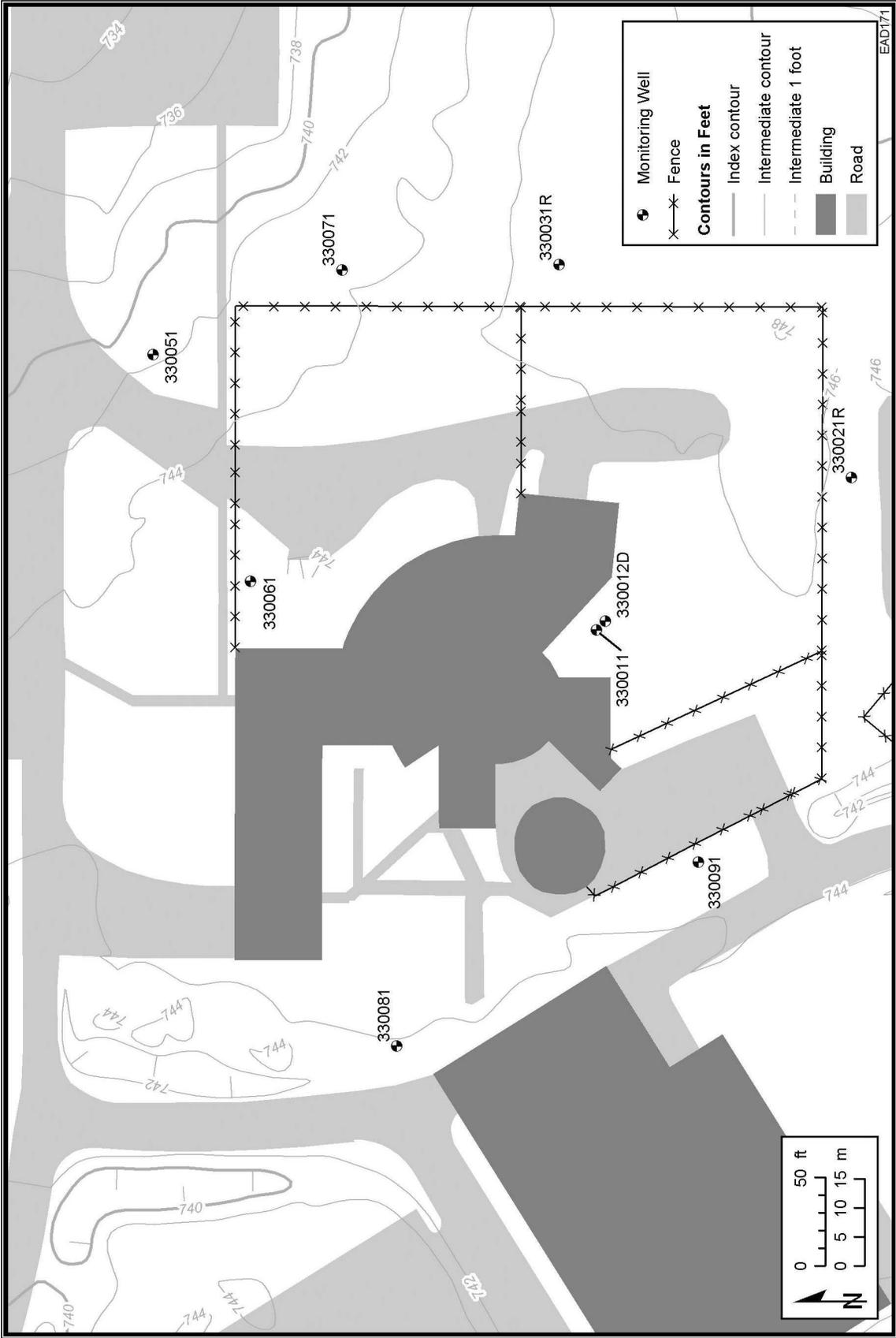


FIGURE 6.24 Monitoring Wells in the CP-5 Reactor Area

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TABLE 6.48

Groundwater Monitoring Wells: 330 Area/CP-5 Reactor

ID Number	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type ^a	Date Drilled
330011	6.1	227.23	224.2–221.0	0.05/PVC	8/89
330012D	41.5	227.08	191.7–185.7	0.05/SS	6/97
330021R ^b	11.9	227.04	216.6–215.2	0.05/PVC	2/03
330031R	9.8	227.65	219.4–217.9	0.05/PVC	2/03
330051	7.0	226.72	221.2–219.7	0.05/PVC	5/00
330061	9.7	227.11	218.8–217.4	0.05/PVC	2/03
330071	8.8	226.64	219.3–217.8	0.05/PVC	2/03
330081	4.5	226.60	223.5–222.0	0.05/PVC	2/03
330091	3.8	227.07	224.7–223.3	0.05/PVC	2/03

^a Inner diameter (m)/well material (PVC = polyvinyl chloride, SS = stainless steel).

^b Well not sampled in 2006 since it was dry.

Descriptions of each well, field parameters measured during sample collection, and the results of chemical and radiological analysis of samples from the wells in the 330 Area are presented in Tables 6.49 to 6.56. All radiological and inorganic analysis results are shown in these tables.

Field Parameters. Field parameters include such items as well and water depth information, pH, specific conductivity, oxidation/reduction potential and temperature of water. These parameters are measured each quarter. Water from four wells (330051, 330061, 330081, and 330091) had elevated conductivity levels compared with the other wells. Well 330091 was higher than the rest by a factor of 10. The high conductivity results corresponded to similarly elevated levels of chloride. The elevated conductivity levels in Wells 330051 and 330061 may be due to elevated chloride levels from road salt. The elevated chloride levels in Wells 330081 and 330091 appear to be related to migration of chloride into the groundwater from a road salt storage facility near the wells. An old steel dome structure immediately southwest of the reactor dome was converted to a road salt storage area several years ago. The building is not closed, and trucks entering and leaving the yard spill salt in the yard and along nearby roadways. Well 330091 is immediately adjacent to the yard area where trucks are loaded. Well 330081 is located along the stormwater flow path from this area. The intrusion of salt into these wells is being monitored to determine if the high salt concentrations are due to migration of the salt through the soil or if the clay seals around the well casings are allowing surface water into the well.

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TABLE 6.49

Groundwater Monitoring Results, 300 Area Well 330011, 2006

Parameter	Unit	Date of Sampling			
		3/2/2006	6/22/2006	9/13/2006	12/6/2006
<i>Field Parameters</i>					
Water elevation ^a	m	224.75	225.56	225.95	226.12
Temperature	°C	10.8	14.9	16.2	14.0
pH	pH	6.97	7.01	6.89	6.89
Redox	mV	2	1	0	3
Conductivity	µS/cm	1,073	891	997	1,073
<i>Filtered Samples</i>					
Chloride	mg/L	42	24	26	21
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	632	766	621	392
Strontium-90	pCi/L	0.37	0.37	0.46	0.53

^a Well point elevation = 220.98 m (MSL); ground surface elevation = 227.23 m (MSL); casing material = stainless steel.

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TABLE 6.50

Groundwater Monitoring Results, 300 Area Well 330012D, 2006

Parameter	Unit	Date of Sampling			
		3/2/2006	6/22/2006	9/13/2006	12/6/2006
<i>Field Parameters</i>					
Water elevation ^a	m	191.09	191.11	191.17	191.38
Temperature	°C	12.6	14.6	13.4	12.7
pH	pH	6.94	7.11	6.95	7.02
Redox	mV	-4	-4	-3	-3
Conductivity	µS/cm	1,140	966	990	964
<i>Filtered Samples</i>					
Chloride	mg/L	70	28	32	28
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	2,003	498	112	< 100
Strontium-90	pCi/L	1.25	0.82	< 0.25	< 0.25

^a Well point elevation = 185.50 m (MSL); ground surface elevation = 227.08 m (MSL); casing material = stainless steel.

6. GROUNDWATER PROTECTION

TABLE 6.51

Groundwater Monitoring Results, 300 Area Well 330031R, 2006

Parameter	Unit	Date of Sampling			
		3/3/2006	6/22/2006	9/14/2006	12/5/2006
<i>Field Parameters</i>					
Water elevation ^a	m	220.46	221.95	221.64	223.32
Temperature	°C	11.0	14.1	14.1	10.0
pH	pH	7.30	7.22	6.86	6.98
Redox	mV	-20	-12	2	-1
Conductivity	µS/cm	1,322	1,211	5,360	2,270
<i>Filtered Samples</i>					
Chloride	mg/L	136	126	1,391	642
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.102	< 0.075	0.233	0.137
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.133	0.123	0.111	0.143
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	39,400	40,740	43,410	42,090
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 217.89 m (MSL); ground surface elevation = 227.65 m (MSL); casing material = stainless steel.

6. GROUNDWATER PROTECTION

TABLE 6.52

Groundwater Monitoring Results, 300 Area Well 330051, 2006

Parameter	Unit	Date of Sampling			
		3/3/2006	6/22/2006	9/13/2006	12/5/2006
<i>Field Parameters</i>					
Water elevation ^a	m	220.97	222.05	222.71	223.22
Temperature	°C	12.1	14.2	13.6	13.5
pH	pH	6.88	6.98	6.83	6.85
Redox	mV	4	3	3	5
Conductivity	µS/cm	3,250	2,390	2,750	2,450
<i>Filtered Samples</i>					
Chloride	mg/L	758	680	717	656
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.425	0.085	0.298	0.224
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	0.261	< 0.05	0.085	0.062
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	318	141	414	202
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 219.71 m (MSL); ground surface elevation = 226.72 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.53

Groundwater Monitoring Results, 300 Area Well 330061, 2006

Parameter	Unit	Date of Sampling			
		3/3/2006	6/22/2006	9/13/2006	12/6/2006
<i>Field Parameters</i>					
Water elevation ^a	m	219.55	220.73	220.94	221.37
Temperature	°C	14.0	14.9	14.2	15.0
pH	pH	6.85	6.77	6.64	6.71
Redox	mV	8	15	13	13
Conductivity	µS/cm	3,500	3,030	3,180	2,640
<i>Filtered Samples</i>					
Chloride	mg/L	956	822	937	853
Arsenic	mg/L	< 0.025	0.027	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0002	< 0.0025	< 0.0025	0.0030
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	0.52	0.58	0.73	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.136	0.085	0.163	0.113
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.004	< 0.002	< 0.004
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,157	961	1,136	1,067
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 217.28 m (MSL); ground surface elevation = 227.11 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.54

Groundwater Monitoring Results, 300 Area Well 330071, 2006

Parameter	Unit	Date of Sampling			
		3/3/2006	6/22/2006	9/13/2006	12/5/2006
<i>Field Parameters</i>					
Water elevation ^a	m	219.05	220.97	220.90	223.12
Temperature	°C	10.5	13.5	11.7	11.0
pH	pH	7.50	7.15	7.00	7.00
Redox	mV	-30	-5	-5	0
Conductivity	µS/cm	972	934	982	1,051
<i>Filtered Samples</i>					
Chloride	mg/L	9	9	9	10
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	449	453	442	446
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 217.80 m (MSL); ground surface elevation = 226.64 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.55

Groundwater Monitoring Results, 300 Area Well 330081, 2006

Parameter	Unit	Date of Sampling			
		3/3/2006	6/22/2006	9/14/2006	12/4/2006
<i>Field Parameters</i>					
Water elevation ^a	m	224.19	224.23	224.76	224.65
Temperature	°C	10.4	15.2	17.9	13.9
pH	pH	6.91	7.27	7.04	7.05
Redox	mV	2	-12	-8	-6
Conductivity	µS/cm	4,730	4,190	3,610	3,950
<i>Filtered Samples</i>					
Chloride	mg/L	1,535	1,297	1,039	1,390
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	3.291	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	0.326	< 0.075	0.075	0.081
Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel	mg/L	1.26	0.085	< 0.05	< 0.05
Silver	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Thallium	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	103
Strontium-90	pCi/L	0.42	0.29	0.30	0.44

^a Well point elevation = 222.03 m (MSL); ground surface elevation = 226.60 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.56

Groundwater Monitoring Results, 300 Area Well 330091, 2006

Parameter	Unit	Date of Sampling			
		3/3/2006	6/22/2006	9/14/2006	12/4/2006
<i>Field Parameters</i>					
Water elevation ^a	m	224.89	225.23	225.47	225.46
Temperature	°C	9.6	14.6	18.4	13.9
pH	pH	6.63	6.57	6.30	6.51
Redox	mV	18	26	33	25
Conductivity	µS/cm	29,700	36,600	40,100	>20,000
<i>Filtered Samples</i>					
Chloride	mg/L	11,786	14,483	15,659	13,548
Arsenic	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Barium	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
Beryllium	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Cadmium	mg/L	0.0052	0.003	< 0.0035	< 0.0025
Chromium	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/L	< 0.25	< 0.25	< 0.25	< 0.25
Copper	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Iron	mg/L	6.97	< 0.5	< 0.5	< 0.5
Lead	mg/L	< 0.004	< 0.004	< 0.004	< 0.004
Manganese	mg/L	5.00	6.40	7.68	4.52
Mercury	mg/L	< 0.0002	< 0.0002	0.0004	< 0.0002
Nickel	mg/L	1.017	0.074	< 0.05	< 0.05
Silver	mg/L	< 0.005	0.0033	0.004	< 0.0025
Thallium	mg/L	< 0.01	< 0.01	< 0.004	< 0.004
Vanadium	mg/L	< 0.075	< 0.075	< 0.075	< 0.075
Zinc	mg/L	< 0.5	< 0.5	< 0.5	< 0.5
<i>Radioactive Materials</i>					
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	874	888	1,186	1,400
Strontium-90	pCi/L	0.49	0.36	0.34	0.32

^a Well point elevation = 223.26 m (MSL); ground surface elevation = 227.07 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

Filtered Metals. Only five of the eight wells sampled had any samples with soluble metals above analytical detection limits. In these five wells, manganese, nickel, iron, and cadmium were detected in at least one sample. Nickel exceeded the GQS of 0.1 mg/L in Wells 330031R, 330081, and 330091. Manganese exceeded the GQS of 0.15 mg/L in these same wells, plus Well 330051. Well 330091 also had one exceedance of the GQS for cadmium (0.005 mg/L) and iron (5 mg/L). Some of the results are highly variable, with samples collected later in the year containing much lower concentrations. It appears that these elevated levels may be associated with disturbance of fine silt in the well during sampling, thereby increasing the turbidity of the sample. Even though these samples were filtered, it is possible that some colloidal soil particles could get through the filter, adding to the metals concentration. There are no known man-made sources of these metals near the CP-5 reactor.

Radioactive Constituents. Hydrogen-3 was detected during at least one quarter in all of the wells. The levels of hydrogen-3 in these wells ranged from less than 100 to 43,410 pCi/L. The only well that exceeded the GQS of 20,000 pCi/L was Well 330031R, which is a replacement well for 300031. Strontium-90 was detected during each quarter in four of the wells with the highest value being 1.25 pCi/L. All the results are well below the GQS of 8 pCi/L. No cesium-137, or other gamma-ray-emitting radionuclides were detected above the detection limit of 1 pCi/L.

The CP-5 was a heavy-water-moderated reactor. The normal operation of the reactor systems released significant amounts of water vapor containing hydrogen-3 from the main ventilation system. Over the years of operation, condensed tritiated water vapor falling to the ground with precipitation may have resulted in low levels of hydrogen-3 in the shallow groundwater. In addition, during its operational life, several incidents occurred that released small amounts of heavy water, containing high concentrations of hydrogen-3, to the environment. In two separate incidents, one in 1964 and a second in 1971, the cooling system for the reactor failed, releasing tritiated water into the cooling tower. Overspray, spills, and sewer disposal of this contaminated water appear to have released small amounts of hydrogen-3 to the subsurface. These activities are believed to be responsible for the low levels of hydrogen-3 that have been found in the groundwater for a number of years. The hydrogen-3 levels near the reactor (Well 330011) have been decreasing since monitoring began in 1990 due to radioactive decay as well as dilution. Figure 6.25 shows hydrogen-3 and strontium-90 levels in Well 330011 since monitoring started. It also contains a projection of hydrogen-3 concentrations if only radioactive decay had been occurring since 1999, assuming the initial concentration was 12,000 pCi/L. The reason for the sharp drop in hydrogen-3 between 1997 and 1999 is not known. Strontium-90 experienced a similar decline during those years.

The high levels of hydrogen-3 at Well 330031R may be the result of other factors as well as those mentioned above. Before replacement, Well 330031 had hydrogen-3 concentrations that averaged 260 pCi/L. After the replacement well was installed in February 2003, the hydrogen-3 concentrations averaged 3,330 pCi/L for the balance of 2003 — about a factor of 10 higher than the old well. The first quarter results in 2004 revealed that hydrogen-3 concentrations had increased by another factor of 10, to 43,670 pCi/L, and they have remained in the 30,000 to 40,000 pCi/L range since. These high levels have been traced back to the 1964 cooling tower

6. GROUNDWATER PROTECTION

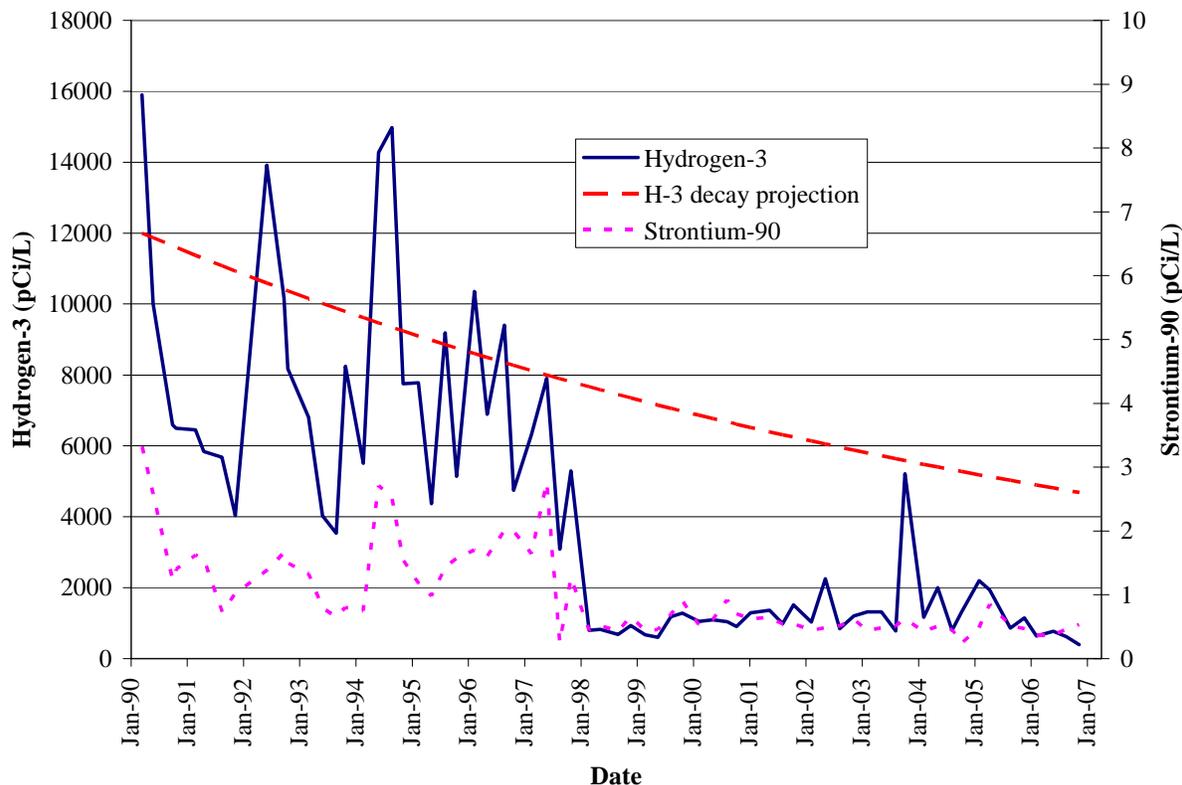


FIGURE 6.25 Hydrogen-3 and Strontium-90 in Well 330011

incident. After this leak was stopped, the contaminated cooling water was disposed of by diluting it, in batches, with large amounts of ordinary, uncontaminated wastewater and processing the mixture through the regular wastewater disposal system. This discharge was conducted over a period of about 3 months. The contaminated cooling water was pumped to a laboratory sewer manhole near the cooling tower. The sewer line ran east to the CP-5 yard fence and then north to Bluff Road where it connected to a larger sewer and eventually flowed to the LWTP. A manhole exists at the point where the sewer line turns north. This manhole is located within 10 m (33 ft) of monitoring Well 330031R. It is theorized that a small amount of leakage from this sewer mixed with groundwater in an isolated porous region of soil near the sewer, thereby creating a pocket of relatively high levels of hydrogen-3. The hydrogen-3 appears to have remained isolated at this location since 1964. Apparently replacement Well 330031R happened to penetrate this isolated zone.

To determine the size of this region of high hydrogen-3 concentration and to determine if it was migrating away from the area, a soil and groundwater sampling project was completed in 2006. Soil samples were collected at six locations radiating from Well 330031R to a depth of 11 m (35 ft). Any groundwater encountered during the drilling was sampled and analyzed for hydrogen-3. Only very low levels of hydrogen-3 were found, with the highest being 810 pCi/L immediately east of Well 330031R. Geological characterization of the soil in these borings, as well as a hydrogeological measurement of the groundwater movement in Well 330031R, confirmed that there is little migration of groundwater away from the reactor.

6.7. Groundwater Monitoring Program Summary

This chapter summarizes the information on groundwater monitoring results from various voluntary and permit-required monitoring programs. Compiling and analyzing these results support the Argonne groundwater management strategy. The groundwater monitoring strategy focuses monitoring resources on those areas that have the potential to impact groundwater. Analytical results generated demonstrate the degree of compliance to applicable groundwater standards and limits and 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 on the extreme southern end of the site. Concentrations of VOCs and hydrogen-3 above applicable standards exist in groundwater associated with a former liquid waste disposal unit and landfill. Some of this groundwater comes to the surface in several small groundwater seeps in an isolated part of the Waterfall Glen Forest Preserve. Several active remedial actions are underway in this area to reduce contaminant levels. Groundwater under the 800 Area Landfill exhibits elevated levels of a number of naturally occurring metals; 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 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 significant contamination above applicable limits. There is no known off-site impact to groundwater in this aquifer.

Argonne groundwater sampling activities during 2006 are summarized in Table 6.57. Because the various elements of the program are integrated into the overall monitoring schedule, some of the wells, monitoring events, and analytical results are used for multiple purposes that address different elements of the groundwater protection program. The vast majority of the analytical results were below detection limits. Only a small fraction of the detectable results represents releases of chemical or radioactive materials above applicable groundwater quality standards. These instances are discussed in detail in other sections of this chapter.

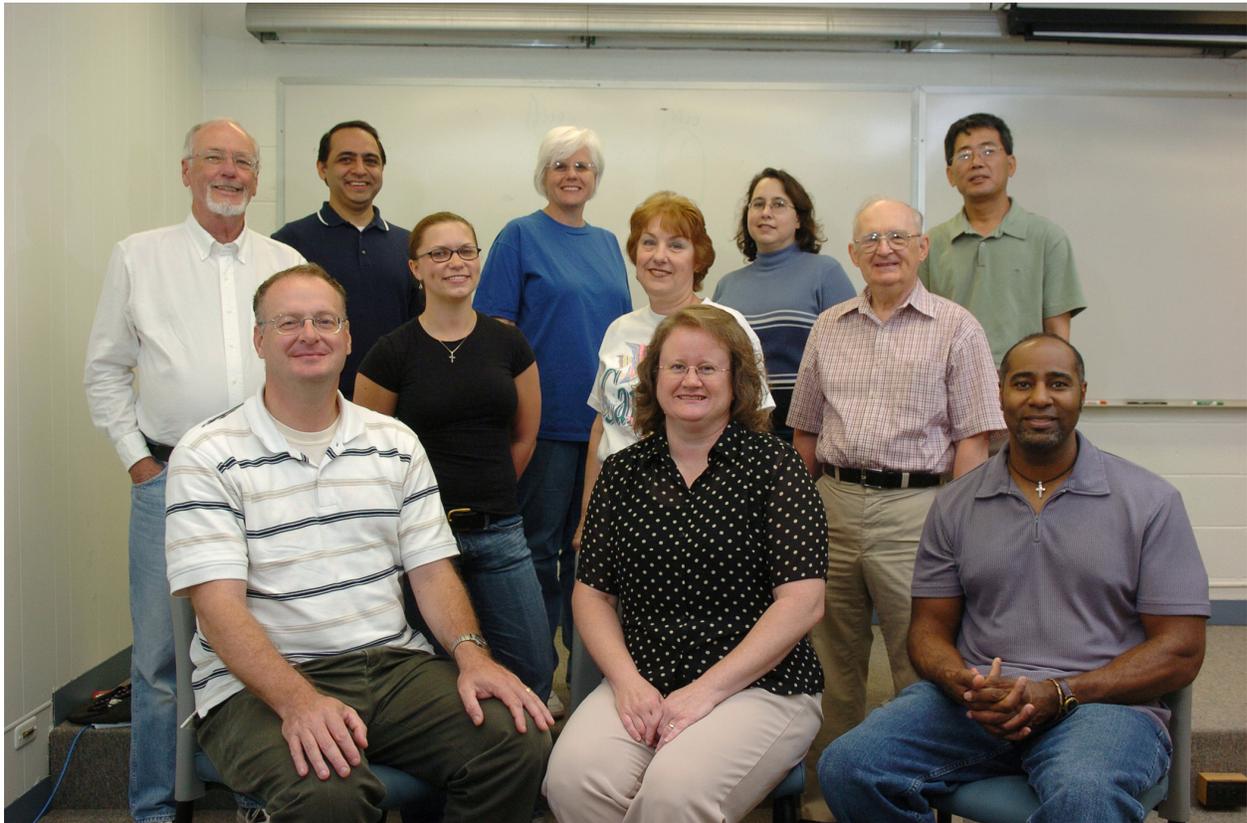
6. GROUNDWATER PROTECTION

TABLE 6.57

Summary of Groundwater Monitoring by Area, 2006

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
Former water supply wells	Environmental Surveillance	4	3	12	783	95%
Dolomite wells	Environmental Surveillance	10	10	40	40	95%
317/319 Area wells and manholes	Environmental Surveillance	10	10	58	8,070	98%
317/319/ENE and GMZ wells	Permit Compliance/LTS Program	111	80	195	12,566	90%
800 Area Landfill wells	Permit Compliance	28	21	75	9,341	90%
CP-5 wells	Environmental Surveillance	9	8	32	640	82%

7. QUALITY ASSURANCE



7. QUALITY ASSURANCE

Quality assurance (QA) plans and associated documents exist for both radiological and nonradiological analyses. QA documents were prepared in accordance with DOE Order 414.1C³⁰ and discuss who is responsible for QA and for auditing. Operating manuals have been prepared and are periodically reviewed and revised if necessary.

7.1. Sample Collection

Many factors enter into an overall QA program other than the analytical quality control. Representative sampling is of prime importance. Appropriate sampling protocols are followed for each type of sampling being conducted. Water samples are pretreated in a manner designed to maintain the integrity of the analytical constituent. 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.

The monitoring wells are sampled by using the protocols listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.²⁷ The volume of water in the casing is determined by measuring the water depth from the surface and the depth to the bottom of the well. This latter measurement also determines whether siltation has occurred that might restrict water movement in the screened area. For those wells in the glacial drift that do not recharge rapidly, the well is emptied and the volume removed is compared with the calculated volume. In most cases, these volumes are nearly identical. The well is then sampled by bailing with a Teflon[®] bailer. In a number of wells, low-flow sampling equipment has been installed to minimize the turbidity created by sampling with a bailer.

Samples for parameters such as priority pollutants are collected, and field parameters for these samples (pH, specific conductivity, redox potential, and temperature) are measured per well volume while purging. For samples in the porous saturated zone, which recharges rapidly, three well volumes are purged by using submersible pumps. If field parameters are measured, samples are collected as soon as these readings stabilize. All samples are placed in precleaned bottles, labeled, and preserved. All field measurement and sampling equipment is cleaned by field rinsing with Type II deionized water. The sample log-in information is transferred to the analytical laboratory along with a computer disk that generates a one-page list of all samples. This list acts as the chain-of-custody transfer document.

7.2. Radiochemical Analysis and Radioactivity Measurements

The documentation for radiological analyses is contained in the EQO-AS procedure manual. All nuclear instrumentation is calibrated with standard sources obtained from or traceable to the National Institute of Standards and Technology (NIST). The equipment is checked with secondary counting standards to ensure proper operation. Samples are periodically analyzed in duplicate or with the addition of known amounts of a radionuclide to check precision and accuracy. When a nuclide is not detected, the result is given as “less than” (<) the detection

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limit by the analytical method used. The detection limits are chosen so that the measurement uncertainty at the 95% confidence level is equal to the measured value. The air and water detection limits for all radionuclides for which measurements were made in 2006 are given in Table 7.1.

The 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% at the 95% confidence level.

Average values are accompanied by a plus-or-minus (\pm) 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 \pm limit value is a measure of the range in the concentrations encountered at that location. It does not represent the conventional uncertainty in the average of repeated measurements on the same or identical samples. Because 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. When a \pm value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

In 2006, Argonne participated in the Mixed Analyte Performance Evaluation Program (MAPEP) administered by the Radiological and Environmental Sciences Laboratory (RESL). The program consists of semiannual distribution of three different sample matrices containing combinations of radionuclides that are analyzed. The results are provided in Tables 7.2 and 7.3.

The Argonne performance on the MAPEP intercomparison samples resulted in 95% (60 out of 63) of the analyses being in the MAPEP acceptable range. Of the three results outside the acceptable range, all were within the warning range.

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
Radium-226	—	0.02
Radium-228	—	0.02
Strontium-89	0.1	2
Strontium-90	0.01	0.25
Uranium-234	—	0.01
Uranium-235	—	0.01
Uranium-238	—	0.01
Uranium – natural	—	0.2
Alpha	0.2	0.2
Beta	0.5	1

^a A dash indicates that a value is not required.

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TABLE 7.2

Summary of May MAPEP Intercomparison Samples, 2006

Parameter	Unit	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
<i>Air Filter</i>					
Am-241	Bq/filter	0.101	0.093	0.07–0.12	Acceptable
Cs-134	Bq/filter	2.47	2.93	2.05–3.81	Acceptable
Cs-137	Bq/filter	2.28	2.53	1.77–3.29	Acceptable
Co-57	Bq/filter	3.86	4.10	2.87–5.32	Acceptable
Co-60	Bq/filter	2.15	2.19	1.53–2.84	Acceptable
Mn-54	Bq/filter	0.05	NR ^a	NR	Acceptable
Pu-238	Bq/filter	0.075	0.067	0.05–0.09	Acceptable
Pu-239/240	Bq/filter	0.002	0.00041	NR	Acceptable
Sr-90	Bq/filter	0.74	0.79	0.55–1.03	Acceptable
U-233/234	Bq/filter	0.017	0.020	0.01–0.03	Acceptable
U-238	Bq/filter	0.020	0.021	0.01–0.03	Acceptable
Zn-65	Bq/filter	2.50	3.42	2.40–4.45	Acceptable with Warning
<i>Soil</i>					
Am-241	Bq/kg	55.0	57.1	39.96–74.20	Acceptable
Cs-134	Bq/kg	2.79	NR	NR	Acceptable
Cs-137	Bq/kg	399	340	238–442	Acceptable
Co-57	Bq/kg	742	656	459–853	Acceptable
Co-60	Bq/kg	533	447	313–581	Acceptable
Mn-54	Bq/kg	422	347	243–451	Acceptable with Warning
Pu-238	Bq/kg	63.0	61.2	42.8–79.5	Acceptable
Pu-239/240	Bq/kg	43.00	45.85	32.09–59.61	Acceptable
K-40	Bq/kg	693	604	423–785	Acceptable
Sr-90	Bq/kg	301	314	220–409	Acceptable
U-233/234	Bq/kg	30	37	26–48	Acceptable
U-238	Bq/kg	33	39	27–51	Acceptable
Zn-65	Bq/kg	782	657	460–855	Acceptable
<i>Water</i>					
Am-241	Bq/L	1.22	1.30	0.91–1.69	Acceptable
Cs-134	Bq/L	78	95	67–124	Acceptable
Cs-137	Bq/L	0.76	NR	NR	Acceptable
Co-57	Bq/L	161	166	116–216	Acceptable
Co-60	Bq/L	152	154	107–200	Acceptable
H-3	Bq/L	969	952	666–1238	Acceptable
Mn-54	Bq/L	308	315	221–409	Acceptable
Pu-238	Bq/L	0.84	0.91	0.70–1.30	Acceptable
Pu-239/240	Bq/L	0.011	0.0071	NR	Acceptable
Sr-90	Bq/L	11.63	13.16	9.21–17.11	Acceptable
U-233/234	Bq/L	2.06	2.09	1.46–2.72	Acceptable
U-238	Bq/L	2.06	2.17	1.52–2.82	Acceptable
Zn-65	Bq/L	215.00	228.00	160–297	Acceptable

^a NR = not assigned, no acceptance limits were assigned for this radionuclide.

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TABLE 7.3

Summary of October MAPEP Intercomparison Samples, 2006

Parameter	Unit	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
<i>Air Filter</i>					
Am-241	Bq/filter	0.120	0.142	0.10–0.18	Acceptable
Cs-134	Bq/filter	2.50	3.15	2.20–4.09	Acceptable with Warning
Cs-137	Bq/filter	1.80	1.80	1.26–2.35	Acceptable
Co-57	Bq/filter	2.70	2.58	1.81–3.36	Acceptable
Co-60	Bq/filter	1.80	1.58	1.10–2.05	Acceptable
Mn-54	Bq/filter	1.80	1.92	1.34–2.50	Acceptable
Pu-238	Bq/filter	0.10	0.12	0.08–0.15	Acceptable
Pu-239/240	Bq/filter	-0.01	NR ^a	NR	Acceptable
Sr-90	Bq/filter	0.72	0.62	0.43–0.81	Acceptable
U-233/234	Bq/filter	0.12	0.13	0.09–0.17	Acceptable
U-238	Bq/filter	0.12	0.13	0.10–0.18	Acceptable
Zn-65	Bq/filter	-0.70	NR	NR	Acceptable
<i>Water</i>					
Am-241	Bq/L	2.14	2.31	1.62–3.00	Acceptable
Cs-134	Bq/L	93	113	79–147	Acceptable
Cs-137	Bq/L	194	196	137–255	Acceptable
Co-57	Bq/L	218	213	149–277	Acceptable
Co-60	Bq/L	47	48	33–62	Acceptable
H-3	Bq/L	443	429	300–557	Acceptable
Mn-54	Bq/L	-0.01	NR	NR	Acceptable
Pu-238	Bq/L	1.23	1.39	0.97–1.81	Acceptable
Pu-239/240	Bq/L	1.64	1.94	1.36–2.52	Acceptable
Sr-90	Bq/L	15.9	15.7	11.0–20.4	Acceptable
U-233/234	Bq/L	1.96	2.15	1.50–2.80	Acceptable
U-238	Bq/L	1.99	2.22	1.55–2.89	Acceptable
Zn-65	Bq/L	166	176	123–229	Acceptable

^a NR = not assigned, no acceptance limits were assigned for this radionuclide.

7.3. Chemical Analysis

The documentation for nonradiological analyses is contained in the EQO-AS procedure manual. All samples for NPDES and groundwater are collected and analyzed in accordance with EPA regulations found in 40 CFR Part 136,²⁰ EPA-600/4-84-017,³¹ and EPA-SW-846.²⁸

Standard reference materials traceable to the NIST exist for most inorganic analyses (see Table 7.4) and are replaced annually. Detection limits are determined with techniques listed in 40 CFR Part 136²⁰ and are given in Table 7.5. 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 as measured over an extended time period. Recovery of inorganic metals, as determined by “spiking” unknown solutions, must be within the range of 75 to 125%. The precision, as determined by analysis of duplicate samples, must be within 20%. These measurements must be taken for at least 10% of the samples. Comparison samples for organic constituents were formerly available from the EPA. They are now commercially available under the Cooperative Research and Development Agreement that exists between the EPA and commercial laboratories. In addition, standards are available that are certified by the American Association for Laboratory Accreditation, under a MOU with the EPA. Many of these standards were used in this work. At least one standard mixture is analyzed each month; Tables 7.6 and 7.7 show the 2006 results for VOCs and SVOCs, respectively. The recoveries listed are those required by the respective methods.

7.4. NPDES Analytical Quality Assurance

Argonne conducts the majority of the analyses required for inclusion in the DMR. These analyses are conducted in accordance with EPA-approved methods set out in 40 CFR Part 136.²⁰ To demonstrate the capabilities of the Argonne laboratory for these analyses, the EPA requires that Argonne participate in the DMR-QA Program. An EPA-accredited provider sends a series of intercomparison samples to Argonne annually, and the ensuing analytical results are submitted to the provider for review. The proficiency of the laboratory is determined by comparing the analytical results for the submitted samples with the provider values. The Argonne laboratory has consistently performed very well on these tests. In 2006, all results were acceptable, with the exception of TDS. A Corrective Action Statement was prepared and forwarded to the EPA provider and the IEPA. The results of these analyses are shown in Table 7.8.

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TABLE 7.4

Standard Reference Materials Used for Inorganic Analysis	
Parameter	Reference Material ^a
Antimony	HP10002-2
Arsenic	HP10003-1
Barium	HP10004-1
Beryllium	HP10005-1
Boron	HP-10007-1
Cadmium	HP-10008-1
Chromium	HP100012-1
Cobalt	HP100013-1
Copper	HP100014-1
Iron	HP100026-1
Lead	HP100028-1
Manganese	HP100032-1
Mercury	CO304130
Nickel	HP100036-1
Selenium	HP100049-1
Silver	HP100051-1
Thallium	HP100058-1
Vanadium	HP100065-1
Zinc	HP100068-1
Sulfate	HACH 891-49
Chloride	ORION 941708
Fluoride	ORION 940907

^a HACH = Hach Company; HP = High Purity; ORION = Orion, Inc.

TABLE 7.5

Parameter	Detection Limit (mg/L)	
	AA ^a	ICP ^b
Antimony	0.0030	NA ^c
Arsenic	0.0030	0.025
Barium	NA	0.012
Beryllium	0.0025	0.0025
Boron	NA	0.1
Cadmium	0.0025	0.0025
Chromium	0.015	0.05
Cobalt	NA	0.25
Copper	0.010	0.025
Hexavalent chromium ^d	0.011	NA
Iron	0.040	0.021
Lead	0.0040	0.09
Manganese	0.015	0.010
Mercury	0.0001	NA
Nickel	0.030	0.05
Selenium	0.010	0.121
Silver	0.0025	0.0025
Thallium	0.0020	0.082
Vanadium	NA	0.075
Zinc	0.010	0.02

^a AA = atomic absorption spectroscopy.

^b ICP = inductively coupled plasma-atomic emission spectroscopy.

^c NA = not analyzed.

^d Colorimetric measurement.

TABLE 7.6

Quality Check Sample Results: Volatile Analyses, 2006

Parameter	Recovery ^a (%)	Quality Limit (%)
Benzene	109	73-126
Bromobenzene	109	76-133
Bromodichloromethane	105	50-140
Bromoform	84	57-156
Butylbenzene	106	71-125
sec-Butylbenzene	107	71-145
<i>t</i> -Butylbenzene	107	69-134
Carbon tetrachloride	97	86-118
Chlorobenzene	105	80-137
Chloroform	108	68-120
<i>o</i> -Chlorotoluene	107	81-146
<i>p</i> -Chlorotoluene	107	73-144
1,2-Dibromo-3-chloropropane	76	36-154
Dibromochloromethane	99	68-130
1,2-Dibromoethane	107	75-149
Dibromomethane	115	65-143
1,2-Dichlorobenzene	107	59-174
1,3-Dichlorobenzene	102	84-143
1,4-Dichlorobenzene	106	58-172
1,1-Dichloroethane	116	71-142
1,2-Dichloroethane	117	70-134
1,1-Dichloroethene	95	18-209
<i>cis</i> -1,2-Dichloroethene	126	85-124
<i>trans</i> -1,2-Dichloroethene	93	67-141
1,2-Dichloropropane	110	19-179
1,3-Dichloropropane	120	73-145
1,1-Dichloropropene	107	71-133
Ethyl benzene	103	84-130
Isopropylbenzene	107	70-144
4-Isopropyltoluene	102	72-140
Methylene chloride	114	D-197 ^b
<i>n</i> -Propylbenzene	105	78-139
1,1,1,2-Tetrachloroethane	100	88-133
Tetrachloroethene	105	84-132
Toluene	106	81-130
1,1,1-Trichloroethane	107	68-149
1,1,2-Trichloroethane	107	70-133
Trichloroethene	110	91-135
1,2,3-Trichloropropane	104	50-158
1,2,4-Trimethylbenzene	111	80-144
1,3,5-Trimethylbenzene	109	76-142
<i>o</i> -Xylene	108	79-141
<i>p</i> -Xylene	105	74-138

^a Average of two determinations.

^b D denotes that the compound was detected.

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TABLE 7.7

Quality Check Sample Results:
Semivolatile Analyses, 2006

Parameter	Recovery ^a (%)	Quality Limit (%)
2-Fluorophenol ^b	63.7	21–100
Phenol-d5 ^b	36.5	10–94
Phenol	33.8	17–100
2-Chlorophenol	79.0	36–120
1,3-Dichlorobenzene	56.0	33–95
1,4-Dichlorobenzene	54.8	37–106
<i>n</i> -Nitroso- <i>n</i> -propylamine	41.2	24–198
Nitrobenzene-d5 ^b	80.6	35–114
1,2,4-Trichlorobenzene	74.8	57–129
4-Chloro-3-methylphenol	69.4	41–128
2-Fluorobiphenyl ^b	78.6	43–116
2-Methylnaphthalene	92.7	45–113
Acenaphthene	69.6	47–145
2,4-Dinitrotoluene	99.4	48–127
2,4,6-Tribromophenol ^b	95.0	10–123
Pentachlorophenol	102.0	38–152
Pyrene	106.0	70–100
Terphenyl-d14 ^b	108.0	33–141

^a Average of three independent determinations.

^b Required surrogates.

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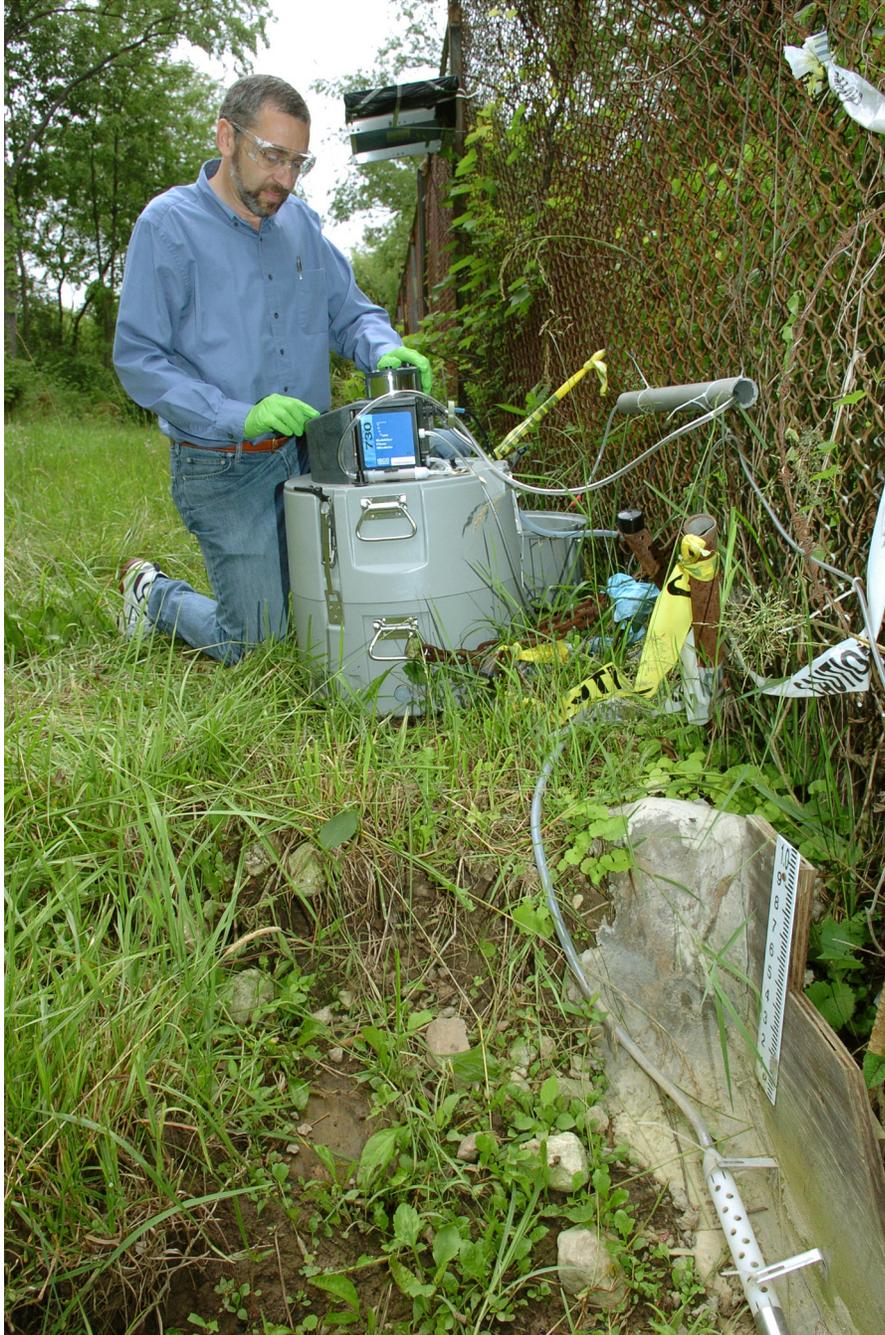
TABLE 7.8

Summary of DMR-QA Intercomparison Samples, 2006

Parameter	Unit	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Antimony	µg/L	277	275	186–334	Acceptable
Arsenic	µg/L	360	384	320–451	Acceptable
Barium	µg/L	1,320	1,300	1,130–1,470	Acceptable
Beryllium	µg/L	311	306	260–346	Acceptable
Boron	µg/L	1,201	1,190	977–1,390	Acceptable
Cadmium	µg/L	442	471	402–535	Acceptable
Chromium	µg/L	305	305	264–346	Acceptable
Cobalt	µg/L	782	773	680–866	Acceptable
Copper	µg/L	458	463	417–509	Acceptable
Iron	µg/L	431	440	386–501	Acceptable
Lead	µg/L	265	282	242–321	Acceptable
Manganese	µg/L	494	474	425–527	Acceptable
Mercury	µg/L	20.6	20.4	12.5–27.5	Acceptable
Nickel	µg/L	207	203	177–230	Acceptable
Selenium	µg/L	1,103	1,150	915–1,330	Acceptable
Silver	µg/L	290	274	235–314	Acceptable
Thallium	µg/L	740	672	549–801	Acceptable
Vanadium	µg/L	492	490	429–548	Acceptable
Zinc	µg/L	1,225	1,230	1,060–1,410	Acceptable
Hexavalent chromium	µg/L	578	558	454–656	Acceptable
Chloride	mg/L	50.4	55.4	47.1–64.2	Acceptable
Fluoride	mg/L	2.14	2.03	1.65–2.41	Acceptable
Sulfate	mg/L	25.0	28.0	22.3–33.0	Acceptable
Biochemical oxygen demand	mg/L	65.0	67.1	33.8–100	Acceptable
Chemical oxygen demand	mg/L	102	108	80.6–126	Acceptable
Ammonia nitrogen	mg/L	12.5	10.9	8.08–13.6	Acceptable
Total residual chlorine	mg/L	1.04	1.05	0.756–1.31	Acceptable
Total cyanide	mg/L	0.440	0.433	0.245–0.625	Acceptable
pH	S.U.	7.45	7.45	7.25–7.65	Acceptable
Total phenolics	mg/L	0.220	0.222	0.115–0.329	Acceptable
Total suspended solids	mg/L	46.5	50.9	39.6–58.2	Acceptable
Total dissolved solids	mg/L	379	284	212–356	Not acceptable
Oil and grease	mg/L	57.1	57.5	38.0–69.3	Acceptable
Fathead minnow acute toxicity	LC ₅₀	44.5	50.4	6.25–100	Acceptable
Water flea acute toxicity	LC ₅₀	28.5	43.9	12.4–75.3	Acceptable

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8.1. References

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8. APPENDIX

8.2. Distribution for 07/02

Internal:

B. Arnold	J.F. MacLean
T. Barkalow	R.H. McCook
S.I. Baker	B.J. Micklich
G.L. Barrett	L.P. Moos
R.M. Beaver	H.S. Morss
J.J. Benkert	G.D. Mosho
R.K. Carder	W.J. Munyon
E.N. Carter	J.L. Palasik
A.B. Cohen	B.G. Pierce
D.R. Cook	R.E. Piorkowski
T.M. Davis	J. Quinn
A.J. Dvorak	C.M. Rock
G.R. Dyrkacz	R. Rosner
A.T. Fracaro	A.P. Sattelberger
J.M. Gibson	C.M. Sholeen
N.W. Golchert (50)	V.C. Stamoudis
G.E. Griffin	R. Stevens
M.R. Hale	T.J. Tess
A.M. Harris	M.M. Torres
D.A. Haugen	K. Trychta
D.S. Hodge	J.L. Tucker
P.E. Hollopeter	D. Whitaker-Sheppard
R. Hrabak	C.L. Wilkinson (6)
D. Joyce	G. Winner (3)
M.A. Kamiya	B.M. Wozny
G.A. Kulma	R.A. Wynveen
S. K. Lorenz	G.H. Zeman
W.D. Luck	

External:

DOE-HQ, Glenn Podonsky, Chief Health, Safety and Security Officer, HS-1
DOE-HQ, Andrew C. Lawrence, Director, Office of Nuclear Safety and Environment, HS-20
DOE-HQ, Charles B. Lewis, Acting Director, Office of Corporate Safety Analysis, HS-30
DOE-HQ, Bradley A. Peterson, Director, Office of Independent Oversight, HS-60
DOE-HQ, Ross Natoli, Office of Corporate Safety Analysis, Office of Analysis, HS-32(3)
DOE-HQ, P.M. Dehmer, Office of Science, SC-10
DOE-HQ, Van Nguyen, Office of Science, SC-83
DOE-NBL, J.W. Neuhoff
DOE-ASO, R.J. Lutha (15)
R. Allen, Illinois Emergency Management Agency, Springfield, Illinois
David Antonacchi, Illinois Department of Public Health, Springfield, Illinois

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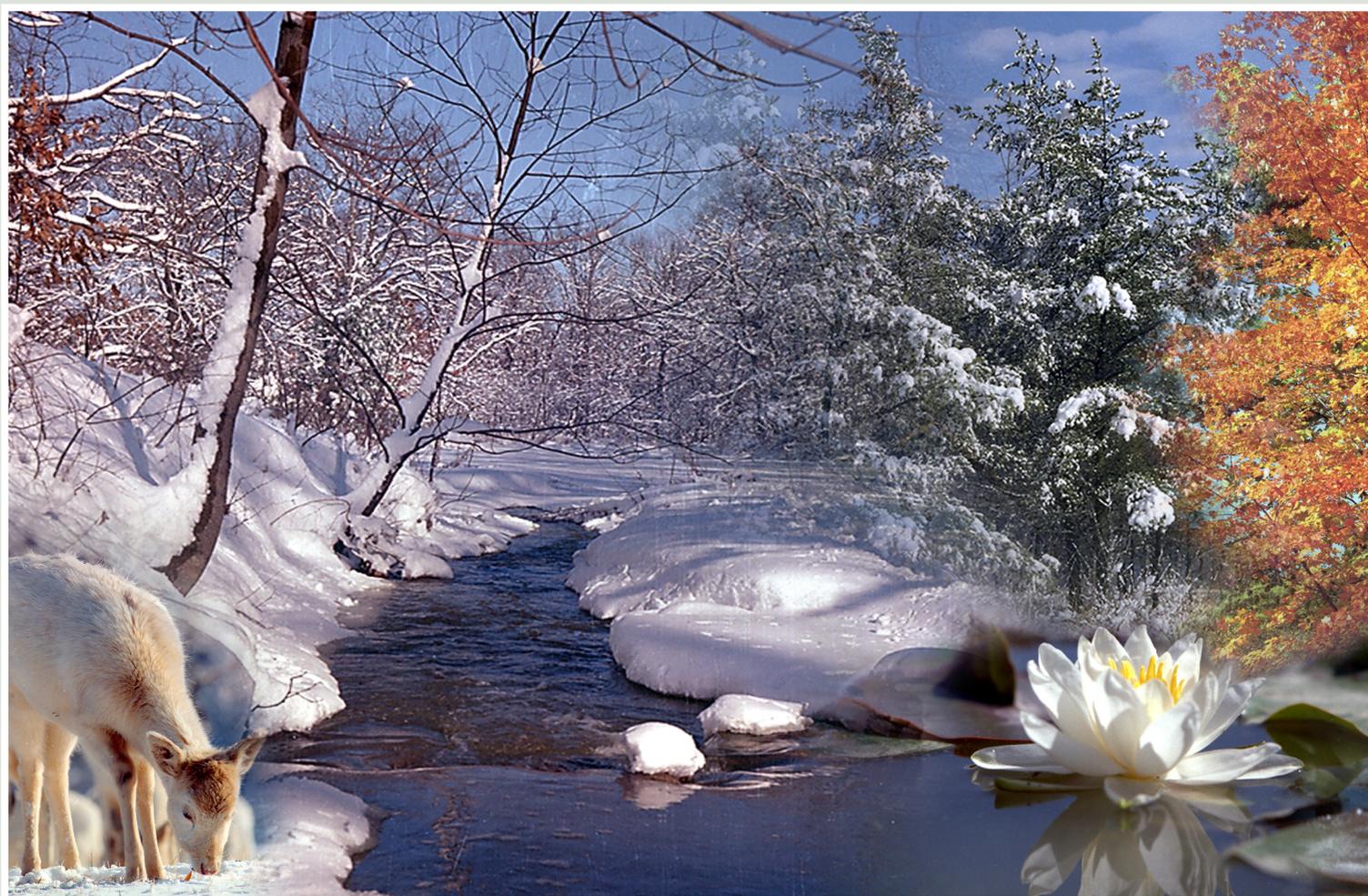
8. APPENDIX



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