ARGONNE NATIONAL LABORATORY

ANL-05/02

Site Environmental Report

for Calendar Year 2004

prepared by
Environment, Safety, and Health/Quality Assurance Oversight Division
Argonne National Laboratory

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ANL-05/02

Argonne National Laboratory Site Environmental Report for Calendar Year 2004

Preceding Report in This Series; ANL-04/2

by
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Environment, Safety, and Health/Quality Assurance Oversight Division
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September 2005

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This Site Environmental Report (SER) was prepared by the Environment, Safety, and Health/Quality Assurance Oversight (EQO) division at Argonne National Laboratory (ANL) 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/.

The majority of the figures and tables were prepared by Jennifer Tucker of the Data Management Team. Some figures, however, were prepared by Brian Cantwell of the Ecological and Geographical Sciences Section of ANL's Environmental Assessment Division. Sample collection and field measurements were conducted, under the direction of Ronald Kolzow of the Environmental Monitoring and Surveillance Group, by:

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ACM	Asbestos-Containing Material
AEA	Atomic Energy Act of 1954
AEM-X	Argonne Equipment and Materials Exchange
AGHCF	Alpha Gamma Hot Cell Facility
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
AOC	Area of Concern
APS	Advanced Photon Source
ATLAS	Argonne Tandem Linac Accelerating System
ATSR	Argonne Thermal Source Reactor
BAT	Best Available Technology
BCG	Biota Concentration Guide
BOD_5	Biochemical Oxygen Demand
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CAP-88	Clean Air Act Assessment Package-1988
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
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
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOE-ASO	DOE, Argonne Site Office
DOE-EML-QAP	DOE, Environmental Measurements Laboratory, Quality Assurance Program
E2	Energy Efficiency
EA	Environmental Assessment
EBWR	Experimental Boiling Water Reactor
EHS	Extremely Hazardous Substance
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENE	East-Northeast
EO	Executive Order
EPA	U.S. Environmental Protection Agency

ACRONYMS

EPCRA	Emergency Planning and Community Right to Know Act
EQO	Environment, Safety, and Health/Quality Assurance Oversight
EQO-AS	EQO, Analytical Services
ERP	Environmental Remediation Program
ESA	Endangered Species Act
ESH	Environment, Safety and Health
FFCA	Federal Facility Compliance Act
FY	Fiscal Year
GRO	Groundwater Remediation Objectives
HAP	Hazardous Air Pollutant
HEPA	High-Efficiency Particulate Air
HSWA	Hazardous and Solid Waste Amendments
HVEM	High-Voltage Electron Microscopy
IAC	*Illinois Administrative Code*
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
LC_{50}	Median Lethal Concentration
LEPC	Local Emergency Planning Committee
LLW	Low-Level Radioactive Waste
LTS	Long-Term Stewardship
LWTP	Laboratory Wastewater Treatment Plant
MACT	Maximum Achievable Control Technology
MAPEP	Mixed Analyte Performance Evaluation Program
MSDS	Material Safety Data Sheet
MY	Model Year
NBL	New Brunswick Laboratory
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFA	No Further Action
NHPA	National Historic Preservation Act
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
PA	Preliminary Assessment
PBT	Persistent, Bioaccumulative Toxic
PCB	Polychlorinated Biphenyl
PFS	Plant Facilities and Services
PPOA	Pollution Prevention Opportunity Assessment
PQL	Practical Quantification Limit
PSTP	Proposed Site Treatment Plan
PWA	Process Waste Assessment
QA	Quality Assurance
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
RFI	RCRA Facility Investigation
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SER	Site Environmental Report
SERC	State Emergency Response Commission
SHPO	State Historic Preservation Office
SIP	Site Implementation Plan
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SSI	Site Screening Investigation
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
SWPPC	Storm Water Pollution Prevention Committee
SWPPP	Storm Water Pollution Prevention Plan
SWTP	Sanitary Wastewater Treatment Plant
TCA	1,1,1-Trichloroethane
TDS	Total Dissolved Solids
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TRI	Toxic Release Inventory
TRU	Transuranic Waste
TSCA	Toxic Substances Control Act
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank
VOC	Volatile Organic Compound

ACRONYMS

WMO	Waste Management Operations
WQS	Water Quality Standard
WTP	Wastewater Treatment Plant
ZPR	Zero Power Reactor

This report discusses the accomplishments of the environmental protection program at Argonne National Laboratory (ANL) for calendar year 2004. The status of ANL 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 ANL operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the ANL 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 ANL 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, ANL, 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 (Clean Air Act Assessment Package-1988) computer code, was used in preparing this report.

This report summarizes the ongoing environmental protection program activities conducted by Argonne National Laboratory (ANL) in calendar year 2004. It includes descriptions of the site, ANL 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 conduct regular monitoring for radiation, radioactive materials, and nonradiological constituents on the ANL 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 ANL's impact on the environment. The surveillance program supports the ANL policy of protecting the public, employees, and the environment from harm that may result from ANL activities, and of reducing environmental impacts to the greatest degree practicable.

Compliance Summary

Radionuclide emissions, the management of asbestos, and conventional air pollutants from ANL facilities are regulated under the Clean Air Act (CAA). A number of airborne radiological emission points at ANL are subject to National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulations for radionuclide releases from U.S. Department of Energy (DOE) facilities (Title 40, Part 61, Subpart H, of the *Code of Federal Regulations* [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 ANL activities required to be reported by U.S. Environmental Protection Agency (EPA) regulations for 2004 was 0.054 mrem/yr. This is 0.5% 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 ANL, 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 NESHAPs and Occupational Safety and Health Administration worker protection standards. Approximately 311 m^3 (10,972 ft^3) of ACM was removed and disposed of at off-site landfills in Illinois during 2004.

The ANL site contains sources of conventional air pollutants. The steam plant and fuel-dispensing facilities operate continuously and are the only significant sources of continuous air pollutants. The emergency generators at the Advanced Photon Source and the engine test facility are also significant sources, when in operation. The Illinois Environmental Protection Agency (IEPA) issued the final ANL Clean Air Act Permit Program (CAAPP) Permit in April 2001. 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 ANL 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 4 months during 2004. During the period coal was burned, which occurred during colder weather to supplement the other gas-fired boilers, no exceedances were recorded.

The goals of the Clean Water Act 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. An application to renew the existing permit was submitted to the IEPA during December 1998. The IEPA did not reissue the permit in 2004, and, therefore, as provided for in the IEPA regulations, ANL continues to operate under its 1994 permit, as modified, until a renewal permit is issued. During 2004, three exceedances of the NPDES permit limits plus one unpermitted release were reported out of approximately 1,600 measurements.

ANL was granted interim status under the Resource Conservation and Recovery Act upon submitting a Part A Permit application in 1980. The IEPA issued a RCRA Part B Permit on September 30, 1997, which became effective on November 4, 1997. The permit addresses 25 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 continuing monitoring as part of the ANL Long-Term Stewardship Program.

ANL has prepared and implemented a sitewide underground storage tank (UST) compliance plan. The ANL site contains 17 USTs, which are in compliance with UST regulations.

The only Toxic Substances Control Act-regulated compounds present in significant quantities at ANL are polychlorinated biphenyls (PCBs) contained in electrical capacitors, power supplies, and small transformers. The ANL 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. During 2004, no radioactive PCB-contaminated articles, sludge, debris, or oil were shipped off site for disposal, leaving 524 L (137 gal) in storage.

In 2004, most projects requiring National Environmental Policy Act (NEPA) assessment were determined to be Categorical Exclusions. One Environmental Assessment (EA) was completed in 2004 for the decontamination and decommissioning of the Juggernaut Reactor.

Ongoing compliance issues at ANL during 2004 were concentrations of total dissolved solids 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 ANL were monitored during 2004. 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 (CAA Assessment Package-1988) computer code. The estimated maximum perimeter dose from airborne releases was 0.59 mrem/yr in the east direction, while the estimated maximum dose to a member of the public was 0.054 mrem/yr. This latter value is 0.05% of the DOE radiation protection standard of 100 mrem/yr for all pathways. 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 0.054 mrem/yr. The estimated population dose from releases to the approximately nine million people living within 80 km (50 mi) of the site was 3.75 person-rem.

Monitoring of particulates in ambient air was conducted for total alpha activity, total beta activity, strontium-90, isotopic thorium, isotopic uranium, and plutonium-239 at the ANL site perimeter and at off-site locations. No statistically significant difference was identified between samples collected at the ANL perimeter and samples collected off site. Monitoring was not conducted for hazardous chemical constituents in ambient air.

The only detectable radionuclides and chemical pollutants in surface water due to ANL 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 0.09 Ci of hydrogen-3. The other radionuclides were released at less than 0.001 Ci total. The hydrogen-3 was added to the wastewater as part of normal ANL operations. The dose to a hypothetical individual using water from Sawmill Creek as his or her sole source of drinking water would be 0.018 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 ANL 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 0.09 pCi/g) and americium-241 (up to 0.02 pCi/g) were detected in the sediment below the outfall and are attributed to past ANL releases.

Dose rates from penetrating radiation (gamma rays) were measured at 17 perimeter and on-site locations and at 5 off-site locations in 2004 using thermoluminescent dosimeters. The off-site results averaged 98 ± 8 mrem/yr, which is slightly elevated compared with the long-term average dose. Above-background doses occurred at one perimeter location and were due to ANL operations. At the south fence, radiation from a temporary storage facility for radioactive waste resulted in an average dose of 107 ± 13 mrem/yr for 2004, 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.

The potential radiation doses to members of the public from all sources and pathways due to ANL operations during 2004 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The inhalation pathway would be primary. The highest estimated dose was approximately 0.073 mrem/yr to a hypothetical individual living east of the site, assuming 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 ANL 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 ANL site in 2004. The former ANL 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.

Ten monitoring wells screened in the glacial drift and two in the dolomite were sampled quarterly at the 317 and 319 Areas and analyzed for radiological, volatile organic, semivolatile, PCB, and pesticide and herbicide constituents. The major organic contaminants detected were 1,4-dioxane, 1,1,1-trichloroethane, 1,1-dichloroethane, and trichloroethene. Measurable levels of hydrogen-3 and strontium-90 were present in several of the wells. Remediation continued in this area using phytoremediation and groundwater extraction to remove volatile organic compounds (VOCs) and hydrogen-3 from groundwater.

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, metals, VOCs, semivolatile organic compounds (SVOCs), pesticides, herbicides, and PCBs. Measurable levels of hydrogen-3 and strontium-90 were detected regularly.

Twenty-six monitoring wells at the 800 Area Landfill were sampled on a quarterly basis and analyzed for metals, cyanide, phenols, total organic carbon, total organic halogens, VOCs, SVOCs, PCBs, pesticides, herbicides, and hydrogen-3. As in previous years, levels above Illinois Class I Groundwater Quality Standards for iron, lead, manganese, sulfate, and TDS were found in some wells. Above-background levels of hydrogen-3 were detected in several of the wells, with concentrations up to 453 pCi/L. This is well below the standard of 20,000 pCi/L.

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 the annual report.

1. INTRODUCTION

1.1. General

This annual report for calendar year 2004 of the Argonne National Laboratory (ANL) 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 ANL, and the amounts, if any, added to the environment by ANL operations. It also summarizes the compliance of ANL operations with applicable environmental laws and regulations and highlights significant accomplishments and issues related to environmental protection and environmental remediation. The report was prepared in accordance with the guidelines of DOE Orders 450.1[1] and 231.1A[2] and supplemental DOE guidance.

ANL 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 ANL operations is of special interest, because one important function of this program is verification of the adequacy of the site's pollution control systems.

ANL 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 2004 included safety studies for light-water reactors; high-temperature superconductivity experiments; development of electrochemical energy sources, including fuel cells and batteries for vehicles and for energy storage; and studies to promote clean, efficient transportation.

Other areas of research are 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 ANL 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 ANL site.

1. INTRODUCTION

The principal nonnuclear activities at ANL in 2004 that could have measurable impacts on the environment include the use of a coal-fired boiler (No. 5), discharge of wastewater from various sources, and the cleanup of inactive waste disposal areas.

1.2. Description of Site

ANL 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 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 ANL 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 ANL 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 ANL 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 ANL has experienced significant population growth in the past 30 years. Large areas of farmland have been converted into housing. Table 1.1 gives the directional and annular 80-km (50-mi) population distribution for the area, which is used to derive the population dose calculations presented later in this report. The population distribution, centered on the Chicago Pile-Five (CP-5) reactor (Location 9G in Figure 1.1), was prepared by the Risk

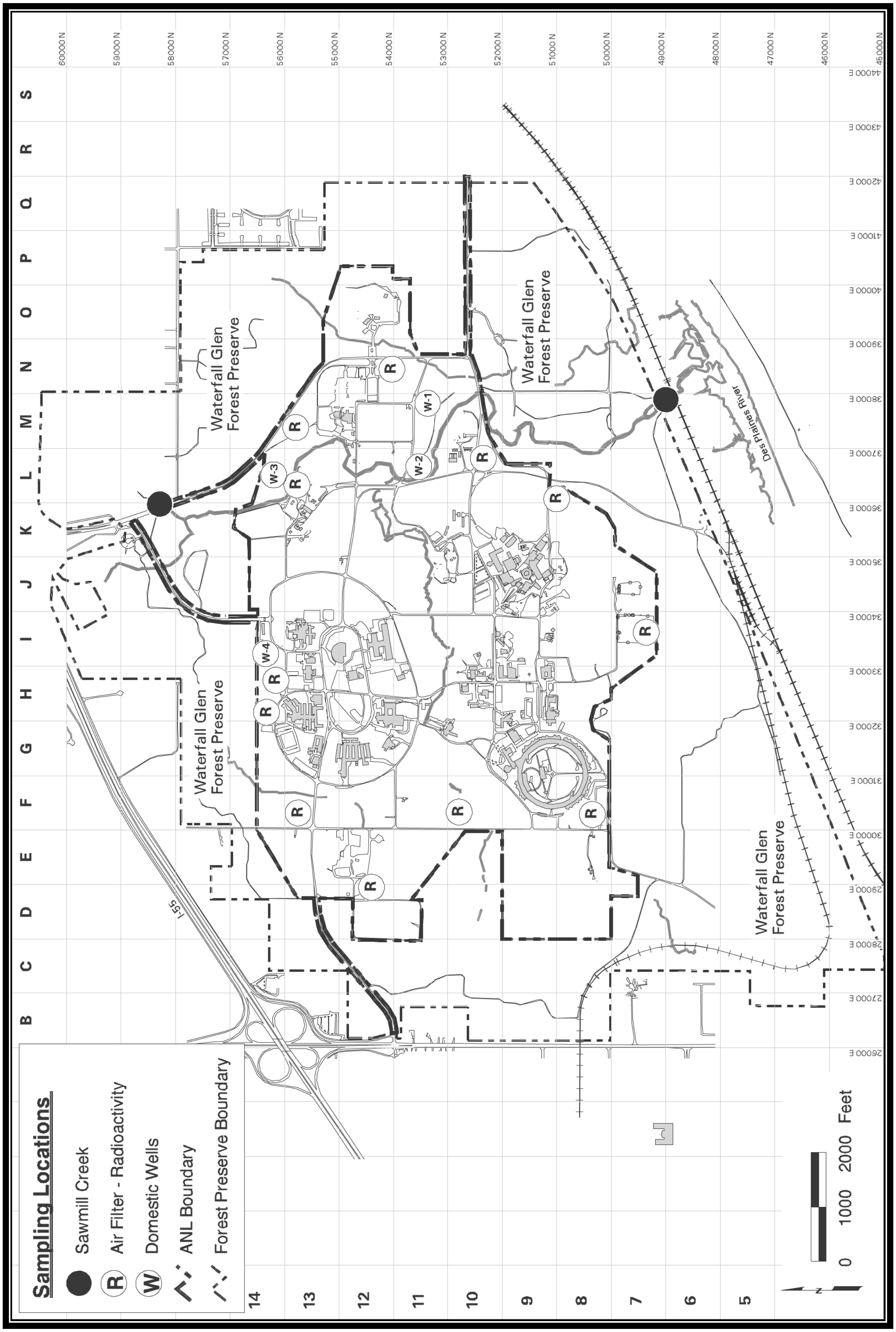


FIGURE 1.1 Sampling Locations at Argonne National Laboratory

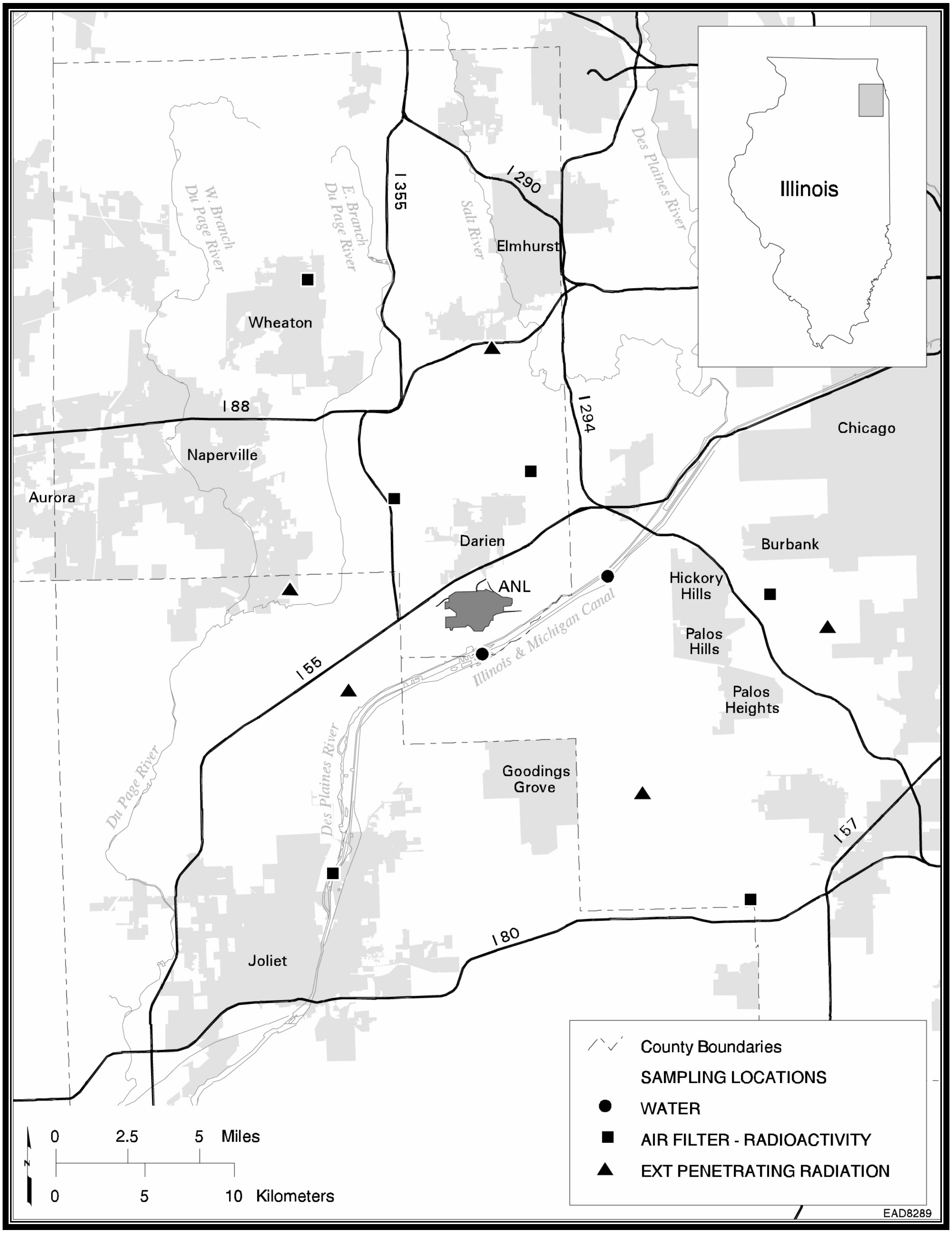


FIGURE 1.2 Sampling Locations near Argonne National Laboratory

TABLE 1.1

Population Distribution in the Vicinity of ANL, 2000

	Miles[a]									
Direction	0 – 1	1 – 2	2 – 3	3 – 4	4 – 5	5 – 10	10 – 20	20 – 30	30 – 40	40 – 50
N	0	1,269	3,646	6,190	9,651	46,597	183,061	353,821	222,737	309,159
NNE	0	611	4,112	5,971	6,169	40,711	302,525	492,536	102,273	1,094
NE	0	837	2,010	2,138	1,846	42,637	712,685	1,009,469	0	0
ENE	0	1,021	1,291	2,308	1,986	33,931	633,468	195,890	0	0
E	0	1,163	557	366	386	42,520	467,488	216,642	9,770	26,128
ESE	0	590	269	371	509	18,494	190,441	293,764	230,611	91,154
SE	0	309	271	459	947	25,059	131,937	120,187	34,557	17,023
SSE	0	451	400	1,014	1,327	18,433	42,321	9,904	14,172	15,963
S	0	628	2,302	2,148	1,221	8,181	31,084	4,436	36,505	36,639
SSW	0	529	2,329	2,645	1,001	18,156	89,111	12,221	20,350	7,739
SW	0	213	596	409	142	14,931	66,453	12,394	17,310	7,385
WSW	0	168	159	554	2,628	17,249	23,864	5,422	8,705	11,633
W	0	186	2,026	7,735	9,338	40,270	93,303	23,547	17,727	6,810
WNW	0	528	1,862	5,815	6,516	46,444	154,113	37,805	7,469	58,587
NW	0	711	2,317	7,057	7,769	45,993	83,324	123,290	23,881	19,530
NNW	0	1,088	2,628	5,961	9,457	34,008	217,040	263,590	172,437	122,112
Total	0	10,302	26,775	51,141	60,893	493,614	3,422,218	3,174,918	918,504	730,956
Cumulative total[b]	0	10,302	37,077	88,218	149,111	642,725	4,064,943	7,239,861	8,158,365	8,889,321

[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.

Assessment and Safety Evaluation Group of the Environmental Assessment Division at ANL and represents projections 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 2004 data were obtained from the on-site ANL meteorological station. The 2004 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 the wind rose represents the percentage of observations of wind speed less than 2 m/s (4.5 mph) in all directions. The direction of the radii from the center represents the direction from which the wind blows. Sixteen radii are shown on each plot at 22.5º intervals; each radius represents the average wind speed for the direction covering 11.25º on either side of the radius. The annual average wind rose for 2004 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 2004 precipitation and temperature data. The monthly precipitation data for 2004 show a few differences from the ANL average. For example, March and August were above the monthly average, while January, February, and September were below the average. The annual total was 9% below the annual average for the ANL data. The monthly temperatures were generally similar when compared with the long-term monthly average. The 2004 annual monthly average was essentially the same as the long-term annual average. The climatology information was provided by the Atmospheric Research Section of the Environmental Research Division.

1.5. Geology

The geology of the ANL 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.

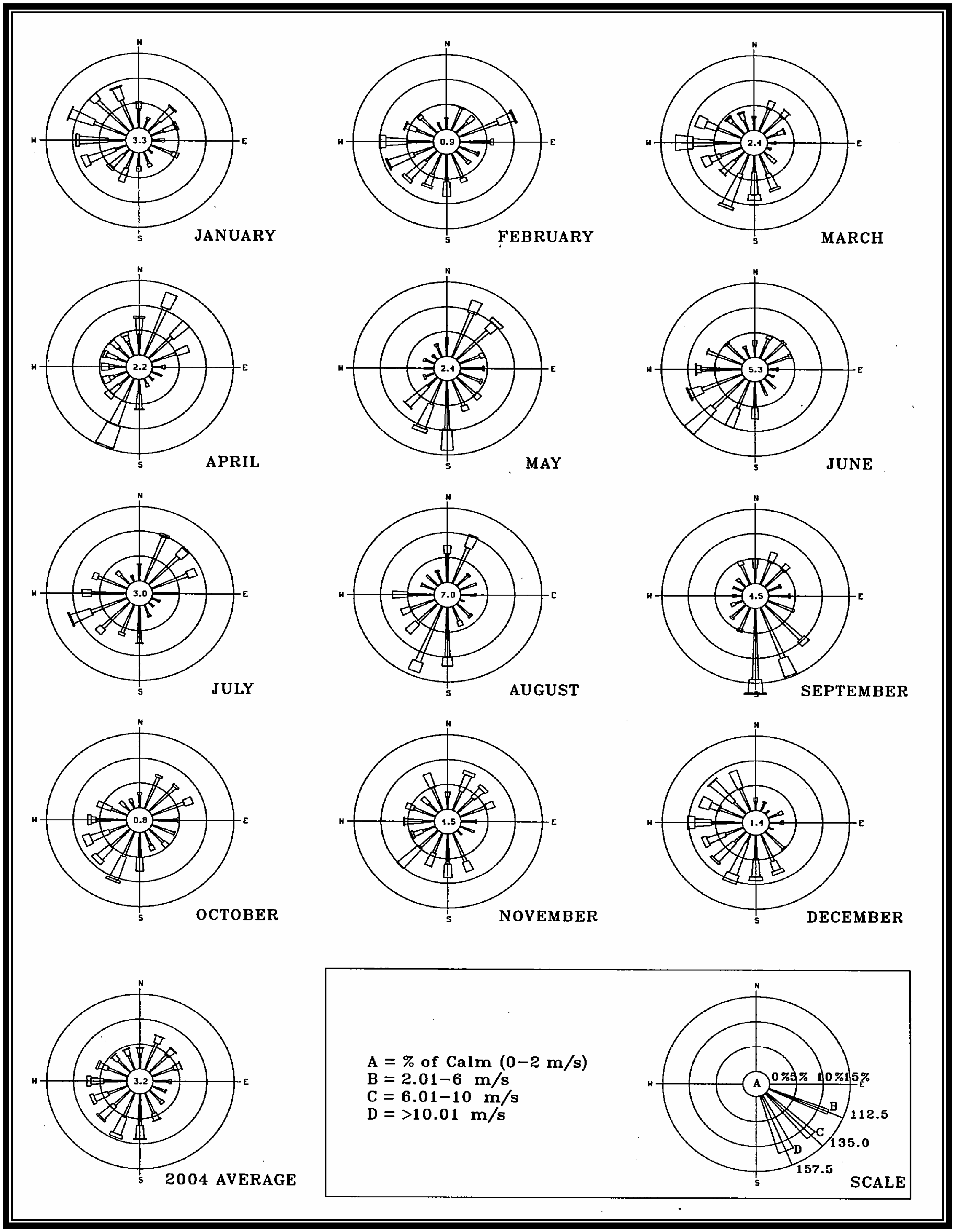


FIGURE 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory, 2004

TABLE 1.2

ANL Weather Summary, 2004

	Precipitation (cm)			Temperature (°C)	
Month	ANL 2004	ANL Historical[a]		ANL 2004	ANL Historical[a]
January	1.70	4.15		–6.9	–4.5
February	1.60	4.42		–2.0	–1.9
March	9.80	5.98		4.9	3.0
April	4.90	8.64		10.6	9.2
May	8.58	9.73		15.5	15.2
June	10.16	8.99		20.1	20.6
July	9.02	10.43		21.6	23.1
August	18.28	10.34		19.7	22.1
September	1.35	8.76		20.1	17.9
October	5.44	8.70		13.0	11.3
November	10.34	8.61		6.5	7.2
December	3.99	4.65		–1.7	–2.8
Total	85.16	93.40	Monthly Average	10.1	10.0

[a] Averages were obtained from the ANL meteorological tower by using data from the last 20 years (1983–2002).

The southern boundary of ANL 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 ANL 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 ANL. 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 ANL 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 ANL. The upper aquifer is the Niagaran and Alexandrian dolomite, which is approximately 60 m (200 ft) thick in the ANL 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 ANL 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 major suburban areas is expected to relieve this problem. ANL now obtains all 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, which enter the site from the western boundary, 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 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 ANL site is drained by Freund Brook. Two intermittent 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 ANL are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. In 2004, this effluent averaged 3.05 million L/day (0.81 million gal/day), which is similar to the averages for the last few years. The combined ANL effluent consisted of 60% laboratory wastewater and 40% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 24 million L/day (6.4 million gal/day) during 2004.

Sawmill Creek and the Des Plaines River upstream of Joliet, about 21 km (13 mi) southwest of ANL, receive very little recreational or industrial use. A few people fish in these waters downstream of ANL, and some duck hunting takes place on the Des Plaines River. Water from the Chicago Sanitary and Ship Canal is used by ANL for cooling towers and by others for industrial purposes, such as hydroelectric generators and condensers. ANL usage is approximately 1.9 million L/day (0.5 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 ANL. 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 ANL. In the vicinity of ANL, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

The principal recreational area near ANL 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 ANL 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 ANL site (Location 12-0 in Figure 1.1) is for use by ANL 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 ANL and DOE employees.

1.9. Vegetation

ANL 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, northwest 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 ANL 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 sugar maple, 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 ANL 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 ANL 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 ANL 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 ANL 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 ANL site. The white-tailed and fallow deer populations are each maintained at a target density of 15 deer/mi^2 under an ongoing deer management program.

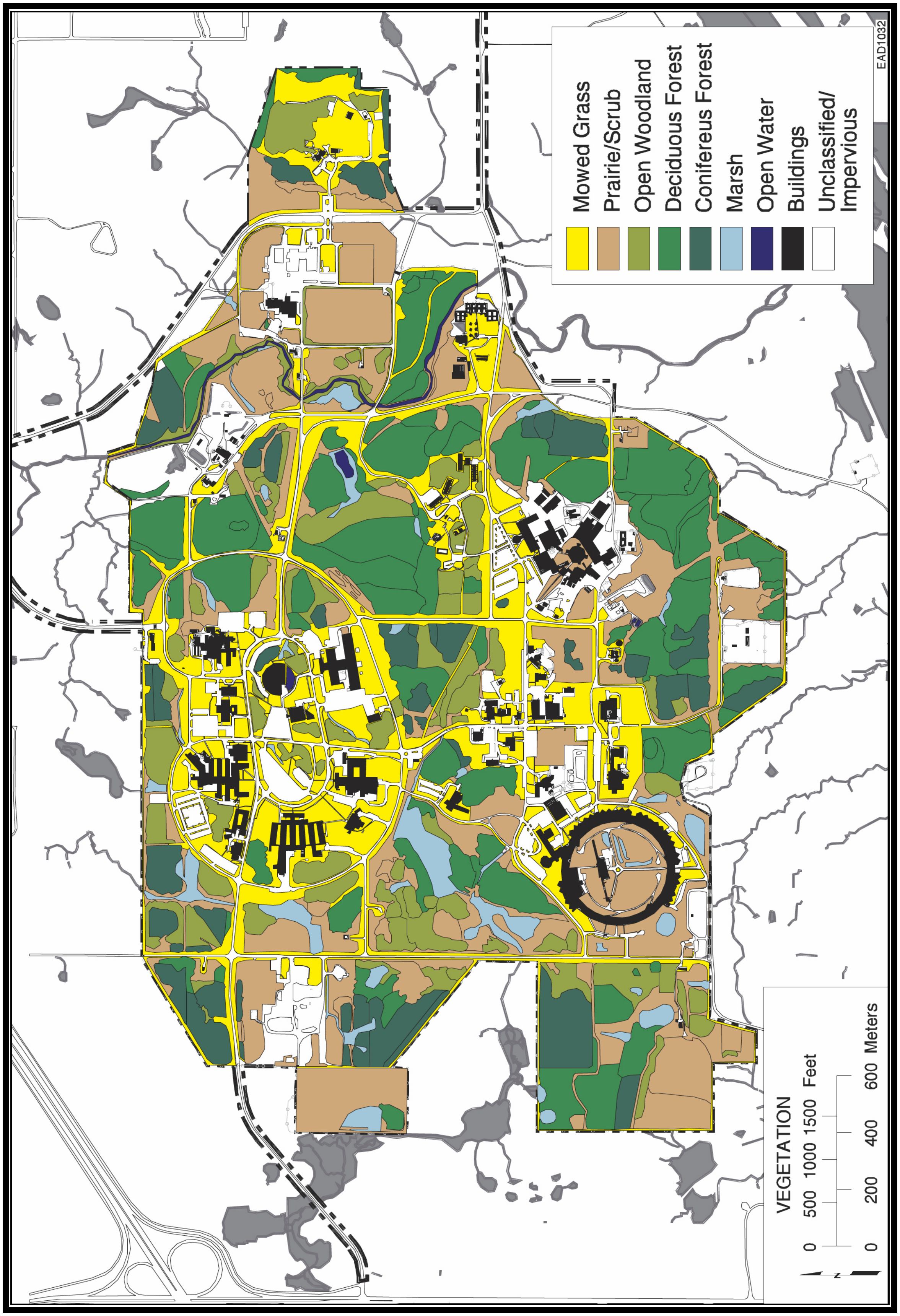


FIGURE 1.4 ANL Vegetation Communities

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 ANL 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 ANL 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 ANL streams, as "poor" in terms of the fish species present because of domestic and industrial pollution and stream modification.

1.11. Cultural Resources

ANL, 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 ANL area either by professional cultural resource investigators or through interviews of local artifact collectors by ANL 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 ANL. 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.

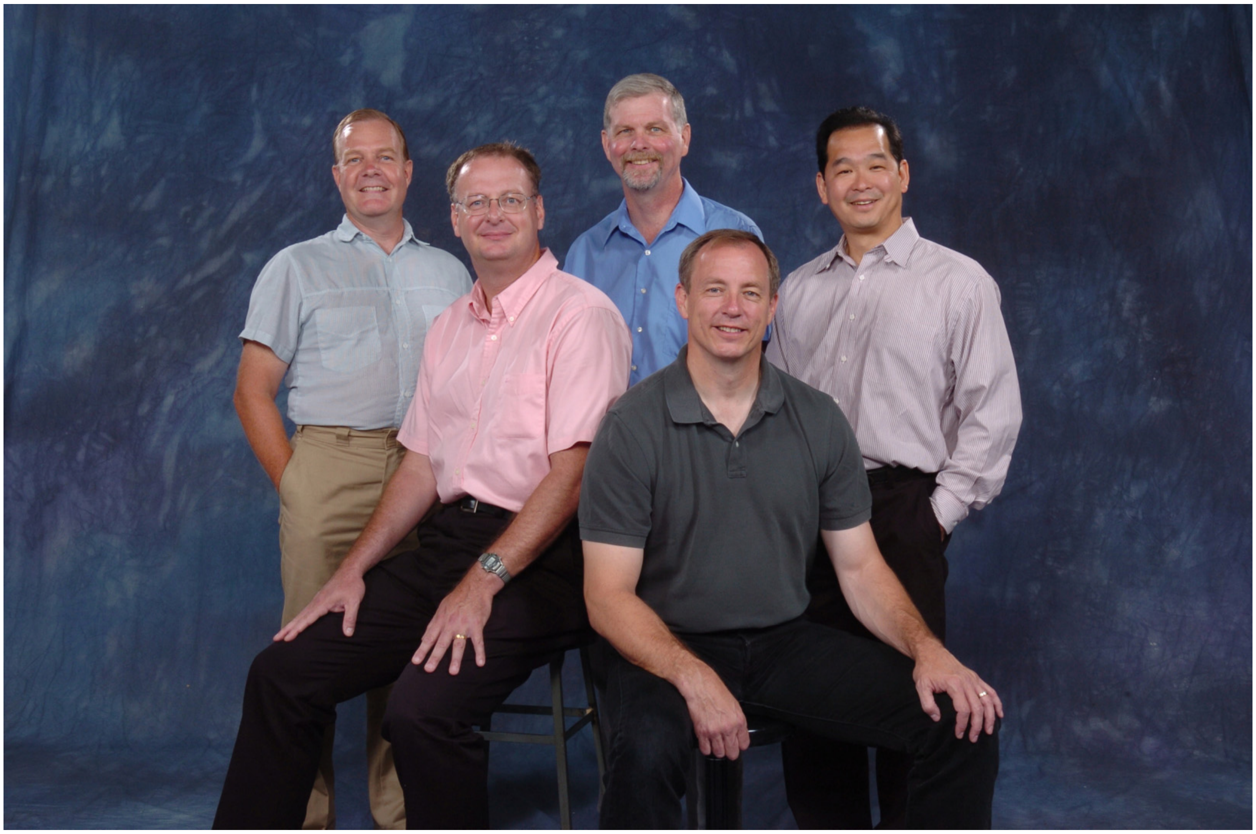
Cultural resources also include historic structures. Historic property surveys over the past several years identified two areas at ANL that are eligible for listing in the NRHP as historic districts, as well as several buildings that are individually eligible for listing in the NRHP.

1.12. Endangered Species

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

The Hine's emerald dragonfly (*Somatochlora hineana*), federal 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 federal 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 federal and state listed as endangered, indicates that this species may occur in the area. The federal-listed threatened lakeside daisy (*Hymenoxys herbasea*) has a planted population in Waterfall Glen Forest Preserve. Additional state-listed species that occur in the area are identified in Section 2.10. Of these, Kirtland's snake, pied-billed grebe, black-crowned night heron, brown creeper, and red-shouldered hawk have been observed on ANL property.

2. COMPLIANCE SUMMARY



ANL is a 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 ANL during 2004 with regard to these authorities is discussed in this chapter.

ANL has made a commitment to comply with all applicable environmental requirements, as described in the following policy statement:

> The policy of Argonne National Laboratory is that its activities are to be conducted in such a manner that worker and public health and safety and protection of the environment are given the highest priority. The Laboratory will comply with all applicable federal and state health, safety, and environmental laws, regulations, and orders, so as to protect the health and safety of workers and the public and to minimize accidental damage to property.

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, ANL 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. ANL meets the definition of a major source because of potential emissions of oxides of nitrogen in excess of 22.68 t/yr (25 tons/yr) and sulfur dioxide in excess of 90.72 t/yr (100 tons/yr) at the Building 108 Central Heating Plant (see Table 2.4).

On October 26, 2004, ANL received a renewal notice from the IEPA notifying the Laboratory that a permit renewal application was due no later than nine months prior to expiration of the CAAPP permit (April 3, 2006). ANL began preparation of the permit renewal application in the fall of 2004. The target date for submission is spring 2005. The application will include documentation to address the Compliance Assurance Monitoring Rule, as well as a determination of the applicability of all state and federal environmental regulations finalized since the original application was submitted. All new emission sources that have commenced operation under special conditions of their construction permits will be included in the new permit.

Facilities subject to Title V must characterize emissions of all regulated air pollutants, not only those that qualify them as major sources. In addition to oxides of nitrogen and sulfur dioxide, ANL 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 ANL 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 2004, there was one construction permit issued for the Building 335 Juggernaut Reactor Decontamination and Decommissioning (D&D) project. The IEPA conducted an air inspection at ANL on September 23, 2004. There were no violations or noncompliances at that time.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAPs) constitute a body of federal regulations that set forth emissions limits and other requirements, such as monitoring, record keeping, and operational and reporting requirements, for activities generating emissions of certain HAPs. The only standards affecting ANL operations are those for asbestos and radionuclides. By the time of the issuance of the sitewide ANL Title V Permit, the IEPA had issued a total of 23 air pollution control permits to ANL for NESHAPs sources. All ANL operating NESHAPs Permits were incorporated into the sitewide ANL Title V Permit.

In 2002, the EPA proposed a number of additional NESHAPs that could have potential impacts on ANL operations. Specifically, NESHAPs (also known as Maximum Achievable Control Technology or MACT standards) were proposed to regulate HAP emissions from institutional boilers, reciprocal internal combustion engines, and engine testing facilities.

These MACT standards would be applicable to major HAP sources (facilities with emissions or potential emissions of 9 t/yr [10 tons/yr] of any HAP, or 23 t/r [25 tons/yr] of all combined HAPs). While ANL had not been categorized as a major HAP source in the original CAAPP application, HAP emissions from combustion sources had not been included, because at the time, the IEPA indicated that reliable emission factors were not available. In 2002, the IEPA stated that HAP emissions from combustion sources needed to be included to determine applicability of the upcoming MACT standards.

On the basis of potential to emit, it was determined that by considering combustion sources, ANL would now be categorized as a major HAP source and therefore would be subject to the MACT standards when they became final in 2003. As a consequence, following coordination with the IEPA, an application for a minor permit modification was prepared and submitted to the IEPA on November 18, 2002, requesting that an enforceable limit of 11,000 t/yr (12,000 tons/yr) of coal for Boiler No. 5 be included in the CAAPP Permit. This limit would reduce ANL's potential HAP emissions to levels below the major source threshold. The IEPA later determined that this change constituted a significant modification to the CAAPP Permit. The revised CAAPP Permit was issued on March 27, 2003.

2.1.1.1. Asbestos Emissions

Many buildings on the ANL 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 NESHAPs.

ANL maintains an asbestos abatement program designed to ensure compliance with these and other regulatory requirements. In general, ACM is removed from buildings either by specially trained ANL crews (for small-scale, short-duration projects) or by outside contractors (for large-scale insulation removal projects). All removal work is performed in accordance with both NESHAPs and Occupational Safety and Health Administration requirements governing worker safety at ACM removal sites.

Approximately 311 m^3 (10,972 ft^3) of ACM was generated from ANL asbestos removal projects during 2004. The 96 small removal projects that were completed generated 69.7 m^3 (2,462 ft^3) of ACM waste. Approximately 24 m^3 (860 ft^3) of this ACM waste was generated from many separate small removal operations during the HVAC Reheat Coil Upgrade Project in Building 221. Most of the waste material generated was polyethylene sheeting used to construct barriers and decontamination chambers in the work areas. Eleven large removal projects generated the remaining 241 m^3 (8,510 ft^3) of ACM waste. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 2004 that no more than 71 m^3 (2,500 ft^3) of ACM waste is expected to be generated from small-scale projects during 2005.

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. Asbestos disposal information is provided in Table 2.2. Until closure of the ANL 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 NESHAPs standard for radionuclide emissions from DOE facilities (Title 40, Part 61, Subpart H of the *Code of Federal Regulations* [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 record keeping. A number of emissions points at ANL 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

TABLE 2.1

Large-Scale Asbestos Abatement Projects DOE/IEPA Notification, 2004

Completion Date	Asbestos Abatement Contractor	Notification Quantity			Material	Building	Disposal Quantity (ft^3)	Landfill
		ft	ft^2	ft^3				
1/21/2004	ANL PFS Waste Management Operations (WMO)	0	875	0	Sprayed-on Insulation	223	810	Environtech[a]
2/2/2004	Brandenburg Industrial Services Company	60	300	0	Chiller Insulation Transite Panels	213	594	Environtech
3/27/2004	ANL PFS WMO	0	300	0	Floor Tile and Mastic[b]	335	16	Environtech
3/31/2004	ANL PFS WMO	0	2,835	0	Floor Tile and Mastic[b]	200	100	Environtech
4/2/2004	ANL PFS WMO	0	400	0	Floor Tile and Mastic[b]	350	16	Environtech
6/18/2004	ANL PFS WMO	225	160	0	HVAC Pipe Insulation	200	160	Environtech
8/31/2004	ANL PFS WMO	600	0	0	Steam Pipe Insulation[c]	360 362	5,670	Environtech
9/15/2004	ANL PFS WMO	0	180	0	Transient Panels	377	120	Environtech
9/17/2004	ANL PFS WMO	10	520	0	Transient Panels Pipe Insulation	208	276	Environtech
9/30/2004	ANL PFS WMO	0	0	75	Demolition Roofing Tar	329	NA[d]	Environtech
10/29/2004	ANL PFS WMO	1,000	0	0	Drain Pipe Insulation	350	60 336	Environtech Envirocare of Utah[e]
12/23/2004	ANL PFS WMO	290	0	0	HVAC Pipe Insulation	362	352	Environtech

a Morris, IL.

b Courtesy notification, nonfriable material removed intact.

c Includes asbestos-contaminated soil.

d Not applicable, tar is exempt from NESHAP disposal requirements.

e Salt Lake City, UT.

TABLE 2.2

Disposal of Asbestos-Containing Materials, 2004

Project Size	Landfill	Quantity (ft^3)	Total Quantity (ft^3)
Small-scale	Environtech[a]	2,462	2,462
Large-scale (IEPA Notification)	Environtech	8,174	8,510
	Envirocare[b]	336	
		Total	10,972

[a] Environtech, Morris, IL.

[b] Envirocare of Utah, Salt Lake City, UT.

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 ANL emissions 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 2004 was 0.054 mrem, which is less than 0.5% of the 10 mrem/yr EPA standard. Section 4.6.1 contains a more detailed discussion of these emissions points and compliance with the standard.

2.1.2. Conventional Air Pollutants

The ANL 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, the 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 emissions limits for this boiler (30% opacity averaged over 6 minutes and 0.82 kg [1.8 lb] of sulfur dioxide per million Btu averaged over a 1-hour period). Table 2.3 gives the hours that Boiler No. 5 operated on low-sulfur coal during 2004, as well as the amount of low-sulfur coal burned. There were no exceedances at Boiler No. 5 in 2004.

An annual compliance certification must be submitted to the IEPA and the EPA each May 1 for the previous calendar year, detailing any deviations from the Title V Permit and subsequent corrective actions. No deviations were identified for 2004.

TABLE 2.3

Boiler No. 5 Operation, 2004

Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	744.0	2,556.6
February	476.0	1,536.6
March	54.0	152.0
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
November	0	0
December	109.8	320.0
Total	1,383.8	4,565.2

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 or not methane is migrating from the landfill. Results indicate that methane is being generated. No migration of this compound was noted in 2004.

Fuel-dispensing facilities included a commercial service station that was closed in 2004 and the Building 46 Grounds and Transportation facility. Except for ethanol vapors from alternate fuel usage, these facilities have VOC emissions typical of any commercial gasoline service station.

Pursuant to *Illinois Administrative Code*, Title 35, Part 254 (35 IAC Part 254), ANL submits an emissions report to the IEPA each May 1 for the previous year. The summary for 2004 is presented in Table 2.4.

2.1.3. Clean Fuel Fleet Program

As mandated under the CAA and 35 IAC Part 241, the sixth annual Clean Fuel Fleet Program report was submitted to the IEPA on October 15, 2004, for vehicle acquisitions in Model Year (MY) 2004 (September 1, 2003–August 31, 2004). Seven light-duty vehicles and one heavy-duty vehicle were reported. Total vehicle acquisitions were in compliance with the percentages required by the Clean Fuel Fleet Program.

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

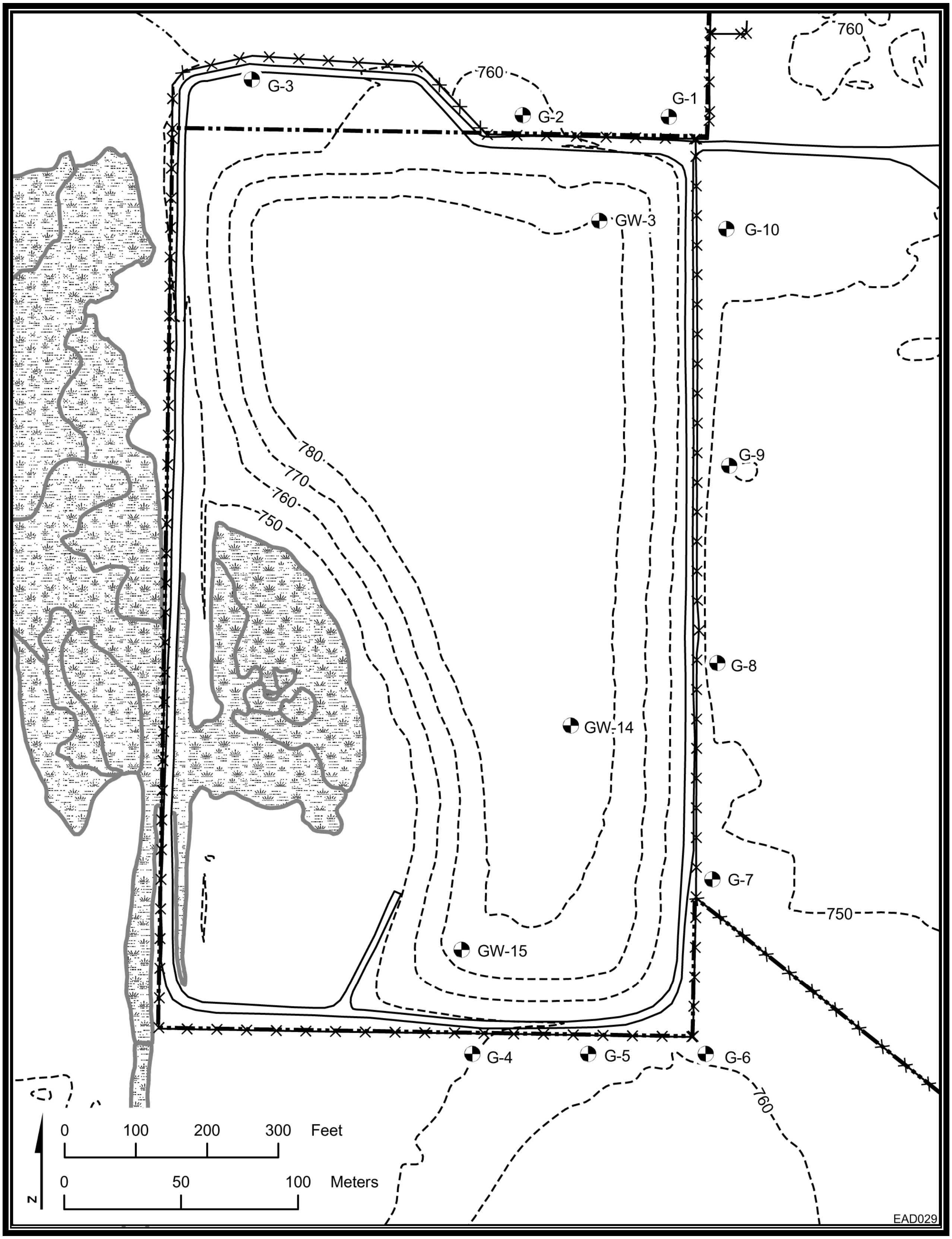


FIGURE 2.1 800 Area Landfill Gas Monitoring Wells

TABLE 2.4

2004 Annual Emissions Report: Emissions Summary

Building No. and Source	CO[a]	NO_x	PM/PM_{10}	$PM_{2.5}$[b]	SO_2	VOM	HAP[c]	NH_3[b]
46: Ethanol/Gasoline	–[d]	–	–	–	–	0.6	–	–
46: 10,000 Gal Gasoline	–	–	–	–	–	13.1	–	–
108: Boiler 1	16,592	55,307	603	375	121	282	–	97
108: Boiler 2	3,566	11,886	130	81	26	61	–	21
108: Boiler 3	22,452	74,841	816	508	163	381	–	131
108: Boiler 4	12,112	40,375	440	274	88	206	–	71
108: Boiler 5 (coal-fired)	23,739	50,208	356	146	98,113	166	6,165	2.6
108: Boiler 5 (gas-fired)	0	0	0	0	0	0	–	0
108: Sulfuric Acid Tank[e]	–	–	–	–	–	–	–	–
200: Peak Shaving Generator	0	0	0	0	0	0	–	0
200: M-Wing Hot Cells (R)[f]	–	–	–	–	–	–	–	–
202: Peak Shaving Generator	0	0	0	0	0	0	–	0
206: Alkali Reaction Booth (R)[f]	–	–	<1	–	–	–	–	
208: Surface Preparation Facility	–	0	0	–	–	–	0	–
212: Alpha Gamma Hot Cell (R)[f]	–	–	–	–	–	–	–	–
212: Building Exhausts[e]	–	–	–	–	–	–	–	–
300: 8,000 Gal Gasoline	–	–	–	–	–	35.3	–	–
300: 10,000 Gal Gasoline	–	–	–	–	–	4.9	–	–
300: 6,000 Gal Gasoline	–	–	–	–	–	11.8	–	–
301: Hot Cell D&D Project (R)[f]	–	–	–	–	–	–	–	–
303: Mixed Waste Storage (R)[f]	–	–	–	–	–	–	–	–
306: Building Vents (R)[f]	–	–	<1	–	–	–	–	–
306: Bulking Sheds[f]	–	–	2.9	–	–	57.1	2.0	–
306: Vial Crusher/Chemical Photooxidation Unit (R)[f]	–	–	–	–	–	2.4	–	–
308: Alkali Reaction Booth[e]	–	–	–	–	–	–	–	–
315: MACE Project (R)[f]	248	–	–	–	–	–	–	–
330: CP-5 D&D Project (R)[f]	–	–	–	–	–	–	–	–
331: Rad Waste Storage (R)[f]	–	–	–	–	–	–	–	–
350: NBL Pu/U Hoods (R)[f]	–	–	–	–	–	–	–	–
363: Central Shop Dust Collector[e]	–	–	–	–	–	–	–	–
368: Woodshop Dust Collector[e]	–	–	–	–	–	–	–	–
370: Alkali Reaction Booth[e]	–	–	–	–	–	–	–	–
375: Intense Pulsed Neutron Source (R)[f]	–	–	–	–	–	–	–	–
400: APS Facility (R)[f]	–	55	–	–	–	–	–	–
400: APS Generator Caterpillar (1 unit)	310	1,617	58	50	134	44	–	0.9
400: APS Generator Kohler (2 units)	2,519	3,466	135	80	712	123	–	1.5
595: Lab Wastewater Plant (R)[f]	–	–	–	–	–	42.4	0.5	–
Lab Rad Hoods (R)[f]	–	–	–	–	–	–	–	–
PCB Tank Cleanout	–	–	–	–	–	0	–	–
Torch Cut Lead-Based Paint[e]	–	–	–	–	–	–	–	–
Transportation Research Facility	8,262	8,569	621	145	553	995	–	7.4
WMO Portable HEPA - (6) (R)[f]	–	–	<1	–	–	–	–	–
Total (lb/yr)	89,850	246,324	3,162	1,659	99,910	2,424	6,167	332
Total (tons/yr)	44.93	123.16	1.58	0.8296	49.95	1.21	3.08	0.1659
CAAPP Permit Limit (tons/yr)	(237.60)[g]	639.10	66.02	–	332.20	18.65	10.00	–

Footnotes on next page.

TABLE 2.4 (Cont.)

[a] Abbreviations: APS = Advanced Photon Source; CAAPP = Clean Air Act Permit Program; CP-5 = Chicago Pile-Five reactor; CO = carbon monoxide; D&D = decontamination and decommissioning; HAP = hazardous air pollutant; HEPA = high-efficiency particulate air; MACE = melt attack and coolability experiment; NBL = New Brunswick Laboratory; NH_3 = ammonia; NO_x = oxides of nitrogen; PCB = polychlorinated biphenyl; PM_{10} = particulate matter less than 10 microns; $PM_{2.5}$ = particulate matter less than 2.5 microns; Pu = plutonium; SO_2 = sulfur dioxide; U = uranium; VOM = volatile organic material; and WMO = Waste Management Operations.

[b] As of 2003, emissions of $PM_{2.5}$ and a precursor, ammonia (NH_3), must be included.

[c] These compounds are HAPs, but are not classified as VOMs or particulates.

[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] These sources have been designated as insignificant in the CAAPP.

[f] (R) = radionuclide source regulated by NESHAPs (40 CFR Part 61, Subpart H).

[g] Not a permit limit, but the maximum potential emission level for CO.

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 monitoring and control of toxic constituents in wastewater, the permitting of outfalls composed entirely of storm water, 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 record-keeping 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 ANL is permitted by NPDES Permit No. IL 0034592. This permit was renewed during 1994 (effective October 30, 1994), modified in 1995 (effective August 24, 1995), and was to expire on July 1, 1999. An application to renew the existing permit was submitted in a timely manner to the IEPA on December 28, 1998. In 2001, a previously unknown storm water discharge point was discovered and characterized. On February 12, 2002, ANL submitted a supplementary permit application covering this outfall and an oil water separator for Building 376, along with comments regarding the preliminary draft NPDES Permit. Just prior to the end of 2002, the IEPA issued the “Final Draft Permit” for public comment. ANL sent comments to the IEPA in January 2003 covering the “Final Draft Permit” and several provisions ANL had requested previously. During 2004, the IEPA had not acted on these or any other comments, and ANL continues to operate, as provided for in the IEPA regulations, under the existing permit issued in 1994 until the IEPA issues a renewal permit.

Wastewater at ANL 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 floor drains in most buildings), and storm water. Water softener regenerant from boiler house activities is discharged into the DuPage County sewer system. Cooling water and cooling tower blowdown are discharged into storm water ditches that are monitored as part of the NPDES Permit. The current permit authorizes the release of wastewater from 40 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 2.5 lists these outfalls; Figure 2.2 shows their locations.

2.2.1.1. NPDES Permit Activities

Total dissolved solids (TDS) analyses results historically have demonstrated an annual cycle, culminating in periodic discharge limit violations occurring in the winter at Outfall 001. Investigations into the causes of the heightened TDS concentration during winter have focused on three sources of increased TDS contribution during the winter months: (1) increased boiler activity with its associated increase in high TDS wastewater (i.e., boiler blowdown), (2) salt usage in the boiler house area that drains to the boiler house pond, and (3) road salt used for sitewide snowmelt. To deal effectively with the boiler house area problems, the boiler house equalization pond was routed to DuPage County for periodic discharge of up to 215,517 L/day (57,000 gal/day).

To accomplish this, in 2000, ANL completed an application to DuPage County to allow the discharge of this wastewater under the existing permit with the county. An application was also sent to the IEPA. Historically, all wastewater in the equalization pond was directed to the Sanitary Wastewater Treatment Plant (SWTP). This permit application was acted upon by the IEPA, and a new permit was issued in 2001 covering this discharge (see Table 2.14). Redirection of the equalization pond wastewater to DuPage County is intended to be accomplished only during the heating season in late fall and winter. This was begun in a testing mode late in 2001, and then put into service in the spring of 2002. Experience to date seems to indicate that this

TABLE 2.5

Characterization of NPDES Outfalls at ANL, 2004

Outfall	Description	Average Flow[a]
001A	Sanitary Treatment Plant	0.328
001B	Laboratory Treatment Plant	0.487
001	Combined Outfall	0.815
003A	Swimming Pool	0.0
003B	300 Area (Condensate)	0.011
003C	Building 205 Footing Tile Drainage	0.015
003D&E	Steam Trench Drainage (Condensate)	0.005/<0.001
003F	Building 201 Fire Pond Overflow Storm Water	0.033
003G	North Building 201 Storm Sewer (Condensate)	0.010
003H	Building 212 Cooling Tower Blowdown	<0.001
003I	Buildings 200 and 211 Cooling Tower Blowdown	0.013
003J	Building 213 and Building 213 Parking Lot Storm Water	0.003
004	Building 203 Cooling Tower and Building 221 Footing Drainage and Storm Water	0.017
005A	Westgate Road Storm Water	Storm water only
005B	800 Area East Storm Water	Storm water only
005C	Building 200 West	0.012
005D	Storm Water	Storm water only
005E	Building 203 West Footing Drainage and Condensate	0.008
006	Cooling Tower Blowdown and Storm Water	0.026
007	Domestic Cooling Water for Compressor and Storm Water	0.011
008	Transportation and Grounds Storm Water	0.005
010	Coal Pile Runoff Emergency Overflow	Storm water only
101	North Fence Line Marsh Storm Discharge	Storm water only
102	100 Area Storm Water Discharge	Storm water only
103	Southeast 100 Area Storm Water	Storm water only
104	Northern East Area Storm Water Discharge	Storm water only
105A&B	Building 40 Storm Water Discharge	Storm water only
106A&B	Southern East Area Storm Water Discharge	Storm water only
108	Eastern 300 Area Storm Water and Cooling Water	0.014
110	Shooting Range Storm Water Discharge	Storm water only
111	319 Landfill and Northeast 317 Area	<0.055
112A	Southern 317 Area	<0.053
112B	Western 317 Area	<0.069
113	Southern and Eastern 800 Area Landfill Storm Water Runoff	<0.012
114	Northern and Western 800 Area Landfill Storm Water Runoff	<0.003
115	314, 315, and 316 Cooling Water, Eastern and Southern APS Area	0.004
116	Water Treatment Plant and Storm Water	0.005

[a] Flow is measured in million gallons per day, except for outfalls with storm water only.

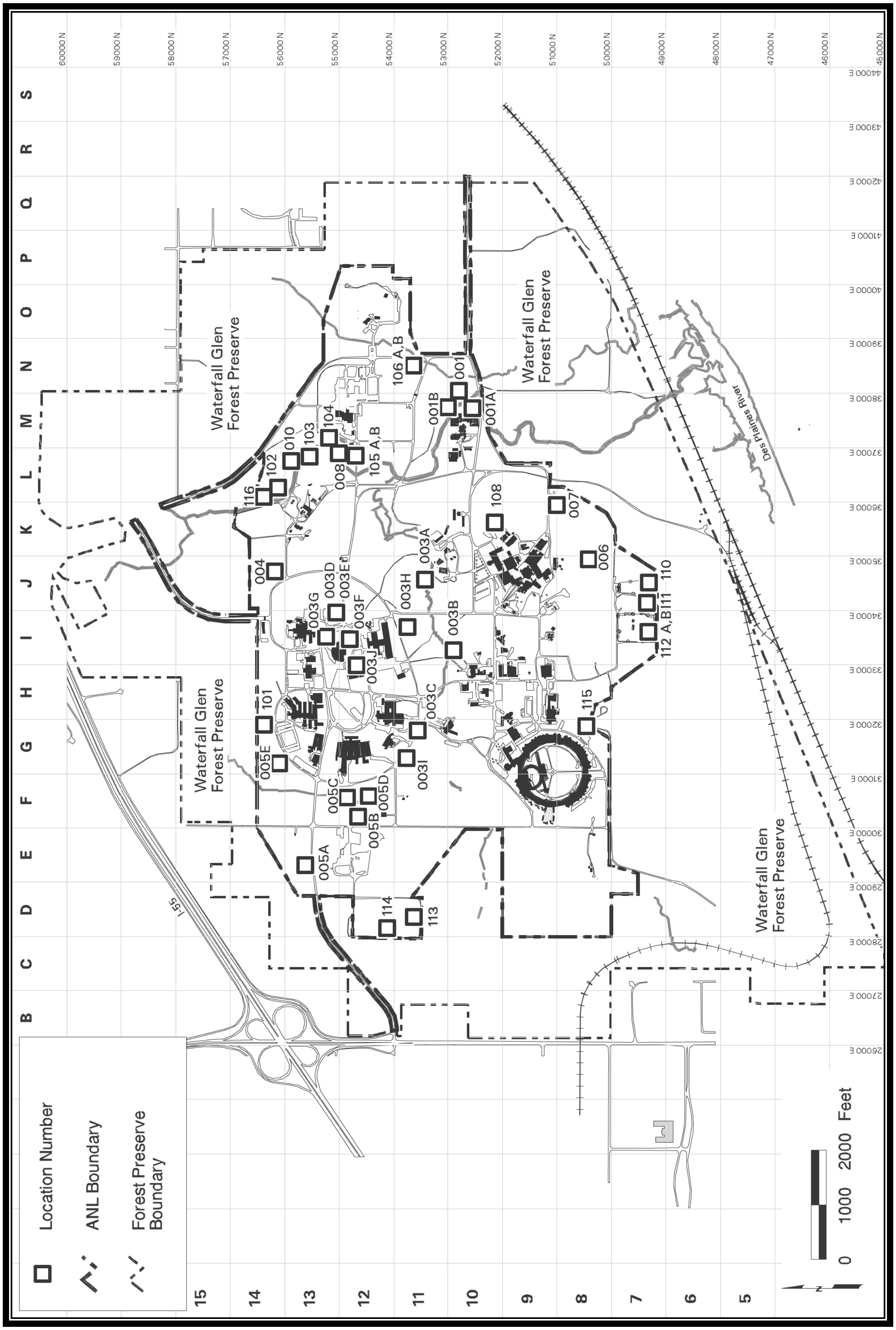


FIGURE 2.2 NPDES Outfall Locations

action has reduced TDS concentrations at the wastewater treatment plant (WTP) during the heating season.

2.2.1.2. Compliance with NPDES Permit

Wastewater is treated at ANL 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, 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 that are pumped to the laboratory wastewater sewer after radiological analysis and release certification. Treatment in the Laboratory Wastewater Treatment Plant (LWTP) consists primarily of aeration, solids-contactor clarification, and pH adjustment. Additional steps can be added, including powdered-activated carbon addition for organic removal, alum addition, and polymer addition 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 2004 averaged 1.31 million L/day (0.33 million gal/day) for the sanitary wastewater and 1.87 million L/day (0.49 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 2004, there were three exceedances of NPDES Permit limits out of approximately 1,600 measurements. These exceedances of the TDS limit were at Outfall 001 (1,000 μg/L) and are attributed to road salt associated with excessive infiltration/inflow from snowmelt. ANL experienced one additional NPDES excursion of a permit condition that required reporting to the IEPA. On January 15, 2004, there was a release from the broken Canal Plant water main close to Building 201. Canal water was released to Outfall 003G. This was reported as an unpermitted release to surface water. Figure 2.4 presents the data for the total number of permit limit exceedances each year over the past 15 years.

2.2.1.3. Priority Pollutant Analysis and Biological Toxicity Testing

The NPDES Permit requires semiannual testing of Outfall 001B, the LWTP outfall, for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 2004, this sampling was conducted in June and December. Results were similar to past years. Organic compound concentrations were very low. Chloroform (1 μg/L

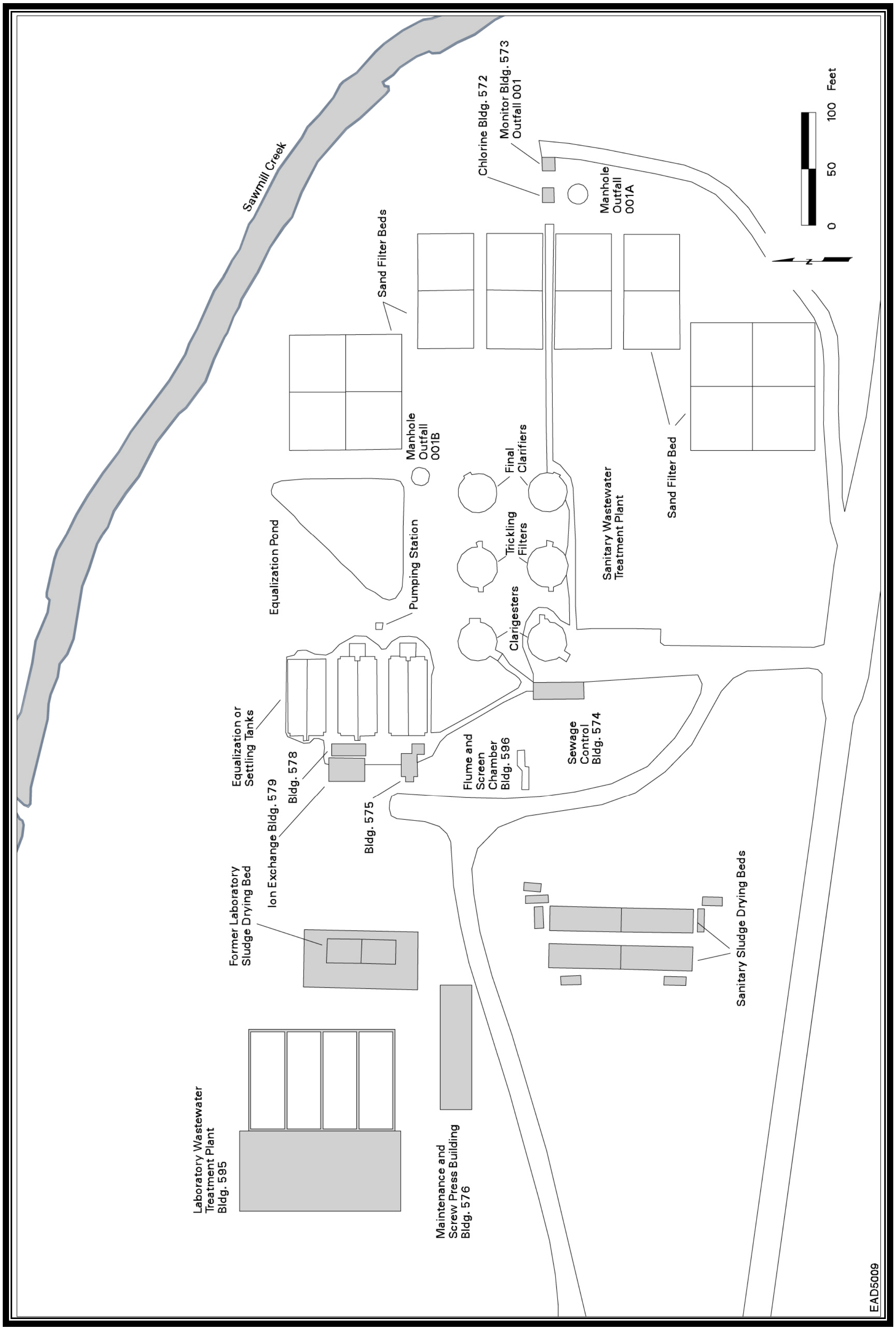


FIGURE 2.3 ANL Wastewater Treatment Plant

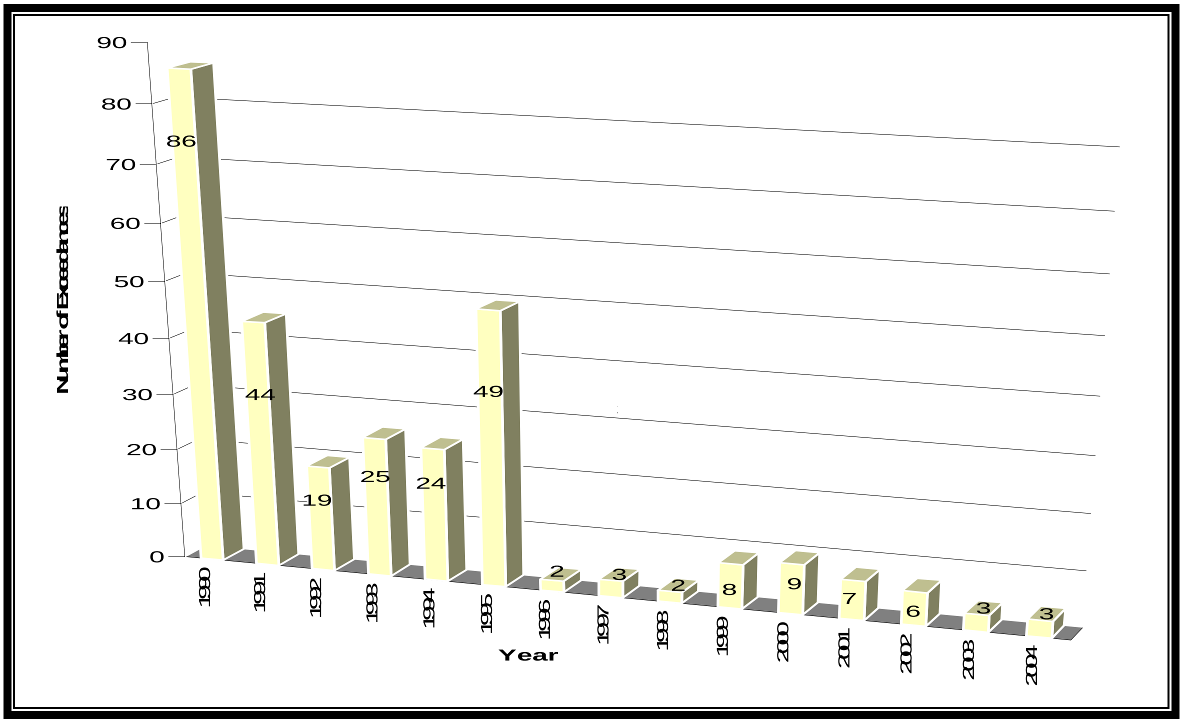


FIGURE 2.4 Total Number of NPDES Exceedances, 1990 to 2004

and 3 µg/L) was detected in both the June and December samples. Bromodichloromethane (2 µg/L) and dibromochloromethane (1 µg/L) were detected in the December sample. 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 treatment chemicals. All semivolatile concentrations were below the detection limits. Low concentrations of mercury (0.0004 mg/L), phenols (0.02 mg/L), and zinc (0.05 mg/L and 0.09 mg/L) were detected at levels well below the corresponding effluent limits (see Table 5.9). These findings are discussed further in Chapter 5.

In addition to the priority pollutant analysis, the permit requires annual biological toxicity testing of the combined effluent stream, Outfall 001. This testing was conducted June 21 through June 25, 2004. 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 ANL effluent can be correlated with a beneficial effect on aquatic life in the receiving streams.

Special Condition No. 9 of the NPDES Permit requires annual aquatic toxicity testing of Outfalls 003H, 003I, 003J, 004, 006, and 115 during the months of July and August. The samples were collected July 26 through July 30, 2004, and August 23 through August 27, 2004. The 2004 results were similar to the 2003 results with the exception of Outfall 115 during August. A review of the July data indicates that Outfalls 003H, 003I, 003J, 004, and 006 exhibited no toxicity for either the water flea or the fathead minnow. Outfall 115 was acutely toxic to the water flea but not to the fathead minnow. The toxicant was unidentified, but may have been chlorinated drinking water. The August data indicate that Outfalls 003H, 003I, 003J, 004, and

006 were not actually toxic for either the water flea or the fathead minnow. Outfall 115 was acutely toxic to the water flea. The toxicant was unidentified.

The acute toxicity observed at these outfalls is believed to be related primarily to residual chlorine levels in the domestic water, some of which is discharged to the outfalls. Chlorine levels that are necessary to protect the water distribution system are high enough to cause measurable acute toxic effects in these tests. Another source of halogen compounds identified earlier is discharged cooling water containing water treatment chemicals used in various cooling towers throughout the site. Steps are being taken to redirect these nonstorm wastewater discharges into ANL's sewer systems to reduce the toxicity problems at these outfalls.

2.2.1.4. Storm Water Regulations

In November 1990, the EPA promulgated regulations governing the permitting and discharge of storm water from industrial sites. The ANL 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 storm water characterization and permitting program was initiated in 1991 and continues as required in present and pending NPDES Permits; ANL's NPDES Permit includes both industrial and stormwater discharges to surface water.

The NPDES Permit contains two special conditions requiring Storm Water Pollution Prevention Plans (SWPPPs): (1) a stand-alone plan for the APS construction site (Special Condition No. 12), which was accomplished years ago and no longer is required since the completion of APS construction, and (2) a sitewide plan for the remainder of the ANL site (Special Condition No. 11). Special Condition No. 11 additionally requires ANL to inspect and report annually on the effectiveness of the sitewide SWPPP. In 2004, the annual inspection was completed and a report was submitted to the IEPA in December. The Storm Water Pollution Prevention Committee (SWPPC), the ANL organization that performs the annual inspection, concluded that the SWPPP should undergo a complete joint review with the DOE-Argonne Site Office (ASO), and then be rewritten and reissued. The joint review, completed in spring 2004, concluded the same, and this will be accomplished in summer 2005.

2.2.2. NPDES Inspections and Audits

The IEPA conducted a compliance inspection on March 25 and 26, 2004. No issues were identified.

2.2.3. General Effluent and Stream Quality Standards

In addition to specific NPDES Permit conditions, ANL discharges are required to comply with general effluent limits contained in 35 IAC Part 304. Also, wastewater discharges must be of sufficient quality to ensure that Sawmill Creek complies with IEPA General Use Water Quality Standards (WQSs) found in 35 IAC Part 302, Subpart B. Chapter 5 of this report, which presents the results of the routine environmental monitoring program, also describes the general effluent limits and WQSs applicable to the outfalls and discusses compliance with these standards.

2.2.4. Spill Prevention Control and Countermeasures Plan

ANL 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 record-keeping requirements mandated by the regulations. Regular training is conducted on implementation of this plan. No reportable spills occurred in 2004 that required activation of the SPCC Plan.

The SPCC Plan was revised and certified in December 2004. Among the new requirements are secondary containment for all oil storage containers 55-gallons or greater, tank integrity testing, and additional training. In August 2004, the EPA extended the deadlines for amending the existing Plan from August 17, 2004, to February 17, 2006, and implementation of the revised Plan from February 17, 2005, to August 18, 2006.

2.2.5. 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 ANL, several activities have been undertaken to support this initiative. ANL has worked with the 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 ANL 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 and copper that are discharged (water with lower TDS levels is less aggressive at dissolving copper from piping). The rehabilitation of the SWTP resulted in compliance with the ammonia-nitrogen limit. The upgrade of the LWTP also was completed, which gives ANL a number of options for treating various waste streams, such as coal pile runoff and laboratory sink discharge, more effectively.

During 2004, the chlorinated water overflow in Building 213 from the cooling tower, the cafeteria, and other treated water discharges inside the building were connected and routed to the sanitary sewer. No further work of this nature is planned in 2005.

The Clean Water Action Plan includes a strategy to achieve a net national increase of 100,000 wetland acres per year by 2005. ANL 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 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 includes regulations governing 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 ANL and DOE on September 30, 1997. The permit became effective on November 4, 1997. The permit has been modified eight times. Table 2.6 presents a summary of the RCRA Part B Permit modifications.

The ANL Environmental Remediation Program (ERP) 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 provides the primary regulatory vehicle. This program was completed on September 30, 2003. However, seven SWMUs could not be remediated to free release status (No Further Action [NFA]). The long-term monitoring of these inactive waste sites has been incorporated into the ANL 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.

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

The nature of the research activities conducted at ANL 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. ANL has 25 Hazardous Waste Management Units: 17 container storage units, 1 tank storage unit, 4 miscellaneous treatment units, and 3 tank chemical treatment units. Table 2.7 provides descriptions of all of the units. The closure report for Building 329 was submitted to IEPA for review and approval in December 2004. When the IEPA approves the closure, there will be 16 container storage areas. Figure 2.5 shows the locations of the major active hazardous waste treatment, storage, and disposal areas at ANL.

TABLE 2.6

Summary of Modifications to the RCRA Part B Permit

Modification Application Number	Purpose	IEPA Approval Date
1	Allows ANL to accept the ash from the incineration of ANL generated mixed waste at the DOE-owned Waste Experimental Reduction Facility in Idaho, in the event that it cannot be disposed of otherwise.	February 1999
2	(1) Allows use of Building 303 to store surplus chemicals; (2) updates the operating procedures for the Building 308 Alkali Metal Passivation Booth, and (3) updates the RCRA Contingency Plan.	August 2000
3	One Class 1 Modification and one Class 2 Modification allow ANL to (1) change the name of the DOE signatory authorized to sign documents related to the ANL RCRA Part B Permit, and (2) use a concrete pad at Building 331 for the storage of solid radioactive and mixed waste.	January 2001
4	Class 1 Modification allows ANL to update the RCRA Contingency Plan.	February 2002
5	Class 1 Modification allows ANL to change the name of the ANL signatory authorized to sign documents related to the ANL RCRA Part B Permit.	March 2002
6	(1) Update the RCRA Contingency Plan, and (2) allow ANL to receive seven drums of defense contact-handled mixed transuranic waste from the Missouri University Research Reactor facility in Columbia, Missouri. At ANL, the drums will be characterized and certified for disposal and shipped to the Waste Isolation Pilot Plant located in Carlsbad, New Mexico. (3) Approve design and equipment changes to the permitted Building 306 Metal Precipitation/Filtration Treatment Unit.	November 2002
7	(1) Remove references to the Facility 317 Concrete Storage Pad, and (2) remove condition regarding the management of seven 55-gallon drums of contact-handled transuranic mixed waste from the Missouri University Research Reactor facility.	August 2003
8	Allow for some waste management operational changes. Also, the application has been updated to agree with the permit.	September 2004

TABLE 2.7

Permitted Hazardous Waste Treatment and Storage Facilities, 2004

Description	Location	Purpose
Storage		
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 325C, East	Storage of liquid and solid bulk or lab-packed flammable and reactive hazardous waste and solid and liquid bulk polychlorinated biphenyls (PCBs) and miscellaneous PCB units.
	Building 325C, West	Storage of bulk and lab-packed liquid flammable hazardous waste.
	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.
Mixed Waste Container Storage[a]	Building 329	Storage of containers of bulk and lab-packed ignitable MW or compatible waste.
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).
Hazardous Waste Storage Facility[b]	Building 307	Proposed permitted storage facility for hazardous waste.

TABLE 2.7 (Cont.)

Description	Location	Purpose
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.
Treatment		
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	Building 306	Treatment of ignitable liquid MW containing organic contaminants.
Dry Ice Pellet Decontamination Unit (Removed in 2004)	317 Area	Treatment of solid MW having radionuclide and/or RCRA metal surface contamination.
Low-Level Radioactive Waste (LLW) Neutralization/ 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) Neutralization/Precipitation Treatment Unit	Building 306	Treatment of corrosive, aqueous MW containing transuranic radionuclides and RCRA metals.

[a] Closure report submitted to IEPA December 2004.

[b] This facility is permitted. However, it has not yet been built.

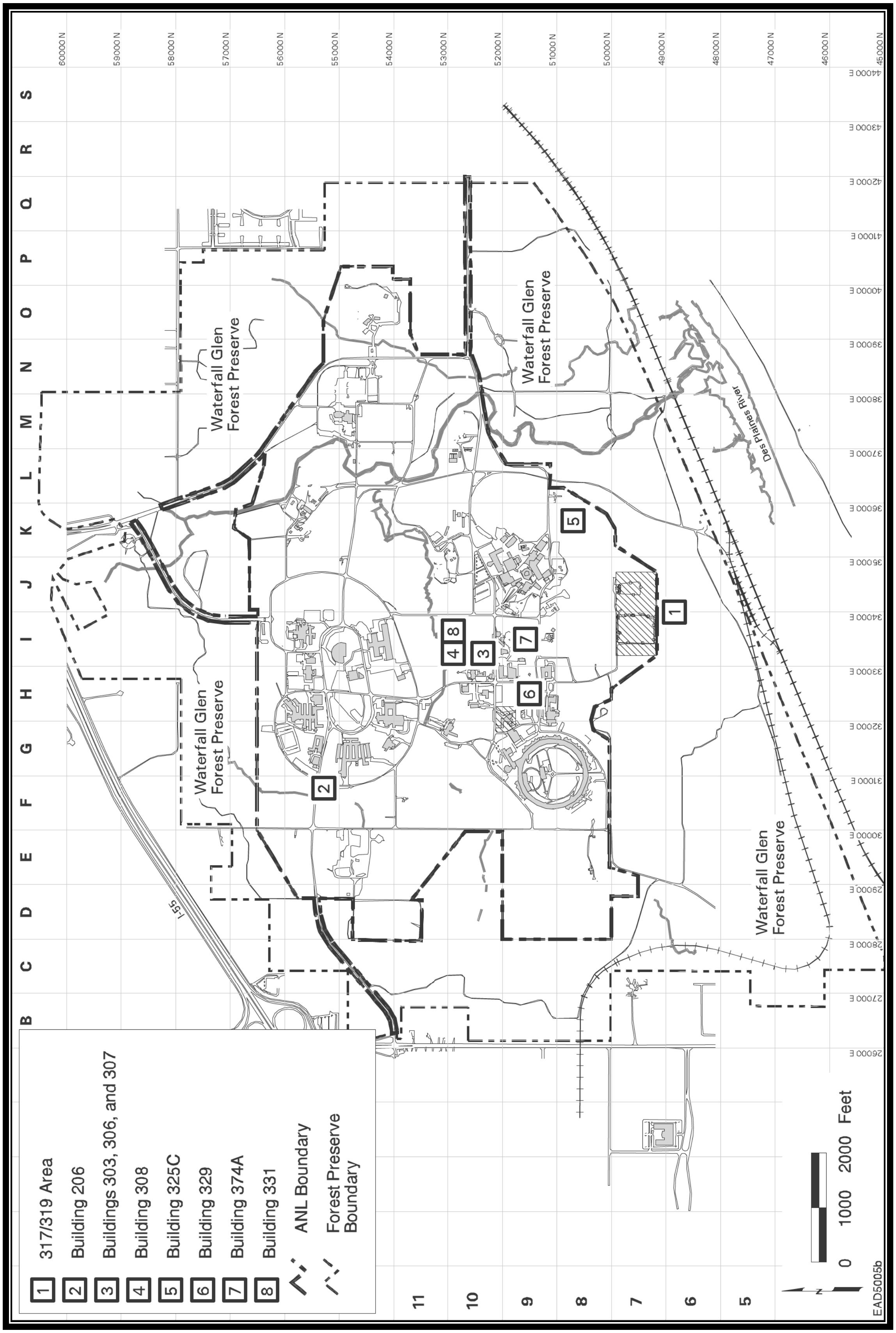


FIGURE 2.5 Major Treatment, Storage, and/or Disposal Areas at ANL

ANL 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 2004 was submitted to the IEPA on March 1, 2005. The RCRA-permitted storage facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and storage of waste pending off-site disposal. ANL's on-site permitted treatment facilities address a small number of hazardous wastes generated by ANL 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 2004 are described in Table 2.8.

2.3.2. Hazardous Waste Treatability Studies

The IEPA requires ANL to 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 2004.

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

A small number of hazardous wastes that ANL generates also exhibit radioactivity, thereby making them "mixed waste." The hazardous component of mixed waste is subject to RCRA regulations, while the radioactive component is subject to regulation under the Atomic Energy Act of 1954 (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. ANL generates several types of mixed waste, including acids, solvents, and sludges 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 radioactive waste (LLW) and transuranic (TRU) corrosive aqueous waste and the stabilization of sludge and soil. In addition, during 2004, some of the mixed waste was sent off site to Envirocare of Utah, Inc., Salt Lake City, Utah, a commercial treatment and disposal facility. Table 2.9 lists the mixed waste generated, stored, treated on site, or shipped off site for disposal in 2004.

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 to allow treatment of mixed waste. 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 ANL was submitted to the IEPA and the Illinois Department of Nuclear Safety (IDNS) in March 1995. Mixed waste at ANL has been managed in accordance with the PSTP since October 1995. ANL's RCRA Part B Permit provides for on-site treatment of certain mixed waste as required by the PSTP.

TABLE 2.8

Hazardous Waste Generation, Treatment, Disposal, or Recycle, 2004

Waste	Volume (gal)[a]	Weight (lb)
Generated and Disposed of or Recycled		
Aerosol cans	35	61
Aqueous solutions with lead	110	920
Brake cleaner fluid[b]	13	108
Bulked laboratory solvents	280	1,960
Caustic solutions with heavy metals	85	714
Compressed gases	25	127
Cutting oils with lead and solvents	110	792
Electropolishing solutions	220	2,420
Gasoline contaminated debris	85	340
Labpacks of liquid chemicals	835	6,676
Labpacks of solid chemicals	521	2,082
Lead-contaminated debris	965	3,860
Mercury contaminated debris	30	120
Oil-based paint	30	300
Used oil-hazardous	365	2,628
Used oil[b]	1,570	3,600
Universal Hazardous Waste		
Mercury-containing lamps[b]	7,200	7,200
Lead acid batteries[b]	625	7,000

[a] In accordance with RCRA regulations, waste amounts are reported in units of gallons, regardless of the physical form of the waste.

[b] Recycled waste.

During 2004, ANL completed the treatment milestones for waste streams that included lead shielding, stored lead waste, and uranium tetrafluoride with mercury.

2.3.5. RCRA Inspections: Hazardous Waste

A RCRA Compliance Inspection was conducted by EPA Region V on July 27 and 28, 2004. EPA Region V reviewed pertinent documentation, such as inspection records; the contingency, waste analysis, and closure plans; training records; and annual reports. All permitted storage and treatment units were inspected. The EPA determined that ANL provided an exemplary waste management program and is in compliance with RCRA regulations.

TABLE 2.9

Mixed Waste Generation, Treatment, Storage, and Disposal, 2004

Waste	Volume (gal)	Weight (lb)
Generated		
MW acidic solutions	122	1,098
MW acidic solutions with heavy metals	171	1,539
MW alkali metals	9	72
MW aqueous solutions with heavy metals	648	5,832
MW debris with elemental mercury	20	80
MW flammable liquids	99	693
MW debris with heavy metals	34,885	348,850
MW debris with organics	30	120
MW soil with heavy metals	8	72
MW uranyl nitrate	35	700
TRU acids with heavy metals	81	729
Shipped for Treatment/Disposal		
MW debris with chromium	8	32
MW debris with heavy metals	34,113	341,130
MW lead articles	166	14,940
MW metal scrap with cadmium	55	1,100
MW sludges with heavy metals	110	1,100
Treated		
MW acidic solutions with heavy metals	193	1,737
MW alkali metals	26	208
In Storage		
MW acidic solutions	358	3,222
MW acidic solutions with heavy metals	637	5,733
MW alkali metals	296	2,368
MW aqueous solutions with heavy metals	943	8,487
MW debris with elemental mercury	105	10,395
MW flammable liquids	408	2,856
MW inorganic nitrates	346	6,920
MW debris with heavy metals	12,791	127,910
MW debris with volatile organics	98	392
MW lead articles	1,669	150,210
MW sludges with heavy metals	720	7,200
MW soil with heavy metals	359	3,231
TRU acids with heavy metals	457	4,113
TRU lead	55	4,950

2.3.6. Underground Storage Tanks

The ANL site currently contains 17 USTs. Seven of the existing tanks are being used to store fuel oil for emergency generators. The on-site vehicle fueling and maintenance facilities (Building 46 and the on-site service station) use underground tanks to store diesel, gasoline, used oil, antifreeze, and ethanol/gasoline blend. On June 13, 2003, the Illinois State Fire Marshal certified that the USTs at ANL are in compliance with the regulations. The Argonne Service Station, Building 300, was closed on November 30, 2004. In December 2004, ANL sent a request to the Office of the State Fire Marshal to place three gasoline USTs and one waste oil UST in out-of-service status.

2.4. Solid Waste Disposal

In September 1992, ANL 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 ANL's RCRA Part B Permit.

Groundwater Quality Standards of some routine indicator parameters have been consistently exceeded. Exceedances occur primarily in shallow, perched pockets of groundwater in the glacial drift that is 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 noted in several wells at the 800 Area Landfill. The 800 Area Landfill groundwater monitoring program is discussed in detail in Section 6.3.

ANL 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 2.10 gives the nonhazardous special and nonspecial wastes generated, stored, disposed of, or recycled during 2004. All nonhazardous special and nonspecial wastes generated at ANL in 2004 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.

ANL also periodically generates radioactive waste containing other regulated materials. Table 2.10 lists the quantities of such waste stored on site or disposed of off site.

TABLE 2.10

Generation, Storage, Disposal, or Recycling of Special and Nonspecial Waste, 2004

Waste	Volume	Weight (lb)
Nonhazardous Special Waste Disposal		
Medical waste	133 ft^3	565
Nonhazardous brine solution	4,700 gal	39,200
Nonhazardous liquid chemicals	1,680 gal	9,661
Nonhazardous potash solution	2,300 gal	19,200
Nonhazardous solid chemicals	1,580 gal	6,074
Petroleum naptha[a] (parts washers)	564 gal	3,779
Used oil[a]	3,775 gal	27,180
Certified Nonspecial Waste Disposal		
Nonspecial fly ash	1,357 yd^3	1,146,665
Nonspecial laboratory sewage sludge	180 yd^3	360,000
Nonspecial sandblast	20 yd^3	40,000
Nonspecial excavated soil	15 yd^3	30,000
Toxic Substances Control Act (TSCA) Special Waste Disposal		
Asbestos	475 yd^3	475,000
PCBs	1,290 gal	11,109
Materials Recycled		
Sanitary sewage sludge[a]	80,000 gal	672,000
TSCA Mixed Waste Generated		
Radioactive PCB articles	10 gal	80
Radioactive PCB oil	20 gal	140
TSCA Mixed Waste in Storage		
Radioactive PCB sludge and debris	57 gal	456
Radioactive PCB articles	40 gal	320
Radioactive PCB oil	40 gal	280

[a] Recycled waste.

2.5. National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) established a national environmental policy that promotes consideration of environmental factors 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 in Title 10, Part 1021 of the *Code of Federal Regulations* (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 2004. One EA was completed in 2004 for the D&D of the Juggernaut Reactor.

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 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 in 40 CFR Parts 141–143 establish Primary and Secondary National Drinking Water Regulations that set forth requirements to protect human health (primary standards) and provide aesthetically acceptable water (secondary standards).

2.6.1. Applicability to ANL

In January 1997, ANL 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, ANL 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, ANL voluntarily provides to on-site personnel the Consumer Confidence Report on drinking water quality that ANL 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 2004, ANL 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 2004, all exterior pesticides and herbicides at ANL were applied by a licensed contractor who provides the chemicals used and removes any unused portions. ANL coordinates the contractor's activities and ensures that the chemicals are EPA-approved, that they are used properly, and that any unused residue is 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 Plant Facilities and Services (PFS)-Custodial Services or on-site contractors, depending on the building involved. The indoor applications involve EPA "Restricted Use" products.

In 2004, approximately 24,339 L (6,405 gal) of commercial-grade herbicide was applied throughout the ANL site. Fertilizer with weed control is included in the quantity of herbicide.

2.8. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (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 (PA) report, followed up by a Site Screening Investigation (SSI). 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 ANL sites are included in the NPL.

On December 21, 1999, the EPA published interim guidance redefining "Federally permitted releases" under CERCLA. This action may have a significant impact on ANL with respect to what types of air emissions will need to be reported under Section 101(10)(H) of CERCLA. The guidance provides an extremely narrow definition of how CERCLA substances released into the air would be exempted from reporting as a federally permitted release. On April 17, 2002, additional guidance was published by EPA and the interim guidance was withdrawn. While the final guidance generally regarded emissions covered by CAA Permits as federally permitted, there remains some ambiguity in the interpretation and the guidance is not considered a regulation.

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 free-standing 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 response to emergency situations involving hazardous materials. Under EPCRA, ANL has been required to submit reports pursuant to Sections 302, 304, 311, 312, and 313, which are discussed in the following paragraphs. Table 2.11 gives ANL'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 ANL, including laboratory usage, that exceed any EHS threshold planning quantity. The Section 302 information for 2004 was transmitted to the LEPC and SERC during June, October, and December of 2004.

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 ANL Emergency Plan Implementing Procedures. There were no incidents requiring notification during 2004.

Under SARA Title III, Section 311, Material Data Safety Sheet (MSDS)/Chemical Inventory, ANL is required to provide applicable emergency response agencies with MSDSs, or a list of MSDSs, for each hazardous chemical stored on site. The 2004 information was transmitted to the LEPC and the Illinois Emergency Management Agency during June, October, and December of 2004.

Pursuant to EPCRA Section 312, ANL 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

TABLE 2.11

Status of EPCRA Reporting, 2004

EPCRA Section	Description of Reporting	Status
Section 302	Planning notification	Required
Section 304	EHS release notification	Not required in 2004
Section 311–312	Material Safety Data Sheet (MSDS) chemical inventory	Required
Section 313	Toxic Release Inventory (TRI) reporting	Required

reporting. The report on Section 312 (Tier 2) information for 2004 was provided to DOE during February 2005. Table 2.12 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 exceed certain thresholds. ANL is not within the range of Standard Industrial Codes specified in the statute. ANL reports this information, however, because DOE, which is subject to EO 13148, "Greening the Government through Leadership in Environmental Management" (April 21, 2000), directs ANL to do so. No reports were filed from 1997 to 2000, because no listed chemicals were used in amounts that 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, ANL filed one report under Section 313 in 2004 for activities in 2003 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 ANL site concerns the handling of asbestos and PCBs. Suspect PCB-containing items that are subject to this act are identified through the ANL PCB Item Inventory Program.

TABLE 2.12

ANL, SARA, Title III, Section 312, Chemical List, 2004

	Physical Hazard			Health Hazard	
Compound	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.

2.9.1. PCBs in Use at ANL

PCB items in use or in storage for reuse are tracked by the ANL 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 ANL 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 ANL. The Annual PCB Report for 2004 is to be completed by June 30, 2005. The PCBs in use at ANL 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 ANL 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 2.10 contains the amount of PCBs and PCB-contaminated materials and TSCA mixed waste in storage and shipped by ANL during 2004.

Several years ago, contamination from historical PCB spills resulted in the generation of sludge contaminated by both PCBs and low-level radioactivity from the building retention tanks and holding tanks at the laboratory WTP. During 2004, no radioactive PCB-contaminated sludge and debris were shipped off site for disposal. Radioactive PCB-contaminated sludge, debris, articles or oil in storage totaled 524 L (137 gal).

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 development. To comply with the ESA, federal agencies are required to assess the area of a proposed project to determine whether it contains any threatened or endangered species, or critical habitat of such species.

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

The Hine's emerald dragonfly (*Somatochlora hineana*), federal 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 federal and state listed as endangered, indicates that this species may occur in the area. The federal-listed threatened and state-listed endangered lakeside daisy (*Tetraneuris herbacea*) has a planted population in Waterfall Glen Forest Preserve.

Other federal-listed species could occur in the ANL area as extremely rare nonbreeders during migration or in winter. These include the bald eagle (*Haliaeetus leucocephalus*), federal and state-listed as threatened; piping plover (*Charadrius melodus*), federal and state-listed as endangered; and least tern (*Sterna antillarum*), federal and state-listed as endangered.

Although state-listed species that occur in the area are not covered by the ESA, the following state-listed species are evaluated in the NEPA process:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax*)
  - Butler's quillwort (*Isoetes butleri*)
  - Osprey (*Pandion haliaetus*)
  - Shadbush (*Amelanchier interior*)*
  - Tuckerman's sedge (*Carex tuckermanii*)

- Threatened
  - Blanding's turtle (*Emydoidea blandingii*)
  - Brown creeper (*Certhia americana*)**
  - Hill's thistle (*Cirsium hillii*)**
  - Kirtland's snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)
  - Pied-billed grebe (*Podilymbus podiceps*)**
  - Red-shouldered hawk (*Buteo lineatus*)**
  - River otter (*Lutra canadensis*)**
  - Slender sandwort (*Minuartia patula*)
  - White lady's slipper (*Cypripedium candidum*)

*Status changed to Threatened, September 1, 2004.
**Removed from list, September 1, 2004.

Of these, Kirtland's snake, pied-billed grebe, black-crowned night heron, red-shouldered hawk, and brown creeper have been observed on ANL property. Impacts to these species also would be assessed during the NEPA process.

2.11. National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966, 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 ANL through the NEPA review process, as well as through the ANL 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 ANL digging permit must be obtained from the PFS 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 ANL, 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 ANL. 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 unlikely to adversely affect historic structures. Work on a Cultural Resources Management Plan (CRMP) that will replace the programmatic agreement is continuing. The CRMP was updated in 2004 and the final draft will be delivered to DOE in 2005.

Cultural resources include both historic structures and archaeological sites. Phase I archaeological surveys have been completed for the entire ANL facility, and 46 archaeological sites have been recorded. Four of the sites are eligible for the NRHP. Twenty-one 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 on the eligibility of the site is expected in 2005.

In fall 2001, ANL 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 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 identifed as part of the D&D program, including the reactors CP-5, Argonne Thermal Source Reactor (ATSR) (removed), Experimental Boiling Water Reactor (EBWR) (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 Main Campus 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 their engineering and design value 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 ANL 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. ANL is developing management plans to augment the procedural mechanisms identified in the programmatic agreement and CRMP.

In fiscal year (FY) 2004, ANL conducted two historic property evaluations prior to the renovation of laboratory areas in historically significant structures. The first of these renovations involved K-Wing in Building 200, which is eligible for the NRHP because of its engineering features and association with the Cold War. K Wing once housed the 30-ft spectrograph that had been the only machine of its design and size in the world. The basic structures of einsteinium and plutonium were developed with this machine. The 30-ft spectrograph ceased operating in 1984 and was removed in the early 1990s. The foundations of the spectrograph remain. The review determined that the planned modification of K-Wing would not affect the remaining features of the 30-ft spectrograph.

The second assessment was done for Room S-143 in Building 315. Building 315 contains the NRHP eligible Zero Power Reactors VI and IX. Room S-143 was used for neutron experiments and storage. The historical review did not identify any historic property issues for the planned renovation of this room. No archaeological investigations were conducted at ANL in FY 2004.

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 Executive Order. 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 ANL 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 near Sawmill Creek, Freund Brook, Wards Creek, and other small streams and associated wetlands and low-lying areas. No significant structures are located in the areas. 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 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.

ANL completed a sitewide wetland delineation in 1993. All wetlands present on site were identified and mapped following the 1987 U.S. Army *Corps of Engineers Wetlands Delineation Manual*.[3] The delineation map shows the areal extent of all wetlands present at ANL down to 500 m^2 (1/8th acre). Thirty-five individual wetland areas were identified; their total area is approximately 20 ha (50 acres).

In February 1989, the COE issued a permit to DOE under Section 404 of the CWA, addressing the construction of the APS facility at ANL. 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, ANL 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, and April 2002. In April 2004, a prescribed burn was performed and planting and herbicide activities continued. Quantitative monitoring of the plant community is underway. A section of asphalt was removed from the parking lot next to Wetland R to reduce the amount of contaminated storm water entering the wetland.

In 1998, the restoration of Wetland C, just under 0.4 ha (1 acre), was begun. In April 2000, the existing wetland was assessed to determine the current status and to identify alternate means of mitigating any damage incurred. This assessment determined that this area no longer meets the criteria for a wetland by virtue of the lack of appropriate hydrological conditions. The conditions no longer existed to maintain enough water in the soil to support a wetland ecology. In response to this finding, a mitigation plan for Wetland C was prepared and submitted to the COE. This plan recommended mitigating the loss of Wetland C by developing an equivalent area of wetland in a location more conducive to the proper conditions required to sustain a wetland ecology. The proposed location is several hundred feet north of the APS facility, adjacent to a large natural wetland area. The wetland restoration could result in up to an additional 2 ha (6 acres) of wetland. The COE approved this mitigation plan on November 21, 2001. Planting of native species and herbicide application began in 2000, and controlled burns were completed in 2001. An EA was completed in September 2001 for wetland management activities. This EA encompasses the Wetland C restoration and management activities. In 2002, the drain tiles were removed from the mitigation wetland to restore groundwater. The area was extensively treated with herbicide. In 2004, the mitigation wetland was again burned, planted, and treated with herbicide. Quantitative monitoring of the plant community has commenced and indicates large areas of low-quality species.

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 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/mi^2 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/mi^2 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 ANL 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 or fallow deer were removed in 2004.

2.14.2. Deer Health Monitoring

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.

2.14.3. Deer Tissue Monitoring

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 2000 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. No samples were collected in 2001, 2002, 2003, or 2004.

2.14.4. 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 in 2000, 2001, 2002, 2003, and 2004 indicate that oak trees do not appear to be regenerating at ANL.

2.15. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 2004. Table 2.13 lists all water effluent exceedances reported during 2004. 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, ANL occasionally exceeded NPDES permit limits in 2004. In past years, the TDS concentration was the most persistent exceedance of the NPDES permit limits. The limit for TDS was exceeded three times at Outfall 001 (the WTP discharge point). Equalization pond sources and road salt runoff contribute to high TDS concentrations at Outfall 001 in the winter. The boiler house equalization pond collects runoff from the coal pile, the paved areas in the 100 Area, boiler blowdown, and continuous bleedoff, all sources of high TDS concentrated wastewater in the winter. To reduce winter concentrations of TDS, in 2002, ANL connected the boiler house equalization pond to the DuPage County sewer so that up to 215,517 L/day (57,000 gal/day) of equalization pond water can be diverted from the WTP to the county sewer system during the heating season.

ANL 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

TABLE 2.13

Summary of 2004 Water Effluent Exceedances

Date	Outfall	Parameter	Assessment
01/15/04	NA[a]	NA	Unpermitted release to surface water from rupture of a treated canal water pressure main
02/10/04	001	TDS	Salt associated with snowmelt infiltration/inflow
02/24/04	001	TDS	Salt associated with snowmelt infiltration/inflow
03/02/04	001	TDS	Salt associated with snowmelt infiltration/inflow

[a] NA = not applicable.

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.

ANL is still awaiting the re-worked draft of the NPDES permit from IEPA. This draft, the third from IEPA, will replace the current permit, which has been held over since its expiration date of January 15, 1999. This is an on-going issue that will be acted on as soon as the final permit is issued.

2.15.2. Solid Waste Disposal

The IEPA-approved 800 Area Landfill groundwater monitoring program continues to indicate that the Ground Water Quality Standards of some inorganic parameters 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 the 800 Area Landfill wells for the past five years were evaluated. Most concentrations were below the hydrogen-3 detection limit; a few wells, however, contained hydrogen-3 levels just above the detection limits, primarily in the south and southeast direction from the landfill. Hydrogen-3 concentrations in wells on the west and north side of the landfill were below the detection limit on all of the samples reviewed. On the basis of historical analytical data from the perimeter monitoring wells, it appears that any potential for hydrogen-3 to migrate to the northwest and west and impact the water supplies of residents in those directions is extremely low. 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 ANL's LTS Program, were incorporated, in their entirety, into ANL's environmental monitoring and surveillance program. These activities are described in detail in Chapter 6.

2.16. Environmental Permits

Table 2.14 lists all the environmental permits in effect at the end of 2004. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements.

TABLE 2.14

ANL Environmental Permits in Effect December 31, 2004

Type	Subject of Permit	Site Location	Issued	Expiration Date
Air	Title V-ANL	Sitewide	04/03/01	04/03/06
Air	Open-Burning Permit – Fire Dept.[a]	333	04/18/03	04/18/04
Air	Open Burning – Vegetation	Sitewide	01/29/03	01/29/04
Hazardous Waste	RCRA Part B	Sitewide	09/30/97	11/04/07
Miscellaneous	Nuisance Wildlife Control	Sitewide	01/31/04	01/31/05
Water	Discharge to DuPage County Public Works	100 Area	08/10/01	–[b]
Water	Lime Sludge Application – Land Application	Sitewide	10/01/02	09/30/07
Water	NPDES Permitted Outfalls	Sitewide	10/31/94	–

[a] This unit has been designated as an insignificant source in the ANL Title V Permit.

[b] A dash indicates that the existing permit continues to be in effect while the revised permit application is undergoing IEPA review.

3. ENVIRONMENTAL MANAGEMENT SYSTEMS

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, resource protection laws, regulations, and DOE requirements. This objective must be accomplished by implementing 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. ANL Environmental Management System

DOE and ANL 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 ANL to ensure compliance with these authorities and to monitor and minimize the impact of ANL operations on the environment.

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

3.1.1. ANL's EMS Approach

The ANL approach to 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 ANL ISMS in order to demonstrate integration between the two documents. DOE-ASO approved the ANL EMS on July 14, 2003. A critical component of the EMS is the identification of environmental aspects, which are those activities and operations at ANL 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 ANL EMS. The course is part of the implementation process for the ANL 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, ANL addresses its significant 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 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.

3.1.2. Compliance with EO 13148

ANL continues to support DOE in meeting its responsibilities for compliance and reporting required by EO 13148. Quarterly reports provided to DOE describe ANL's progress toward reaching the goal of preparing and implementing an EMS by December 31, 2005. During 2004, ANL reported to DOE the completion of several milestones for EMS implementation: the establishment of a process for providing measurable environmental objectives and targets; description of environmental programs to achieve the objectives and targets; and description of ANL procedures to address objectives, targets, aspects, impacts, corrective actions, self-assessments, and management reviews. The remaining goal for ANL is the preparation and submission of the ANL self-declaration certification.

3.2. EMS Components

The ANL EMS covers a number of elements that are identified in DOE Order 450.1. These elements are also similar to the topics covered in ISO 14001. A number of the most critical elements are discussed below.

3.2.1. Environmental Policy

Within the ANL ES&H policy, ANL has established an environmental protection policy. This policy applies to all ANL activities that could or do have an impact on the environment or on compliance with environmental regulations. The policy states that "ANL activities (including experiments, facility operations, construction activities, and other activities) will be conducted in an environmentally safe and sound manner and consistent with ANL permits. To support this policy, ANL 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, ANL implements the EMS to minimize or eliminate any potential impact. ANL evaluates its operations, identifies that aspects of its operations that can impact the environment, and determines which of those impacts are significant. The environmental aspects addressed in the ANL 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.

3.2.3. Objectives and Targets

The objectives describe ANL's goals for environmental performance. The objectives are a set of measurable or qualitative goals concerning how ANL 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 2004, ANL generated the FY2005 objectives and targets.

3.2.4. Waste Minimization and Pollution Prevention

During 2004, ANL continued to enhance its pollution prevention and waste minimization efforts. ANL implements a comprehensive sitewide Pollution Prevention (P2) program in accordance with local, state, federal, DOE, and site-specific P2 regulations and requirements. Individuals in the P2 program perform tracking and trending of waste and pollution at ANL and monitor the progress with regard to DOE P2/Energy Efficiency (E2) Goals and Performance Measures. ANL continues to maintain waste generation rates below the levels established by the DOE P2 and E2 Leadership Goals.

ANL management fosters a work environment that promotes the development and implementation of P2 activities. ANL 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, ANL uses the ISMSs to promote and institutionalize P2 strategies across the ANL site.

3.2.4.1. P2 Assessments and Reviews

Historically, those involved in the ANL P2 program have identified, developed, and performed Pollution Prevention Opportunity Assessments (PPOA's) and Process Waste Assessments (PWAs). During 2004, the following PWAs were performed:

- Aqueous Parts Washing in Vehicle Maintenance;
- Battery Recycle Program; and

- Desktop Printer Cartridge Recycling.

On the basis of the success of the Electronic Equipment Recycling Pilot program between ANL and Fermi National Accelerator laboratory that was conducted in 2003, the program is now permanent. During 2004, ANL shipped approximately 51 t (57 tons) of excess computers, monitors, and printers to Fermilab, which works with a demanufacturer who disassembles the equipment to recycle the useful materials. Transferring this material generated a cost savings for ANL of approximately $20,000. During 2004, the Battery Recycling Program was available to all of the buildings at ANL. This program diverts routinely used batteries, approximately 3,175 kg/yr (7,000 lb/yr), from the ANL waste stream.

3.2.4.2. Waste Reduction and Recycling

ANL'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 light bulbs, computers, and electric equipment. ANL annually maintains sanitary waste levels below the 2005 DOE P2 target goals and recycles materials at levels beyond the established goal of 45%. During 2004, ANL recycled 80% of sanitary wastes, such as office paper, metal, plastics, and oil, from all operations. Since 1996, ANL has recycled approximately 87,000 t (95,000 tons) of material, generating a cost savings estimated at about $4.0 million.

ANL has consistently generated routine LLW, mixed waste, and hazardous waste at levels below the 2005 DOE P2 target goal. ANL aggressively tracks, reviews, and assesses (by using PPOA and PWA), the hazardous and radioactive waste streams in an effort to identify alternatives to disposal (e.g., segregation, treatment, reuse, recycling) for these materials/waste.

ANL continues to utilize programs, such as the Argonne Chemical Exchange System and the Surplus Office Supply Exchange, that allow employees and contractors to minimize waste and reuse available materials. ANL expanded this reuse opportunity with the development of the Argonne Equipment and Materials Exchange (AEM-X). The AEM-X program was developed to assist ANL employees in recycling and reusing surplus equipment, supplies, and materials by promoting the availability or need for items via the ANL e-mail system.

3.2.4.3. Affirmative Procurement Program (EO 13101)

ANL'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 item. In 2004, the Affirmative Procurement purchases rose to 95% of purchases containing recycled products.

3.2.4.4. Sustainable Design

The P2 program continues to promote sustainable design and environmentally preferable building material and construction methods by including a Sustainable Design web page on the ANL P2 web site.

3.2.5. Environmental Training

ANL has a comprehensive training program that includes mechanisms to identify, track, and document training requirements for every employee. Environmental protection training for ANL personnel is provided primarily by the ESH/QA (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 ANL 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. A schedule is prepared and assignments are made to manage the organization’s self-assessment program. The ANL-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 ANL 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 the undeveloped areas on the ANL site. Six acres (2.4 ha) of vacant land that formerly was occupied by Quonset huts has been converted to prairie. 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 Activities

This section describes several activities that cover a number of the environmental aspects in terms of providing information and data to demonstrate and assess ANL's level of compliance. ANL's compliance status for the various applicable regulations is also discussed in Chapter 2.

3.3.1. Environmental Monitoring and Surveillance Program

As required by DOE Orders 450.1 and 231.1A, supplemental DOE guidance, and permit conditions, ANL conducts a routine environmental monitoring program designed to determine the effects of ANL 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 parameters known to be used or generated at ANL. 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 ANL Site Environmental Report [SER]), are prepared. In 2004, a total of 2,227 samples were collected and 28,800 analytical results were generated. A discussion of the rationale for sampling and analyses for each media is presented in the ANL Environmental Monitoring Plan.

3.3.2. Long-Term Stewardship Program

By September 30, 2003, ANL had completed all the corrective actions required by the IEPA. The remediation work on all units listed in the RCRA Part B Permit — 49 SWMUs and 6 Areas of Concern (AOCs) — was completed. ANL 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 remediations systems that were established by the remediation program were incorporated into the ANL Long-Term Stewardship (LTS) Program.

During 2004, members of the LTS Program conducted quarterly groundwater monitoring of water from wells in the 317/319/ENE 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. Maintenance activities included well cleaning, servicing of pumps and compressors, and grass mowing. ANL 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 ANL 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 (outstanding, excellent, good, or marginal) 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, 2003 to September 30, 2004, 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 and implement an ANL EMS training program (Outstanding);
- Develop comprehensive FY2005 EMS objectives and targets (Outstanding);
- Complete Land Management and Habitat Restoration Implementation Plan tasks by due dates and demonstrate to ASO committed ecological stewardship (Outstanding);
- Complete FY2004 Land Management and Habitat Restoration work plan activities (Outstanding).
- Number of reportable unpermitted releases at ANL and ANL-W (Outstanding);
- Cumulative costs from incidents resulting in environmental cleanup or remediation at ANL and ANL-W (Outstanding);
- Quarters with air effluent violation at ANL boiler house (Outstanding);
- Number of water effluent violations at ANL (Outstanding); and
- Enforcement action at ANL not withdrawn by regulator (Outstanding).

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

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1. Description of Monitoring Program

The radioactivity of the environment around ANL in 2004 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/m^3 and aCi/m^3 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 guidance[5] 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. The guidance requires that sufficient data on exposure to radionuclide sources be available to ensure that at least 90% of the total CEDE is accounted for. The primary radiation dose limit for members of the public is 100 mrem/yr. The effective dose equivalents for members of the public from all routine DOE operations (natural background and medical exposures excluded) shall not exceed 100 mrem/yr and must adhere to the as-low-as-reasonably-achievable (ALARA) process or be as far below the limits as is practical, taking into account social, economic, technical, practical, and public policy considerations. Routine DOE operations are normally planned operations and exclude actual or potential accidental or unplanned releases.

The measured or calculated environmental radionuclide concentrations were converted to a 50-year CEDE with the use of the CEDE conversion factors[8] and were compared with the annual dose limits for uncontrolled areas. The CEDEs were calculated from the DOE Derived Concentration 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 4.25). Occasionally, other standards are used, and their sources are identified in the text.

4.2. Air

The radioactive content of particles in the air was determined by collecting and analyzing air filter samples. The sampling locations are shown in Figures 1.1 and 1.2. ANL 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 13 locations around the ANL perimeter and at 6 off-site locations, approximately 8 km (5 mi) from ANL, to determine the ambient or background concentrations.

Airborne particle samples for measurement of total alpha, total beta, and gamma-ray emitters are collected continuously at 12 perimeter locations and at 5 off-site locations on glass fiber filter media. Average flow rates on the air samplers are about 70 m^3/h (2,472 ft^3/h). Filters are changed weekly. ANL staff change the filters on perimeter samplers, and the filters on off-site samplers are changed and mailed to ANL by cooperating local agencies. Additional samples of particles in air, used for radiochemical analysis of plutonium and other radionuclides, are collected at one perimeter location and at one off-site location. These samples are collected on special filter media that are changed by ANL staff every 10 days. 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 ANL, 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 the 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.

The air filter samples collected for radiochemical analysis are composited by location for each month. After the addition of appropriate tracers, the samples are ashed, then sequentially analyzed for plutonium, thorium, uranium, and strontium, because these radionuclides are those most likely to be in the air due to ANL operations.

Stack monitoring is conducted continuously at four locations (see Section 4.7.1), that is, 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.

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 ANL, 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.

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 run 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/m^3, 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/m^3, the

TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 2004
(Concentrations in fCi/m^3)

			Alpha Activity			Beta Activity		
Month	Location	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	48	1.58	0.52	2.68	18.64	7.51	33.90
	Off-Site	17	2.65	0.59	3.92	28.01	1.25	41.80
February	Perimeter	48	1.34	0.41	3.24	18.95	5.98	32.90
	Off-Site	12	2.40	1.11	5.97	27.20	12.90	45.80
March	Perimeter	60	1.11	0.08	2.58	12.54	0.68	26.50
	Off-Site	14	2.38	1.35	4.60	18.72	4.82	28.70
April	Perimeter	48	1.33	0.54	3.02	12.45	4.89	20.1
	Off-Site	8	1.64	0.60	2.35	14.04	5.36	22.1
May	Perimeter	48	0.90	0.38	1.61	10.24	4.65	17.4
	Off-Site	11	1.49	0.51	2.60	11.86	2.52	21.8
June	Perimeter	60	0.92	0.46	2.19	11.17	4.64	22.2
	Off-Site	17	1.57	0.18	3.52	11.22	1.92	21.2
July	Perimeter	47	1.13	0.51	2.45	13.39	7.93	21.8
	Off-Site	14	1.91	0.52	3.86	15.48	1.33	34.5
August	Perimeter	48	0.97	0.19	1.89	14.22	3.62	21.9
	Off-Site	11	1.29	0.57	1.92	15.90	4.22	28.2
September	Perimeter	60	1.23	0.56	2.31	16.59	4.61	30.9
	Off-Site	15	1.73	0.28	3.85	16.96	1.50	37.1
October	Perimeter	48	1.14	0.46	2.11	15.37	6.47	27.2
	Off-Site	12	1.73	0.94	2.83	19.16	9.31	32.1
November	Perimeter	48	1.20	0.38	2.34	15.75	8.64	27.5
	Off-Site	13	2.05	1.25	3.00	22.45	10.2	33.1
December	Perimeter	59	1.62	0.65	3.14	21.66	12.6	37.3
	Off-Site	17	2.99	0.63	6.93	28.50	6.59	50.0
Annual	Perimeter	622	1.21 ± 0.3	0.08	3.24	15.11 ± 4.1	0.68	37.3
Summary	Off-Site	161	2.04 ± 0.5	0.18	6.93	19.6 ± 6.5	1.25	50.0

TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 2004
(Concentrations in fCi/m^3)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	56	18
	Off-Site	89	31
February	Perimeter	50	17
	Off-Site	65	24
March	Perimeter	57	10
	Off-Site	54	14
April	Perimeter	77	9
	Off-Site	72	8
May	Perimeter	57	9
	Off-Site	69	9
June	Perimeter	71	8
	Off-Site	61	8
July	Perimeter	78	10
	Off-Site	74	9
August	Perimeter	81	11
	Off-Site	64	10
September	Perimeter	69	13
	Off-Site	61	13
October	Perimeter	60	12
	Off-Site	26	13
November	Perimeter	63	13
	Off-Site	66	16
December	Perimeter	52	18
	Off-Site	68	22
Annual	Perimeter	64 ± 9	12
Summary	Off-Site	64 ± 11	15
Dose(mrem)	Perimeter	(0.00016)	(1.37)
	Off-Site	(0.00016)	(1.71)

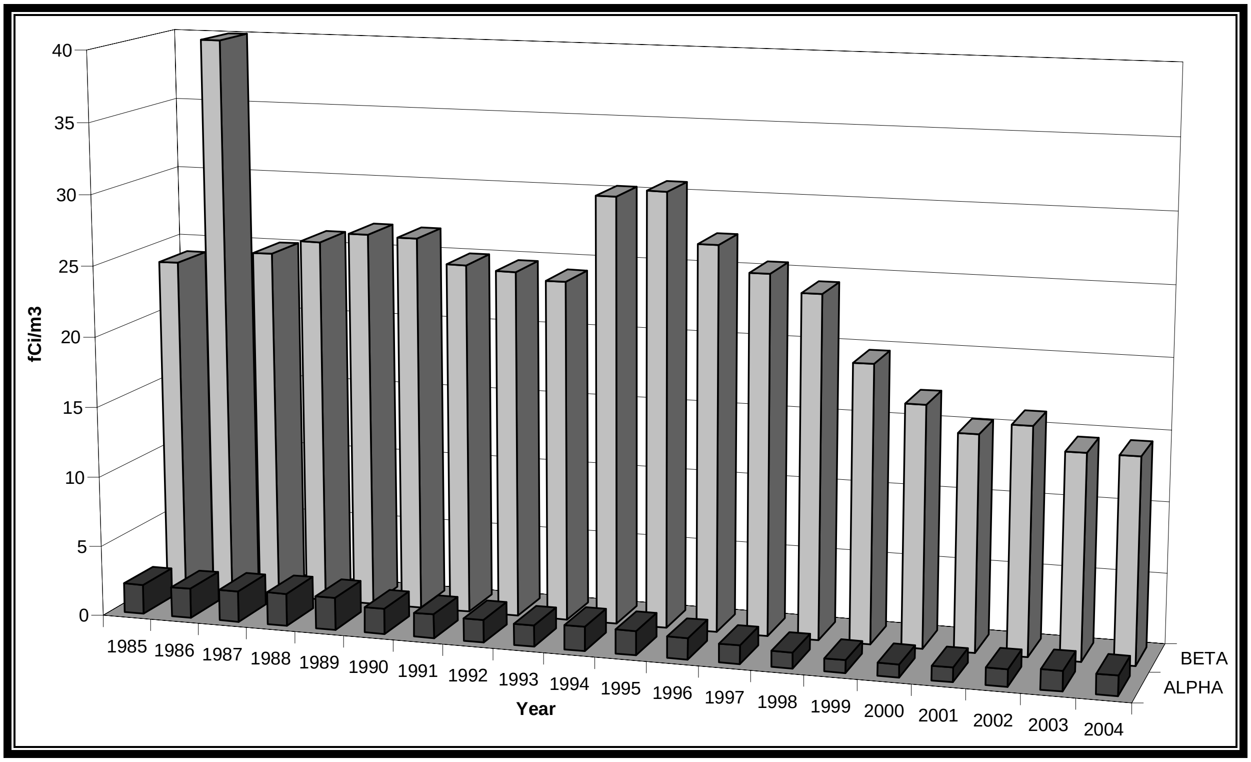


FIGURE 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples

net would be 27 fCi/m^3, 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]

Samples for radiochemical analyses were collected at perimeter location 7I (Figure 1.1) and off the site in Downers Grove (Figure 1.2). Collections were made on polystyrene filters. The total air volume filtered for the monthly samples was approximately 20,000 m^3 (700,000 ft^3). Samples were ignited at 500°C (950°F) to remove organic matter and were prepared for analysis by vigorous treatment with hot hydrochloric, hydrofluoric, and nitric acids.

Plutonium and thorium were separated on an ion-exchange column, and the uranium was extracted from the column effluent. Following the extraction, the aqueous phase was analyzed for radiostrontium by a standard radiochemical procedure. The separated plutonium, thorium, and uranium fractions were electrodeposited and measured by alpha spectrometry. The chemical recoveries were monitored by adding known amounts of plutonium-242, thorium-229, and uranium-236 tracers prior to ignition. Because spectrometry cannot distinguish between plutonium-239 and plutonium-240, when plutonium-239 is mentioned in this report, the alpha activity due to the plutonium-240 isotope is also included. The results are given in Table 4.3.

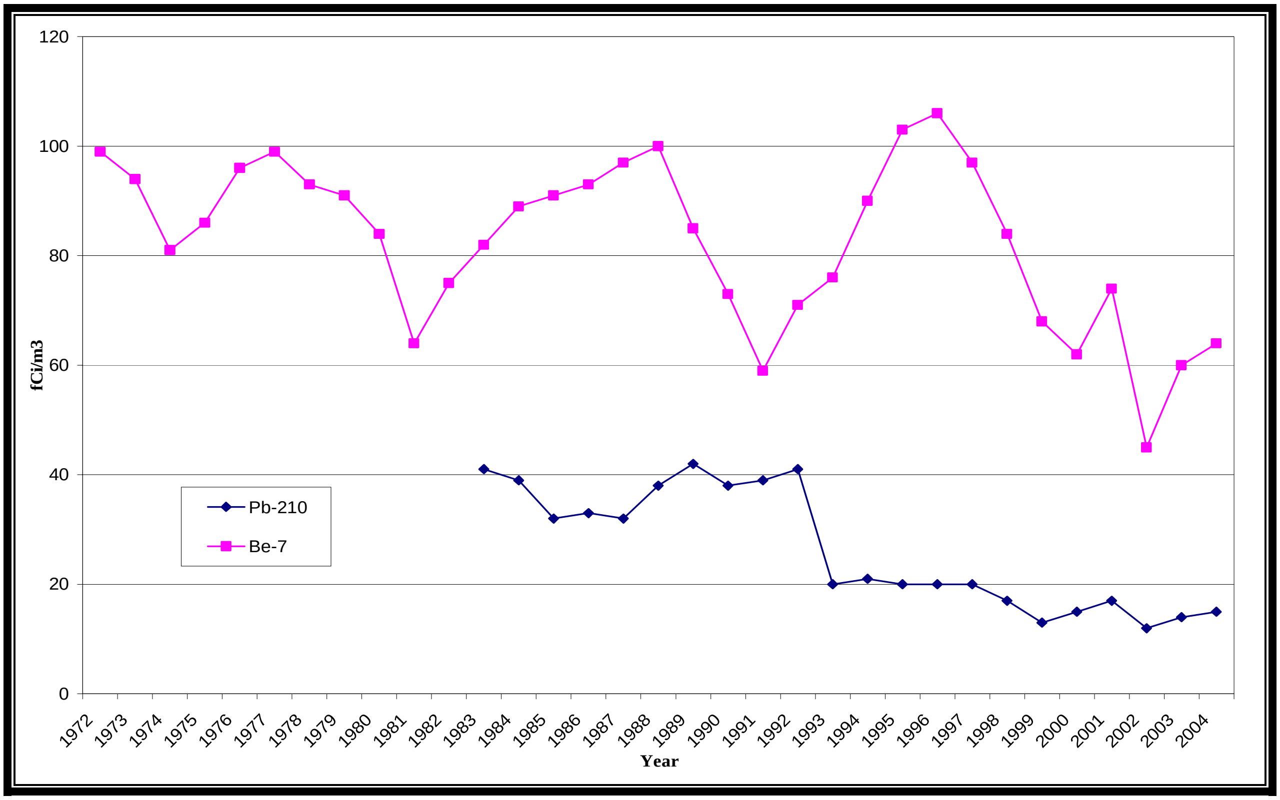


FIGURE 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples

The strontium-90 concentrations have decreased over the past several years; consequently, during 2004, all of the results were less than the detection limit of 10 aCi/m^3. Strontium-89 was not observed above the detection limit of 100 aCi/m^3. The plutonium-239 concentrations at all locations were similar to those of the last few years. The thorium and uranium concentrations were in the same range as in the past and are considered to be of natural origin. The amounts of thorium and uranium in a sample were proportional to the mass of inorganic material collected on the filter paper. The presence of most of these airborne elements can be attributed to the resuspension of soil. This radionuclide air monitoring program was terminated at the end of 2004 because the concentrations of these airborne radionuclides have been consistently low over a number of years of monitoring.

The major airborne effluents released at ANL during 2004 are listed by location in Table 4.4; Figure 4.3 shows the annual releases of the major sources since 1985. 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 4.4, several other fission products also were released in millicurie or smaller amounts. The quantities listed in Table 4.4 were measured by on-line stack monitors in the exhaust systems of the buildings, except those for Building 350.

TABLE 4.3

Strontium, Thorium, Uranium, and Plutonium Concentrations
in Air Filter Samples, 2004
(Concentrations in aCi/m^3)

Month	Location[a]	Strontium-90	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-238	Plutonium-239
January	7I	< 10	1 ± 1	1 ± 1	1 ± 1	1 ± 1	2 ± 1	< 0.1
	Off-Site	< 10	1 ± 1	2 ± 1	1 ± 1	1 ± 1	1 ± 1	0.1 ± 0.1
February	7I	-[b]	-	-	-	-	-	-
	Off-Site	< 10	< 1	< 1	< 1	1 ± 1	1 ± 1	0.2 ± 0.2
March	7I	< 10	2 ± 1	1 ± 1	1 ± 1	2 ± 2	1 ± 1	0.1 ± 0.1
	Off-Site	< 10	1 ± 1	< 1	< 1	< 1	< 1	< 0.1
April	7I	< 10	3 ± 1	3 ± 1	2 ± 1	1 ± 1	1 ± 1	0.1 ± 0.1
	Off-Site	< 10	< 1	1 ± 1	< 1	1 ± 1	1 ± 1	< 0.1
May	7I	< 10	1 ± 1	1 ± 1	1 ± 1	1 ± 1	1 ± 1	0.1 ± 0.1
	Off-Site	< 10	< 1	1 ± 1	< 1	4 ± 1	3 ± 1	< 0.1
June	7I	< 10	2 ± 1	2 ± 1	1 ± 1	2 ± 1	1 ± 1	< 0.1
	Off-Site	< 10	1 ± 1	1 ± 1	1 ± 1	1 ± 1	1 ± 1	< 0.1
July	7I	< 10	1 ± 1	1 ± 1	1 ± 1	1 ± 1	1 ± 1	< 0.1
	Off-Site	< 10	< 1	1 ± 1	< 1	1 ± 1	1 ± 1	< 0.1
August	7I	< 10	1 ± 1	1 ± 1	< 1	1 ± 1	1 ± 1	< 0.1
	Off-Site	< 10	1 ± 1	1 ± 1	< 1	1 ± 1	1 ± 1	0.1 ± 0.1
September	7I	< 10	1 ± 1	2 ± 1	1 ± 1	2 ± 1	1 ± 1	0.3 ± 0.4
	Off-Site	< 10	1 ± 1	1 ± 1	< 1	1 ± 1	1 ± 1	< 0.1
October	7I	< 10	1 ± 1	2 ± 1	1 ± 1	2 ± 1	< 1	0.3 ± 0.2
	Off-Site	< 10	< 1	1 ± 1	< 1	1 ± 1	< 1	0.2 ± 0.1
November	7I	< 10	1 ± 1	2 ± 1	1 ± 1	3 ± 1	2 ± 1	< 0.1
	Off-Site	< 10	< 1	1 ± 1	< 1	< 1	< 1	0.3 ± 0.1
December	7I	< 10	1 ± 1	1 ± 1	1 ± 1	2 ± 1	2 ± 1	< 0.1
	Off-Site	< 10	< 1	< 1	< 1	< 1	< 1	< 0.1
Annual	7I	< 10	1 ± 1	1 ± 1	1 ± 1	1 ± 1	1 ± 1	0.1 ± 0.1
Summary	Off-Site	< 10	1 ± 1	1 ± 1	< 1	1 ± 1	1 ± 1	0.1 ± 0.1
Dose	7I	<(0.00011)	(0.0027)	(0.0025)	(0.0063)	(0.00008)	(0.00005)	(0.00023)
(mrem)	Off-Site	<(0.00011)	(0.0027)	(0.0025)	< (0.0063)	(0.00008)	(0.00005)	(0.00023)

[a] Perimeter locations are given in terms of the grid coordinates in Figure 1.1.

[b] Sample not collected.

TABLE 4.4

Summary of Airborne Radioactive Emissions from ANL Facilities, 2004

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 (HTO)	12.3 yr	13.9	5.1×10^{11}
	Hydrogen-3 (tritiated hydrogen gas [HT])	12.3 yr	28.2	1.0×10^{12}
	Krypton-85	10.7 yr	7.6	2.8×10^{11}
	Radon-220	56 s	0.5	1.8×10^{10}
350 (NBL)	Uranium-234	2.4×10^{5} yr	3.2×10^{-5}	1.2×10^{6}
	Uranium-238	4.5×10^{9} yr	3.2×10^{-5}	1.2×10^{6}
	Neptunium-237	2.1×10^{6} yr	9.4×10^{-9}	3.4×10^{2}
	Plutonium-239	2.4×10^{4} yr	4.3×10^{-6}	1.6×10^{5}
	Plutonium-240	6.6×10^{4} yr	2.5×10^{-6}	9.2×10^{4}
375 (IPNS)	Carbon-11	20 m	2345.9	8.7×10^{13}
	Argon-41	1.8 h	65.4	2.4×10^{11}
411/415 (APS)	Carbon-11	20 m	0.15	5.5×10^{9}
	Nitrogen-13	10 m	10.71	4.0×10^{11}
	Oxygen-15	122 s	1.16	4.4×10^{10}

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 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. A mixture of grasses and legumes are also planted around the trees to address shallow soil contamination and to prevent soil erosion. Approximately 800 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.

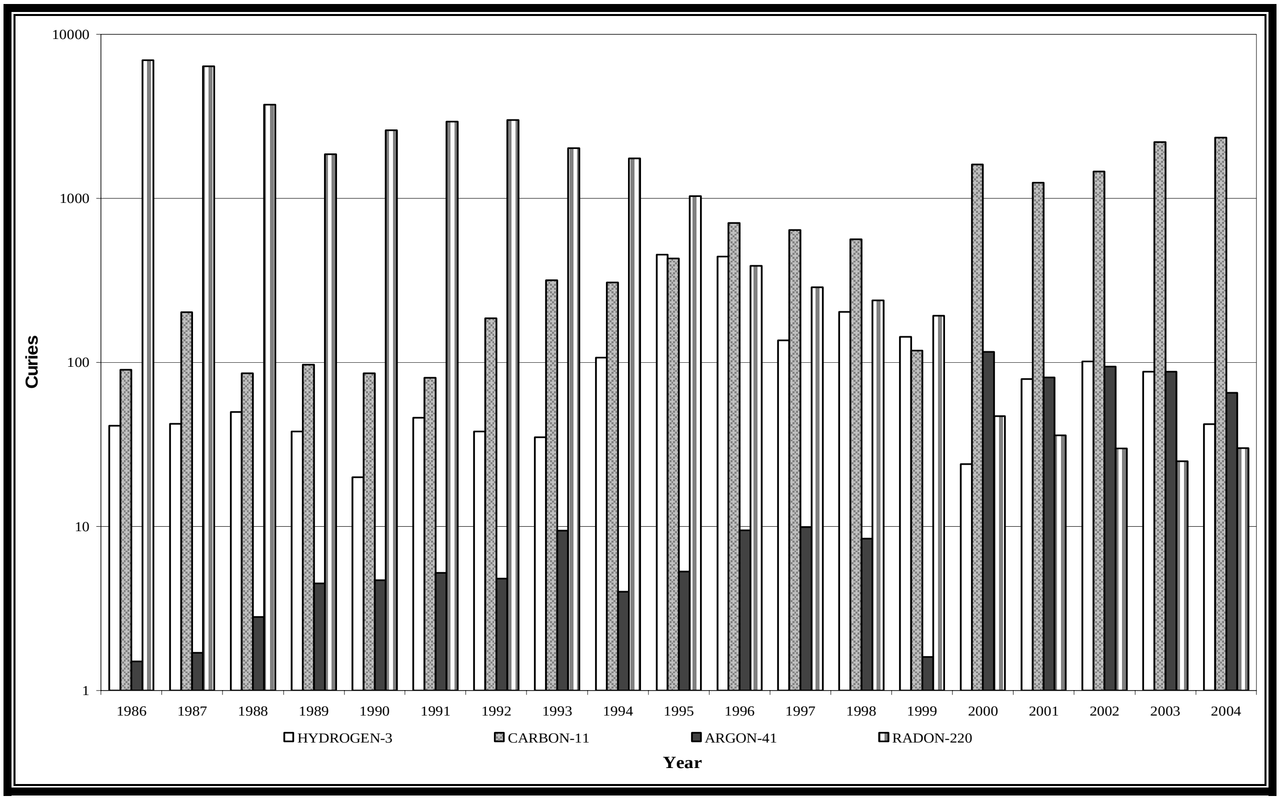


FIGURE 4.3 Selected Airborne Radionuclide Emissions

Quarterly monitoring is conducted at the 18 wells that are within the phytoremediation plantation. The average hydrogen-3 concentration for 2004 for all the wells was 577 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 2004, the total hydrogen-3 released was 0.01 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 NESHAPs.

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 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 (0.03 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-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 by evaporation and the residue is disposed of as solid LLW. If the radioactivity is below the release limits, the wastewater is conveyed to the laboratory WTP in dedicated pipes to waste storage tanks. At the influent to the WTP, all effluent wastewater is screened for gamma-ray radioactivity. 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. The effluent monitoring program documents that no liquid releases 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 5.8). 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 4.5 gives the results for 2004. The results show that the radionuclides hydrogen-3 and possibly strontium-90 detected in the effluent water can be attributed to ANL operations. However, analysis of the ANL domestic water, which is obtained from Lake Michigan, indicates strontium-90 at about 0.4 pCi/L. This was confirmed by the direct analysis of Lake Michigan water. The concentrations are very low and a small fraction of the DOE limits; these findings reinforce ANL 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 (1.12×10^9 L) is computed. These results are given in Table 4.6.

ANL wastewater is discharged into Sawmill Creek (Location 7M in Figure 1.1). The creek runs through the ANL 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 ANL wastewater outfall. Sawmill Creek was sampled upstream from the ANL site and downstream from the wastewater discharge point to determine whether radioactivity was added to the stream by ANL 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 4.5

Radionuclides in Effluents from the ANL Wastewater Treatment Plant, 2004

		Concentrations in pCi/L			Dose (mrem)		
Activity	No. of Samples	Avg.	Min.	Max.	Avg	Min.	Max.
Alpha	52	0.9 ± 1.2	0.2	2.9	–[a]	–	–
Beta	52	11 ± 3	7.9	22.4	–	–	–
Hydrogen-3	52	< 100	< 100	142	< 0.0046	< 0.0046	0.0065
Strontium-90	52	0.47 ± 0.12	0.32	0.71	0.045	0.031	0.068
Cesium-137	52	< 2.0	< 2.0	< 2.0	< 0.07	< 0.07	< 0.07
Uranium-234	52	0.292 ± 0.320	0.10	0.63	0.056	0.019	0.119
Uranium-238	52	0.260 ± 0.144	0.10	0.59	0.043	0.017	0.098
Neptunium-237	52	< 0.0010	< 0.0010	0.0105	< 0.0028	< 0.0028	0.0294
Plutonium-238	52	0.0024	< 0.0010	0.0487	< 0.0028	< 0.0028	0.1364
Plutonium-239	52	0.0073	< 0.0010	0.3250	0.0226	< 0.0031	1.0075
Americium-241	52	0.0052	< 0.0010	0.1960	0.0172	< 0.0033	0.6468
Curium-242 and/or Californium-252	52	< 0.0010	< 0.0010	0.0061	< 0.0007	< 0.0007	0.0043
Curium-244 and/or Californium-249	52	< 0.0010	< 0.0010	0.0039	< 0.0034	< 0.0034	0.0133

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

Table 4.7 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 ANL 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 ANL outfall, the annual average concentrations of most measured radionuclides were similar to recent annual averages. All the annual averages were well below the applicable DOE standards.

On the basis of the results of the Storm Water Characterization Study (see Section 2.2.2), 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. The results are presented in Table 4.8.

TABLE 4.6

Total Radioactivity Released, 2004

Radionuclide	WTP Outfall (Ci)
Hydrogen-3	0.09
Strontium-90	0.0005
Plutonium-239	<0.0001
Americium-241	<0.0001
Total	0.09

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.

One of the ANL waste management locations is within the 398A 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 storm water flow through the 398A area, quarterly sampling is conducted from the 398A 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 ANL 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 ANL 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 4.9 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 were analyzed by the same methods described in Section 4.2 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 (110ºC [230ºF]) weight.

TABLE 4.7

Radionuclides in Sawmill Creek Water, 2004

			Concentrations (pCi/L)			Dose (mrem)		
Activity	Location[a]	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	16K	12	0.97 ± 0.62	0.34	2.22	–[b]	–	–
(Nonvolatile)	7M	52	1.00 ± 0.49	0.10	3.76	–	–	–
Beta	16K	12	6.42 ± 0.32	4.11	12.2	–	–	–
(Nonvolatile)	7M	52	9.13 ± 0.32	3.77	34.4	–	–	–
Hydrogen-3	16K	12	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	7M	52	< 100	< 100	199	< 0.0046	< 0.0046	0.0092
Strontium-90	16K	12	< 0.25	< 0.25	0.34	< 0.024	< 0.024	0.033
	7M	51	0.36 ± 0.04	< 0.25	0.80	0.035	< 0.024	0.077
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	0.758 ± 0.093	0.160	1.32	0.140	0.033	0.291
	7M	52	0.480 ± 0.061	0.130	0.95	0.065	0.002	0.171
Uranium-238	16K	12	0.690 ± 0.086	0.140	1.22	0.109	0.023	0.208
	7M	52	0.421 ± 0.056	0.091	0.80	0.050	0.004	0.127
Neptunium-237	16K	12	< 0.0010	< 0.0010	0.0010	< 0.0028	< 0.0028	0.0028
	7M	52	< 0.0010	< 0.0010	0.0050	< 0.0028	< 0.0028	0.0140
Plutonium-238	16K	12	< 0.0010	< 0.0010	0.0070	< 0.0028	< 0.0028	0.0196
	7M	52	< 0.0010	< 0.0010	0.0060	< 0.0028	< 0.0028	0.0168
Plutonium-239	16K	12	< 0.0010	< 0.0010	0.0120	< 0.0031	< 0.0031	0.0372
	7M	52	< 0.0010	< 0.0010	0.0100	< 0.0031	< 0.0031	0.0310
Americium-241	16K	12	< 0.0010	< 0.0010	0.0030	< 0.0033	< 0.0033	0.0099
	7M	50	< 0.0010	< 0.0010	0.0220	< 0.0033	< 0.0033	0.0726
Curium-242 and/or	16K	12	0.0010	0.0012	0.0056	0.0007	0.0008	0.0039
Californium-252	7M	50	< 0.0010	< 0.0010	0.0040	< 0.0007	< 0.0007	0.0028
Curium-244 and/or	16K	12	< 0.0010	< 0.0010	0.0023	< 0.0034	< 0.0034	0.0078
Californium-249	7M	50	< 0.0010	< 0.0010	0.0021	< 0.0034	< 0.0034	0.0071

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

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

TABLE 4.8

Radionuclides in Storm Water Outfalls, 2004
(concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
March 5	<100	0.61	<2	<100
May 14	<100	0.65	<2	<100
August 4	<100	0.78	<2	Dry
November 1	<100	0.40	<2	479

A set of sediment samples was collected on November 3, 2004, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which ANL discharges its treated wastewater (Location 7M in Figure 1.1). The results, as listed in Table 4.10, show that the concentrations in the samples collected above the outfall at Location 7M are similar to those of the off-site samples collected in past years.[11] The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, which indicates that their origin is in ANL wastewater. Plutonium results varied widely among locations and were strongly dependent on the retentiveness of the bottom 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 ANL 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 9/10 I), south of Building 331 (Location 9 H/I), and next to the 398A radioactive waste storage area (Location 9J).

The results are summarized in Tables 4.11 and 4.12, and the site boundary and on-site readings are shown in Figure 4.4. 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 98 ± 8 mrem/yr and were slightly higher than last year's off-site average of 87 ± 5 mrem/yr.[12] To compare boundary results for individual sampling periods, the standard deviation of the 20 individual off-site results is useful. This value is 9 mrem/yr; thus, individual results in the range of 98 ± 18 mrem/yr may be considered to be the average natural background with a 95% probability.

TABLE 4.9

Radionuclides in Des Plaines River Water, 2004

Activity	Location[a]	No. of Samples	Concentrations (pCi/L) Avg.	Concentrations (pCi/L) Min.	Concentrations (pCi/L) Max.	Dose (mrem) Avg.	Dose (mrem) Min.	Dose (mrem) Max.
Alpha	A	12	1.1 ± 0.9	0.33	2.0	–[b]	–	–
(Nonvolatile)	B	24	1.1 ± 1.0	0.21	2.1	–	–	–
Beta	A	12	10 ± 3	6	16	–	–	–
(Nonvolatile)	B	24	11 ± 3	6	18	–	–	–
Hydrogen-3	A	12	< 100	< 100	130	< 0.0046	< 0.0046	0.0060
	B	24	< 100	< 100	183	< 0.0046	< 0.0046	0.0084
Strontium-90	A	12	< 0.25	< 0.25	0.26	< 0.024	< 0.024	0.025
	B	24	< 0.25	< 0.25	0.33	< 0.024	< 0.024	0.032
Uranium-234	A	12	0.443 ± 0.488	0.166	0.823	0.084	0.032	0.156
	B	24	0.476 ± 0.392	0.184	0.769	0.090	0.035	0.146
Uranium-238	A	12	0.385 ± 0.311	0.154	0.737	0.064	0.026	0.123
	B	24	0.407 ± 0.358	0.155	0.736	0.068	0.026	0.123
Neptunium-237	A	13	< 0.0010	< 0.0010	0.0046	< 0.0028	< 0.0028	0.0129
	B	12	< 0.0010	< 0.0010	0.0024	< 0.0028	< 0.0028	0.0067
Plutonium-238	A	13	0.0049	< 0.0010	0.0417	0.0137	< 0.0028	0.1168
	B	12	< 0.0010	< 0.0010	0.0055	< 0.0028	< 0.0028	0.0154
Plutonium-239	A	13	0.0037	< 0.0010	0.0302	0.0115	< 0.0031	0.0936
	B	12	< 0.0010	< 0.0010	0.0021	< 0.0031	< 0.0031	0.0065
Americium-241	A	13	0.0018	< 0.0010	0.0103	0.0059	< 0.0033	0.0340
	B	12	< 0.0010	< 0.0010	0.0021	< 0.0033	< 0.0033	0.0069
Curium-242 and/or	A	13	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Californium-252	B	12	< 0.0010	< 0.0010	0.0023	< 0.0007	< 0.0007	0.0016
Curium-244 and/or	A	13	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
Californium-249	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.

TABLE 4.10

Radionuclides in Bottom Sediment, 2004

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	7.53 ± 0.42	< 0.01	0.47 ± 0.04	0.30 ± 0.03	0.26 ± 0.05	< 0.1	0.56 ± 0.39	0.51 ± 0.46
Sawmill Creek at outfall	11.4 ± 0.41	0.21 ± 0.02	0.88 ± 0.05	0.53 ± 0.03	0.47 ± 0.06	10.1 ± 1.60	88.8 ± 6.70	24.8 ± 2.41
Sawmill Creek 50 m below outfall	6.09 ± 0.31	0.04 ± 0.01	0.48 ± 0.04	0.32 ± 0.03	0.25 ± 0.03	0.13 ± 0.28	5.38 ± 1.20	1.39 ± 0.64
Sawmill Creek 100 m below outfall	9.91 ± 0.46	0.08 ± 0.02	0.50 ± 0.04	0.41 ± 0.03	0.36 ± 0.06	3.04 ± 0.87	18.1 ± 2.29	3.12 ± 0.99
Sawmill Creek at Des Plaines River	17.3 ± 0.56	0.76 ± 0.03	1.36 ± 0.06	0.92 ± 0.04	0.72 ± 0.07	2.92 ± 0.86	41.3 ± 4.01	12.6 ± 1.93

TABLE 4.11

Environmental Penetrating Radiation at Off-Site Locations, 2004
Dose Rate (mrem/yr)

Location	Period of Measurement				
	Jan 5- April 1	April 1- July 1	July 1- Oct 1	Oct 1 – Jan 4	Average
Lemont	96	85	94	102	94 ± 8
Oak Brook	91	96	96	105	97 ± 9
Orland Park	102	110	118	101	108 ± 10
Woodridge	99	94	102	110	101 ± 8
Willow Springs	90	80	94	96	90 ± 9
Average	96 ± 10	89 ± 8	101 ± 10	103 ± 8	98 ± 8

The site boundary at Location 7I had dose rates above the average background. This was the result of radiation from ANL’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 2004, the dose at this perimeter fence location was 107 ± 13 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose dropped to 104 ± 8 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 2004.

Three new locations were added to monitor radioactive waste facilities and areas. Significant movement of radioactive waste took place, principally waste from the D&D of the CP-5 reactor and the relocation of radioactive waste from the 317 Area to the 398A Area. Some waste is repacked in Building 306 (Location 9/10 I). 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 9 H/I) is being used as a staging area to load trucks for shipment off site. A number of radioactive waste shipments were made during 2004, 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.

TABLE 4.12

Environmental Penetrating Radiation at ANL, 2004
Dose Rate (mrem/yr)

Location[a]	Period of Measurement				Average
	Jan. 2–April 1	April 1–July 1	July 1–Oct. 2	Oct. 2–Jan. 5	
14G - Boundary	109	108	107	116	110 ± 6
14I – Boundary	100	98	97	97	98 ± 2
14L – Boundary	105	92	99	104	100 ± 8
6I – 200 m N of Quarry Road	104	96	109	107	104 ± 8
7I – Center, Waste Storage Area Facility 317	124	116	116	115	118 ± 6
7I – Boundary	99	114	103	112	107 ± 13
8H – Boundary	99	89	100	100	97 ± 8
8H – 65 m S of Building 316	96	90	98	104	97 ± 7
8H – 200 m NW of Waste Storage Area (Heliport)	101	95	102	102	100 ± 5
8H – Boundary, Center, St. Patrick Cemetary	105	101	102	101	102 ± 3
9H – 50 m SE of CP-5	93	92	93	97	94 ± 3
9H/I – 50 m E of Building 331	584	465	475	581	526 ± 62
9/10 I – E of D306	497	438	368	373	419 ± 77
9/10 I – 65 m NE of Building 350 230 m NE of Building 316	100	87	87	96	93 ± 8
9/10 EF – Boundary	–[b]	102	107	111	106 ± 3
9J – 50 m W of 398A Area	323	365	444	463	399 ± 84
10/11 K – Lodging Facilities	93	83	96	95	92 ± 9

[a] See Figure 1.1.

[b] A dash indicates that the sample was lost.

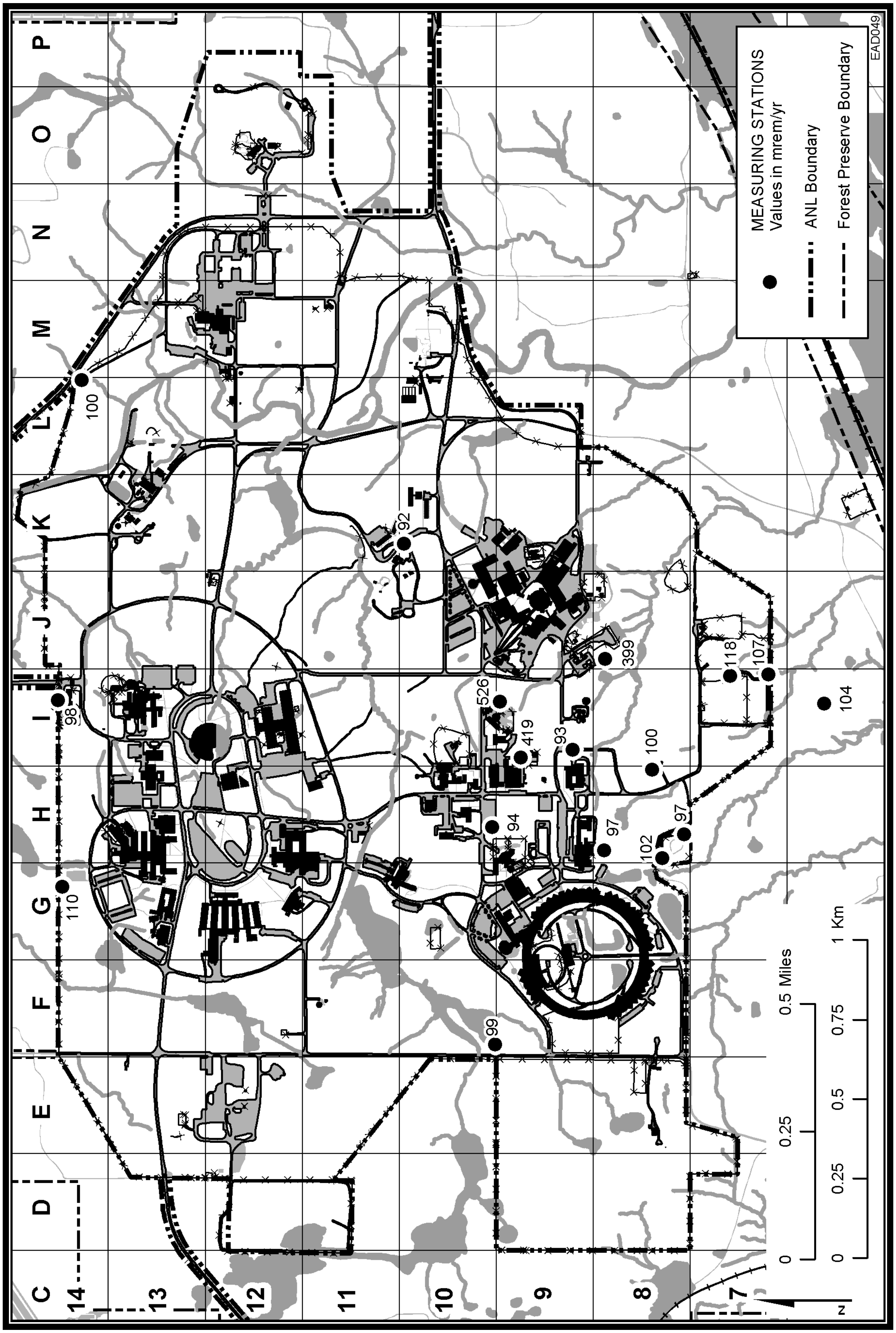


FIGURE 4.4 Penetrating Radiation Measurements at the ANL Site, 2004

4.6. Neutron Monitoring

An environmental fast neutron monitoring program was first established in 2002 at IPNS. Although ANL 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 4.7.1.

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 uneffected by ANL operations. The neutron dosimeters were changed quarterly. The results are given in Table 4.13 and shown in Figure 4.5.

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 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 to the facility. Although these areas are not continuously occupied, measurements in 2004 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.

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 4.13. No fast neutron dose was measurable at any of the ATLAS dosimeter locations. This program will be continued.

TABLE 4.13

Fast Neutron Dose at ANL, 2004
(dose in mrem)

	Period of Measurement				
On-Site Location	Jan 5–Apr 1	Apr 1– July 1	July 1–Oct 1	Oct 1–Jan 4	Total
60 m NE of Bldg. 375	50	80	30	50	210
30 m NW of Bldg. 375	50	80	20	50	200
45 m SW of Bldg. 375	30	50	20	30	130
60 m S of Bldg. 375	20	20	< 1	< 1	40
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
Off-Site Location					
Woodridge	< 1	< 1	< 1	< 1	< 1

4.7. 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.

4.7.1. Airborne Pathway

DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,[13] which requires the use of the EPA's CAP-88 code[9] to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 2004 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 2004, doses were calculated for hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 plus daughters, and a number of actinide radionuclides. The annual releases are those listed in Table 4.4; 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

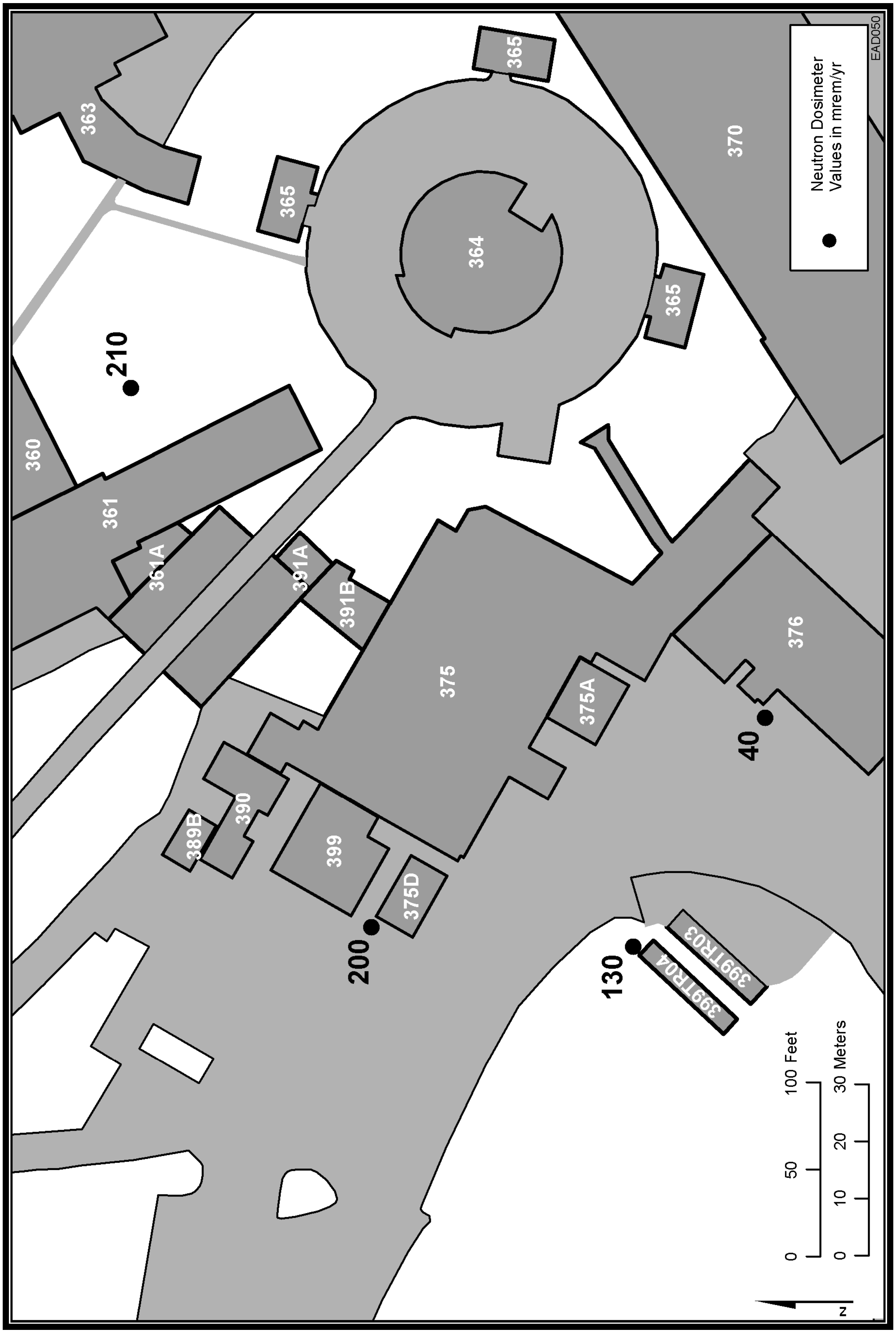


FIGURE 4.5 Neutron Dose Measurements, 2004

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 ANL. 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 4.4) 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 4.14 and 4.15), Building 212 (Tables 4.16 and 4.17), Building 350 (Tables 4.18 and 4.19), Building 375 (Tables 4.20 and 4.21), and Building 411/415 (APS) (Tables 4.22 and 4.23). The doses given in these tables are the committed whole body effective dose equivalents.

TABLE 4.14

Radiological Airborne Releases from Building 200, 2004

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).

TABLE 4.15

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 2004
(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}
Radionuclide		
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}

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 IPNS were established for each perimeter and actual resident location. The five individual building assessments were then overlayed 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 east direction, with a maximum value of 0.59 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 slightly higher

TABLE 4.16

Radiological Airborne Releases from Building 212, 2004

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	800	2.1×10^{-3}	2,000	4.9×10^{-4}
NNE	1,000	1.5×10^{-3}	2,500	3.5×10^{-4}
NE	1,300	7.7×10^{-4}	2,000	3.8×10^{-4}
ENE	1,500	5.6×10^{-4}	2,500	2.4×10^{-4}
E	1,600	5.4×10^{-4}	2,800	2.1×10^{-4}
ESE	1,200	7.7×10^{-4}	2,500	2.3×10^{-4}
SE	1,400	5.6×10^{-4}	3,500	1.3×10^{-4}
SSE	1,400	5.5×10^{-4}	4,500	8.6×10^{-5}
S	1,500	2.4×10^{-4}	5,000	3.9×10^{-5}
SSW	1,600	5.7×10^{-4}	5,000	9.5×10^{-5}
SW	1,400	1.1×10^{-3}	2,400	5.1×10^{-4}
WSW	1,300	7.0×10^{-4}	2,300	2.8×10^{-4}
W	1,700	2.9×10^{-4}	2,200	1.9×10^{-4}
WNW	1,500	3.0×10^{-4}	2,000	1.9×10^{-4}
NW	1,300	3.6×10^{-4}	2,000	1.8×10^{-4}
NNW	1,000	1.0×10^{-3}	2,000	3.4×10^{-4}

[a] Source terms:
hydrogen-3 (HT) = 28.2 Ci
hydrogen-3 (HTO) = 13.9 Ci
krypton-85 = 7.6 Ci
antimony-125 = 1.2×10^{-6} Ci
radon-220 = 0.5 Ci

than last year and is due to higher carbon-11 emissions from the IPNS. The programmatic need for continued operation of the facility will result in continued releases of carbon-11.

The full-time resident who would receive the largest annual dose (0.054 mrem/yr), if he or she were outdoors during the entire year, is located approximately 2.5 km (1.6 mi) ENE of the IPNS facility. The major contributor to the whole body dose is the air immersion dose from carbon-11 (0.051 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 NESHAPs reportable dose to the maximally exposed individual would be 0.054 mrem/yr.

The individual doses to the maximally exposed member of the public and the maximum fence line dose are shown in Figure 4.6. 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

TABLE 4.17

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 2004
(dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2400 m SW)
Ingestion	5.0×10^{-4}	1.2×10^{-4}
Inhalation	1.6×10^{-3}	3.9×10^{-4}
Air immersion	3.2×10^{-6}	7.7×10^{-7}
Ground surface	2.7×10^{-6}	6.9×10^{-8}
Total	2.1×10^{-3}	5.1×10^{-4}
Radionuclide		
Hydrogen-3	2.1×10^{-3}	5.1×10^{-4}
Krypton-85	4.8×10^{-6}	1.2×10^{-6}
Antimony-125	2.7×10^{-7}	7.0×10^{-8}
Radon	8.7×10^{-6}	3.7×10^{-8}
Total	2.1×10^{-3}	5.1×10^{-4}

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 ANL operations. The results are given in Table 4.24, along with the natural external radiation dose. The natural radiation dose listed is the product of the 80-km (50-mi) population and the natural radiation dose of 300 mrem/yr.[14] It is assumed that this dose is representative of the entire area within an 80-km (50-mi) radius. The population dose resulting from ANL operations since 1987 is shown in Figure 4.7.

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 m^3/yr.[15] This annual intake is then multiplied by the CEDE conversion factor for the appropriate lung retention class.[5] The CEDE conversion factors are in units of rem/μCi, and this calculation gives the 50-year CEDE. Table 4.25 lists the applicable CEDE factors.

The calculated doses in Tables 4.1 and 4.2 were derived by using this procedure. Because they are all essentially at perimeter locations, these doses represent the fence-line values for those

TABLE 4.18

Radiological Airborne Releases from Building 350, 2004

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,700	7.9×10^{-4}	2,200	5.4×10^{-4}
NNE	1,800	7.3×10^{-4}	3,200	3.1×10^{-4}
NE	2,200	4.3×10^{-4}	3,100	2.5×10^{-4}
ENE	2,000	4.5×10^{-4}	3,100	2.3×10^{-4}
E	1,700	6.0×10^{-4}	2,500	2.6×10^{-4}
ESE	900	1.3×10^{-3}	3,000	2.3×10^{-4}
SE	900	1.2×10^{-3}	3,000	2.5×10^{-4}
SSE	700	1.5×10^{-3}	2,700	2.4×10^{-4}
S	600	6.2×10^{-3}	2,700	1.1×10^{-4}
SSW	400	2.2×10^{-3}	2,500	3.6×10^{-4}
SW	600	2.5×10^{-3}	2,700	4.6×10^{-4}
WSW	800	1.5×10^{-3}	2,100	4.1×10^{-4}
W	900	7.6×10^{-4}	2,200	2.4×10^{-4}
WNW	1,000	5.6×10^{-4}	2,100	2.1×10^{-4}
NW	1,900	2.5×10^{-4}	2,400	1.7×10^{-4}
NNW	1,900	4.6×10^{-4}	2,200	3.7×10^{-4}

[a] Source terms: neptunium-237 = 9.4×10^{-9} Ci
uranium-234 = 3.2×10^{-5} Ci
uranium-238 = 3.2×10^{-5} Ci
plutonium-239 = 4.3×10^{-6} Ci
plutonium-240 = 2.5×10^{-6} Ci

radionuclides measured. These doses are the same as the off-site measurements and represent the ambient dose for the area from these nuclides. No doses were calculated for the total alpha and total beta measurements because the guidance does not provide CEDE conversion factors for such measurements.

An evaluation was conducted of potential sensitive receptors of ANL airborne releases, including children at the Argonne Child Development Center (Location 120 in Figure 1.1). The airborne dose from ANL 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.

TABLE 4.19

Maximum Perimeter and Individual Doses
from Building 350 Air Emissions, 2004
(dose in mrem/yr)

Pathway	Perimeter (600 m SW)	Individual (2,200 m N)
Ingestion	2.0×10^{-5}	4.5×10^{-6}
Inhalation	2.4×10^{-3}	5.3×10^{-4}
Air immersion	1.3×10^{-12}	2.8×10^{-13}
Ground surface	2.8×10^{-7}	6.3×10^{-8}
Total	2.5×10^{-3}	5.4×10^{-4}
Radionuclide		
Neptunium-237	1.1×10^{-6}	2.4×10^{-7}
Uranium-234	1.0×10^{-3}	2.2×10^{-4}
Uranium-238	4.0×10^{-4}	2.0×10^{-4}
Plutonium-239	3.5×10^{-4}	7.7×10^{-5}
Plutonium-240	2.0×10^{-4}	4.5×10^{-5}
Total	2.5×10^{-3}	5.4×10^{-4}

4.7.2. 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 (μCi/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 4.25) 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 ANL operations could be found in off-site water was Sawmill Creek below the wastewater outfall (see Table 4.7). 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 ANL wastewater, their net concentrations in the creek, and the corresponding dose rates (if water at these concentrations was used as the sole water supply by an individual for an entire year) are given in Table 4.26. The dose rates were all well below the standards for the general population. It should be emphasized that Sawmill Creek is not used for drinking, swimming, or boating. Inspection of

TABLE 4.20

Radiological Airborne Releases from Building 375 (IPNS), 2004

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,600	1.3×10^{-1}	3,200	3.6×10^{-2}
NNE	1,700	1.4×10^{-1}	3,100	4.2×10^{-2}
NE	1,700	1.1×10^{-1}	2,700	4.3×10^{-2}
ENE	1,500	1.1×10^{-1}	2,500	4.5×10^{-2}
E	600	5.9×10^{-1}	2,500	5.3×10^{-2}
ESE	600	5.4×10^{-1}	2,500	4.3×10^{-2}
SE	600	4.8×10^{-1}	2,500	3.8×10^{-2}
SSE	600	4.7×10^{-1}	3,000	2.5×10^{-2}
S	800	1.3×10^{-1}	3,000	2.2×10^{-2}
SSW	800	3.7×10^{-1}	3,500	2.5×10^{-2}
SW	800	4.9×10^{-1}	4,000	2.2×10^{-2}
WSW	1,500	1.1×10^{-2}	2,700	3.7×10^{-2}
W	2,200	3.6×10^{-2}	2,700	2.2×10^{-2}
WNW	1,500	5.8×10^{-2}	2,600	2.0×10^{-2}
NW	2,200	2.7×10^{-2}	2,500	2.1×10^{-2}
NNW	1,800	7.4×10^{-2}	2,200	5.1×10^{-2}

[a] Source terms: carbon-11 = 2345.9 Ci
argon-41 = 65.4 Ci.

the area shows that there are fish in the stream; however, they do not constitute a significant source of food for any individual. Figure 4.8 is a plot showing the estimated dose a hypothetical individual would receive if ingesting Sawmill Creek water since 1986.

As indicated in Table 4.7, 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 m^3/s (10 ft^3/s); the flow rate of the Des Plaines River in the vicinity of ANL is about 25 m^3/s (900 ft^3/s). Applying this ratio to the concentration of

TABLE 4.21

Maximum Perimeter and Individual Doses from Building 375 (IPNS) Air Emissions, 2004 (dose in mrem/yr)

Pathway	Perimeter (600 m E)	Individual (2,400 m E)
Ingestion	–[a]	–
Inhalation	2.5×10^{-2}	2.2×10^{-3}
Air immersion	5.4×10^{-1}	4.8×10^{-2}
Ground surface	2.1×10^{-2}	2.2×10^{-3}
Total	5.9×10^{-1}	5.3×10^{-2}
Radionuclide		
Carbon-11	5.7×10^{-1}	5.1×10^{-2}
Argon-41	2.0×10^{-2}	2.1×10^{-3}
Total	5.9×10^{-1}	5.3×10^{-2}

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

radionuclides in Sawmill Creek listed in Table 4.26, 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 further 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.

4.7.3. Biota Dose Assessment

DOE Order 5400.5[5] requires an evaluation of the dose to aquatic organisms from liquid effluents. The dose limit is 1 rad/day or 365 rad/yr. The location that could result in the highest dose to aquatic organisms is in Sawmill Creek downstream of the point where ANL 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,

TABLE 4.22

Radiological Airborne Releases from Building 411/415 (APS), 2004

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,500	5.7×10^{-4}	2,000	3.1×10^{-4}
NNE	1,600	5.6×10^{-4}	2,100	3.2×10^{-4}
NE	2,200	2.3×10^{-4}	3,100	1.1×10^{-4}
ENE	2,500	1.6×10^{-4}	3,300	8.5×10^{-5}
E	1,600	4.3×10^{-4}	3,400	8.7×10^{-5}
ESE	1,500	4.3×10^{-4}	3,500	6.9×10^{-5}
SE	400	4.8×10^{-3}	3,000	8.3×10^{-5}
SSE	400	4.8×10^{-3}	3,000	8.2×10^{-5}
S	350	2.6×10^{-3}	2,500	6.1×10^{-5}
SSW	400	6.1×10^{-3}	2,800	1.2×10^{-4}
SW	550	4.4×10^{-3}	3,000	1.1×10^{-4}
WSW	800	1.5×10^{-3}	1,400	4.9×10^{-4}
W	800	9.1×10^{-4}	1,500	2.5×10^{-4}
WNW	500	1.9×10^{-3}	1,400	2.5×10^{-4}
NW	350	3.5×10^{-3}	1,600	1.8×10^{-4}
NNW	1,500	3.9×10^{-4}	2,000	2.1×10^{-4}

[a] Source terms: carbon-11 = 0.15 Ci (estimated)
nitrogen-13 = 10.71 Ci (estimated)
oxygen-15 = 1.16 Ci (estimated).

plutonium-239, and americium-241 were obtained from Table 4.7, while maximum sediment concentrations for cesium-137, plutonium-239, and americium-241 were obtained from Table 4.10. Summing the ratios of their respective BCGs for each radionuclide resulted in a dose estimate of 0.0031 rad/yr to aquatic biota. This is well below the 365 rad/yr limit in DOE Order 5400.5 and demonstrates compliance with the limit.

4.7.4. External Direct Radiation Pathway

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

At Location 7I, the fence-line dose from ANL was 107 ± 13 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 104 ± 8 mrem/yr, slightly

TABLE 4.23

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 2004
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	–[a]	–
Inhalation	1.7×10^{-4}	1.4×10^{-5}
Air immersion	5.8×10^{-3}	4.6×10^{-4}
Ground surface	1.0×10^{-4}	9.9×10^{-6}
Total	6.1×10^{-3}	4.9×10^{-4}
Radionuclide		
Carbon-11	8.6×10^{-5}	8.1×10^{-6}
Nitrogen-13	5.6×10^{-3}	4.7×10^{-4}
Oxygen-15	4.0×10^{-4}	1.5×10^{-6}
Total	6.1×10^{-3}	4.9×10^{-4}

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

higher than the off-site average (98 ± 8 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, 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 ANL 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 ANL operations.

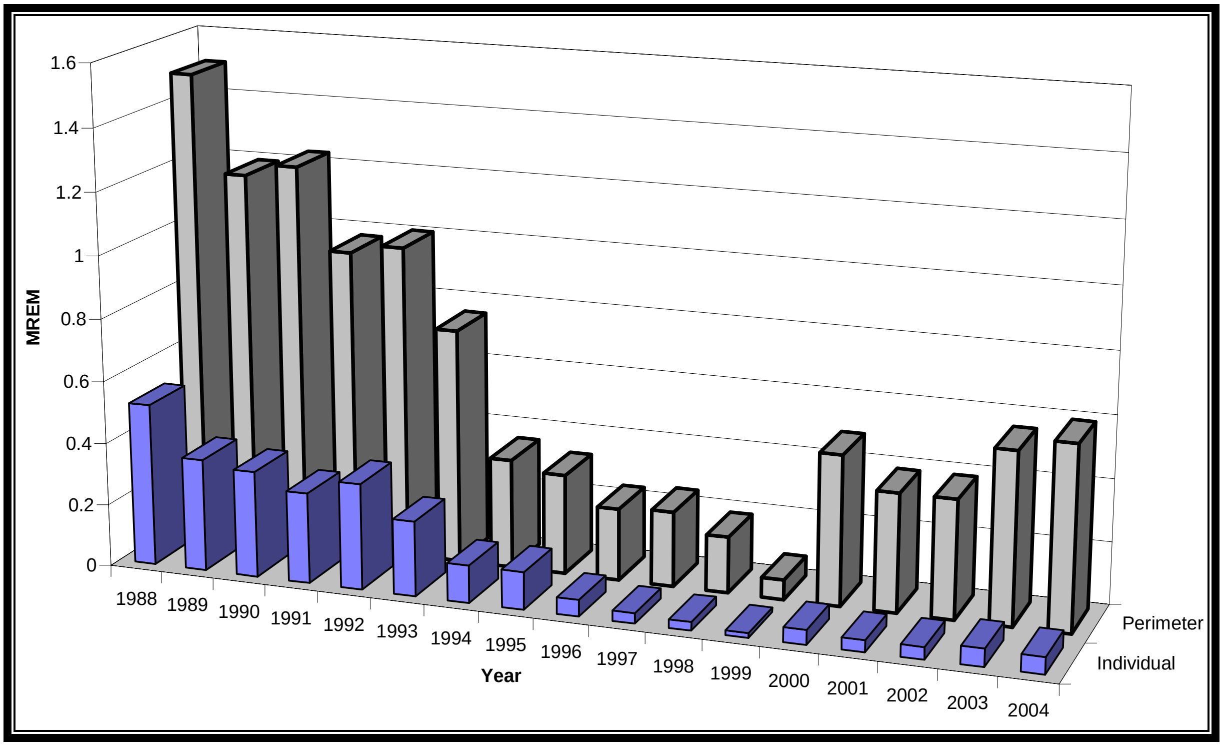


FIGURE 4.6 Individual and Perimeter Doses from Airborne Radioactive Emissions

TABLE 4.24

Population Dose within 80 km (50 mi), 2004

Radionuclide	Person-rem
Hydrogen-3	0.07
Carbon-11	3.14
Nitrogen-13	<0.01
Oxygen-15	<0.01
Argon-41	0.40
Krypton-85	<0.01
Antimony-125	<0.01
Uranium-234	0.05
Uranium-238	0.05
Neptunium-237	<0.01
Plutonium-239	0.02
Plutonium-240	0.01
Total	3.75
Natural	2.7×10^6

4.7.5. Dose Summary

The total effective dose equivalent received by off-site residents during 2004 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 0.054 mrem/yr to individuals living east 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 3.75 person-rem. The dose pathways are presented in Table 4.27 and are compared with the applicable standards.

To receive the hypothetical maximum public dose, an individual would need to live at the point of maximum air and direct radiation exposure and use only water from Sawmill Creek below the ANL wastewater discharge. This is a very conservative and unlikely situation. To put the hypothetical maximum individual dose from all pathways of 0.073 mrem/yr attributable to ANL 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 4.28. These site-related doses are in addition to the background doses. The magnitude of the doses received from ANL operations is insignificant compared with these sources. Therefore, the monitoring program results establish that the radioactive emissions from ANL are very low and do not endanger the health or safety of those living in the vicinity of the site.

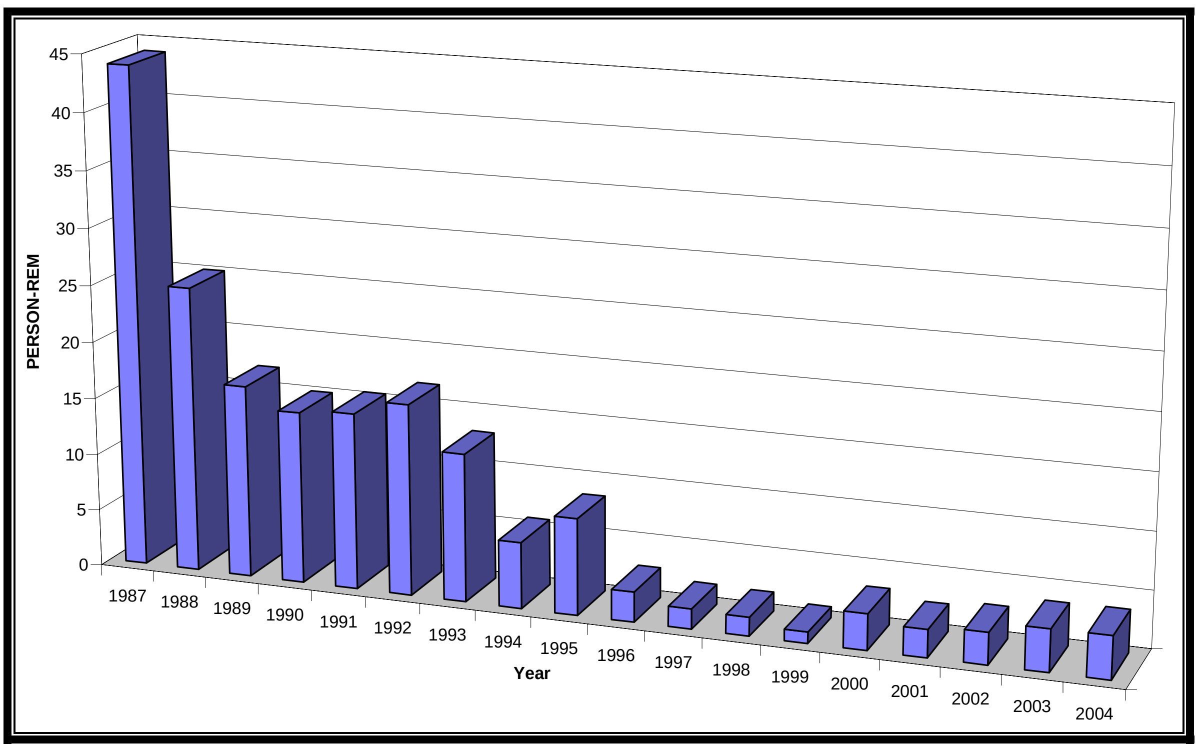


FIGURE 4.7 Population Dose from Airborne Radioactive Emissions

TABLE 4.25

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

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	–	1100
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 4.26

Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 2004

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	0.09	28	0.0013
Strontium-90	0.0005	0.16	0.015
Plutonium-239	<0.0001	0.0005	0.0016
Americium-241	<0.0001	0.0006	0.0002
Total	0.09		0.018

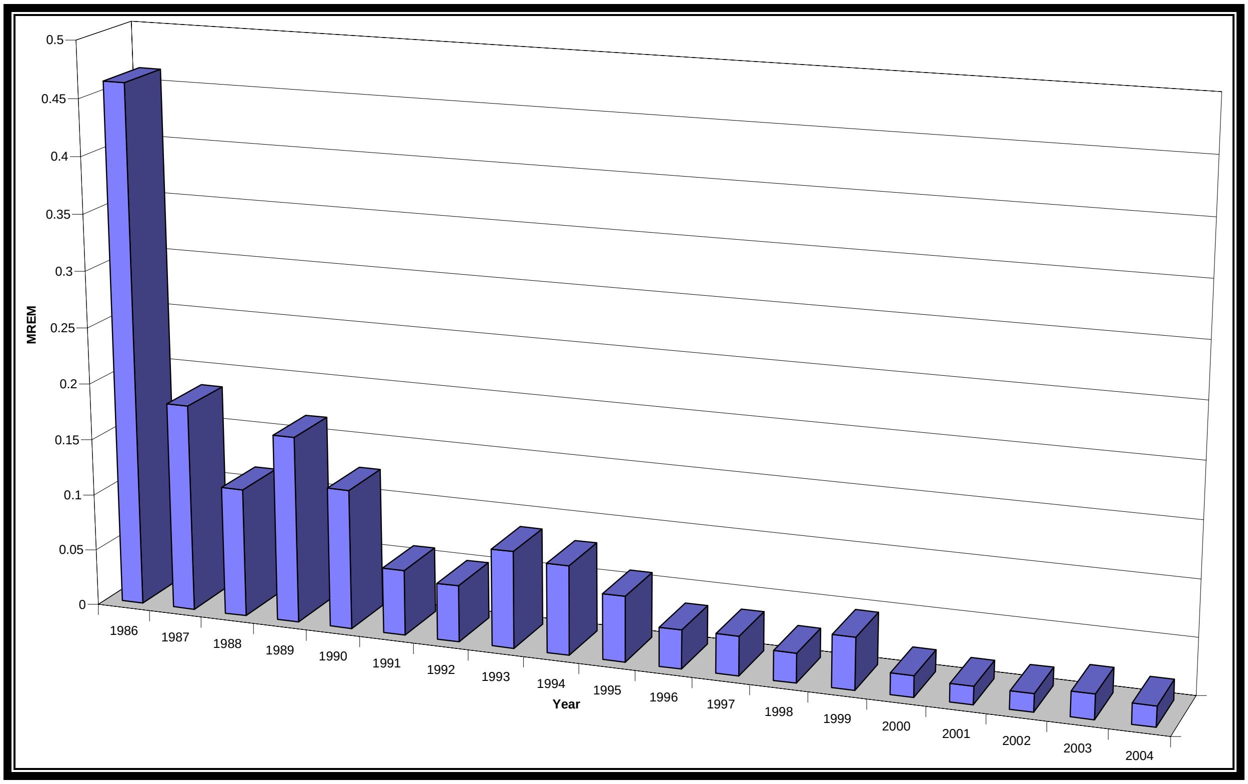


FIGURE 4.8 Comparison of Dose Estimate from Ingestion of Sawmill Creek Water

TABLE 4.27

Summary of the Estimated Dose to a Hypothetical Individual, 2004 (mrem/yr)

Pathway	ANL Estimate	Applicable Standard
Air total	0.054	10 (EPA)
Water	0.018	4 (EPA)[a]
Direct radiation	0.001	25 (NRC)
Maximum dose	0.073	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.

TABLE 4.28

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

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The nonradiological monitoring program primarily involves the collection and analysis of surface water and groundwater samples from numerous locations throughout the site. The amount of nonradiological pollutants released to the air from ANL is extremely small (see Table 2.4), except for the conventional air pollutants emitted from the boiler house while burning coal. This unit is equipped with dedicated monitoring equipment for sulfur dioxide and opacity while burning coal. No exceedances were noted during 2004 over a period of 1,384 hours of coal-burning operation of Boiler No. 5, the coal-burning boiler (see Section 2.1.2). No other air monitoring for nonradiological pollutants is performed, except for landfill gas monitoring (see Section 2.1.2).

Surface water samples for nonradiological chemical analyses are collected from NPDES-permitted outfalls and Sawmill Creek.[18] 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 an official DMR.

In addition to the permit-required monitoring, other analyses are conducted on samples collected from the combined wastewater outfall (NPDES Outfall 001) to provide a more complete evaluation of the impact of the wastewater on the environment. Water samples from Sawmill Creek are also collected and analyzed for a number of inorganic constituents. The results of these additional analyses of the main outfall and receiving streams are then compared with IEPA General Effluent Standards and Stream Quality Standards listed in IAC, Title 35, Subtitle C, Chapter I.[19]

5.1. National Pollutant Discharge Elimination System Monitoring Results

5.1.1. Influent Monitoring

Since initial monitoring in 1989, analyses of the laboratory wastewater influent have shown the presence of a variety of VOCs with variable concentrations. Although disposing of waste chemicals into the drain is not authorized, residual VOCs are released to the laboratory sewer from laboratory-related activities such as rinsing glassware. Also, VOCs are known to be discharged into the laboratory sewer from the 317/319 Lift Station, which pumps contaminated groundwater generated by ANL's RCRA corrective actions. Table 5.1 gives the results of the analysis of laboratory wastewater influent.

The 2004 results for laboratory influent wastewater are quite similar to those from 1997 through 2003. Table 5.1 gives the 2004 results for the most common compounds detected. Bromoform, bromodichloromethane, chloroform, and dibromochloromethane are halomethanes that are produced as the result of contact of the chlorinated water supply with organic chemicals. Research activity may account for the presence of other volatiles.

TABLE 5.1

Laboratory Influent Wastewater, 2004
(concentrations in µg/L)

Month	Acetone	Chloroform	Bromodi-chloroethane	Dibromo-chloromethane	Bromoform
January	13	6	5	2	<1
February	<1	1	2	1	<1
March	31	5	3	2	<1
April	<1	10	2	1	<1
May	7	6	6	5	4
June	315	10	3	1	<1
July	3	6	4	2	1
August	<1	6	4	2	<1
September	66	7	5	5	5
October	10	4	3	2	2
November	67	3	2	2	2
December	192	3	3	2	<1
Average	78	6	4	2	<3

Acetone was detected in nine samples and levels ranged up to 315 µg/L. Infrequent trace levels of other chemicals, that is, 2-butanone, acetaldehyde, ethanol, and ethyl ether, were also noted but not shown in Table 5.1.

Figures 5.1 and 5.2 present comparisons of the 1992 through 2004 laboratory influent wastewater results for the two more common VOCs, acetone and chloroform. The presence of acetone is likely due to laboratory activities such as rinsing glassware. Disposing of hazardous chemicals down laboratory drains is not authorized at ANL. ANL conducts a waste generator education program as part of its site safety awareness training program, in which proper handling and disposal of chemicals are explained. However, normal use of certain chemicals, such as acetone, often results in the discharge of small amounts into the sewer. The decrease in influent concentrations of acetone and chloroform over the past several years shows the effectiveness of educational efforts related to waste disposal and pollution prevention.

5.1.2. Effluent Monitoring

Section 2.2 of Chapter 2 describes the outfalls on the ANL site; Table 2.5 lists all the outfalls. In general, the outfalls fall into two groups: those that have some type of process wastewater discharge and those that contain only storm water runoff following a rain event. The sampling requirements of the process wastewater outfalls depend on the nature of the activity generating the wastewater. This section discusses those requirements and the results of the

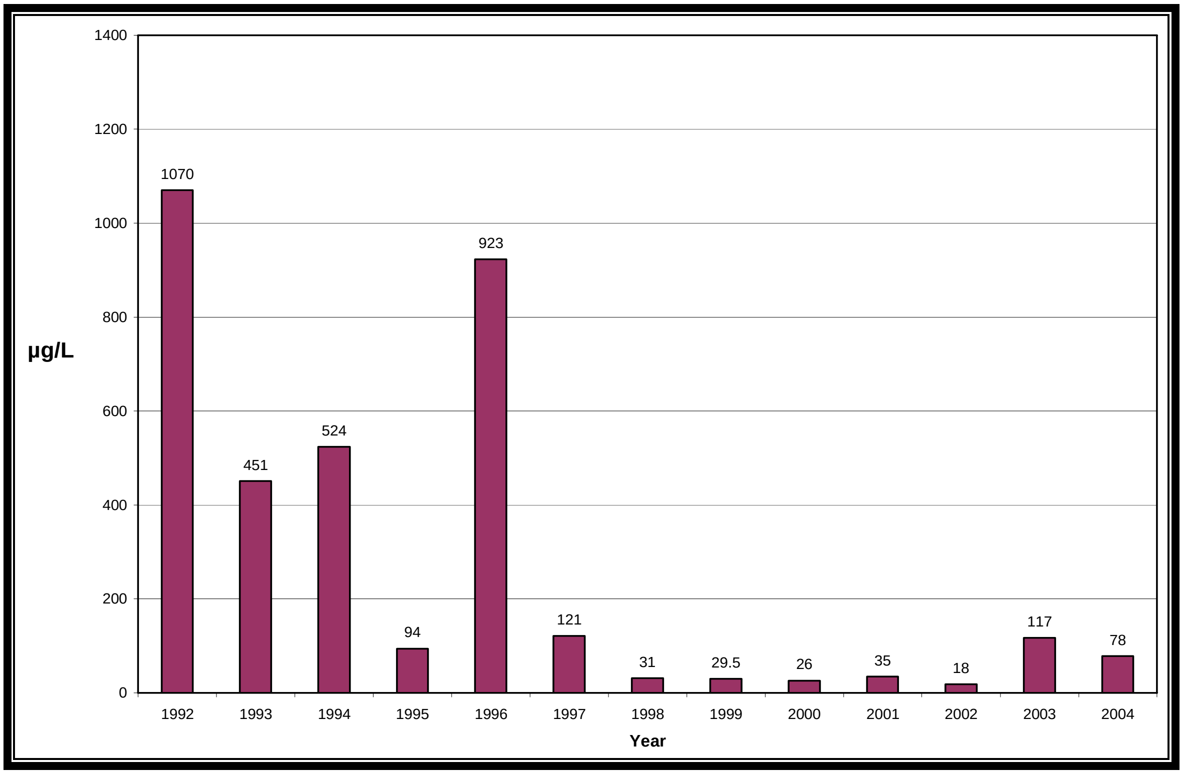


FIGURE 5.1 Average Acetone Levels in Laboratory Influent Wastewater, 1992 to 2004

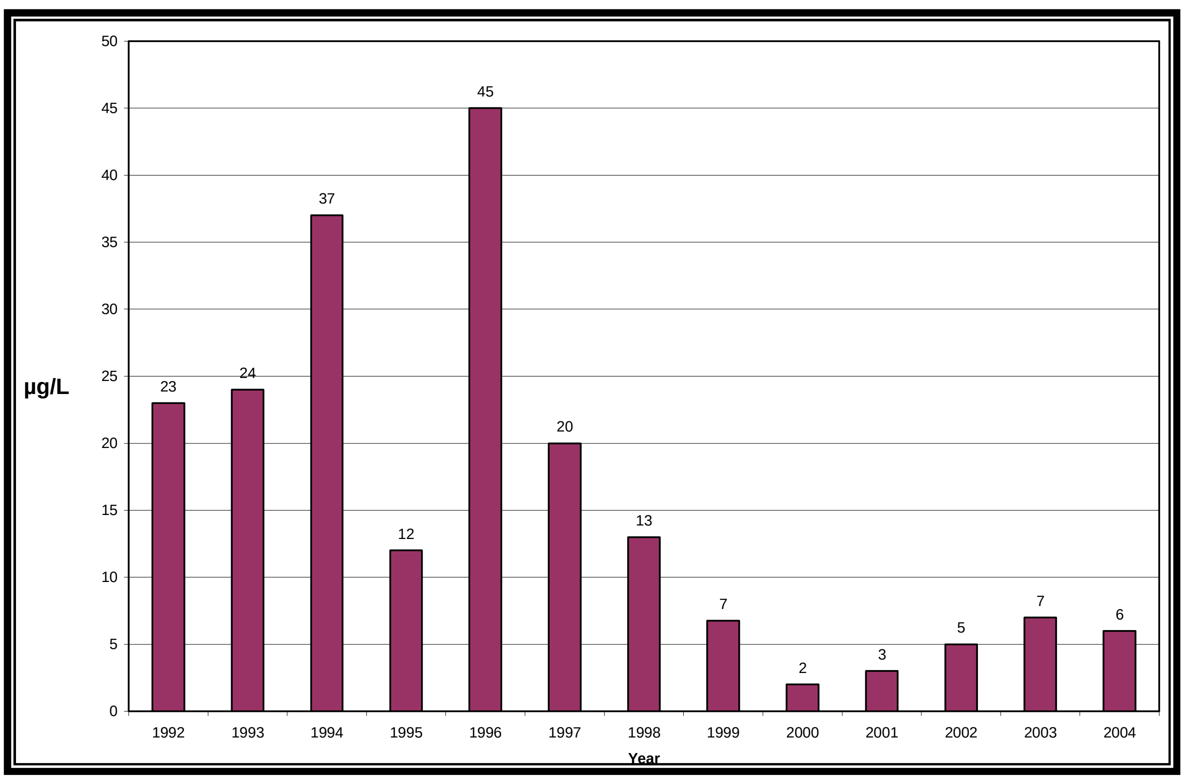


FIGURE 5.2 Average Chloroform Levels in Laboratory Influent Wastewater, 1992 to 2004

monitoring. The storm water outfalls are listed in the permit, but they do not require routine monitoring of the discharges.

Effluent samples are collected from ANL point-source discharges (outfalls) as specified by the NPDES Permit. The permit specifies the frequency of sample collection and the specific parameters to be monitored for each individual outfall. 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]

The NPDES outfall locations are shown in Figure 5.3. Outfalls 001A and 001B, the two internal monitoring points representing the effluent from the sanitary system and laboratory system, respectively, are both located at the WTP. Their flows combine to form Outfall 001, which also is located at the treatment facility. The combined stream flows through an outfall pipe that discharges into Sawmill Creek approximately 1,100 m (3,500 ft) south of the treatment plant.

In addition to the main wastewater outfalls, a small amount of process wastewater, primarily cooling tower blowdown and 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 discharge points are included in the site NPDES Permit as separate regulated outfalls. Most of the cooling tower-associated discharges have been rerouted to the ANL sewer system.

5.1.2.1. Sample Collection

All samples are collected in specially cleaned and labeled bottles with appropriate preservatives added. Custody seals and chain of custody sheets also are used. All samples are analyzed within the required holding time. Samples are collected at Locations 001A, 001B, and 001 on a weekly basis, consistent with permit requirements. Similarly, samples are collected at the other locations in accordance with the NPDES Permit.

5.1.2.2. Sample Analyses — NPDES

NPDES sample analyses were performed in accordance with standard operating procedures (SOPs) that were issued as controlled documents. These SOPs cite protocols that can be found in 40 CFR Part 136, “Test Procedures for the Analysis of Pollutants under the Clean Water Act.”[20] Six metal analyses were performed by using inductively coupled plasma atomic emission spectroscopy. Mercury was determined by cold vapor atomic absorption or atomic fluorescence spectroscopy, depending on the level required at the outfall. Hexavalent chromium determination and chemical oxygen demand (COD) were performed by using a colorimetric technique. Biochemical oxygen demand (BOD_5) was determined by using a dissolved oxygen probe. TSS, TDS, and oils and grease were determined gravimetrically. Sulfate determination was performed by using a turbidimetric technique; chloride was determined by titrimetry.

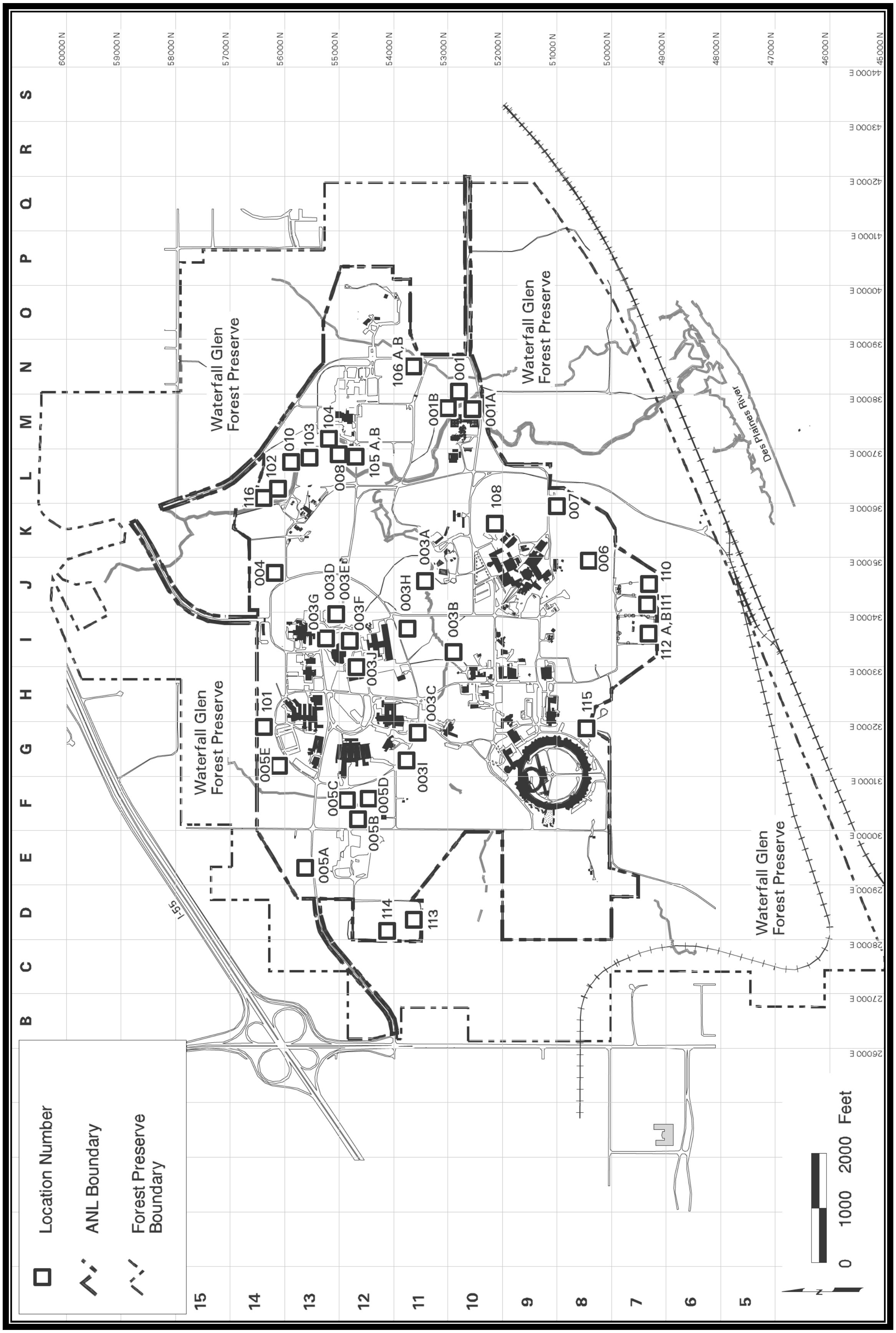


FIGURE 5.3 NPDES Outfall Locations

Ammonia nitrogen was determined by distillation, followed by an ion-selective electrode measurement. VOC concentrations were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. The PCB Aroclor-1260® concentrations were determined by solvent extraction, followed by gas chromatography-electron capture detection. Beta radioactivity was performed by using a gas flow proportional counting technique. Hydrogen-3 concentrations were determined by distillation, followed by a beta liquid scintillation counting technique.

NPDES Outfall 001B is sampled and analyzed semiannually for priority pollutant compounds. VOCs were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. Semivolatile organic compounds (SVOCs) were determined by solvent extraction, followed by gas chromatography-mass spectroscopy detection. PCBs and pesticides were determined by solvent extraction, followed by gas chromatography-electron capture detection. Thirteen metals were determined by graphite furnace atomic absorption and inductively coupled plasma atomic emission spectroscopy. Cyanide and phenol were determined by distillation, followed by a spectrophotometric measurement.

NPDES Outfall 001 is sampled and analyzed annually during June for acute aquatic toxicity parameters. NPDES Outfalls 003H, 003I, 003J, 004, 006, and 115 are tested in July and August for acute aquatic toxicity. An off-site contract laboratory performs both the sample collection and analyses. The testing is performed by diluting a series of ANL effluent samples with Sawmill Creek receiving water, into which species of fish and invertebrates are introduced. Survival is measured over two to four days, and statistically significant mortality is reported as a function of effluent concentration.

5.1.2.3. Results

During 2004, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits. Specific limit exceedances are discussed later in this section, as well as in Chapter 2. A discussion of the analytical results for each outfall follows.

5.1.2.4. Wastewater Treatment Facility Outfalls

Outfall 001A. This outfall consists of treated sanitary wastewater. Until fall of 2001, it also consisted of various wastewater streams from the boiler house area, including coal pile storm water runoff. These wastewater streams are now directed to the DuPage County system. The effectiveness of the sanitary wastewater treatment systems is evaluated by weekly monitoring for BOD_5, pH, and TSS. The limits for BOD_5 are a monthly average of 10 mg/L and a maximum value of 20 mg/L. The permit limits for TSS are a maximum concentration of 24 mg/L and a monthly average of 12 mg/L. The pH must range between values of 6 and 9. No limits were exceeded during 2004.

The permit requires weekly monitoring for total chromium, copper, iron, lead, manganese, zinc, and oil and grease. Table 5.2 gives the effluent limits for these parameters and monitoring results. Two limits are listed; one is a maximum limit for any single sample, and the other is for the average of all samples collected during the month. The constituents in Table 5.2 are present in the coal pile runoff. As of fall 2001, coal pile runoff is discharged to the laboratory sewage system. No limits were exceeded during 2004.

Outfall 001B. This outfall consists of processed wastewater from the laboratory wastewater system and the coal pile runoff. The permit requires that weekly samples be collected and analyzed for BOD_5, TSS, mercury, pH, and COD. Table 5.3 gives the effluent limits for these parameters and monitoring results.

The limits established for BOD_5 are a daily maximum of 20 mg/L and a 30-day average of 10 mg/L. The permit also contains BOD_5 mass loading limits of 52 kg/day (114 lb/day) as a daily maximum and 26 kg/day (57 lb/day) as a 30-day average. The mass loading represents the weight of material discharged per day and is a function of concentration and flow. The daily maximum concentration limit for TSS is 24 mg/L; the 30-day average is 12 mg/L. The TSS mass loading limits are 62 maximum and 31 average kg/day (136 and 68 lb/day), respectively. No limits were exceeded during 2004.

The daily maximum concentration limit for mercury is 0.006 mg/L; the 30-day average is 0.003 mg/L. The corresponding loading values are 0.02 kg/day (0.034 lb/day) and 0.01 kg/day (0.017 lb/day). No exceedances of the mercury loading and concentration limits were noted during 2004. The values obtained in 2004 where all less than 0.0002 mg/L.

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 2004
(concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Average Limit	Maximum Limit
Chromium	–[a]	<0.015	<0.015	1.0	2.0
Copper	<0.015	<0.017	0.025	0.50	1.0
Iron	0.040	0.102	0.333	2.0	4.0
Lead	–	<0.10	<0.10	0.20	0.40
Manganese	<0.010	0.021	0.047	1.0	2.0
Zinc	0.053	0.079	0.115	1.0	2.0
Oil and grease	–	<5.0	<5.0	15.0	30.0

[a] A dash indicates that there is no minimum value.

TABLE 5.3

Outfall 001B Effluent Limits and Monitoring Results, 2004
(concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Average Limit	Maximum Limit
COD	–[a]	<20	<21	–[b]	–[c]
Mercury	–	<0.0002	<0.0002	0.003	0.006
BODs	2	3	4	10	10
TSS	2	3	6	12	24

[a] A dash indicates that there is no minimum value.

[b] Report 30-day average.

[c] Report daily maximum.

No concentration limits have been established for COD. The once-per-week grab samples give a rough indication of the organic and inorganic oxygen-consuming contents of this effluent stream. The values obtained in 2004 ranged from less than 20 to 23 mg/L.

A special condition at Location 001B requires monitoring for the 124 priority pollutants listed in the permit during the months of June and December. 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 24, 2004, and December 3, 2004, and analyzed within the required holding times.

Analysis of these samples indicated that very small amounts of a few chemicals were present. The results for SVOCs, PCBs, and pesticides were all less than the detection limits. The results for metals were similar to concentrations historically found in ANL–treated drinking water. Very low levels of zinc (0.05 and 0.09 mg/L), were noted in the June and December samples. Mercury (0.0004 mg/L) and phenols (0.023 mg/L) were noted in the June sample only. The samples contained some VOCs at very low levels. The majority of compounds detected were halomethanes, which are found in chlorinated drinking water. Table 5.4 lists the concentrations of volatile organics identified in these samples. Currently, no permit limits or effluent standards are available for these compounds for comparison with these results.

Outfall 001. After the treatment processes, the effluents from both the laboratory and sanitary WTP are combined to form one point-source discharge. The combined effluent flows through a 1,100-m (3,500-ft) outfall pipe where it is eventually discharged into Sawmill Creek.

Samples of the combined effluent are collected weekly or monthly as grab samples or 24-hour composite samples as specified in the NPDES Permit. The samples are analyzed for a variety of metals, ammonia nitrogen, chlorides, sulfates, TDS, pH, and beta radioactivity. The permit requires analysis of the combined effluent once a week for TDS, chloride, and sulfate. Table 5.5 gives the results, limits, and number of exceedances.

TABLE 5.4

Outfall 001B Effluent Priority Pollutant Monitoring Results, 2004
(concentrations in μg/L)

Compound	Concentration in June Sample	Concentration in December Sample
Bromodichloromethane	<1	2
Bromoform	<1	<1
Chloroform	1	3
Dibromochloromethane	<1	1

Three exceedances of the TDS limit were noted during 2004. The elevated TDS levels occurred during the 2004 heating season. The TDS exceedances are believed to be related to the combination of reduced flows and increases in TDS concentrations from road salt infiltration/inflow into the sanitary sewer system associated with snowmelt. For the past several years, chemical analysis for chloride has indicated a close relationship between TDS levels and chloride levels. Figure 5.4 shows the results of TDS and chloride analyses for 1995 through 2004. Elevated TDS levels prior to 1997 are attributed to high TDS levels (800 mg/L) in ANL's domestic source water (i.e., groundwater, at that time).

In 1997, Lake Michigan water, which is characterized by low TDS levels (200 to 400 mg/L), became ANL's domestic source water. Figure 5.5 shows that average TDS levels at Outfall 001 have substantially decreased since the introduction of Lake Michigan water.

The permit requires that a biological toxicity screening test be performed on wastewater from Outfall 001 in June of each year. The toxicity testing is run on two trophic levels of aquatic species for acute toxicity. The 2004 testing was conducted on samples collected June 21 through 25; the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*) were used.

No toxicity was observed to the fathead minnow or to the water flea. The concentration of wastewater that produces 50% mortality in the test population (i.e., the median lethal concentration [LC_{50}]) for both species is greater than 100%; that is, the pure, undiluted effluent is not toxic to these species. Tables 5.6 and 5.7 summarize the results of the toxicity tests from 2000 to 2004.

TABLE 5.5

Outfall 001 Monitoring Results and Effluent Limits, 2004
(concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Limit	Exceedances
Chloride	119	212	360	500	0
Copper	<0.015	<0.019	0.025	0.051	0
TDS	574	741	1,085	1,000	3
Ammonia nitrogen	<0.06	0.21	0.52	10.0 (Nov.–March)	0
				3.0 (April–Oct.)	

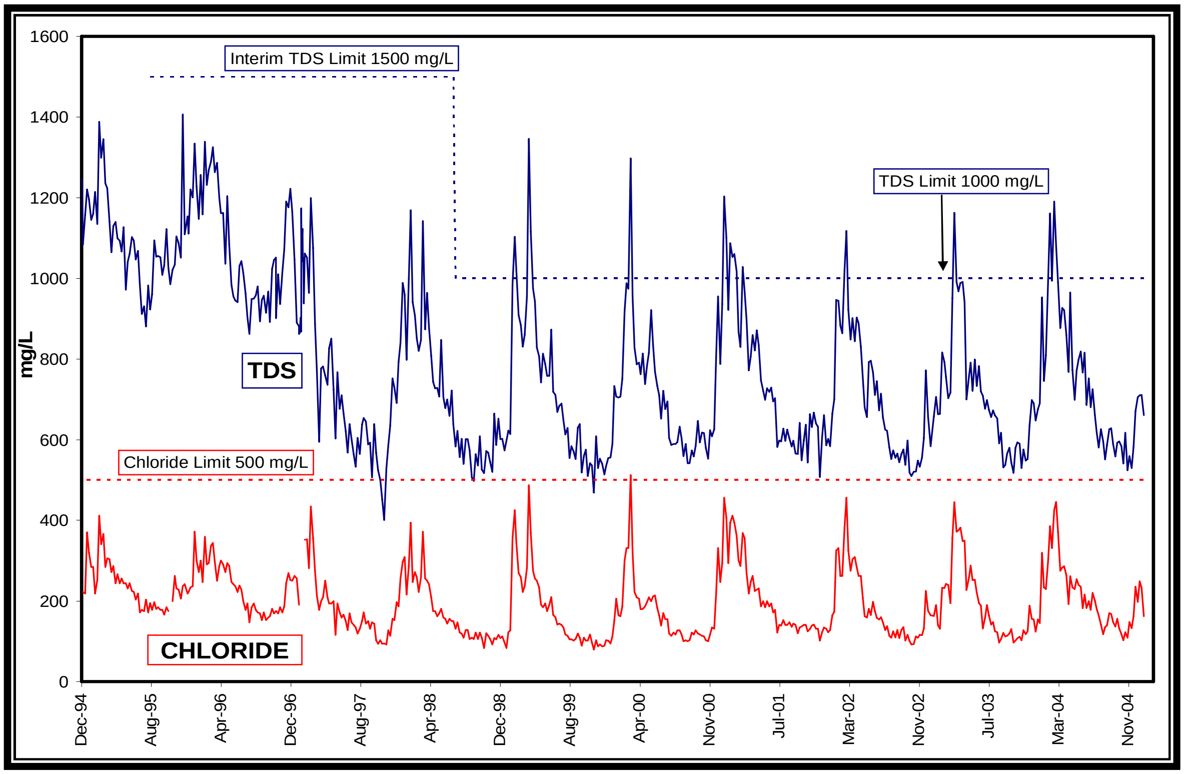


FIGURE 5.4 Total Dissolved Solids and Chloride in Outfall 001 Water, 1995 to 2004

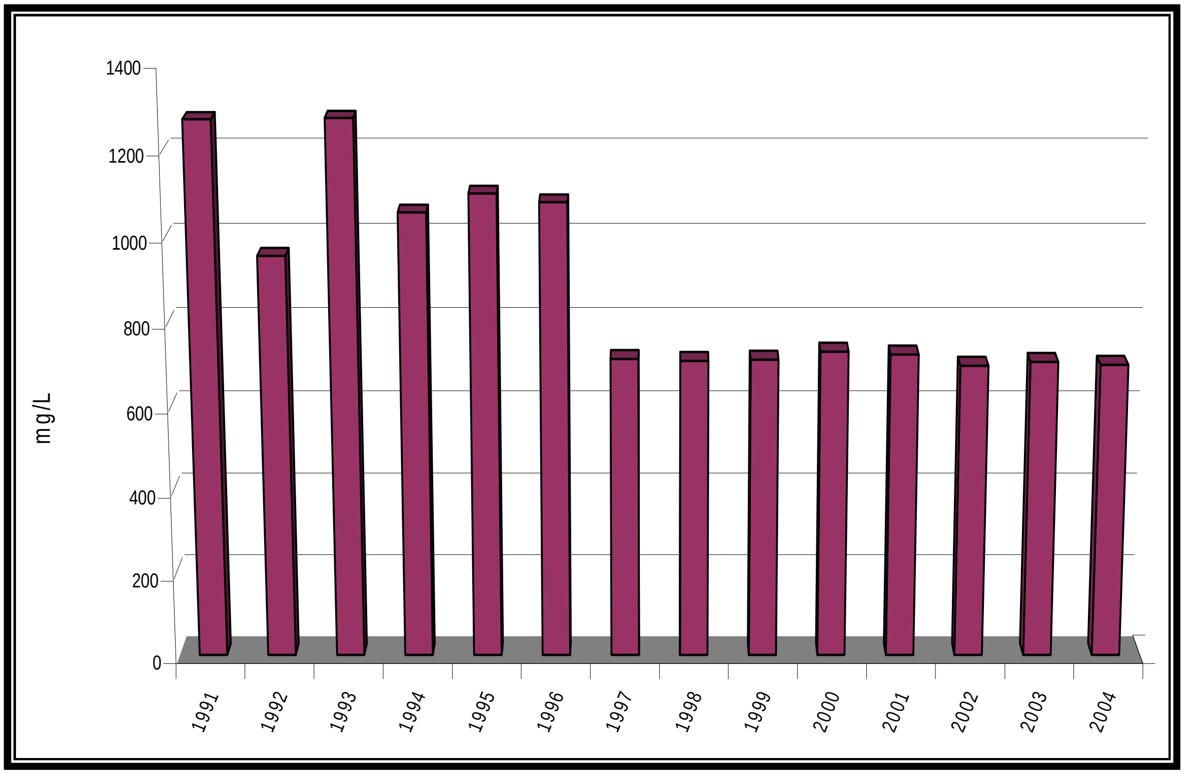


FIGURE 5.5 Average TDS Concentrations at NPDES Outfall 001, 1991 to 2004

TABLE 5.6

Water Flea, 48-Hour Acute Toxicity Results — LC_{50}, 2000 to 2004

	2000 (%)		2001 (%)		2002 (%)		2003 (%)		2004 (%)	
NPDES Outfall	June/ July	August	June/ July	August	June/ July	August	June/ July	August	June/ July	August
001	100	NA[a]	>100	NA	>100	NA	>100	NA	>100	NA
003H	100	>100	>100	>100	>100	>100	>100	>100	>100	>100
003I	>100	>100	**71**[b]	>100	>100	**88**	>100	**82**	>100	>100
003J	>100	**<20**	**<20**	>100	**<20**	**<20**	>100	>100	>100	>100
004	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
006	>100	**30**	**40**	**60**	>100	>100	>100	>100	>100	>100
115	**29**	**<20**	**64**	>100	>100	>100	**57**	>100	34	20

[a] NA = not applicable.

[b] Bold type indicates acute toxicity.

TABLE 5.7

Fathead Minnow, 96-Hour Acute Toxicity Results — LC_{50}, 2000 to 2004

	2000 (%)		2001 (%)		2002 (%)		2003 (%)		2004 (%)	
NPDES Outfall	June/ July	August	June/ July	August	June/ July	August	June/ July	August	June/ July	August
001	>100	NA[a]	>100	NA	>100	NA	>100	NA	>100	NA
003H	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
003I	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
003J	>100	**40**[b]	<20	>100	**30**	**45**	>100	>100	>100	>100
004	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
006	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
115	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100

[a] NA = not applicable.

[b] Bold type indicates acute toxicity.

The permit also requires that weekly pH, ammonia nitrogen, dissolved iron, manganese, and zinc measurements be made. Monthly monitoring for lead, hexavalent and trivalent chromium, and beta radioactivity is required. No exceedances of these parameters were noted in 2004. In addition to the outfalls at the WTP, a number of other outfalls are monitored. The sampling requirements and effluent limits for these outfalls are described in Table 5.8

Special Condition No. 9 of the NPDES Permit requires acute toxicity testing of the effluent from Outfalls 003H, 003I, 003J, 004, 006, and 115. The testing is performed on the fathead minnow and the water flea. The testing is performed during the months of July and August. These outfalls were sampled during the periods of July 26 to 30, and August 23 to 27, 2004. The results are summarized in Tables 5.6 and 5.7. The results are discussed by month below.

July 2004 — Effluents from Outfalls 003H, 003I, 003J, 004, and 006 exhibited no acute toxicity. Outfall 115 was acutely toxic toward the water flea with an LC_{50} value of 34%. The toxicity levels at Outfall 115 toward the water flea were similar to those observed in July 2002 and July 2003. The toxicant at Outfall 115 was unidentified.

August 2004 — Effluents from Outfalls 003H, 003I, 003J, 004, and 006 were not acutely toxic toward the water flea and fathead minnows. Effluent from Outfall 115 was acutely toxic toward the water flea with an LC_{50} value of 20%, but not toward fathead minnows. The toxicant at Outfall 115 was unidentified.

5.2. Additional Effluent Monitoring

To characterize the wastewater from the ANL site more fully, composite samples of the combined effluent from the WTP 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.[21]

5.2.1. Sample Collection

Samples for analysis of inorganic constituents were collected daily from Outfall 001 located at the WTP by using 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. Fifteen metals were determined by inductively coupled plasma emission spectroscopy and graphite furnace atomic absorption spectroscopy. Mercury was analyzed using cold vapor atomic absorption spectroscopy, and fluoride was determined by a specific ion electrode.

TABLE 5.8

Summary of Monitored NPDES Outfalls, 2004

Discharge Location	No. of Samples	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	No. Exceeding Limit
003A	0	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
		TRC[a]	0.05		0
003B	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003C	12	Flow	None		0
		pH	6–9		0
003D	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003E	4	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003F	8	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA[b]
003G	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
003H	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA
003I	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA
		Oil and grease	Monitor only		NA
003J	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA

TABLE 5.8 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	No. Exceeding Limit
004	11	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
005C	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		Oil and grease	Monitor only		NA
005E	9	Flow	None		0
		pH	6–9		0
006	11	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
		TDS	Monitor only		NA
		Temperature	<2.8°C rise		0
007	12	Flow	None		0
	12	pH	6–9		0
	12	Temperature	<2.8°C rise		0
	39	TRC	0.05		0
	12	Oil and grease	Monitor only		NA
008	9	Flow	None		0
		pH	6–9		0
		VOC	Monitor only		NA
010	0	Flow	None		0
		pH	6–9		0
		TSS	15	30	0
		Total iron	2	4	0
		Dissolved iron		1.0	0
		Lead		0.1	0
		Zinc		1.0	0
		Manganese		1.0	0
		Hexavalent chromium	0.011	0.016	0
		Trivalent chromium	0.519	2.0	0
		Copper	0.031	0.051	0
		Oil and grease	15	30	0
108	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0

TABLE 5.8 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit: 30-Day Average	Limit: Daily Maximum	No. Exceeding Limit
111	2	Flow	None		0
		Hydrogen-3	Monitor only		NA
112A	2	Flow	None		0
		Hydrogen-3	Monitor only		NA
112B	2	Flow	None		0
		Hydrogen-3	Monitor only		NA
113	3	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA
114	3	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA
115	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8°C rise		0
		TDS	Monitor only		NA
116	12	Flow	None		0
		pH	6–9		0
		TRC	0.05		0

[a] TRC = total residual chlorine.

[b] NA = not applicable.

TABLE 5.9

Chemical Constituents in Effluents from the ANL
Wastewater Treatment Plant, 2004

Constituent	No. of Samples	Concentration (mg/L) Average	Minimum	Maximum	Limit
Arsenic	52			< 0.0030[a]	0.25
Barium	52	0.0205	0.0141	0.0456	2.0
Beryllium	52			< 0.0002	–[b]
Cadmium	52	< 0.0002	< 0.0002	0.0002	0.15
Chromium	52			< 0.024	1.0
Cobalt	52			< 0.016	–
Copper	52	0.0158	< 0.015	0.0261	0.5
Fluoride	52	0.9147	0.4910	1.236	15.0
Iron	52	0.0306	< 0.02	0.1166	2.0
Lead	52	0.0021	< 0.002	0.0062	0.2
Manganese	52	0.0110	< 0.01	0.0234	1.0
Mercury	52	< 0.0002	< 0.0002	0.0006	0.0005
Nickel	52			< 0.02	1.0
Silver	52			< 0.001	0.1
Thallium	52			< 0.002	–
Vanadium	52			< 0.032	–
Zinc	52	0.0796	0.0391	0.1736	1.0
pH	52	NA[c]	6.76	7.88	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.

5.2.2. Results

Table 5.9 gives the results for 2004. None of the annual average results exceeded General Effluent Limits.[21]

5.3. Sawmill Creek

Sawmill Creek is a small natural stream that is fed primarily by storm water runoff. During periods of low precipitation, the creek above ANL has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of ANL wastewater and discharges to assorted storm drains. To determine the impact ANL wastewaters have on Sawmill Creek, samples of the creek downstream of all ANL 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.[22]

5.3.1. Sample Collection

A time-proportional sampler was used to collect a daily sample at a point well downstream of the combined wastewater discharge point where thorough mixing of the ANL effluent and Sawmill Creek water is assured. Samples were collected in precleaned, labeled bottles and security seals were used. After pH measurement, the daily samples were acidified and then combined into equal volume weekly composites and analyzed for the same set of inorganic constituents as those in Table 5.9.

Fifteen metals were determined by inductively coupled plasma emission spectroscopy and graphite furnace atomic absorption spectroscopy. Mercury was analyzed with cold vapor atomic absorption spectroscopy. Fluoride was determined by a specific ion electrode.

5.3.2. Results

The results obtained for 2004 are shown in Table 5.10. None of the annual average results exceeded General Use Water Quality Standards.[22]

TABLE 5.10

Chemical Constituents in Sawmill Creek, Location 7M,[a] 2004

Constituent	No. of Samples	Concentrations (mg/L) Average	Minimum	Maximum	Limit
Arsenic	51			< 0.0030[b]	0.36[c]
Barium	51	0.0353	0.0165	0.0727	5.0
Beryllium	51			< 0.0002	–[d]
Cadmium	51			< 0.0002	0.03
Chromium	51			< 0.024	3.6
Cobalt	51			< 0.016	–
Copper	51	0.0154	< 0.015	0.0224	0.041[c]
Fluoride	51	0.6493	< 0.25	1.184	1.4
Iron	51	0.0581	< 0.02	0.2302	1.0
Lead	51			< 0.002	0.3[c]
Manganese	51	0.0137	< 0.01	0.0569	1.0
Mercury	51			< 0.0002	0.0026[c]
Nickel	51	0.0200	< 0.02	0.0209	1.0
Silver	51			<0.001	0.005
Thallium	51			< 0.002	–
Vanadium	51			< 0.032	–
Zinc	51	0.0350	< 0.008	0.0877	1.0
pH	51	NA[e]	6.71	7.87	6.5–9.0

[a] Location 7M is 15 m (50 ft) downstream from the ANL 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.

6. GROUNDWATER PROTECTION

6. GROUNDWATER PROTECTION

The groundwater below the ANL site is monitored through the collection and analysis of samples obtained from the former 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 ANL site. Regulations establishing comprehensive WQSs for the protection of groundwater have been enacted: IEPA Groundwater Quality Standards, 35 IAC, Subtitle F, Part 620.[23] In addition, demonstration of compliance with the groundwater protection requirements in DOE Order 450.1,[1] as related to sitewide characterization studies and monitoring well requirements, is presented in this chapter. The permit for the 800 Area Landfill requires a groundwater monitoring program; the program was initiated in July 1992. Information generated by this program is also included in this report.

6.1. Former Potable Water System

Domestic water for ANL was supplied by four wells (see Section 1.7 and Table 6.1) until early 1997, when Lake Michigan water was obtained. The well locations are shown in Figure 1.1. Lake Michigan water was obtained to provide better-quality drinking water. The dolomite water from the on-site wells had deteriorated in quality — the TDS content of the supply water was approaching 800 mg/L, which made it difficult to consistently meet the 1,000-mg/L TDS discharge limit at NPDES Outfall 001. Lake Michigan water has a TDS range of approximately 200 to 400 mg/L. In addition, Lake Michigan water is lower in bicarbonate, which makes it less corrosive on the piping system. The former potable wells, however, are maintained as a backup in the case of a loss of Lake Michigan water.

6.1.1. Informational Monitoring

Samples were collected quarterly at the wellhead, except at Well 2, which is no longer operational. The samples were analyzed to determine the presence of several types of radioactive constituents and VOCs in ANL groundwater. Samples from each well were tested for total alpha, total beta, hydrogen-3, and strontium-90. Samples also were analyzed annually for radium-226, radium-228, and isotopic uranium. 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 separations followed by proportional counting. Radium and uranium were analyzed by using ion-exchange separations followed by gamma and alpha spectrometry, respectively. The results are presented in Table 6.2.

VOC samples were collected quarterly, analyzed for SDWA volatile compounds, and quantified by EPA Method 524.2,[24] which includes purge and trap pretreatment, followed by gas chromatography-mass spectroscopy detection. The reporting limit is the Practical Quantification Limit (PQL), which is defined as 10 times the method detection limit.

All radiological results were within their normal range of concentrations as compared with previous results. No VOCs were detected.

TABLE 6.1

ANL 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 not operational.

6.1.2. Dolomite Well Monitoring

Past analytical data were used to track the presence of hydrogen-3 in ANL domestic Well 1 and at a lower concentration in Well 2. It is speculated that the source of the hydrogen-3 was liquid waste placed in an unlined holding pond in the wastewater treatment area (Location 10M in Figure 1.1) in the 1950s. The hydrogen-3 as tritiated water appeared to have migrated through the glacial drift to the dolomite aquifer and was drawn into the wells. Well 1, which is about 200 m (650 ft) north of the wastewater treatment area, had higher hydrogen-3 concentrations than Well 2, which is about 300 m (1,000 ft) from the treatment area. Hydrogen-3 is only occasionally identified at concentrations just above the detection limit because of dilution and radioactive decay. Although the normal subsurface water flow gradient is toward the south-southeast, the cone of depression created by pumping these wells while they were still in use would overpower the normal flow pattern.

With the conversion of local well water to Lake Michigan water in early 1997, the water table elevations began to recover. ANL was concerned that the direction of subsurface migration of radionuclides, particularly hydrogen-3, could change because of the lack of the influence of pumping. Because hydrogen-3 from the 570 Area Pond was already known to have migrated to the dolomite, a monitoring network of three ANL and seven forest preserve wells was established to monitor the magnitude and direction of hydrogen-3 movement in this area. The well locations are shown in Figure 6.l. Samples were collected quarterly and analyzed for hydrogen-3. Table 6.3 shows the results for 2004. Hydrogen-3 was noted at very low levels in a few wells.

TABLE 6.2

Radioactivity in ANL Former Water Supply Wells, 2004
(concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Average	Minimum	Maximum
Alpha	Well 1	4	3.6	2.9	4.2
	Well 3	4	2.1	1.6	2.4
	Well 4	4	3.2	0.5	5.0
Beta	Well 1	4	7.1	6.0	7.9
	Well 3	4	8.6	7.9	9.2
	Well 4	4	9.6	8.3	10.3
Hydrogen-3	Well 1	4	–[a]	–	< 100
	Well 3	4	–	–	< 100
	Well 4	4	–	–	< 100
Strontium-90	Well 1	4	–	–	< 0.25
	Well 3	4	–	–	< 0.25
	Well 4	4	–	–	< 0.25
Uranium-234	Well 1	1	–	–	0.51
	Well 3	1	–	–	0.21
	Well 4	1	–	–	0.18
Uranium-235	Well 1	1	–	–	0.01
	Well 3	1	–	–	< 0.01
	Well 4	1	–	–	< 0.01
Uranium-238	Well 1	1	–	–	0.33
	Well 3	1	–	–	0.11
	Well 4	1	–	–	0.09

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

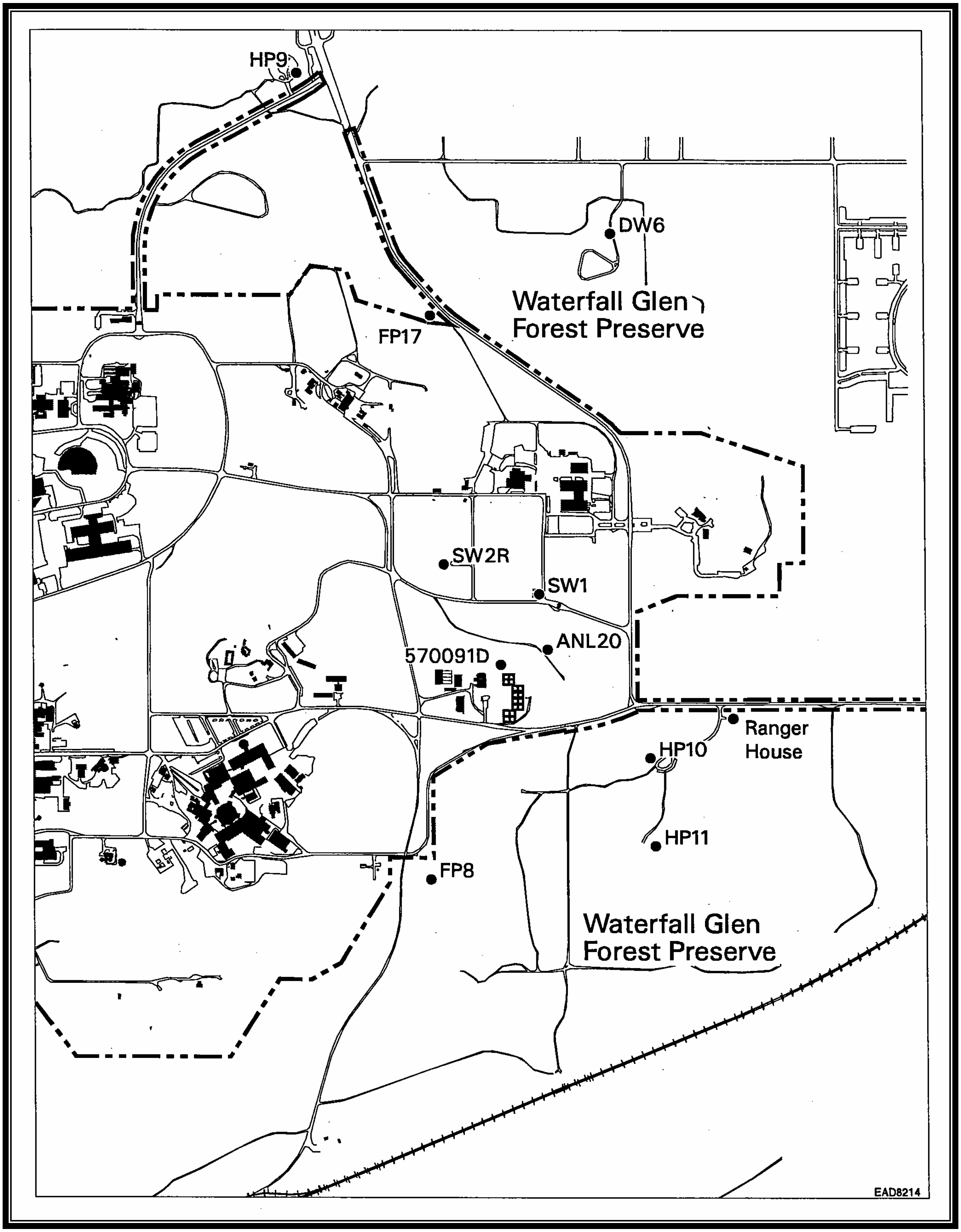


FIGURE 6.1 East Area/Forest Preserve Monitoring Wells

TABLE 6.3

Hydrogen-3 in Dolomite Wells, 2004
(concentrations in pCi/L)

	Date Collected			
Well	02/04/04	05/12/04	08/30/04	12/02/04
Waterfall Glen				
DW 6	138	<100	<100	<100
HP 9	104	<100	<100	<100
HP 10	123	<100	<100	<100
HP 11	<100	<100	<100	<100
FP 8	<100	<100	<100	<100
FP 17	104	<100	<100	<100
Ranger House	<100	<100	102	<100
ANL				
5700910	<100	<100	<100	<100
ANL-20	<100	<100	<100	<100
SW2R	<100	<100	<100	<100
Trip Blank	<100	119	<100	<100

6.2. Groundwater Monitoring at 317/319/ENE Landfill Areas

ANL has occupied its current site since 1948. Since that time, waste generated by ANL was placed in a number of on-site disposal units; these ranged from ditches filled with construction and demolition debris during the 1950s to a former sanitary landfill used for nonhazardous solid waste disposal until September 1992. Several of these units contain significant amounts of hazardous materials and, therefore, represent a potential threat to the environment. Groundwater below these sites is monitored routinely to assess the amount and nature of hazardous chemical releases from these units. Routinely monitored sites include the sanitary landfill in the 800 Area and the 317/319 ENE Area, which consists of seven separate waste management units located within a small geographical area. The site of the CP-5 reactor is also monitored periodically to determine whether any radionuclides are being released from this unit. To aid the reader, results presented in the well tables that exceed State of Illinois' Class I Groundwater Quality Standards are in bold type.

The ANL ERP was responsible for achieving compliance with all applicable environmental requirements related to assessing and cleaning up releases of hazardous materials from inactive waste sites. This program was completed on September 30, 2003. However, five SWMUs and two AOCs could not be remediated to free release status and continue to be monitored as part of the LTS Program (refer to Chapter 3). LTS areas that continue to be routinely monitored for groundwater releases include the 317 and 319 Areas (Sections 6.2.3

and 6.2.4), ENE Landfill Area (Section 6.2.5), and off-site seeps (Section 6.2.6). During 2004, data from the LTS Program were integrated with those from the ANL Sitewide Environmental Groundwater Monitoring and Surveillance Program.

6.2.1. 317/319 Area

The 317/319 Area contains seven separate current or former units that have been used in the past for handling or disposal of various types of waste. The 317 Area is currently an active radioactive waste processing and storage area. It includes the North Vault, an in-ground storage vault that was emptied in May 2001 and has remained empty since. The Deep Vault was demolished and backfilled during 2002. The area also contained a small building used for decontamination of metal objects, such as lead bricks and tools. This structure was closed and removed in 2004. 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. This unit was operational during the late 1950s. Because of these past disposal practices, there is a region of contaminated soil in the north half of the 317 Area. The contaminants are primarily VOCs such as cleaning solvents. The groundwater below this area also contains concentrations of these chemicals. General features in the 317/319 Area are identified in Figure 6.2.

The groundwater below the 317/319 Area exists in several shallow (3- to 16-m [10- to 50-ft]) sand and gravel units up to 6 m (20 ft) thick within the glacial drift, as well as in the upper portions of the dolomite bedrock. There are no known consumers of this groundwater downgradient of the ANL site.

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 was detected during sampling activities completed several years ago. The only radionuclide found to be migrating from the landfill is hydrogen-3, although strontium-90 was noted during one quarter in a well south of the 319 Area. The 319 waste burial 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 contains a French drain that was used for several years after the French drain in the 317 Area was closed. The presence of liquid chemical wastes from the French drain, as well as the presence of hydrogen-3 in the waste mound, have resulted in the generation of a plume of contaminated groundwater extending from the waste mound to the south, toward the Des Plaines River.

During late 1996, a series of small natural groundwater discharge points (groundwater seeps) was discovered approximately 183 m (600 ft) south of the 319 Area. Two of these seeps were found to contain low levels of three VOCs. These two seeps and one additional seep, which normally does not contain VOCs, were found to contain hydrogen-3 at concentrations below all applicable standards. Since their discovery, these seeps have been monitored on a regular basis (see Section 6.2.6). A characterization study was completed in 1998 to identify the source and

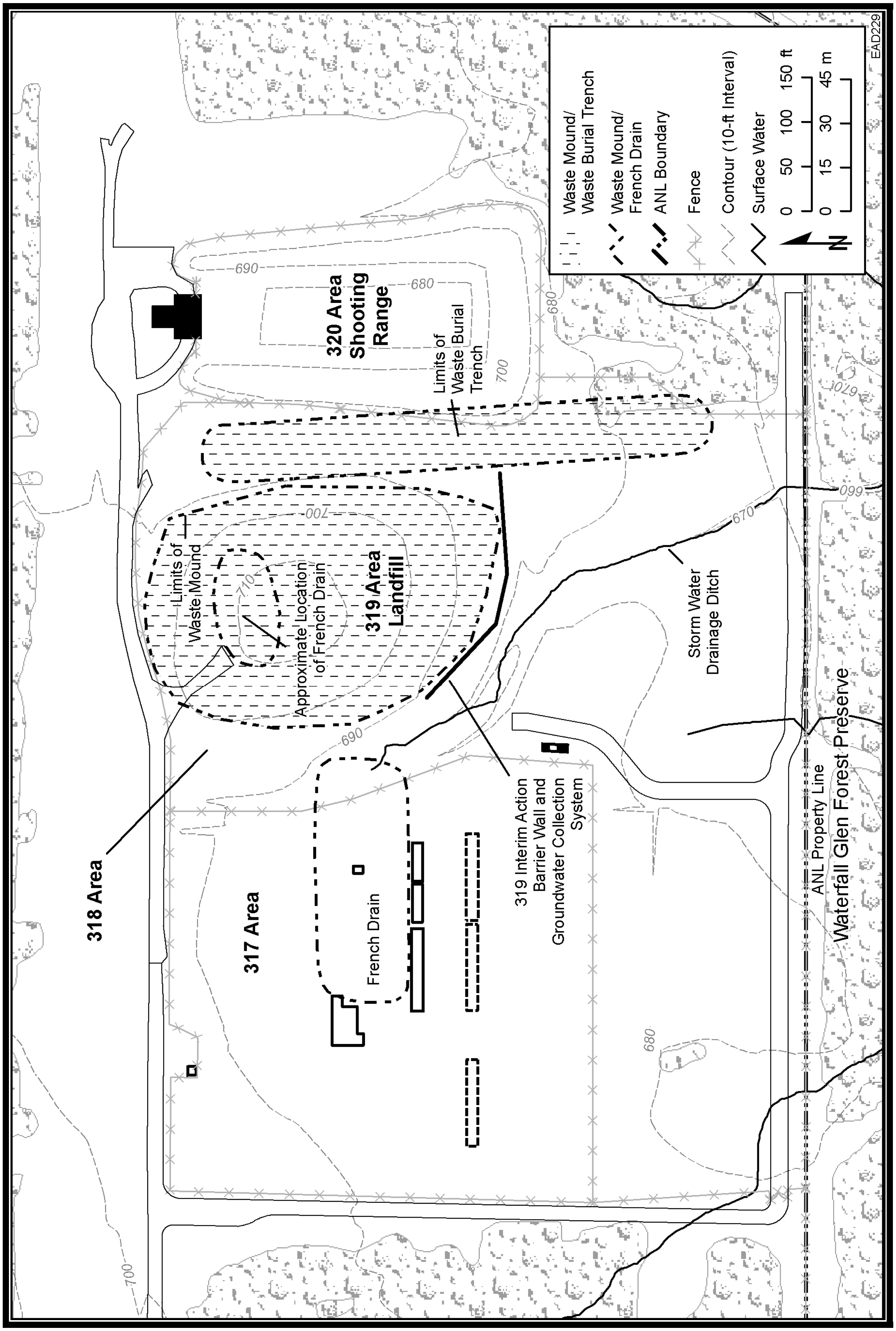


FIGURE 6.2 Locations of Components within the 317/319/ENE Area

migration pathways for the hydrogen-3 and VOCs. The hydrogen-3 appears to be emanating from the 319 Landfill and is likely an extension of the on-site hydrogen-3 plume, albeit at much lower concentrations than those measured on site. The source of VOCs was not clearly discerned, although it is likely that they also emanated from some past waste disposal activities in the 319 or 317 Area. The known extent of contaminated groundwater covers much of the area from the 317 French Drain and 319 Landfill, southeast of the seeps.

Cleanup of the 317/ 319 Area has been under way since the late 1980s. The cleanup has been carried out as a series of interrelated actions that ultimately removed or contained the contaminants so that they will no longer migrate away from the waste disposal units. Several remedial actions are already in place and functioning as designed. These actions include a leachate and groundwater collection system for the 319 Landfill, capping of the 319 Landfill, demolition of five waste storage vaults contaminated with radioactive materials, sealing of an underground drainage system, installation of 15 groundwater extraction wells south of the 317 Area, construction of a concrete cover over a region containing buried compressed gas cylinders (318 Area), treatment of highly contaminated soil near the former French drain, and phytoremediation of residual soil and groundwater contamination. Sampling and analysis of groundwater and surface water are ongoing as part of the LTS Program and routine environmental monitoring program.

The North Vault was repaired because ANL has decided to continue storing waste in the vault. Part of the north wall of the vault was rebuilt, and new roof covers were fabricated.

In 1999, the IEPA approved the installation of a phytoremediation system in the 317 Area. Phytoremediation involves the use of trees to remove contaminated groundwater by evapotranspiration and to degrade contaminants in soil and groundwater. 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 French Drain and the former 319 Landfill are in place and will be monitored over the next several years for their ability to remediate those areas.

The results of the required routine monitoring of the groundwater collection systems in the 317 and 319 Areas, the phytoremediation system, and the monitoring of the off-site groundwater seeps continue to be transmitted to the IEPA on a quarterly basis through the submittal of Quarterly Progress Reports. The data from this monitoring are too voluminous to include in this report; however, the general conclusions are discussed below as part of the ANL LTS Program (see Sections 6.2.4, 6.2.5, and 6.2.6).

6.2.2. Groundwater Monitoring at the 317/319 Area

Groundwater monitoring in the 317/319 Area as part of the sitewide monitoring and surveillance program has been conducted since 1986. Wells 319011, 317021, and 319031 were installed in September 1986; Well 317061 was originally installed in August 1987 but replaced in May 2000; Wells 317101 and 317111 were installed in September 1988; and Wells 319032 and 317052 were installed in June 1989 (Figure 6.3). These wells were all completed in the glacial drift. Wells 317121D and 319131D were installed in November 1989 and reach the dolomite aquifer at about 20 m (64 ft) below the surface.

Wells 317101 and 317111 are upgradient of the 317 Area, and Well 319011 is upgradient of the 319 Area Landfill. A sand lens present at 5 to 8 m (15 to 25 ft) is monitored at Wells 317052, 319031, 319032, and 317021. Groundwater in the dolomite bedrock aquifer is monitored at Wells 317121D and 319131D. Table 6.4 lists well data for these areas. These wells are not used to monitor the progress of the remediation systems, but rather serve the 317 and 319 Areas as a whole. In addition to wells in this area, two manholes associated with the vault sewer system were monitored on a monthly basis. Figure 6.3 shows the locations of the manholes.

The LTS Program involves the collection of groundwater data from an extensive network of wells located throughout the 317/319 Area. These data are transmitted to the IEPA quarterly and are summarized in Sections 6.2.3 and 6.2.4. To monitor the performance of the various remedial actions constructed in the 317 and 319 Areas, samples are collected on a quarterly basis. The purpose of this monitoring is to track the movement of contaminated groundwater and to determine the rate at which contaminant levels are decreasing. Monitoring results in 2004 indicate that the two groundwater collection systems south of the 319 Landfill and south of the 317 Area are effectively preventing off-site migration of contaminated groundwater. The analysis of groundwater samples for contaminants reveals that high concentrations of VOCs are present in groundwater in the immediate vicinity of the former 317 Area French Drain. Concentrations of up to 326,000 μg/L of chlorinated VOCs (i.e., carbon tetrachloride) were detected. However, at the ANL fence line, near the groundwater collection wells, the level of contamination is much lower; the highest concentration noted in 2004 was 330 μg/L of 1,1,1-trichloroethane (TCA). This groundwater is being collected by the extraction system so that it does not migrate off site.

Plant tissue monitoring at the phytoremediation system site indicates that the trees are indeed taking up the organic materials and breaking them down. The effect of the trees on groundwater movement was also measured; however, the trees are not full grown, so their effect was not great enough to be easily measured. Long-term monitoring of this system will determine its effectiveness at removing groundwater and degrading contaminants.

6.2.2.1. Sample Collection

The monitoring wells are sampled by using the protocol listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[25] 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, which 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 of water removed is compared with the calculated volume. In most cases, these volumes are nearly identical. The well is then sampled, following recovery, by bailing with a dedicated Teflon® bailer. The field parameters for these

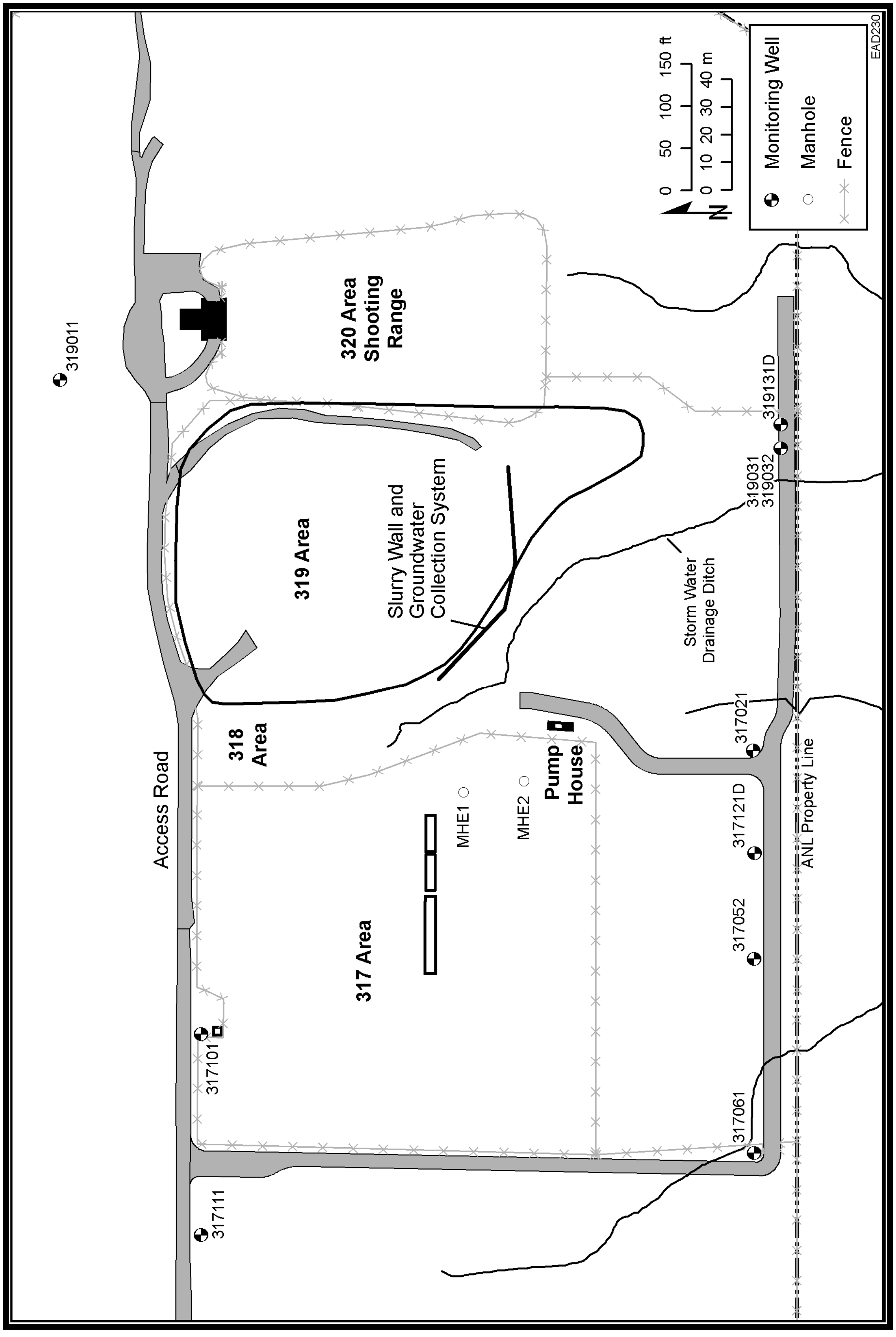


FIGURE 6.3 Monitoring and Characterization Wells in the 317/319 Area, 2004

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	9/86
317021	12.19	209.2	198.5–197.0	0.05/PVC	9/86
319031	12.50	204.3	194.8–191.8	0.05/PVC	9/86
319032	7.62	204.3	198.2–196.7	0.05/PVC	6/89
317052	4.27	208.3	207.1–204.0	0.05/PVC	6/89
317061[b]	10.36	207.6	197.3–199.7	0.05/PVC	5/00
317101	11.89	211.0	202.2–199.1	0.05/PVC	9/88
317111	11.89	210.3	201.4–198.4	0.05/PVC	9/88
317121D[c]	24.08	207.6	185.0–183.5	0.15/CS	11/89
319131D	21.03	203.5	184.0–182.5	0.15/CS	11/89

[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.

samples (pH, specific conductance, redox potential, and temperature) are measured statically. For those wells in the porous, saturated zone that recharges rapidly, three well volumes are purged by using dedicated submersible pumps, while the field parameters are measured continuously. Field parameters stabilize quickly in these wells. In the case of the dolomite wells, samples are collected as soon as these readings stabilize. 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.

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.

6.2.2.2. Sample Analyses — 317/319 Area

Groundwater chemical analyses in the 317/319 Area were performed using SOPs that were written, reviewed, and issued as controlled documents by members of EQO, Analytical Services (EQO-AS). These SOPs reference protocols in EPA-SW-846.[26] Fifteen metals were routinely measured using inductively coupled plasma atomic emission spectrometry and graphite furnace atomic absorption spectroscopy. Mercury was determined by using cold vapor atomic absorption spectroscopy. Chloride was determined by means of titrimetry. VOCs were determined by using a purge and trap sample pretreatment followed by gas chromatography-mass spectroscopy detection. SVOCs were determined by means of solvent extraction followed by gas chromatography-mass spectrometry 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.

6.2.2.3. Results of Analyses

Descriptions of each well, the field parameters measured during sample collection, and the results of chemical and radiological analyses of samples from the wells in the 317/319 Area are contained in Tables 6.5 through 6.14. All radiological and inorganic analytical results are provided in these tables. The analytical methods used for organic compounds could identify and quantify all the compounds contained in the Contract Laboratory Program (CLP) Target Compound List. However, the vast majority of these compounds were not detected in the samples. To simplify the format of these tables, those results less than the detection limit are not included. Only those constituents that were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 5 μg/L.

Field Parameters. The purging of wells to produce water representative of the groundwater being studied was followed by measuring the field parameters. For the wells reported in this study, temperature, pH, redox potential, and specific conductance remained fairly constant after two well volumes were removed. On the basis of this information, sampling was conducted after the removal of three well volumes. The field parameters listed in the tables are the final readings obtained at the time of sampling. Wells 319011, 317021, 317061, 317111, 319031, and 319131D usually dry up after one well volume is removed. Therefore, field parameters were measured on one well volume. Well 319031 was dry during sampling for two quarters. Well 319011 was dry the second quarter. As in past years, conductivity was elevated in Wells 317101 and 317111. This is probably related to the fact that chloride levels in these two wells are elevated. Both wells are located near a road that is salted during the winter.

Inorganic Parameters. ANL chose a conservative approach for evaluating the monitoring results by selecting as the standard of comparison the Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater, 31 IAC, Section 620.410. The standards are presented in Tables 6.15 and 6.16. The groundwater that is mentioned is not used as a source of domestic water supply. In 2004, all samples for metals analyses were field-filtered prior to preservation with acid (a requirement for the IEPA-approved groundwater monitoring program at the 800 Area Landfill, Section 6.3.2.3).

As noted in previous years, no elevated levels, with respect to the WQS for inorganics, were noted with the exception of pH during the first quarter at dolomite Well 317121D and

TABLE 6.5

Groundwater Monitoring Results, 300 Area Well 317021, 2004

		Date of Sampling			
Parameter	Unit	2/26/2004	6/3/2004	9/2/2004	11/22/2004
Water elevation[a]	m	199.15	202.24	201.13	199.86
Temperature	°C	11.2	13.1	12.1	10.6
pH	pH	7.50	7.45	7.47	7.29
Redox	mV	-53	-17	-19	0
Conductivity	µmhos/cm	826	814	684	756
Chloride[b]	mg/L	22	11	14	81
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0386	0.0345	0.0406	0.0406
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	0.0016
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	0.012	< 0.008	0.012	0.010
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	146	< 100	< 100	116
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
1,1,1-Trichloroethane	µg/L	5	2	3	22
1,1-Dichloroethane	µg/L	2	< 1	< 1	10

[a] Well point elevation = 197.27 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.6

Groundwater Monitoring Results, 300 Area Well 317052, 2004

		Date of Sampling			
Parameter	Unit	2/26/2004	6/3/2004	9/2/2004	11/22/2004
Water elevation[a]	m	206.00	206.45	205.47	204.69
Temperature	°C	8.3	10.1	15.2	13.0
pH	pH	7.40	6.93	7.06	7.00
Redox	mV	-48	11	7	12
Conductivity	µmhos/cm	1,019	1,128	1,051	998
Chloride[b]	mg/L	39	58	58	66
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0475	0.0625	0.0556	0.0595
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	0.014	0.592	0.016
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	0.019	0.010	0.009
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	278	221	148	201
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 204.04 m (MSL); ground surface elevation = 208.32 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.7

Groundwater Monitoring Results, 300 Area Well 317061, 2004

		Date of Sampling			
Parameter	Unit	2/25/2004	6/1/2004	9/1/2004	11/15/2004
Water elevation[a]	m	197.80	200.06	198.43	198.03
Temperature	°C	10.6	11.7	12.5	10.7
pH	pH	7.60	7.51	7.25	7.14
Redox	mV	-59	-19	-3	4
Conductivity	µmhos/cm	922	1,053	866	809
Chloride[b]	mg/L	17	28	20	39
Arsenic[b]	mg/L	0.012	0.0124	0.0106	0.0090
Barium[b]	mg/L	0.0593	0.0593	0.0592	0.0560
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.676	0.024	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0206	0.0144	0.0153	0.0163
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.009	0.010
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	128	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 197.26 m (MSL); ground surface elevation = 207.62 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.8

Groundwater Monitoring Results, 300 Area Well 317101, 2004

Parameter	Unit	Date of Sampling 2/25/2004	6/1/2004	9/1/2004	11/15/2004
Water elevation[a]	m	201.67	203.44	202.53	202.12
Temperature	°C	11.5	12.1	14.1	11.8
pH	pH	7.06	7.04	7.19	7.12
Redox	mV	-29	5	-8	6
Conductivity	µmhos/cm	2,810	3,350	2,720	2,290
Chloride[b]	mg/L	595	877	763	779
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.1105	0.1108	0.1134	0.0999
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	0.027
Lead[b]	mg/L	< 0.002	< 0.002	0.0021	< 0.002
Manganese[b]	mg/L	0.0388	0.0184	0.0230	0.0283
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.004	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	0.011	0.010	0.010
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	114	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 198.66 m (MSL); ground surface elevation = 211.04 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.9

Groundwater Monitoring Results, 300 Area Well 317111, 2004

Parameter	Unit	Date of Sampling			
		2/25/2004	6/1/2004	9/1/2004	11/15/2004
Water elevation[a]	m	198.98	200.95	200.05	199.73
Temperature	°C	10.6	11.3	11.6	10.7
pH	pH	7.24	7.02	7.03	7.00
Redox	mV	-39	7	7	7
Conductivity	µmhos/cm	1,511	1,389	1,229	1,253
Chloride[b]	mg/L	249	196	229	346
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0946	0.0817	0.0885	0.0871
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	0.0023	< 0.002
Manganese[b]	mg/L	0.0224	0.1182	0.0405	0.0270
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.008
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] Well point elevation = 198.37 m (MSL); ground surface elevation = 210.25 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.10

Groundwater Monitoring Results, 300 Area Well 317121D, 2004

		Date of Sampling			
Parameter	Unit	2/26/2004	6/3/2004	9/2/2004	11/9/2004
Water elevation[a]	m	186.39	186.46	186.47	186.28
Temperature	°C	10.7	14.8	13.6	10.5
pH	pH	9.10	8.56	8.28	7.22
Redox	mV	-143	-81	-55	-25
Conductivity	µmhos/cm	432	820	738	851
Chloride[b]	mg/L	62	73	56	87
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0589	0.0748	0.0724	0.0510
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.010	0.009
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	207	260	234
1,4-Dioxane	µg/L	< 1	16	3	13
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 183.49 m (MSL); ground surface elevation = 207.57 m (MSL); casing material = steel.

[b] Filtered sample.

TABLE 6.11

Groundwater Monitoring Results, 300 Area Well 319011, 2004

Parameter	Unit	Date of Sampling 2/25/2004	9/2/2004	11/22/2004
Water elevation[a]	m	199.19	202.41	202.11
Temperature	°C	10.6	12.6	10.4
pH	pH	7.37	7.25	7.30
Redox	mV	-47	-6	0
Conductivity	µmhos/cm	883	783	752
Chloride[b]	mg/L	39	47	49
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0354	0.0360	0.0345
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	0.079	0.035
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	0.011	0.009
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 197.60 m (MSL); ground surface elevation = 209.81m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.12

Groundwater Monitoring Results, 300 Area Well 319031, 2004

		Date of Sampling	
Parameter	Unit	6/3/2004	9/7/2004
Water elevation[a]	m	193.17	193.09
Temperature	°C	10.7	11.7
pH	pH	7.22	7.16
Redox	mV	-3	-1
Conductivity	µmhos/cm	999	869
Chloride[b]	mg/L	30	26
Arsenic[b]	mg/L	< 0.003	< 0.003
Barium[b]	mg/L	0.0775	0.0565
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032
Zinc[b]	mg/L	0.0581	0.0305
Cesium-137	pCi/L	< 2.0	< 2.0
Hydrogen-3	pCi/L	583	550
Strontium-90	pCi/L	0.31	0.31
1,1,1-Trichloroethane	µg/L	2	2
1,4-Dioxane	µg/L	12	3
Trichloroethene	µg/L	3	3

[a] Well point elevation = 191.78 m (MSL); ground surface elevation = 204.28 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 319032, 2004

Parameter	Unit	Date of Sampling				
		2/26/2004	6/3/2004	9/7/2004	11/22/2004	11/22/2004
Water elevation[a]	m	197.38	198.77	197.75	197.33	197.33
Temperature	°C	10.6	10.3	11.8	11.0	11.0
pH	pH	7.65	7.24	7.04	7.28	7.28
Redox	mV	-59	-4	6	2	2
Conductivity	µmhos/cm	941	1,013	843	802	802
Chloride[b]	mg/L	10	16	23	16	16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0412	0.0792	0.0647	0.0656	0.0672
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	0.0144	0.0213	0.0088	0.0125	0.0104
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	231	357	317	289	263
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
1,1,1-Trichloroethane	µg/L	< 1	< 1	2	1	1
1,4-Dioxane	µg/L	20	19	< 1	< 1	< 1

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

[b] Filtered sample.

TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319131D, 2004

		Date of Sampling			
Parameter	Unit	2/26/2004	6/3/2004	9/16/2004	11/9/2004
Water elevation[a]	m	184.40	184.96	184.58	184.35
Temperature	°C	10.8	13.0	11.2	11.4
pH	pH	7.57	7.41	7.41	7.11
Redox	mV	-58	-14	0	-21
Conductivity	µmhos/cm	994	1,047	933	901
Chloride[b]	mg/L	54	61	63	75
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0719	0.0718	0.0684	0.0708
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	0.1876	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	0.0191	< 0.01
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.011	0.010
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,519	581	990	521
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
1,4-Dioxane	µg/L	< 1	2	< 1	< 1
Carbon Tetrachloride	µg/L	1	< 1	< 1	< 1

[a] Well point elevation = 182.88 m (MSL); ground surface elevation = 203.56 m (MSL); casing material = steel.

[b] Filtered sample.

TABLE 6.15

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
Beryllium	0.004
Boron	2
Cadmium	0.005
Chloride	200
Chromium	0.1
Cobalt	1
Copper	0.65
Cyanide	0.2
Fluoride	4
Iron	5
Lead	0.0075
Manganese	0.15
Mercury	0.002
Nickel	0.1
Nitrate, as N	10
Radium-226	20 pCi/L
Radium-228	20 pCi/L
Selenium	0.05
Silver	0.05
Sulfate	400
Thallium	0.002
TDS	1,200
Zinc	5
pH	6.5–9.0

TABLE 6.16

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

Constituent	Standard	Constituent	Standard
Alachlor	0.002	1,1-Dichloroethene	0.007
Aldicarb	0.003	*cis*-1,2-Dichloroethylene	0.07
Atrazine	0.003	*trans*-1,2-Dichloroethylene	0.1
Benzene	0.005	1,2-Dichloropropane	0.005
Benzo(a)pyrene	0.0002	Ethylbenzene	0.7
Carbofuran	0.04	Methoxychlor	0.04
Carbon tetrachloride	0.005	Monochlorobenzene	0.1
Chlordane	0.002	Pentachlorophenol	0.001
Dalapon	0.2	Phenols	0.1
Dichloromethane	0.005	Picloram	0.5
Di(2-ethyhexyl)phthalate	0.006	PCBs (decachlorobiphenyl)	0.0005
Dinoseb	0.007	Simazine	0.004
Endothall	0.1	Styrene	0.1
Endrin	0.002	2,4,5-TP (Silvex)	0.05
Ethylene dibromide	0.00005	Tetrachloroethylene	0.005
Heptachlor	0.0004	Toluene	1
Heptachlor epoxide	0.0002	Toxaphene	0.003
Hexachlorocyclopentadiene	0.05	1,1,1-Trichloroethane	0.2
Lindane	0.0002	1,1,2-Trichloroethane	0.005
2,4-D	0.07	1,2,4-Trichlorobenzene	0.07
o-Dichlorobenzene	0.6	Trichloroethylene	0.005
p-Dichlorobenzene	0.075	Vinyl chloride	0.002
1,2-Dibromo-3-Chloropropane	0.0002	Xylenes	10
1,2-Dichloroethane	0.005		

chloride at Wells 317101 and 317111. Historically, elevated pH values at Well 317121D have been reported. Chloride levels in these wells ranged from 196 to 877 mg/L and may be due to road salt usage near the wells. Barium was noted each quarter at very low levels in each of the wells. Barium levels ranged from 0.03 to 0.11 mg/L. Elevated manganese was noted only one quarter in Well 317052. Low levels of zinc were noted at least one quarter in all wells. Zinc levels ranged from less than 0.008 to 0.06 mg/L. Similar to past years, arsenic was noted each quarter in Well 317061 at levels ranging from 0.009 to 0.012 mg/L. Iron was noted one quarter in Well 319131D. Lead was noted at very low levels during one quarter in Wells 317101 and 317111.

Organic Parameters. Low VOC levels were noted each quarter in Wells 317021, 319031, and 319032. Well 317021 continues to show persistent but very low levels of TCA and 1,1-dichloroethane (DCA). Low levels of TCA were also noted in Wells 319031 and 319032. TCA levels ranged from less than 1.0 to 22.0 µg/L. 1,4-dioxane was noted in Well 319131D (one quarter), 319031 and 319032 (two quarters), and 317121D (three quarters); 1,4-dioxane levels ranged from less than 1.0 to 20.0 µg/L. Trichloroethene was noted each quarter in Well 319031, and carbon tetrachloride was noted at the detection level only during the first quarter in

Well 319131D. It should be noted that monitoring conducted as part of the LTS Program, described in Sections 6.2.3 and 6.2.4, routinely detects orders of magnitude higher concentrations of VOCs than those described above; many results are well in excess of WQSs. These samples are collected near areas where waste was placed in the ground and where active remediation was conducted. Higher concentrations at these locations are expected at this point in time.

Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, pesticides, and herbicides. None of these parameters were found in 2004.

Figure 6.4 shows selected VOC results for Well 317021 since 1988. The major components are TCA and DCA; the latter can be a decomposition product of TCA. As shown in Figure 6.4, the concentrations roughly parallel each other, and the levels are consistent until 1991, at which time a trend of increasing, then decreasing, concentrations can be observed. Since early 1998, the level of contamination has dropped dramatically. The well is immediately below a former discharge line that was known to be contaminated from leaks in the system. The sewer line was permanently closed in 1986 and sealed in 1997. A groundwater collection system was installed in the vicinity of this well in late 1997.

Manholes E1 and E2 in the 317 Area were sampled monthly and analyzed for VOCs. The results are presented in Table 6.17. Contributions of groundwater into Manholes E1 and E2 include a quarterly average of 1,072 L/day (282 gal/day) from the 319 Area groundwater collection system, a quarterly average of 9,424 L/day (2,479 gal/day) from the 317 Area groundwater collection system, and groundwater from existing 317 Area foundation drains around the storage vault.

Manhole 1E receives water from the 317 Area foundation drains around the storage vault. The combined flow of water from the 317 Area groundwater collection system and the 319 Area groundwater collection system is pumped to Manhole 2E. Prior to 2004, flows from both areas had decreased since 1999. The 319 Area decrease can be mainly attributed to a considerable drop in groundwater extraction rates due to the addition of the 319 Landfill cap installed during summer 1999. Flows from the 317 Area are influenced by the increased uptake of groundwater by the phytoremediation system and changes in seasonal precipitation. However, the flows from both areas increased substantially compared with flows noted in 2003. Flows from the 319 Area collection system increased from 555 L/day (146 gal/day) in 2003 to 1,072 L/day (282 gal/day) in 2004. Flows from the 317 Area collection system increased from 4,210 L/day (1,108 gal/day) in 2003 to 9,424 L/day (2,479 gal/day) in 2004. Based on quarterly averages, these increases can be mainly attributed to heavy precipitation during the winter months in the form of rain versus snow, allowing for increased infiltration into the ground. Despite the increased flows in the 319 Area, the high-density polyethylene liner over the 319 Landfill appears to be successfully reducing water movement throughout the southern end of the 319 Area.

In general, annual average VOC concentrations in Manholes E1 and E2 decreased from levels noted in previous years (see Figure 6.5). The decrease is mainly associated with remediation activities in the 317 and 319 Areas. A soil remediation project conducted in 1998 resulted in the removal of approximately 80% of the VOCs from several locations within the

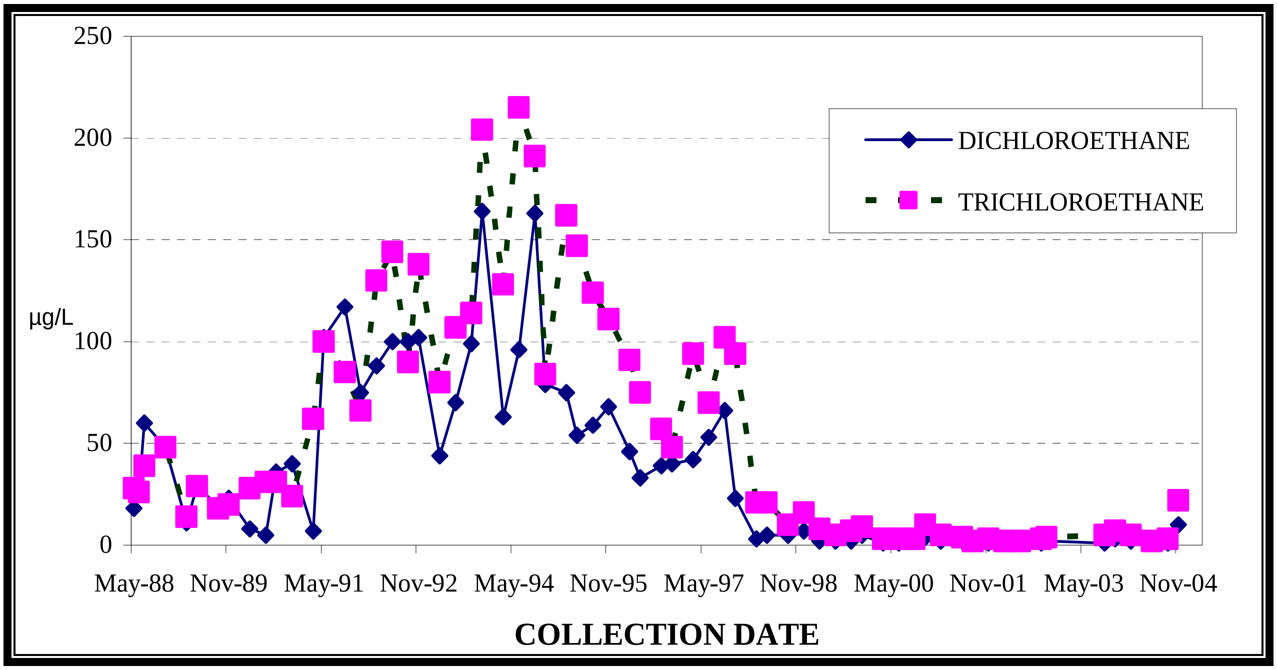


FIGURE 6.4 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

TABLE 6.17

Volatile Organic Compounds in the 317 Area: Manholes E1 and E2, 2004
(Concentrations in µg/L)

Date Collected	Chloroform		Tetra-chloroethene		Trichloro-ethene		*cis*-1,2-Dichloro-ethene		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
January	151	9	16	2	15	9	5	2	22	32	126	6	33	47
February	128	2	12	1	13	11	4	1	28	44	105	2	36	60
March	185	6	22	3	17	14	6	3	29	47	206	10	50	88
April	112	2	14	1	14	3	5	1	12	12	97	3	10	7
May	2	1	1	1	2	2	1	1	10	11	2	1	6	6
June	26	1	8	4	17	1	2	1	23	3	39	2	49	7
July	275	173	50	66	41	62	17	28	19	14	449	343	28	19
August	222	1	20	2	63	4	25	5	23	12	215	1	30	1
September	159	18	16	2	42	9	11	4	14	12	117	10	17	11
October	106	3	11	1	34	3	11	1	16	7	67	2	16	5
November	146	11	17	1	49	7	16	3	8	5	111	7	11	2
December	234	123	26	25	49	59	15	23	5	3	304	154	8	3

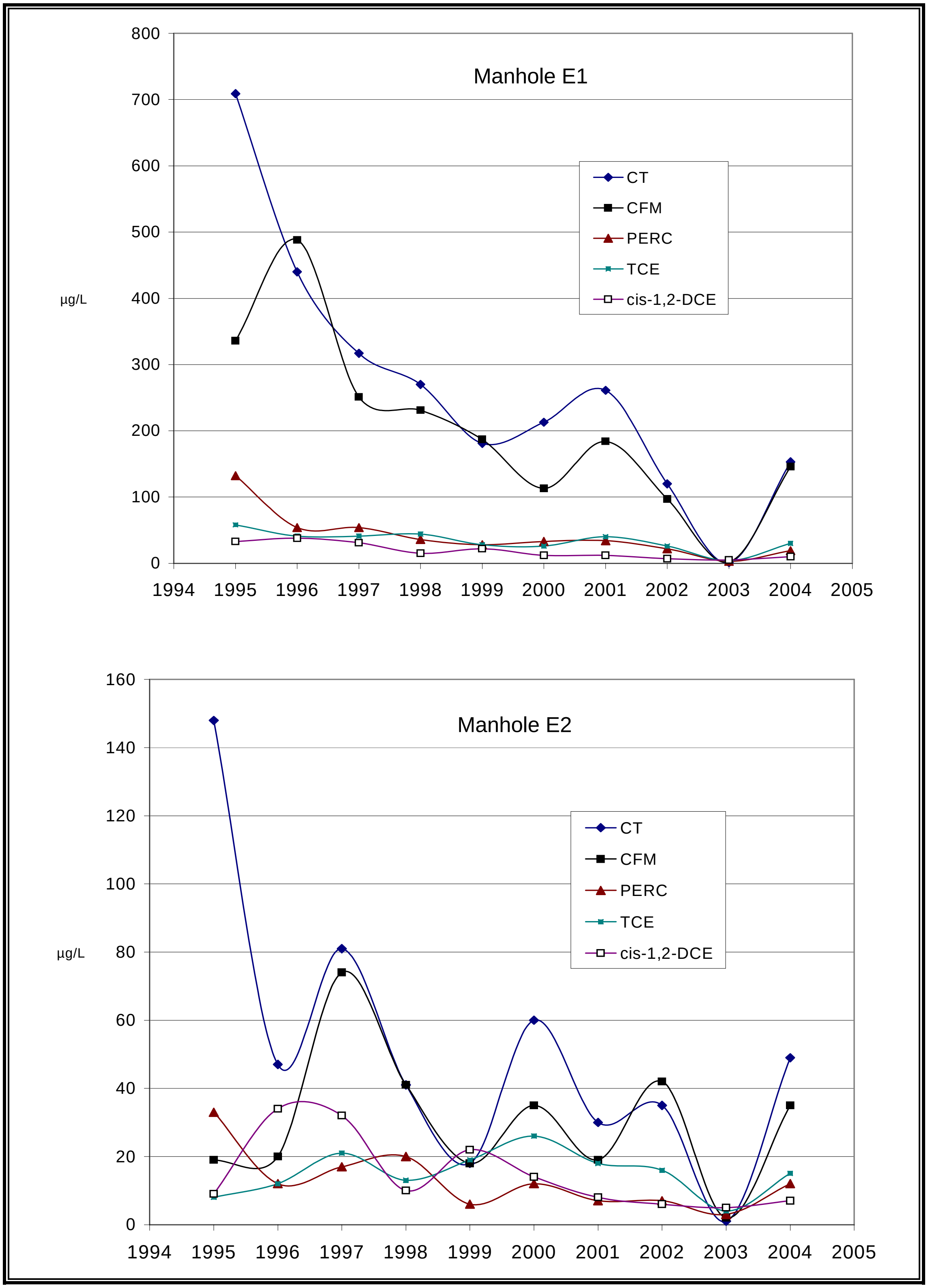


FIGURE 6.5 Manholes E1 and E2 Annual Average Groundwater Concentrations, 1995 to 2004

317 French Drain Area. As previously mentioned, the addition of the 319 Landfill cap in summer 1999 has decreased leachate production in this area and has resulted in a substantial decrease in the amount of water pumped to Manhole E2 from the 319 Area groundwater collection system. These activities probably account for the decrease in VOC concentrations in Manhole E2 from levels noted in previous years (see Figure 6.5). Decreases in VOC concentrations in Manhole 1E may be associated with the substantial increase of groundwater extraction from the 317 Area groundwater collection system, as well as the removal of contaminated groundwater by evapotranspiration and contaminant degradation in the soil. Figures 6.6 to 6.12 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). Monthly VOC concentrations are precipitation dependent — that is, increased concentrations are indicative of drier periods.

Radioactive Constituents. Samples collected quarterly from the monitoring wells in the 317 and 319 Areas were analyzed for hydrogen-3, strontium-90, and gamma-ray emitters. The results are presented in Tables 6.5 to 6.14. Evidence of possible off-site migration of radionuclides is noted by the low concentrations of hydrogen-3 in wells located near the south perimeter fence in the 317/319 Area. Well 317101 is at the north perimeter of the 317 Area, and hydrogen-3 was noted at a very low level (near detection) and only during one quarter. The wells near the south perimeter fence that contained hydrogen-3 include 317061 (one quarter); 317021 and 319031 (two quarters); 317121D (three quarters); and 317052, 319032, and 319131D (four quarters). Hydrogen-3 levels in these wells ranged from less than 100 to 1,519 pCi/L, which is well below the WQS for drinking water of 20,000 pCi/L. Well 319031 was dry during two quarters. Strontium-90 was noted during two quarters in Well 319031.

Water from the 317/319 Area groundwater collection systems is pumped to Manhole 2E. Manhole 1E is connected to the footing drain system around the operating vault. In addition to VOCs, the manhole water is analyzed for hydrogen-3 and gamma-ray-emitting radionuclides. Table 6.18 gives the hydrogen-3 results. Although the hydrogen-3 concentrations are relatively high, the volume is fairly low. Because hydrogen-3 concentrations are generally higher in Manhole 2E, the source of the hydrogen-3 appears to be the 319 Area groundwater pumping system. No gamma-ray-emitting radionuclides were detected in any samples.

6.2.3. Phytoremediation Groundwater Monitoring

The soil treatment action 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 natural process by which woody and herbaceous plants extract pore water and entrained chemical substances from subsurface soils, degrade and/or sequester them, and transpire water vapor and some volatile constituents into the atmosphere. To monitor the source term, a number of monitoring wells were installed in the phyto plantation area to measure the progress of contaminant removal from the subsurface. The monitoring wells are shown in Figure 6.13.

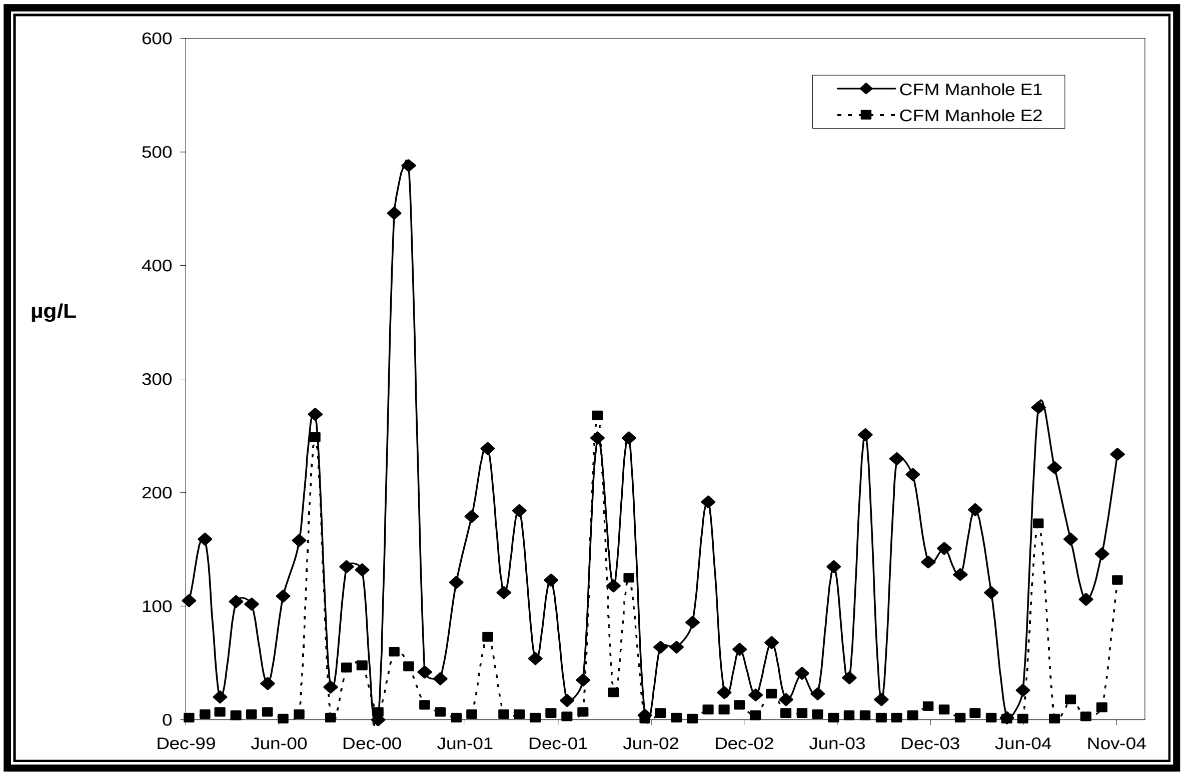


FIGURE 6.6 Manholes E1 and E2 Chloroform Levels, 2000 to 2004

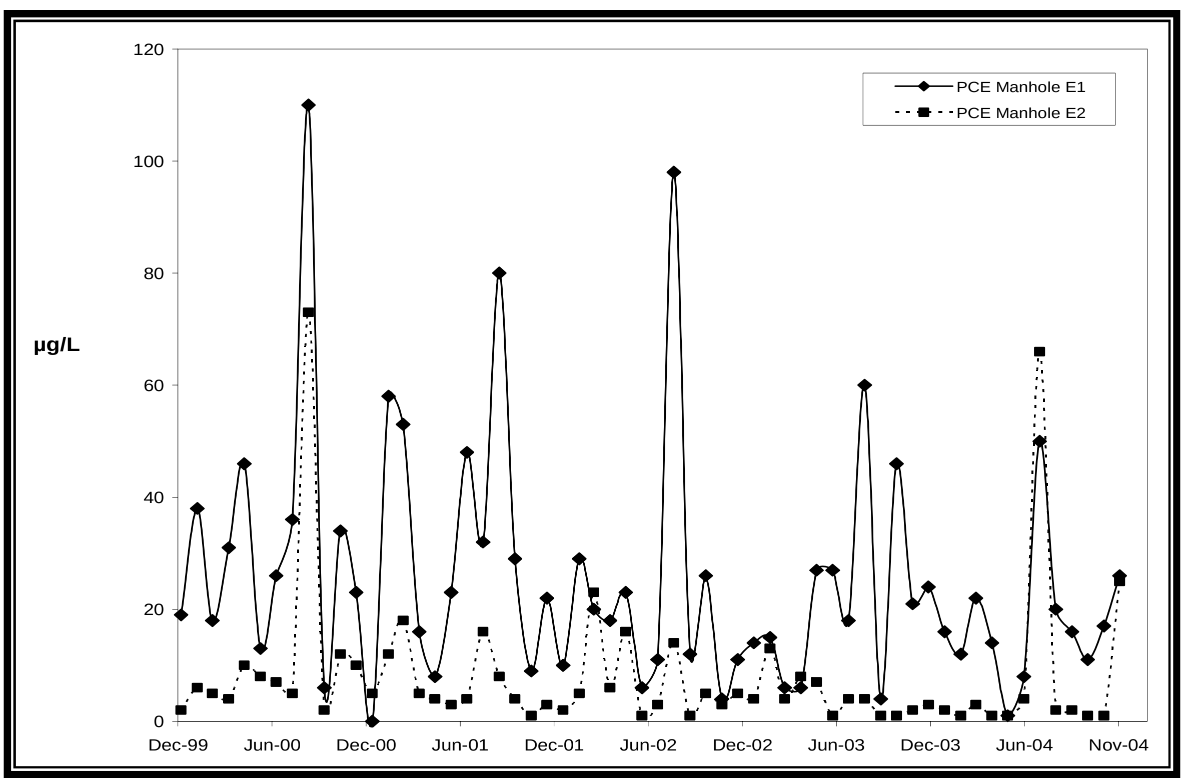


FIGURE 6.7 Manholes E1 and E2 Tetrachloroethene Levels, 2000 to 2004

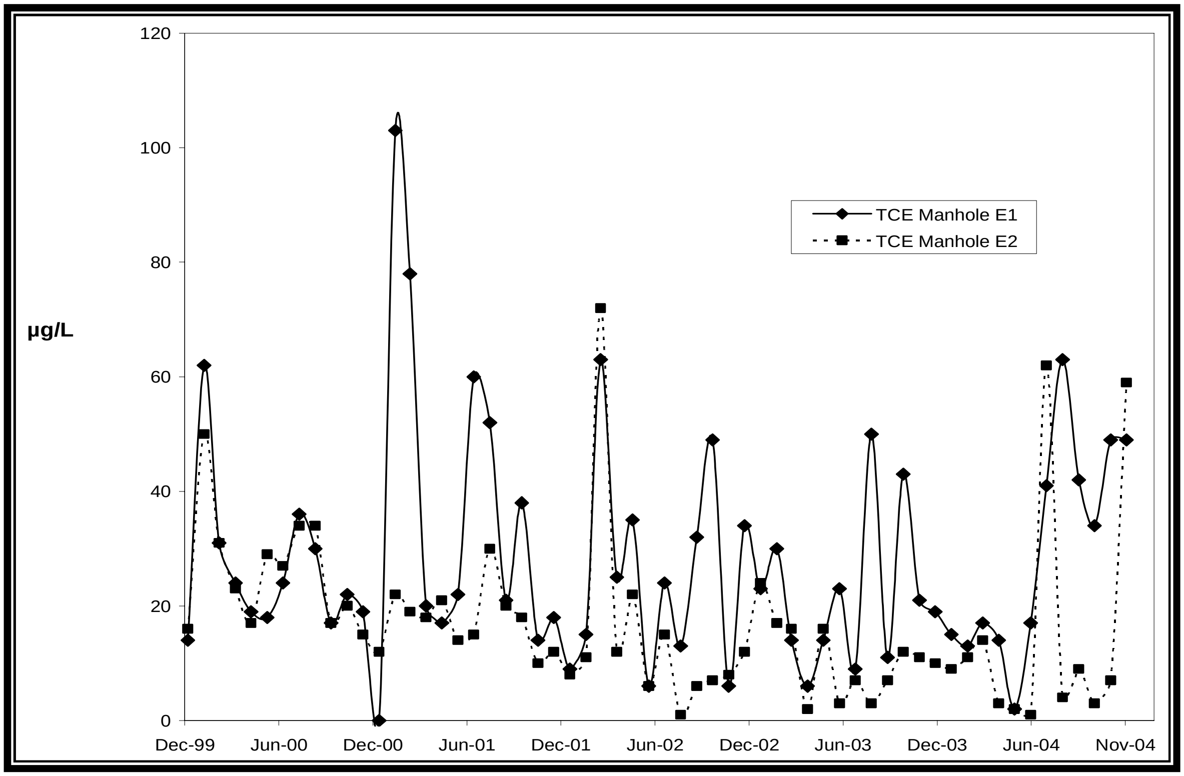


FIGURE 6.8 Manholes E1 and E2 Trichloroethene Levels, 2000 to 2004

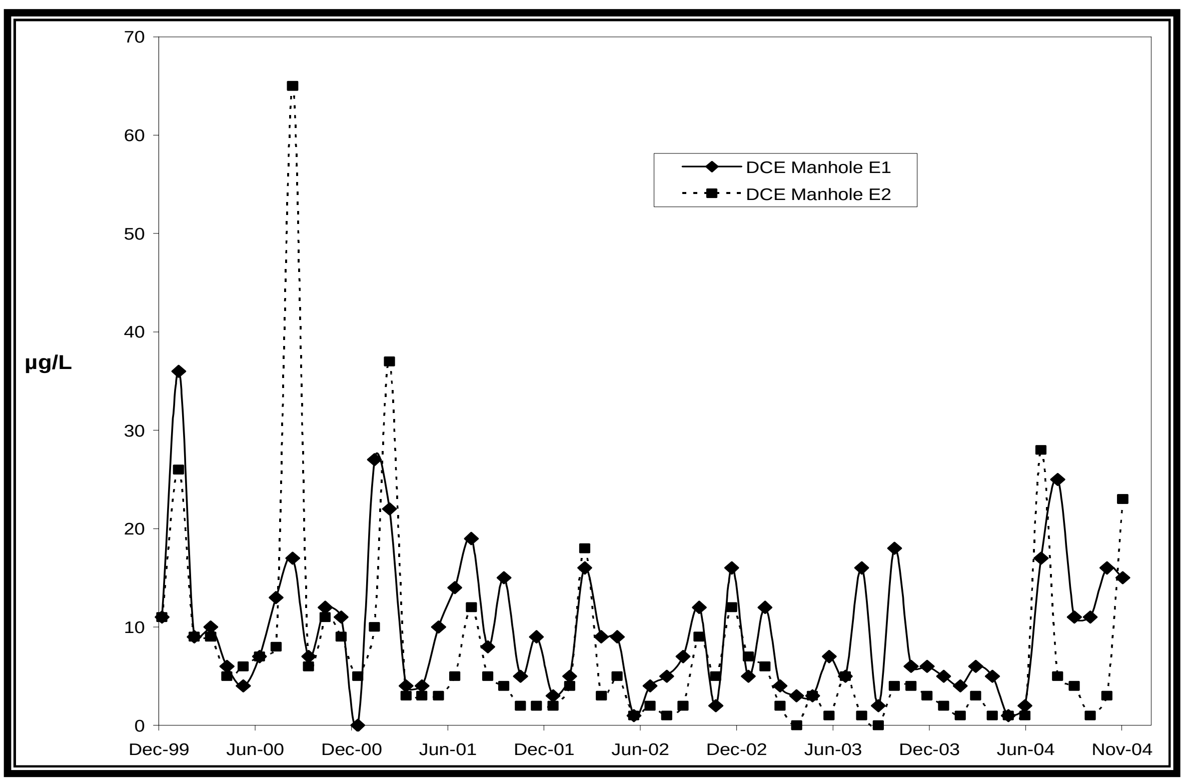


FIGURE 6.9 Manholes E1 and E2 *cis*-1,2-Dichloroethene Levels, 2000 to 2004

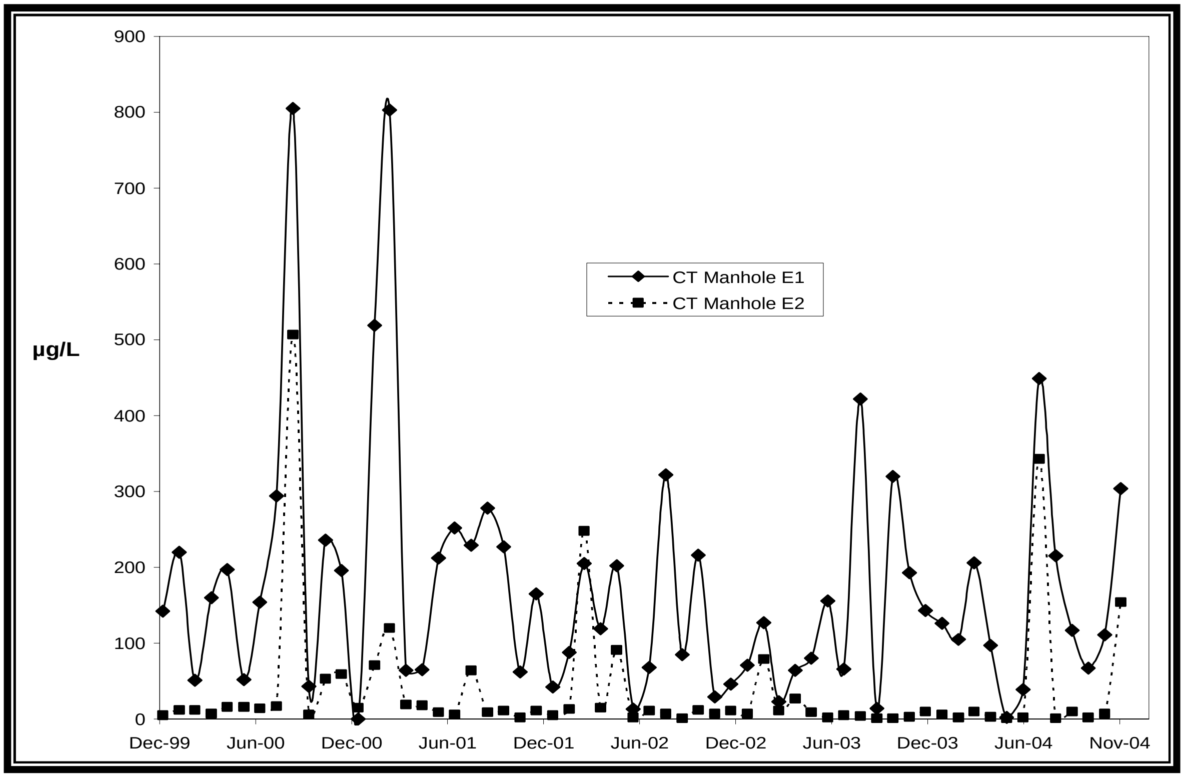


FIGURE 6.10 Manholes E1 and E2 Carbon Tetrachloride Levels, 2000 to 2004

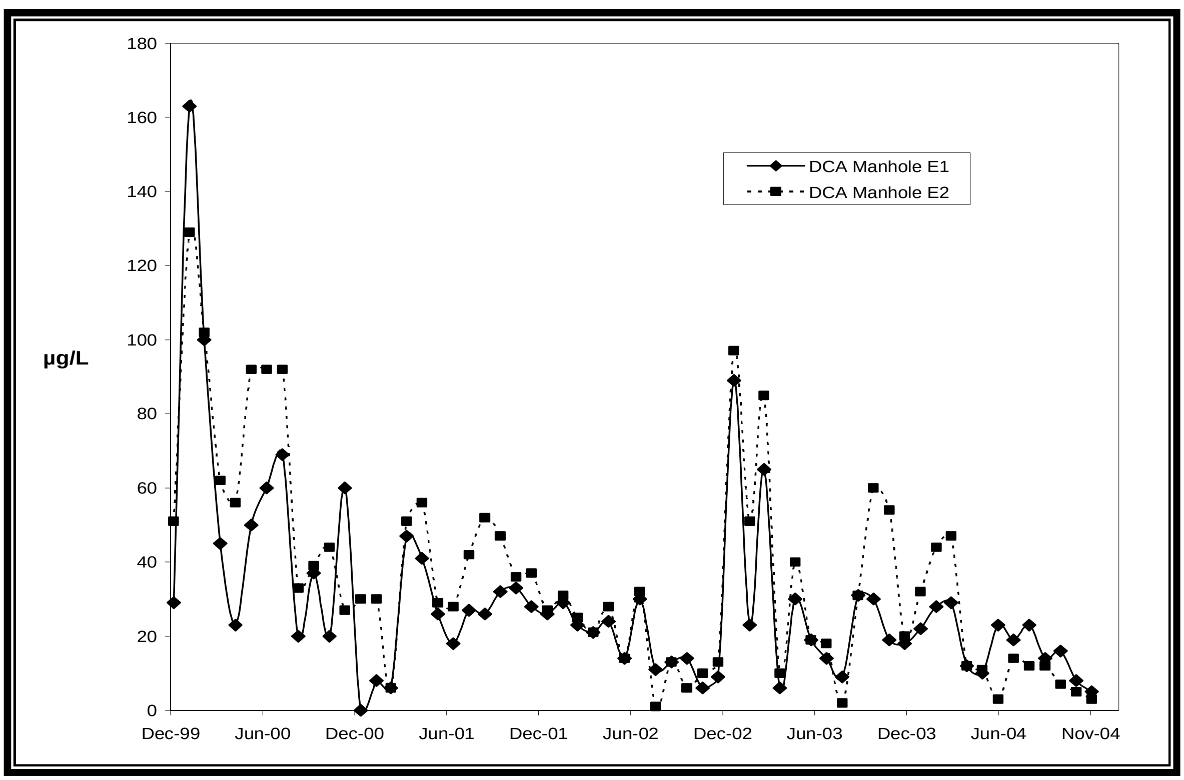


FIGURE 6.11 Manholes E1 and E2 1,1-Dichloroethane Levels, 2000 to 2004

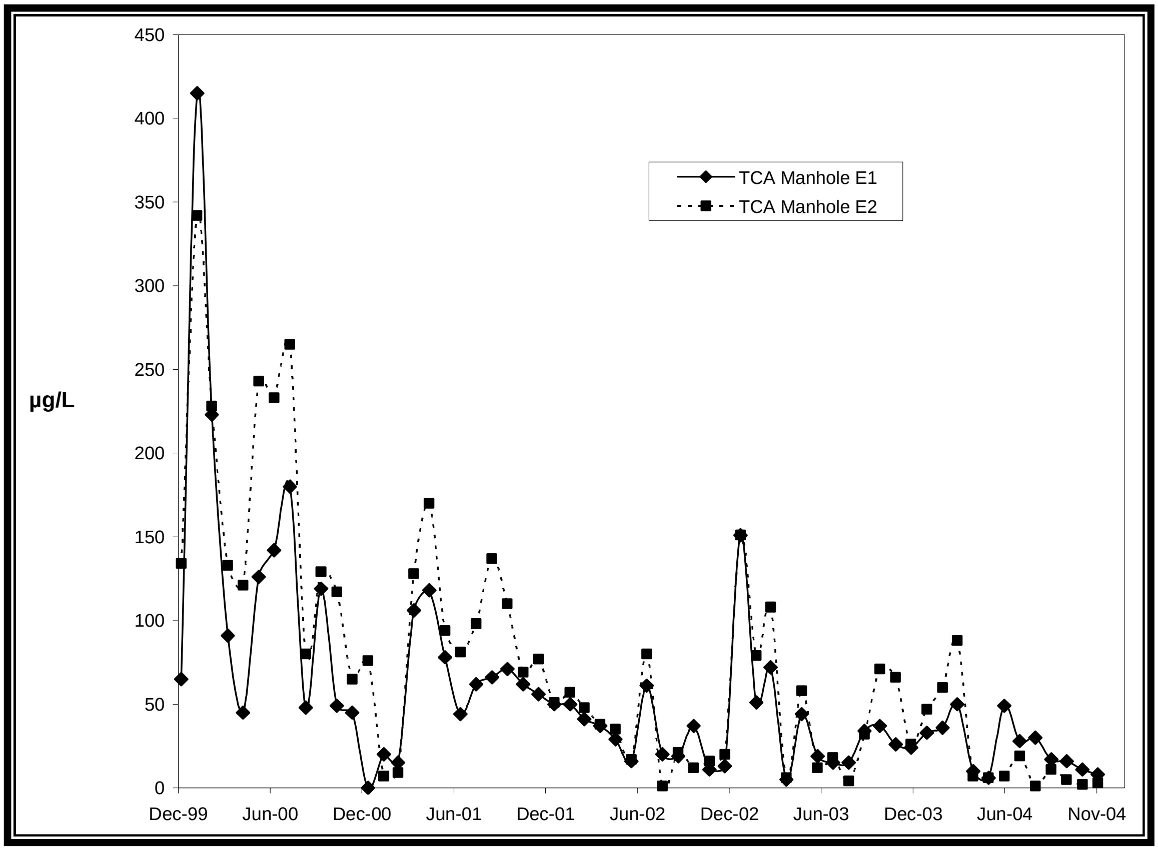


FIGURE 6.12 Manholes E1 and E2 1,1,1-Trichloroethane Levels, 2000 to 2004

Samples are collected quarterly from the phyto wells and analyzed for VOCs and hydrogen-3. Table 6.19 gives the analytical results only for wells from which measurable concentrations were obtained. Wells that were dry or contained levels of organics that were all below the quantification limit were excluded. The results in the table are the annual average of the quarterly results, and those values that exceed the applicable standards are indicated in bold type.

Most of the monitoring results are from within the 317 Area French Drain. Although portions of the area were treated using a soil mixing process with zero-valent iron addition, this treatment was effective at removing about 80% of the VOCs. The data in Table 6.19 indicate that small pockets of elevated VOCs remain to be treated by the phytoremediation process. For example, the areas around Wells 317151, 317181, 317321, and 317331 appear to contain elevated levels of a number of VOCs. Although the concentrations of a significant number of the VOCs are substantially above the standards, which are the targets for cleanup, examination of the individual quarterly results indicates that the concentrations of a number of VOCs are gradually decreasing as a result of natural attenuation.

6.2.4 Extraction Well Monitoring

The groundwater management system in the 317/319 Area includes 25 extraction wells installed to intercept the flow of contaminated groundwater off the ANL site. A line of extraction wells was installed near the 317 Area south fence and south of the 319 Area landfill. The 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 discharges from the extraction wells are routed to a pump house, where the water is pumped to a lift station. The groundwater is then transferred by force main to the ANL WTP. The locations of the extraction wells are shown in Figure 6.14.

TABLE 6.18

Hydrogen-3 Concentrations in Manhole Water Samples, 2004
(concentrations in pCi/L)

Date Collected	Manhole 1E	Manhole 2E
01/04	1,295	1,306
02/04	575	437
03/04	1,215	1,664
04/04	8,919	1,014
05/04	1,000	958
06/04	400	103
07/04	1,315	857
08/04	2,806	5,108
09/04	1,651	2,845
10/04	873	399
11/04	1,219	1,041
12/04	543	255

Monitoring of the individual extraction wells is conducted annually to determine the concentrations of contaminants in the groundwater near the ANL property line. Samples are analyzed for VOCs and selected radionuclides. The concentrations of most of the parameters were below laboratory detection limits. To provide a comparison of these concentrations with concentrations of the same parameters measured in the phytoremediation wells, Table 6.20 presents the range of concentrations for each parameter.

Examination of Table 6.20 shows that, although several extraction wells contained VOCs at concentrations that exceeded the standards (cleanup levels), these exceedances were orders of magnitude lower than the measured concentrations in the phytoremediation wells (see Section 6.2.3.). The extraction wells appear to be effective at preventing migration of contaminated groundwater from the ANL site.

In addition to the VOCs, the extraction well water was also analyzed for gross alpha, gross beta, gamma-ray emitters, isotopic uranium, plutonium-238 and 239, and hydrogen-3. All the radiological constituents, except hydrogen-3, were not detected or were within the range of normal ambient concentrations. The hydrogen-3 concentrations ranged from 100 to 68,000 pCi/L; most of the elevated hydrogen-3 concentrations were found in groundwater from the extraction wells just south of the 319 Landfill. Although some of these concentrations exceed the Class 1 Ground Water Quality Standard for hydrogen-3, concentrations in the past have been much higher.

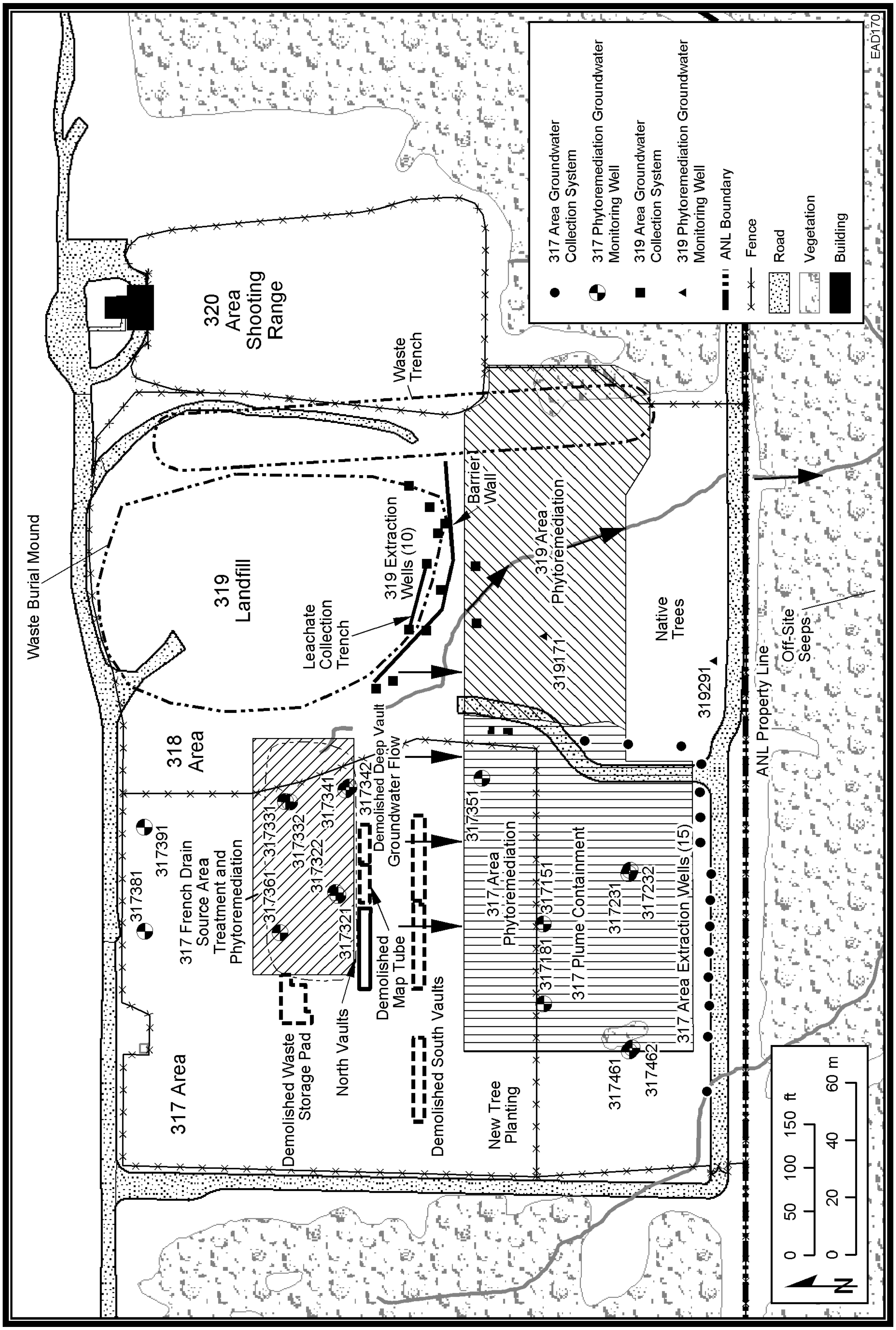


FIGURE 6.13 Phytoremediation Monitoring Wells

TABLE 6.19

Annual Average Concentrations of Phytoremediation Well Water Constituents, 2004

Parameter	317151	317181	317321	317322	317331	317332	317341	317342	317351	317462	Standard
VOC (µg/L)											
1,1,1-Trichloroethane	**6,399**[a]	**10,839**	ND[b]	255	**185,264**	**6,963**	2	**685**	ND	**209**	200
1,1,2-Trichloroethane	ND	ND	ND	ND	**39**	ND	ND	ND	ND	ND	0.5
1,1-Dichloroethane	407	**4,244**	ND	**2,522**	**10,524**	**2,077**	16	**1,134**	ND	**2,456**	700
1,1-Dichloroethene	**102**	**148**	ND	ND	**4,555**	**107**	**15**	**14**	ND	**18**	7
1,2-Dichloroethane	**48**	**197**	ND	**42**	**3,767**	**141**	3	**38**	ND	**106**	5
1,4-Dioxane	ND	ND	ND	ND	**5,573**	**3,815**	**94**	**386**	ND	ND	1
Acetone	ND	ND	**7,735**	385	ND	ND	ND	ND	ND	ND	700
Benzene	ND	**29**	**10,473**	**519**	**529**	**23**	0	3	ND	**8**	5
Carbon tetrachloride	ND	ND	**274,988**	**711**	ND	ND	2	ND	**162**	ND	5
Chloroform	**42**	**62**	**71,111**	**4,125**	**958**	**18**	**9**	**2**	**397**	ND	0.2
cis-1,2-Dichloroethene	40	**591**	**343**	**35,679**	**19,918**	**915**	5	40	9	20	70
Methylene chloride	ND	ND	**2,856**	**1,459**	ND	ND	ND	ND	**8**	ND	5
Tetrachloroethene	**23**	**510**	**625**	**998**	ND	ND	4	ND	**465**	ND	5
Toluene	ND	ND	903	39	53	ND	ND	ND	ND	ND	1,000
trans-1,2 Dichloroethene	ND	20	ND	**299**	**1,069**	75	1	3	ND	ND	100
Trichloroethene	**737**	**669**	**27,576**	**555**	**47,833**	**431**	ND	**39**	4	**24**	5
Vinyl chloride	**59**	**41**	ND	**4,381**	**352**	**99**	1	2	**3**	**6**	2
Radioactivity (pCi/L)											
Hydrogen-3	442	513	1,410	709	274	552	442	1,118	749	361	20,000

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

[b] ND = nondetect.

6.2.5 ENE Landfill Groundwater Monitoring

In September 2001, ANL completed the remediation of the ENE Landfill by consolidating all of the waste and constructing a cap over the waste material. Five wells were installed (ENE031, ENE041, ENE051, ENE061, and ENE071) 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 (ENE031, ENE041, and ENE051) were installed immediately downgradient of the landfill. Four other wells (ENE011, ENE012, ENE013D, and ENE021D) were installed as part of the 317/319/ENE RCRA Facility Investigation (RFI) in 1996 and are located south and east of the landfill. The well locations are shown in Figure 6.15.

The purpose of the groundwater monitoring at the ENE Landfill is to verify that chemical contaminants found in the landfill contents, which were all below their respective migration-to-groundwater levels (as found in 35 IAC Part 742 [i.e., Tiered Approach to Corrective Action Objectives]), are not of concern with regard to shallow groundwater. The contaminants in the landfill were of concern because of their ingestion risks and not their migration-to-groundwater risks; the cap placed over the landfill contents was designed to prevent exposure to future site workers and not to prevent the percolation of groundwater (i.e., an impermeable cover).

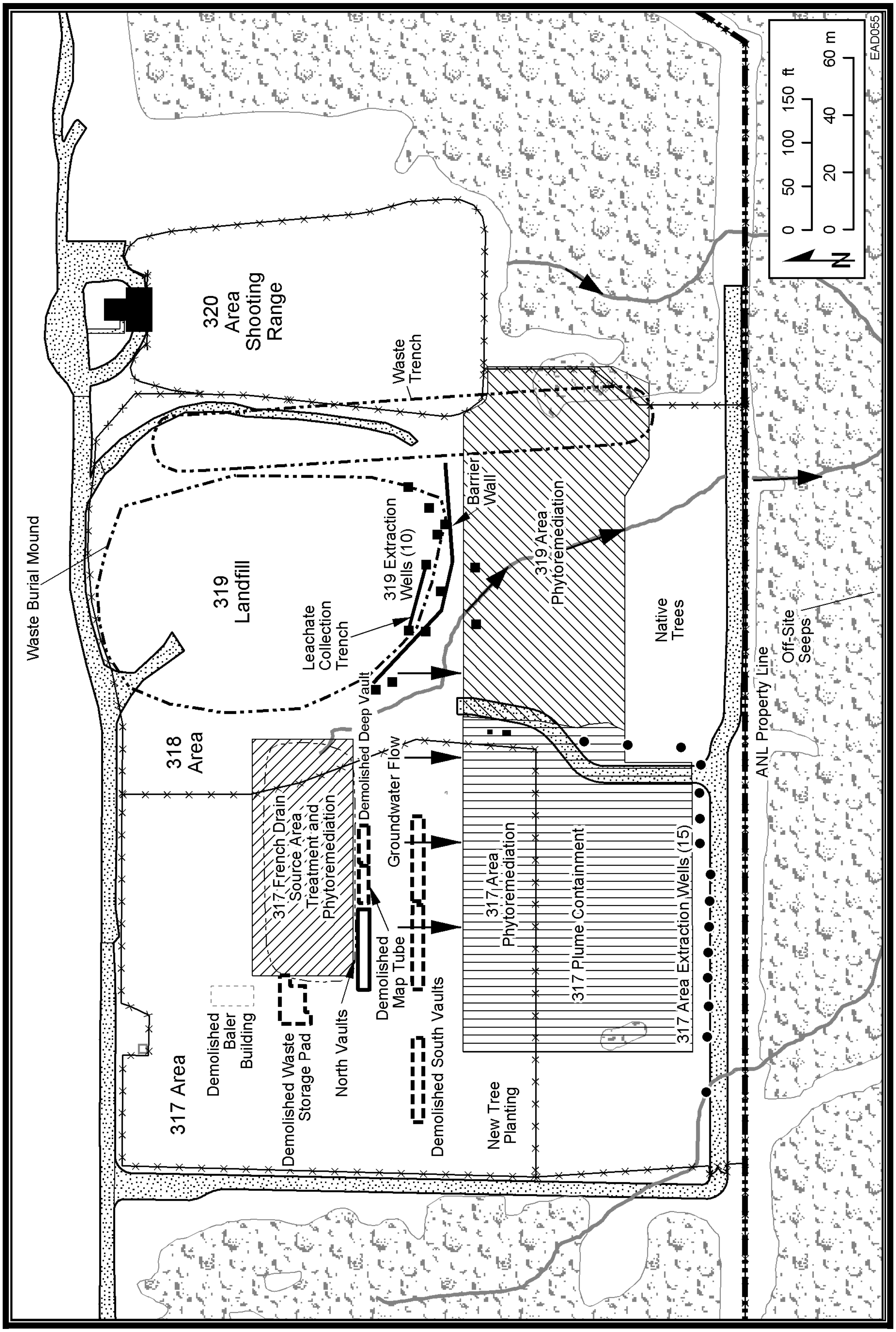


FIGURE 6.14 Extraction Wells

TABLE 6.20

Range of VOC Concentrations in the 317/319
Extraction Wells, 2004

Parameter	Range (µg/L)	Standard
1,1,1-Trichloroethane	ND to 245	200
1,1-Dichloroethane	ND[a] to 143	700
1,1-Dichloroethene	ND to 3	700
1,2-Dichloroethane	ND to 5	5
1,4-Dioxane	ND to 18	1
2-Butanone	ND	NA[b]
2-Heptanone	ND	NA
4-Heptanone	ND	NA
Acetone	ND to 263	700
Benzene	ND	5
Carbon disulfide	ND	NA
Carbon tetrachloride	ND to 2	5
Chloroethane	ND to 2	NA
Chloroform	ND to 3	0.2
Chloromethane	ND	NA
cis-1,2-Dichloroethene	ND to 39	70
Methylene chloride	ND	5
Tetrachloroethene	ND to 1	5
Tetrahydrofuran	ND	NA
Trichloroethene	ND to 33	5
Xylene (total)	ND	5

[a] ND = nondetect.

[b] NA = not applicable.

During the second quarter of CY 2004, steps were taken to fulfill the conditions of IEPA approval of the Groundwater Monitoring Plan for the ENE Area Landfill at ANL. In addition to the five currently sampled wells, extraction wells ENE011, ENE012, ENE013D, and ENE021 were added to the quarterly monitoring program. Parameters to be analyzed on a quarterly basis were established, with data reported electronically to IEPA. The parameters are total polychlorinated biphenyls (PCBs) and filtered and unfiltered arsenic, chromium, lead, manganese, nickel, and selenium; see Table 6.21.

During 2004, results of groundwater monitoring were found to exceed the Groundwater Remediation Objective (GRO) for lead, manganese, nickel, and chromium, but no concentrations above the standard were detected for total PCBs from the nine wells. The data show that total metals results were higher than dissolved metals results, indicating that solids contributed to the elevated metals.

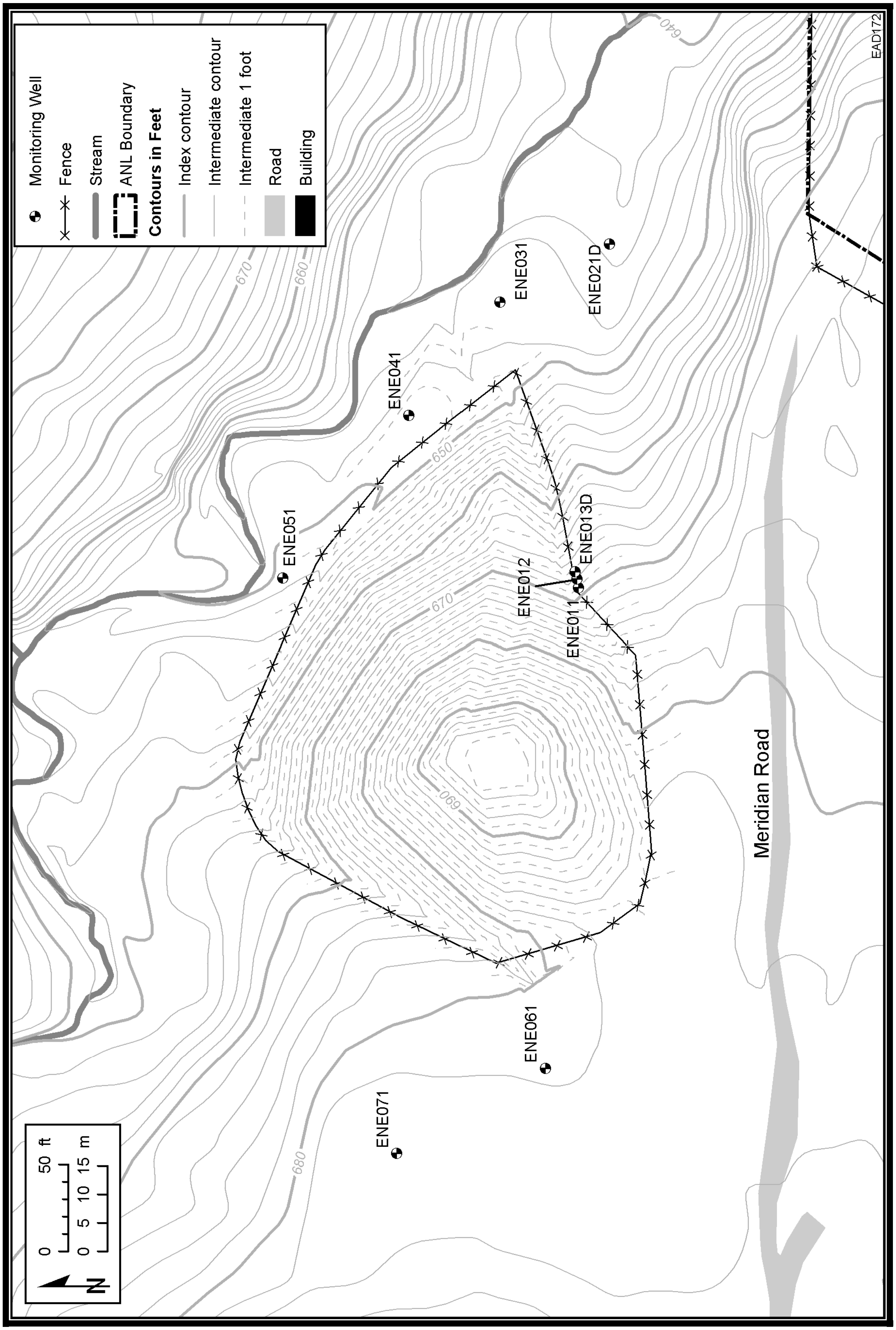


FIGURE 6.15 ENE Area Groundwater Monitoring Wells

In past sampling events, the majority of the metals results exceeding the GRO were for total (unfiltered) metals, which indicates that suspended soil particles in the water contributed to the exceedances. During 2004, ANL utilized low-flow sampling methods that produced more representative samples and greatly reduced the number of exceedances for metals. In future sampling events, ANL intends to use low-flow sampling to continue providing quality samples for analysis. Monitoring at the ENE Landfill will be conducted for a minimum of 15 years, as required by the landfill closure permit issued by the IEPA.

6.2.6. Monitoring of the Seeps South of the 300 Area

In spring 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. Three seeps (SP01, SP02, and SP04) are located about 200 m (600 ft) south of the 319 Area; two other seeps (SP03 and SP05) are located about 360 m (1,200 ft) south of the 317 Area and are considered clean background seeps. The locations are shown in Figure 6.16. The seeps are in ravines that are located in a pristine, heavily wooded section of the forest preserve. The ravines carry storm water drainage from the 317 and 319 Areas. Storm water 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 affected water from the seeps is no longer visible because it drains back into the soil in the bed of the ravine. During extended dry-weather conditions, the flow disappears completely. The IEPA has designated this area as AOC-G — Off-Site Groundwater Seeps.

Initial samples were collected from these seeps and analyzed for metals, VOCs, and selected radionuclides. Two groundwater seeps contained measurable levels of three VOCs: carbon tetrachloride, chloroform, and tetrachloroethene. Carbon tetrachloride and tetrachloroethene concentrations exceeded the Class I Groundwater Quality Standards. The other three 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 obtained through the end of 1997, and quarterly samples were collected until the end of 1998. These results are summarized in the 1998 Site Environmental Report.[11]

During 2004, Seeps SP01, SP02, and SP04 were sampled quarterly for VOCs and hydrogen-3. VOCs were noted in each seep during each quarter. As in previous years, Seep SP04 showed the highest levels of all three VOCs (carbon tetrachloride, chloroform, and tetrachloroethene) for each quarter. The data are presented in Table 6.22. The hydrogen-3 and VOC results are consistent with past data, which indicate a gradual decline in concentrations (with the exception of VOCs in SP04) since measurements began in 1996 (see Figures 6.17 and 6.18).

TABLE 6.21

Annual Average Concentration of ENE Landfill Well Water Constituents, 2004

Metal	ENE-011	ENE-012	ENE-013D	ENE-021D	ENE-031	ENE-041	ENE-051	ENE-061	ENE-071	Standard
Arsenic–filtered	<3.0	<3.0	<3.0	<3.0	4.2	<3.0	<3.0	<3.0	<3.0	50
Arsenic–unfiltered	<3.0	3.3	<3.0	<3.0	6.4	3.7	<3.0	5.5	4.6	50
Chromium–filtered	<24	<24	<24	<24	<24	<24	<24	<24	<24	100
Chromium–unfiltered	24.6	35.4	24.6	**165**[a]	<24	<24	<24	67.9	91.2	100
Lead–filtered	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	7.5
Lead–unfiltered	5.9	**12**	5.9	<2.0	<2.0	7.3	<2.0	**73.6**	**125.1**	7.5
Manganese–filtered	<10	<10	<10	80	**385.8**	18.9	41.7	**183.1**	**215.7**	150
Manganese–unfiltered	**166**	**451**	**166**	78.2	**375.1**	**933.9**	100.2	**2,803.7**	**4214**	150
Nickel–filtered	20	20	20	23	24.4	24	36.7	35.4	29	100
Nickel–unfiltered	23	23	23	23.7	29	71.5	26	**225.7**	**258.4**	100
Selenium–filtered	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	50
Selenium–unfiltered	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	50
PCB–total	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1

[a] Bold type indicates that values exceed the GRO.

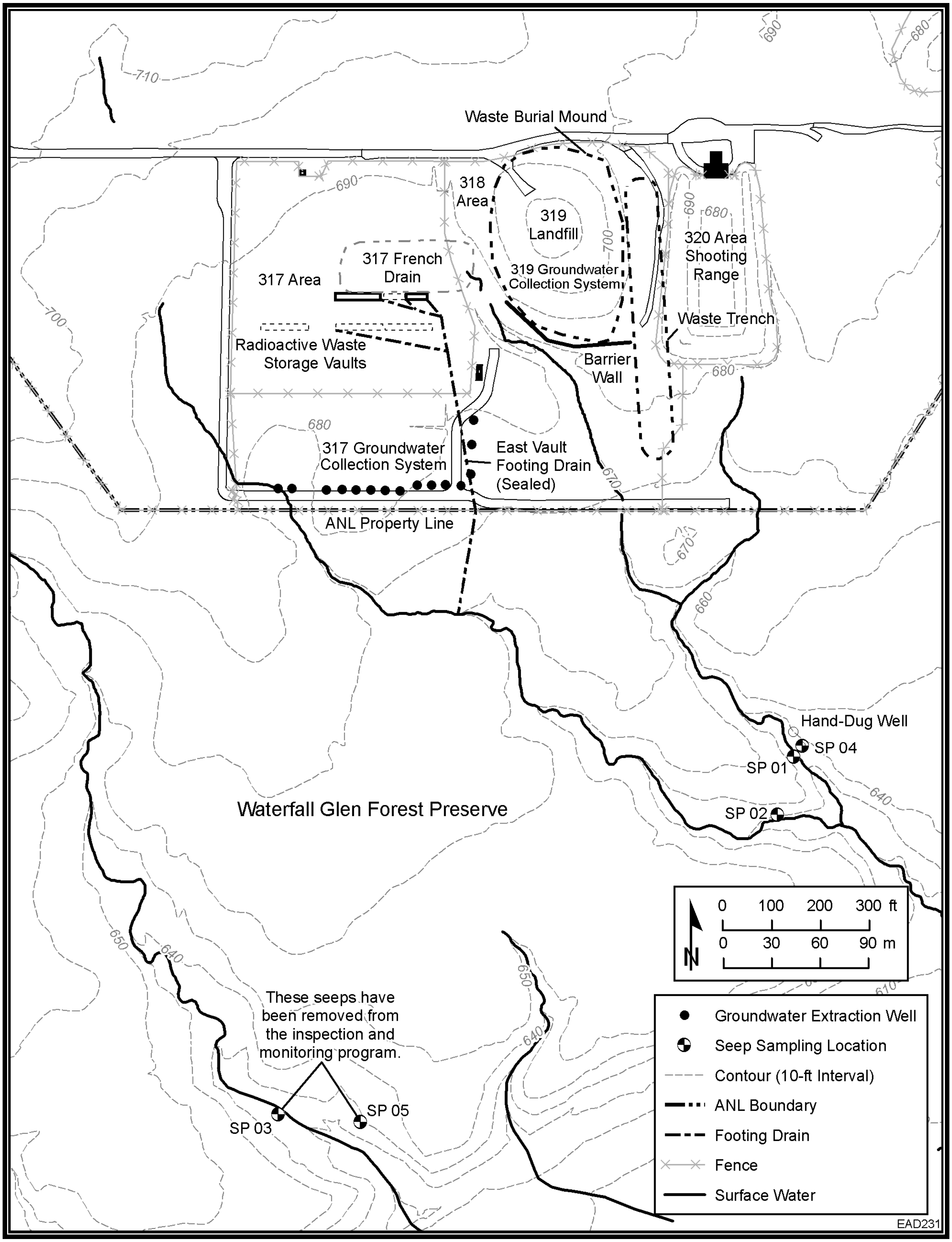


FIGURE 6.16 Seep Locations South of the 317/319 Area

TABLE 6.22

Contaminant Concentrations in Seep Water, 2000 to 2004

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[a]	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
	12/8/03	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
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
	12/8/03	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
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
	3/25/03	Dry	Dry	Dry	Dry
	5/13/03	<100	39	10	2

TABLE 6.22 (Cont.)

Site	Date Collected	Hydrogen-3 (pCi/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)
	8/14/03	<100	**137**	33	4
	12/8/03	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

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

Monitoring was also conducted quarterly at an artesian well located about 2,000 m (6,000 ft) southwest of the 317 Area (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 contaminant movement has not extended to this location and indicates a western limit to the migration.

6.3. Sanitary Landfill

The 800 Area is the site of the ANL sanitary landfill. The 8.8-ha (21.8-acre) landfill is located on the western edge of the ANL property (Figure 1.1). The landfill received 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 being closed 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. On March 25, 2004, the IEPA notified DOE that all future groundwater activities at the 800 Area Landfill will be carried out under the corrective action provisions (Section V) of ANL's RCRA Part B Permit.

6.3.1. French Drain

The landfill area was used for the disposal of certain types of liquid wastes from 1969 to 1978. The wastes were poured into a French drain that consisted of a corrugated steel pipe placed in a gravel-filled pit dug into an area previously filled with waste. The liquid waste was poured into the drain and allowed to permeate into the gravel, and then into the soil and fill material. Available 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 (oil water emulsion). Some of the wastes disposed of in this manner would currently be defined as hazardous wastes. The presence of volatile and other toxic organic compounds has been confirmed by extensive characterization activities conducted at the landfill. Measurable amounts of these materials were identified in leachate but not in groundwater near the landfill.

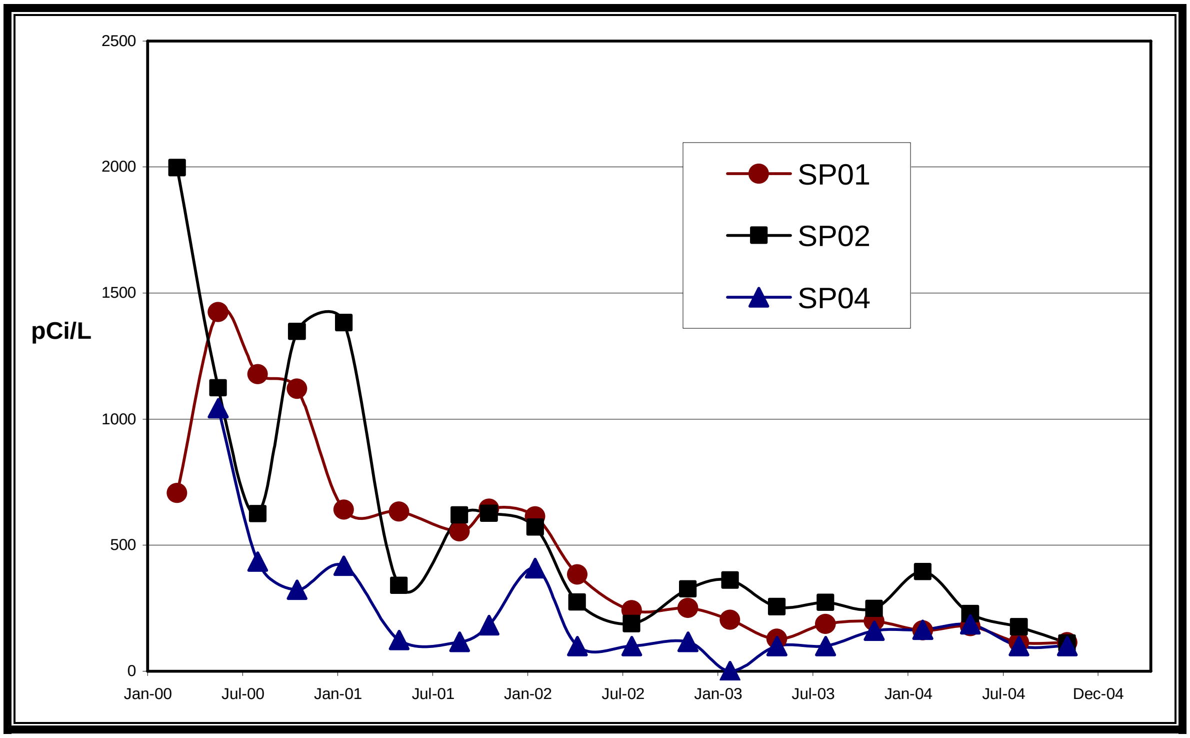


FIGURE 6.17 Hydrogen-3 Concentrations in Seep Water, 2000 to 2004

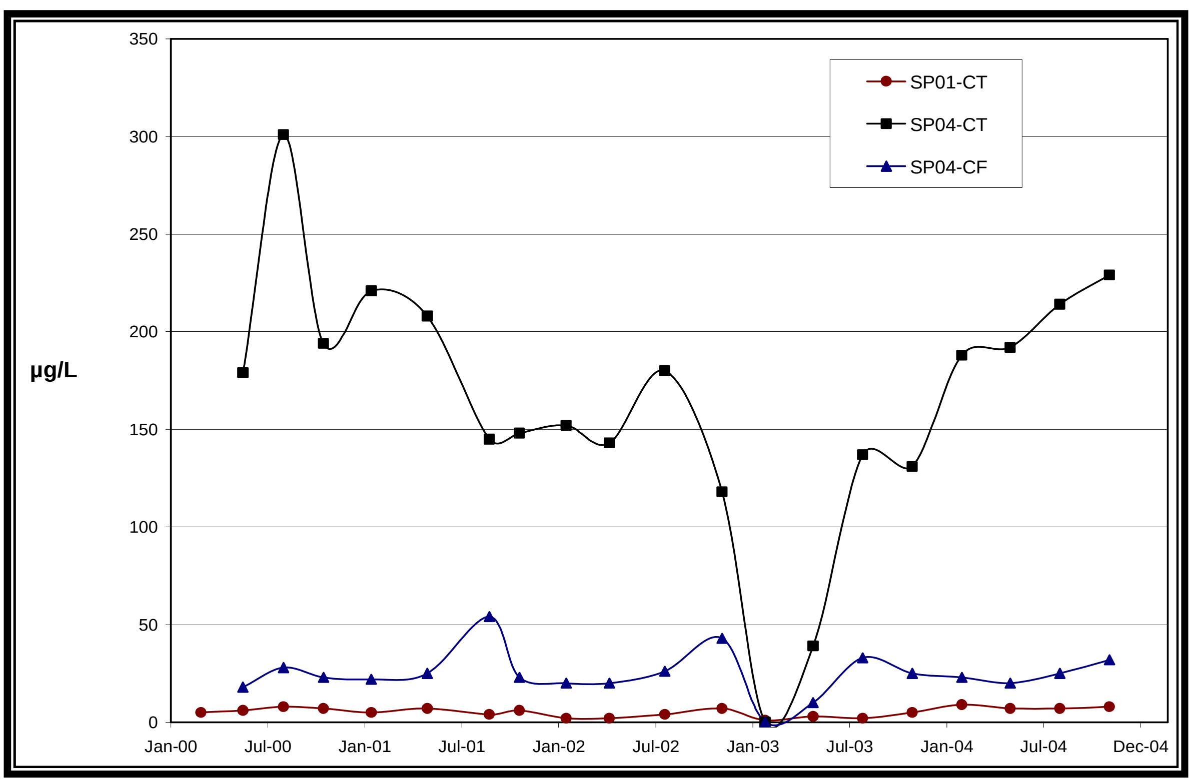


FIGURE 6.18 Carbon Tetrachloride and Chloroform Concentrations in Seep Water, 2000 to 2004

6.3.2. Monitoring Studies

During October 1992, 15 stainless steel wells, 800161 through 800203D, were installed around the landfill as part of the IEPA-approved closure plan. Wells 800172 and 800182 are consistently dry. The 13 active wells are required to be monitored as part of the IEPA-approved groundwater monitoring program, effective January 1995. These wells are set in five clusters; each cluster consists of a shallow, medium, and deep well (see Figure 6.19 and Table 6.23).

In late spring of 1999, an environmental remediation project was completed that resulted in the extension of the landfill cap in the north portion of the landfill to cover some recently identified waste material. As part of this project, the landfill cap, perimeter road, and fence were moved 15 m (50 ft) north, and monitoring wells 800161, 800162, and 800163D were replaced. Sampling of the replacement wells — 800381, 800382, and 800383D — commenced in July 1999.

IEPA Supplemental Permit No. 1999-107-SP, effective June 16, 1999, provided for (1) the installation and addition of 3 new upgradient groundwater monitoring wells (800271, 800272, and 800273D) and (2) the addition of 10 new downgradient groundwater monitoring wells (800281, 800291, 800301, 800311, 800321, 800331, 800341, 800351, 800361, and 800371). Sampling of these wells commenced in October 1999. Table 6.23 provides information on these wells, and Figure 6.19 shows their locations. Wells 800272 and 800311 have been dry since installation.

6.3.2.1. Sample Collection

The same well water sample collection procedure described for the 300 Area was used for the landfill area. Each well is sampled annually for SVOCs, PCBs, pesticides, and herbicides. In accordance with the IEPA-approved groundwater monitoring plan, collection of both filtered and unfiltered samples for analysis of numerous parameters (e.g., metals, chloride, and sulfate) is required during the second quarter. Volatile organics are monitored each quarter, although VOC monitoring is only required by permit during the second quarter. Beginning in April 2003, a low-flow technology was used for groundwater sampling in Well 800191. The IEPA informed ANL that the technology was not approved, and low-flow sampling at Well 800191 ceased during the fourth quarter. Well 800191 will be replaced with a new well, which will be sampled by using an IEPA-approved low-flow technology. Wells 800281 and 800381 were sampled by using low-flow technology beginning October 2003 and throughout 2004. Low-flow sampling technology was initiated during the third quarter for Wells 800201 and 800361 and during the fourth quarter for Wells 800171, 800271, 800291, and 800301.

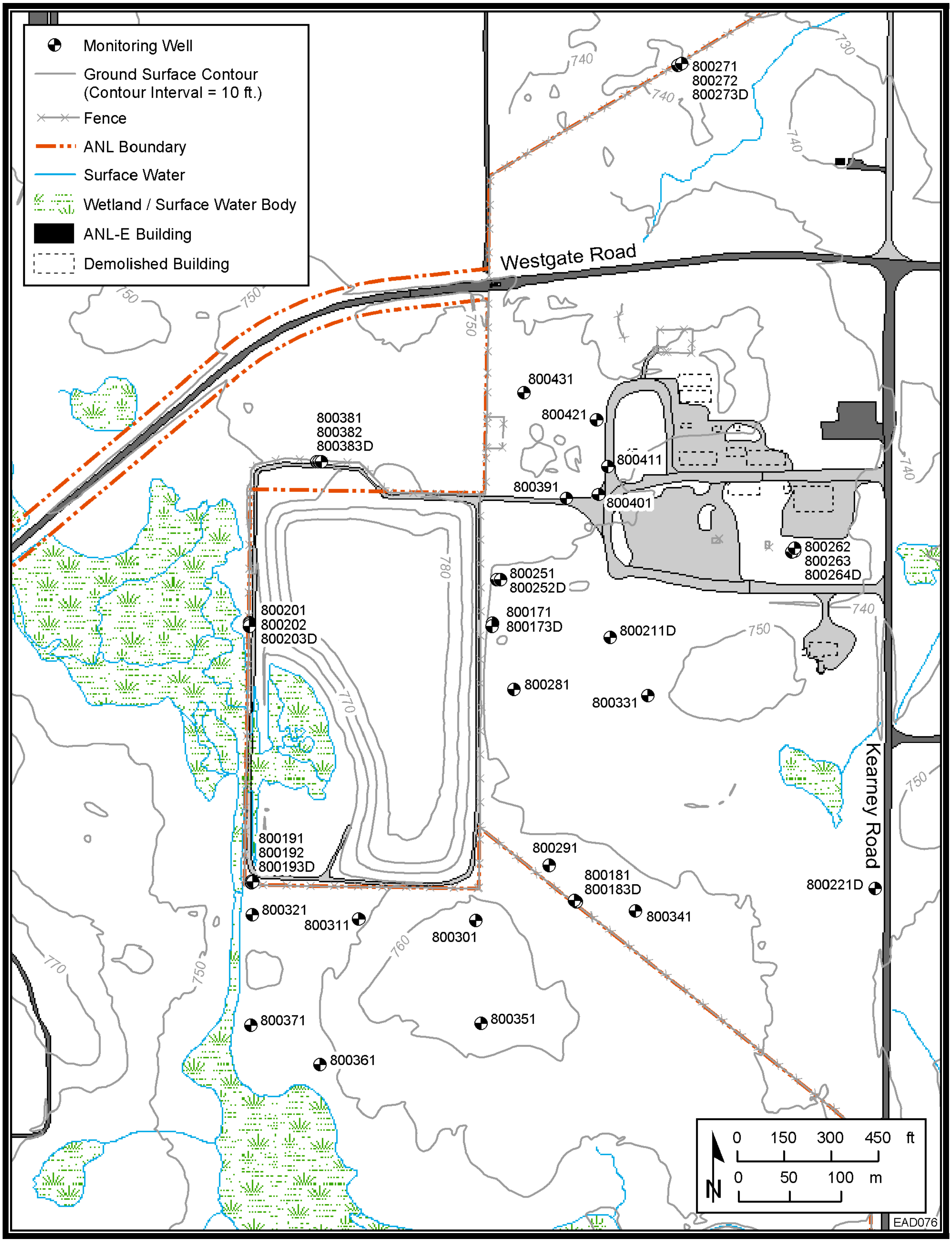


FIGURE 6.19 Monitoring Wells in the 800 Area

TABLE 6.23

Groundwater Monitoring Wells: 800 Area Landfill

ID Number[a]	Well Depth (m bgs)	Ground Elevation (m AMSL)	Monitoring Zone (m AMSL)	Well Type[b]	Date Drilled
800171	7.62	228.42	222.32–220.80	0.05/SS	10/92
800173D	39.62	228.40	192.13–189.09	0.05/SS	10/92
800181	10.67	230.52	221.37–219.85	0.05/SS	10/92
800183D	49.99	230.37	183.43–180.38	0.05/SS	10/92
800191	4.63	227.38	224.43–222.90	0.05/SS	10/92
800192	18.29	227.40	210.63–209.11	0.05/SS	10/92
800193D	46.02	227.34	184.40–181.35	0.05/SS	10/92
800201	10.67	227.93	218.78–217.26	0.05/SS	10/92
800202	18.38	227.92	211.07–209.54	0.05/SS	10/92
800203D	38.40	227.92	192.63–189.47	0.05/SS	9/92
800271	4.57	225.62	223.18–221.65	0.05/SS	8/99
800272	13.72	225.61	213.42–211.90	0.05/SS	8/99
800273D	37.49	225.61	191.78–188.12	0.05/SS	8/99
800281	3.96	227.66	225.52–224.00	0.05/SS	9/99
800291	7.01	230.49	225.00–223.48	0.05/SS	9/99
800301	7.62	232.53	226.51–224.91	0.05/SS	9/99
800311	13.72	227.41	217.35–214.31	0.05/SS	9/99
800321	4.27	227.93	225.26–223.66	0.05/SS	9/99
800331	5.18	227.93	224.27–222.75	0.05/SS	9/99
800341	3.96	229.97	227.53–226.01	0.05/SS	9/99
800351	11.89	232.75	223.91–220.86	0.05/SS	9/99
800361	7.01	227.24	222.12–220.52	0.05/SS	9/99
800371	9.75	227.50	219.27–217.44	0.05/SS	9/99
800381[c]	7.31	231.11	227.44–224.40	0.05/SS	6/99
800382[c]	19.20	231.18	215.33–212.28	0.05/SS	6/99
800383D[c]	44.50	231.24	190.39–187.35	0.05/SS	6/99

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

[b] Inner diameter (m)/well material (SS = stainless steel).

[c] Replacement wells used after July 1, 1999.

6.3.2.2. Sample Analyses — 800 Area

The 800 Area sample analyses were performed by using SOPs written, reviewed, and issued as controlled documents by members of EQO-AS. These SOPs reference protocols in EPA-SW-846.[26] Fifteen metals were analyzed by using inductively coupled plasma atomic emission spectroscopy and graphite furnace atomic absorption spectroscopy. Mercury was determined by means of cold vapor atomic absorption spectroscopy. VOCs were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. SVOCs were determined by using solvent extraction followed by gas chromatography-mass spectroscopy 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 means of titrimetry. Ammonia nitrogen was determined by using distillation followed by an ion-selective electrode technique.

Some analyses were performed at an off-site contractor laboratory. EPA-SW-846[26] procedures were specified and used. Cyanide and phenol were determined by distillation followed by a spectrophotometric measurement. Total organic carbon (TOC) and total organic halogen (TOX) were determined by using combustion techniques followed by infrared detection and coulometric titration, respectively. Chlorinated organic compounds and carbamate pesticides were analyzed by extractions followed by gas and liquid chromatography techniques, respectively.

The 800 Area groundwater radiological analyses were performed by using SOPs written, reviewed, and issued as controlled documents by members of EQO-AS. Hydrogen-3 was determined by means of distillation followed by a beta liquid scintillation counting technique. Cesium-137 was determined by using gamma-ray spectrometry.

6.3.2.3. Basis for Evaluation of Analytical Results

For filtered samples, the permit requires the comparison of the individual results with a background data set (derived from well nest 800271, 800272, and 800273D) that represents at least 20 quarters of data. For comparison of the 2004 data, ANL used 21 quarters of data covering the period from the fourth quarter of 1999 through the fourth quarter of 2004. The statistical evaluation was conducted by using the procedures outlined in the permit for the shallow upgradient well results (800271) and the deep upgradient well results (800273D). The intermediate well, 800272, was dry during the entire period.

For unfiltered samples, the results are compared to the Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater (35 IAC Part 620.410).

6.3.2.4. Results of Analyses

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 800 Area are presented in Tables 6.24 to 6.47. All radiological and inorganic analysis results are shown in these tables. The analytical methods used for organic compounds could be used to identify and quantify all the compounds contained in the CLP Target Compound List. However, the vast majority of these compounds were not detected in the samples. Only those constituents that were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 5 μg/L.

The IEPA has mandated that ANL utilize the Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater (35 IAC Part 620.410) for comparison with groundwater quality results for all unfiltered parameters.

In general, groundwater quality at the 800 Area Landfill appears to be related to the level of turbidity in the sample. A low-flow sampling technology is now used for eight wells to reduce the effect of turbidity on measured parameter levels. The application of a clay cap to the landfill, which was completed in October 1993, may prevent migration of contaminants from the glacial drift. Comparison of a number of years' monitoring results indicates that several parameters consistently exceed the WQSs at selected wells.

The constituents most commonly detected at elevated levels (filtered samples) and at levels above the WQS (unfiltered samples) in the shallow wells are chloride, iron, lead, manganese, sulfate, and TDS. Figure 6.20 shows the trend for unfiltered manganese WQS exceedances for the shallow wells. When comparing unfiltered results of bailer-sampled wells with low-flow-technology sampled wells, it appears that reduced turbidity has a noticeable effect on measured parameter levels. Further studies are continuing with IEPA approval to further evaluate the low-flow sampling technique.

Field Parameters. Field parameters include well and water depth information, pH, specific conductance, and temperature of water. These parameters are measured each quarter. No standards exist for comparative purposes, with the exception of pH. However, results are consistent from quarter to quarter and are similar to results obtained in previous years.

Filtered Routine Indicator Parameters. Filtered routine indicator parameters include ammonia nitrogen, arsenic, cadmium, chloride, iron, lead, manganese, mercury, sulfate, and TDS. These parameters are measured each quarter. As noted in past years, manganese is the most persistent elevated parameter noted in the shallow wells. Manganese concentrations were elevated in 9 of the 16 shallow wells. Elevated levels were noted each quarter in Wells 800191, 800201, 800291, 200301, and 800361. Manganese levels ranged from 0.16 to 1.3 mg/L. Chloride was detected in seven shallow wells at levels ranging from 11 to 249 mg/L. TDS levels were elevated in all shallow wells, ranging from 591 to 2,738 mg/L. Sulfate levels were also elevated in all shallow wells, ranging from 52 to 1,630 mg/L.

Historically, fewer indicator parameters are found in the intermediate wells, and those are detected infrequently. Elevated levels of manganese were measured during three quarters in Well 800192. Iron concentrations were elevated during one quarter in Wells 800192 and 800202.

TABLE 6.24

Groundwater Monitoring Results, Sanitary Landfill Well 800381, 2004

		Date of Sampling			
Parameter	Unit	1/20/2004	4/27/2004	7/20/2004	10/19/2004
Water elevation[a]	m	228.07	229.25	227.96	227.07
Temperature	º C	10.0	12.5	21.1	12.5
pH	pH	6.95	6.91	7.02	7.11
Redox	mV	-4	16	6	2
Conductivity	µmhos/cm	1,581	1,552	1,539	1,244
Chloride[b]	mg/L	39	37	39	44
Sulfate[b]	mg/L	371	303	420	287
TDS[b]	mg/L	1,110	1,066	1,215	1,069
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[c]	mg/L	0.0350	0.0584	0.0427	0.0694
Boron[c]	mg/L	–[d]	0.0902	0.0584	0.0602
Cadmium[c]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[c]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[c]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[c]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[c]	mg/L	0.2278	0.5325	1.4125	1.2159
Lead[c]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[c]	mg/L	**0.3189**[e]	**0.2043**	**0.2911**	**0.2202**
Mercury[c]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[c]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[c]	mg/L	0.0254	0.0257	0.0488	0.0203
Ammonia nitrogen[b]	mg/L	0.07	0.07	0.55	0.06
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0367	0.0598	0.0485	0.0630
Boron[b]	mg/L	–	0.0607	0.0456	0.0577
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.015	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	0.0392
Copper[b]	mg/L	< 0.01	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0806	0.0933	0.3752	0.5530
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.3460	0.2206	0.3206	0.2237
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.1133	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0266	0.0203	0.0143	0.0237
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	0.08	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	41	–	44
Fluoride[c]	mg/L	–	0.356	–	0.459
Sulfate[c]	mg/L	–	296	–	281
TOCs[c]	mg/L	3.2	3.2	4.5	3.7
TOCs[c]	mg/L	3.2	3.3	4.5	3.7
TOCs[c]	mg/L	3.2	3.2	4.6	3.6
TOCs[c]	mg/L	3.1	3.1	4.5	3.7
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	0.021	< 0.02	< 0.02

[a] Well point elevation = 224.40 m (MSL); ground surface elevation = 231.11 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.25

Groundwater Monitoring Results, Sanitary Landfill Well 800382, 2004

		Date of Sampling				
Parameter	Unit	1/17/2004	4/14/2004	7/19/2004	7/19/2004	10/4/2004
Water elevation[a]	m	218.98	219.07	219.07	219.57	219.54
Temperature	º C	9.9	13.4	13.0	13.0	11.8
pH	pH	7.46	7.18	7.73	7.73	7.13
Redox	mV	–30	1	–57	–57	3
Conductivity	µmhos/cm	846	932	1,085	1,085	895
Chloride[b]	mg/L	82	72	113	113	97
Sulfate[b]	mg/L	78	79	78	87	84
TDS[b]	mg/L	678	751	671	675	663
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0032	–	–	–
Barium[c]	mg/L	–	0.1332	–	–	–
Boron[c]	mg/L	–	0.0737	–	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–	–
Chromium[c]	mg/L	–	< 0.024	–	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–	–
Copper[c]	mg/L	–	< 0.015	–	–	–
Iron[c]	mg/L	–	**7.518[e]**	–	–	–
Lead[c]	mg/L	–	< 0.002	–	–	–
Manganese[c]	mg/L	–	**0.1780**	–	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–	–
Nickel[c]	mg/L	–	< 0.02	–	–	–
Selenium[c]	mg/L	–	< 0.003	–	–	–
Silver[c]	mg/L	–	< 0.001	–	–	–
Zinc[c]	mg/L	–	0.0188	–	–	–
Ammonia nitrogen[b]	mg/L	0.21	< 0.05	< 0.05	0.09	0.25
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.1144	0.1240	0.1178	0.1168	0.1293
Boron[b]	mg/L	–	0.0534	0.0477	0.0447	0.0491
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.6450	1.176	0.1448	0.1439	0.9086
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0656	0.1133	0.0679	0.0727	0.1200
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Nitrate[c]	mg/L	–	< 0.1	–	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	96	–	–	–
Fluoride[c]	mg/L	–	0.236	–	–	–
Sulfate[c]	mg/L	–	76	–	–	–
TOCs[c]	mg/L	2.6	2.7	3.0	2.8	4.0
TOCs[c]	mg/L	2.5	2.8	2.8	3.0	4.1
TOCs[c]	mg/L	2.5	3.0	2.8	2.8	4.3
TOCs[c]	mg/L	2.5	2.8	2.7	2.9	4.2
TOXs[c]	mg/L	< 0.02	0.026	0.026	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	0.031	0.031	0.028	< 0.02

[a] Well point elevation = 212.28 m (MSL); ground surface elevation = 231.18 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.26

Groundwater Monitoring Results, Sanitary Landfill Well 800383D, 2004

		Date of Sampling				
Parameter	Unit	1/13/2004	1/13/2004	4/14/2004	7/19/2004	10/4/2004
Water elevation[a]	m	191.76	191.76	191.93	192.30	191.83
Temperature	º C	10.5	10.5	13.4	13.4	11.9
pH	pH	7.36	7.36	7.09	7.32	7.17
Redox	mV	-25	-25	5	-43	0
Conductivity	µmhos/cm	1,020	1,020	1,159	1,408	1,250
Chloride[b]	mg/L	135	133	117	204	233
Sulfate[b]	mg/L	149	161	161	136	127
TDS[b]	mg/L	806	794	863	955	918
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	–	0.0106	–	–
Barium[c]	mg/L	–	–	0.1161	–	–
Boron[c]	mg/L	–	–	0.1476	–	–
Cadmium[c]	mg/L	–	–	< 0.0002	–	–
Chromium[c]	mg/L	–	–	0.0244	–	–
Cobalt[c]	mg/L	–	–	< 0.016	–	–
Copper[c]	mg/L	–	–	0.0393	–	–
Iron[c]	mg/L	–	–	2.625	–	–
Lead[c]	mg/L	–	–	< 0.002	–	–
Manganese[c]	mg/L	–	–	0.081	–	–
Mercury[c]	mg/L	–	–	< 0.0002	–	–
Nickel[c]	mg/L	–	–	0.0401	–	–
Selenium[c]	mg/L	–	–	< 0.003	–	–
Silver[c]	mg/L	–	–	< 0.001	–	–
Zinc[c]	mg/L	–	–	0.1036	–	–
Ammonia nitrogen[b]	mg/L	0.76	0.80	0.08	0.57	0.91
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0690	0.0668	0.0701	0.0727	0.0770
Boron[b]	mg/L	–	–	0.1576	0.1511	0.1548
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	1.298	1.296	0.952	1.435	1.004
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0488	0.0474	0.0485	0.0517	0.0532
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0212	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	< 0.008	0.021
Nitrate[c]	mg/L	–	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	453	< 100	< 100
Chloride[c]	mg/L	–	–	124	–	–
Fluoride[c]	mg/L	–	–	0.450	–	–
Sulfate[c]	mg/L	–	–	168	–	–
TOCs[c]	mg/L	1.4	1.5	1.6	1.7	3.1
TOCs[c]	mg/L	1.4	1.5	1.7	1.7	2.8
TOCs[c]	mg/L	1.4	1.4	1.7	1.6	2.8
TOCs[c]	mg/L	1.4	1.5	1.7	1.7	2.9
TOXs[c]	mg/L	< 0.02	< 0.02	0.021	0.024	0.021
TOXs[c]	mg/L	< 0.02	< 0.02	0.024	0.021	< 0.02

[a] Well point elevation = 187.35 m (MSL); ground surface elevation = 231.24 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 2004

Parameter	Unit	Date of Sampling 1/12/2004	4/5/2004	7/6/2004	10/25/2004
Water elevation[a]	m	226.75	227.19	226.12	225.59
Temperature	º C	9.4	10.6	12.0	14.8
pH	pH	7.28	7.35	6.73	6.98
Redox	mV	-13	-45	24	10
Conductivity	µmhos/cm	804	849	1,030	918
Chloride[b]	mg/L	8	8	8	8
Sulfate[b]	mg/L	95	77	79	85
TDS[b]	mg/L	646	600	636	687
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	< 0.003
Barium[c]	mg/L	–	0.0621	–	0.0543
Boron[c]	mg/L	–	0.1728	–	0.1461
Cadmium[c]	mg/L	–	< 0.0002	–	< 0.0002
Chromium[c]	mg/L	–	< 0.024	–	< 0.024
Cobalt[c]	mg/L	–	< 0.016	–	< 0.016
Copper[c]	mg/L	–	< 0.015	–	< 0.015
Iron[c]	mg/L	–	3.9116	–	0.1118
Lead[c]	mg/L	–	< 0.002	–	< 0.002
Manganese[c]	mg/L	–	**0.4157[e]**	–	0.0279
Mercury[c]	mg/L	–	< 0.0002	–	< 0.0002
Nickel[c]	mg/L	–	< 0.02	–	< 0.02
Selenium[c]	mg/L	–	< 0.003	–	< 0.003
Silver[c]	mg/L	–	< 0.001	–	< 0.001
Zinc[c]	mg/L	–	0.0237	–	< 0.008
Ammonia nitrogen[b]	mg/L	< 0.05	0.05	< 0.05	< 0.05
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0476	0.0455	0.0535	0.0533
Boron[b]	mg/L	–	0.1254	0.1493	0.1483
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.015	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.01	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1397	0.0564	0.0724	0.0201
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0852	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0291	< 0.008	< 0.008	0.0089
Nitrate[c]	mg/L	–	0.61	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Cesium-137[c]	pCi/L	–	< 2.0	–	–
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	8	–	5
Fluoride[c]	mg/L	–	0.214	–	0.279
Sulfate[c]	mg/L	–	75	–	84
TOCs[c]	mg/L	2.2	3.0	3.1	2.4
TOCs[c]	mg/L	2.2	3.0	3.1	2.6
TOCs[c]	mg/L	2.2	3.0	3.1	2.5
TOCs[c]	mg/L	2.3	3.1	3.1	2.6
TOXs[c]	mg/L	< 0.02	< 0.02	0.022	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	0.024	< 0.02

[a] Well point elevation = 220.80 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 2004

Parameter	Unit	Date of Sampling 1/12/2004	4/5/2004	7/6/2004	10/4/2004
Water elevation[a]	m	192.54	192.59	192.83	192.57
Temperature	º C	10.6	13.0	13.4	12.7
pH	pH	7.11	7.26	6.93	7.10
Redox	mV	-12	-39	12	-5
Conductivity	µmhos/cm	1,129	1,238	1,366	1,287
Chloride[b]	mg/L	200	186	202	196
Sulfate[b]	mg/L	108	130	138	107
TDS[b]	mg/L	874	820	888	944
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0046	–	–
Barium[c]	mg/L	–	0.0836	–	–
Boron[c]	mg/L	–	0.1637	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	< 0.015	–	–
Iron[c]	mg/L	–	3.848	–	–
Lead[c]	mg/L	–	< 0.002	–	–
Manganese[c]	mg/L	–	0.1063	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.0121	–	–
Ammonia nitrogen[b]	mg/L	1.0	0.13	0.44	0.74
Arsenic[b]	mg/L	0.0039	0.003	0.0040	< 0.003
Barium[b]	mg/L	0.0783	0.0773	0.0813	0.0837
Boron[b]	mg/L	–	0.1405	0.1452	0.1446
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	1.787	0.8451	1.5916	0.7654
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0667	0.0764	0.0647	0.0747
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	0.0218	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0082
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	0.0053
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	167	–	–
Fluoride[c]	mg/L	–	0.426	–	–
Sulfate[c]	mg/L	–	125	–	–
TOCs[c]	mg/L	3.6	4.2	3.2	4.5
TOCs[c]	mg/L	3.6	4.1	3.2	4.2
TOCs[c]	mg/L	3.5	4.1	3.2	4.7
TOCs[c]	mg/L	3.6	4.1	3.2	4.3
TOXs[c]	mg/L	0.021	0.037	< 0.02	< 0.02
TOXs[c]	mg/L	0.027	0.034	0.02	< 0.02

[a] Well point elevation = 189.09 m (MSL); ground surface elevation = 228.40 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 2004

		Date of Sampling		
Parameter	Unit	1/19/2004	4/12/2004	7/7/2004
Water elevation[a]	m	224.37	226.24	224.20
Temperature	º C	7.4	9.6	10.8
pH	pH	7.19	7.71	7.50
Redox	mV	-11	-29	-24
Conductivity	µmhos/cm	1,175	643	847
Chloride[b]	mg/L	7	6	6
Sulfate[b]	mg/L	148	52	90
TDS[b]	mg/L	803	432	524
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0117	–
Barium[c]	mg/L	–	0.1150	–
Boron[c]	mg/L	–	0.0639	–
Cadmium[c]	mg/L	–	< 0.0002	–
Chromium[c]	mg/L	–	0.0380	–
Cobalt[c]	mg/L	–	< 0.016	–
Copper[c]	mg/L	–	0.0151	–
Iron[c]	mg/L	–	**18.62**[e]	–
Lead[c]	mg/L	–	**0.0093**	–
Manganese[c]	mg/L	–	**0.4115**	–
Mercury[c]	mg/L	–	< 0.0002	–
Nickel[c]	mg/L	–	0.0355	–
Selenium[c]	mg/L	–	< 0.003	–
Silver[c]	mg/L	–	< 0.001	–
Zinc[c]	mg/L	–	0.0681	–
Ammonia nitrogen[b]	mg/L	< 0.05	0.080	< 0.05
Arsenic[b]	mg/L	0.0061	0.0084	0.006
Barium[b]	mg/L	0.0326	0.0127	0.0241
Boron[b]	mg/L	–	< 0.016	< 0.016
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0145	< 0.008	< 0.008
Nitrate[c]	mg/L	–	< 0.1	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100
Chloride[c]	mg/L	–	6	–
Fluoride[c]	mg/L	–	1.766	–
Sulfate[c]	mg/L	–	59	–
TOCs[c]	mg/L	2.7	2.4	3.0
TOCs[c]	mg/L	2.7	2.3	3.1
TOCs[c]	mg/L	2.6	2.4	2.7
TOCs[c]	mg/L	2.7	2.4	3.0
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 219.85 m (MSL); ground surface elevation = 230.52 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 2004

		Date of Sampling			
Parameter	Unit	1/19/2004	4/12/2004	7/7/2004	10/13/2004
Water elevation[a]	m	192.54	192.62	192.83	192.79
Temperature	º C	9.1	11.3	12.6	11.7
pH	pH	7.33	7.30	7.34	6.76
Redox	mV	-23	-6	-16	-11
Conductivity	µmhos/cm	1,151	1,140	1,254	1,298
Chloride[b]	mg/L	108	109	138	120
Sulfate[b]	mg/L	175	159	187	141
TDS[b]	mg/L	816	791	855	887
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	–
Barium[c]	mg/L	–	0.0472	–	–
Boron[c]	mg/L	–	0.1730	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	< 0.015	–	–
Iron[c]	mg/L	–	1.1004	–	–
Lead[c]	mg/L	–	< 0.002	–	–
Manganese[c]	mg/L	–	0.0153	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	< 0.008	–	–
Ammonia nitrogen[b]	mg/L	0.73	0.08	0.13	0.12
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0487	0.0425	0.0474	0.0462
Boron[b]	mg/L	–	0.1603	0.1661	0.1796
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.6160	0.2464	0.5612	0.6521
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	0.0053
Manganese[b]	mg/L	0.0159	0.0119	0.0148	0.0142
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0231
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	0.0064	0.0061
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	124	–	–
Fluoride[c]	mg/L	–	0.496	–	–
Sulfate[c]	mg/L	–	167	–	–
TOCs[c]	mg/L	2.2	2.3	2.5	5.4
TOCs[c]	mg/L	2.1	2.3	2.3	3.9
TOCs[c]	mg/L	2.1	2.2	2.3	4.0
TOCs[c]	mg/L	2.2	2.2	2.3	5.2
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

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

b Filtered sample.

c Unfiltered sample.

d A dash indicates that no samples were collected.

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800191, 2004

Parameter	Unit	Date of Sampling			
		1/13/2004	4/19/2004	7/13/2004	10/11/2004
Water elevation[a]	m	225.90	225.89	225.76	225.34
Temperature	º C	8.0	9.4	14.1	13.1
pH	pH	7.02	6.84	6.88	6.54
Redox	mV	-8	18	12	2
Conductivity	µmhos/cm	1,428	1,685	1,601	1,273
Chloride[b]	mg/L	249	113	124	124
Sulfate[b]	mg/L	284	380	382	192
TDS[b]	mg/L	1,306	1,237	1,275	862
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	< 0.003	< 0.003	< 0.003	–[d]
Barium[c]	mg/L	0.0839	0.0758	0.0699	–
Boron[c]	mg/L	–	0.0888	0.0847	–
Cadmium[c]	mg/L	< 0.0002	< 0.0002	< 0.0002	–
Chromium[c]	mg/L	< 0.024	< 0.024	< 0.024	–
Cobalt[c]	mg/L	< 0.016	< 0.016	< 0.016	–
Copper[c]	mg/L	< 0.015	< 0.015	< 0.015	–
Iron[c]	mg/L	4.306	4.223	3.8688	–
Lead[c]	mg/L	< 0.002	< 0.002	< 0.002	–
Manganese[c]	mg/L	**1.183**[e]	**1.2552**	**1.1942**	–
Mercury[c]	mg/L	< 0.0001	< 0.0002	< 0.0002	–
Nickel[c]	mg/L	< 0.02	< 0.02	< 0.02	–
Selenium[c]	mg/L	–	< 0.003	< 0.003	–
Silver[c]	mg/L	< 0.001	< 0.001	< 0.001	–
Zinc[c]	mg/L	0.0091	0.0081	0.0225	–
Ammonia nitrogen[b]	mg/L	1.70	< 0.05	0.18	0.17
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0838	0.0765	0.0748	0.0974
Boron[b]	mg/L	–	0.0588	0.0592	0.0683
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.015	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.01	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	3.801	3.2488	3.0278	0.6175
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	1.275	1.2922	1.2536	0.9057
Mercury[b]	mg/L	< 0.0001	0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0765	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0795
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	0.005	0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	112	< 100	< 100
Chloride[c]	mg/L	–	114	–	–
Fluoride[c]	mg/L	–	0.532	–	–
Sulfate[c]	mg/L	–	384	–	–
TOCs[c]	mg/L	6.5	5.8	5.8	11.0
TOCs[c]	mg/L	6.6	5.8	5.8	11.0
TOCs[c]	mg/L	6.6	5.8	5.8	11.0
TOCs[c]	mg/L	6.6	5.8	5.8	11.0
TOXs[c]	mg/L	0.028	0.026	0.026	0.038
TOXs[c]	mg/L	0.028	0.030	0.030	0.039

[a] Well point elevation = 222.90 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800192, 2004

		Date of Sampling			
Parameter	Unit	1/20/2004	4/7/2004	7/12/2004	10/5/2004
Water elevation[a]	m	219.75	220.46	218.94	221.96
Temperature	º C	9.7	12.1	13.1	10.6
pH	pH	6.55	6.63	6.09	7.19
Redox	mV	0	-1	57	11
Conductivity	µmhos/cm	1,375	1,256	1,495	1,234
Chloride[b]	mg/L	73	82	98	91
Sulfate[b]	mg/L	309	227	306	299
TDS[b]	mg/L	1,020	1,067	1,195	1,160
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0493	–	–
Barium[c]	mg/L	–	1.2438	–	–
Boron[c]	mg/L	–	0.4027	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	< 0.015	–	–
Iron[c]	mg/L	–	**142.8[e]**	–	–
Lead[c]	mg/L	–	< 0.002	–	–
Manganese[c]	mg/L	–	**0.1703**	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.0173	–	–
Ammonia nitrogen[b]	mg/L	2.90	0.91	0.29	2.2
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.4650	0.4193	0.4782	0.4148
Boron[b]	mg/L	–	0.0525	0.0379	0.0447
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	0.0172	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	11.606	0.1138	0.0505	2.3859
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.2108	0.1269	0.1609	0.2869
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0349
Nitrate[c]	mg/L	–	0.20	–	–
Phenols[c]	mg/L	0.018	0.011	0.011	< 0.005
Hydrogen-3[c]	pCi/L	363	318	373	248
Chloride[c]	mg/L	–	79	–	–
Fluoride[c]	mg/L	–	0.450	–	–
Sulfate[c]	mg/L	–	244	–	–
TOCs[c]	mg/L	17.0	16.0	17.0	21.0
TOCs[c]	mg/L	17.0	16.0	17.0	20.0
TOCs[c]	mg/L	17.0	17.0	16.0	21.0
TOCs[c]	mg/L	17.0	17.0	16.0	21.0
TOXs[c]	mg/L	< 0.02	0.032	0.034	0.040
TOXs[c]	mg/L	< 0.02	0.034	0.032	0.042

[a] Well point elevation = 209.11 m (MSL); ground surface elevation = 227.40 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 2004

Parameter	Unit	Date of Sampling 1/20/2004	4/6/2004	4/6/2004	7/12/2004	10/5/2004
Water elevation[a]	m	192.50	192.7	192.71	192.22	192.57
Temperature	° C	9.8	11.4	11.4	13.2	11.4
pH	pH	6.47	6.99	6.99	7.11	7.06
Redox	mV	5	-24	-24	-7	7
Conductivity	µmhos/cm	1,225	1,196	1,196	1,333	1,145
Chloride[b]	mg/L	542	121	104	145	130
Sulfate[b]	mg/L	200	188	184	201	172
TDS[b]	mg/L	846	828	836	1,003	905
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.006	0.0033	–	–
Barium[c]	mg/L	–	0.0721	0.0723	–	–
Boron[c]	mg/L	–	0.1901	0.1730	–	–
Cadmium[c]	mg/L	–	< 0.0002	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	< 0.016	–	–
Copper[c]	mg/L	–	< 0.015	< 0.015	–	–
Iron[c]	mg/L	–	4.1597	3.0435	–	–
Lead[c]	mg/L	–	< 0.002	< 0.002	–	–
Manganese[c]	mg/L	–	0.0572	0.0394	–	–
Mercury[c]	mg/L	–	< 0.0002	< 0.002	–	–
Nickel[c]	mg/L	–	< 0.02	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	< 0.001	–	–
Zinc[c]	mg/L	–	< 0.008	< 0.008	–	–
Ammonia nitrogen[b]	mg/L	0.70	0.09	0.16	0.09	0.62
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0597	0.0580	0.0603	0.0608	0.0599
Boron[b]	mg/L	–	0.1653	0.1685	0.1543	0.1623
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	1.221	0.9010	1.0853	1.2051	1.1057
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	0.0037
Manganese[b]	mg/L	0.0266	0.0225	0.0384	0.0234	0.0337
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Nitrate[c]	mg/L	–	< 0.1	< 0.1	–	–
Phenols[c]	mg/L	0.016	0.010	< 0.005	0.010	0.0056
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	118	101	–	–
Fluoride[c]	mg/L	–	0.485	0.613	–	–
Sulfate[c]	mg/L	–	192	181	–	–
TOCs[c]	mg/L	2.5	3.3	3.1	3.2	3.5
TOCs[c]	mg/L	2.5	3.2	3.0	3.3	3.5
TOCs[c]	mg/L	2.5	3.2	3.0	3.2	3.4
TOCs[c]	mg/L	2.4	3.2	3.1	3.2	3.5
TOXs[c]	mg/L	0.025	0.064	0.029	0.064	< 0.02
TOXs[c]	mg/L	0.020	0.077	0.022	0.077	< 0.02

[a] Well point elevation = 181.35 m (MSL); ground surface elevation = 227.34 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 2004

		Date of Sampling			
Parameter	Unit	1/12/2004	4/13/2004	7/28/2004	10/13/2004
Water elevation[a]	m	224.56	225.04	224.42	224.17
Temperature	° C	9.3	10.8	17.1	12.9
pH	pH	7.23	7.01	7.13	6.49
Redox	mV	-18	9	3	3
Conductivity	µmhos/cm	841	994	1,088	1,145
Chloride[b]	mg/L	12	14	20	14
Sulfate[b]	mg/L	65	58	80	82
TDS[b]	mg/L	738	737	778	746
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0164	0.0068	0.0077
Barium[c]	mg/L	–	0.3110	0.2796	0.2717
Boron[c]	mg/L	–	0.1100	0.0608	0.0527
Cadmium[c]	mg/L	–	< 0.0002	< 0.0002	< 0.0002
Chromium[c]	mg/L	–	0.0293	< 0.024	< 0.024
Cobalt[c]	mg/L	–	< 0.016	< 0.016	< 0.016
Copper[c]	mg/L	–	0.0191	< 0.015	< 0.015
Iron[c]	mg/L	–	**20.28[e]**	4.4915	3.8157
Lead[c]	mg/L	–	**0.0084**	< 0.002	< 0.002
Manganese[c]	mg/L	–	**0.6986**	**0.3089**	**0.3125**
Mercury[c]	mg/L	–	< 0.0002	< 0.0002	< 0.0002
Nickel[c]	mg/L	–	0.0378	< 0.02	< 0.02
Selenium[c]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[c]	mg/L	–	< 0.001	< 0.001	< 0.001
Zinc[c]	mg/L	–	0.0712	0.0227	0.0256
Ammonia nitrogen[b]	mg/L	3.3	3.3	3.5	3.2
Arsenic[b]	mg/L	0.0033	0.0034	0.0040	0.0042
Barium[b]	mg/L	0.2661	0.2407	0.2678	0.2559
Boron[b]	mg/L	–	0.0440	0.0497	0.0521
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.015	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.010	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	1.499	0.8764	2.5175	2.6242
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.3433	0.2074	0.3245	0.2860
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0970	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0209	0.0082	0.0184	0.0602
Nitrate[c]	mg/L	–	0.48	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	100	< 100
Chloride[c]	mg/L	–	13	–	15
Fluoride[c]	mg/L	–	0.38	–	0.447
Sulfate[c]	mg/L	–	58	–	83
TOCs[c]	mg/L	30.0	30.0	31.0	33.0
TOCs[c]	mg/L	30.0	30.0	30.0	33.0
TOCs[c]	mg/L	30.0	30.0	31.0	32.0
TOCs[c]	mg/L	30.0	30.0	31.0	33.0
TOXs[c]	mg/L	< 0.02	< 0.02	0.032	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 217.26 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800202, 2004

		Date of Sampling				
Parameter	Unit	1/12/2004	4/13/2004	7/14/2004	10/5/2004	10/5/2004
Water elevation[a]	m	221.30	218.61	218.87	218.43	218.43
Temperature	º C	10.0	11.1	12.9	12.4	12.4
pH	pH	7.50	7.16	7.51	7.11	7.11
Redox	mV	-32	0	-53	8	8
Conductivity	µmhos/cm	816	935	1,034	884	884
Chloride[b]	mg/L	22	24	27	24	24
Sulfate[b]	mg/L	74	77	83	76	76
TDS[b]	mg/L	617	641	659	638	651
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	–	–
Barium[c]	mg/L	–	0.1992	–	–	–
Boron[c]	mg/L	–	0.1108	–	–	–
Cadmium[c]	mg/L	–	0.0003	–	–	–
Chromium[c]	mg/L	–	< 0.024	–	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–	–
Copper[c]	mg/L	–	< 0.015	–	–	–
Iron[c]	mg/L	–	**5.8331[e]**	–	–	–
Lead[c]	mg/L	–	< 0.002	–	–	–
Manganese[c]	mg/L	–	0.1016	–	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–	–
Nickel[c]	mg/L	–	< 0.02	–	–	–
Selenium[c]	mg/L	–	< 0.003	–	–	–
Silver[c]	mg/L	–	< 0.001	–	–	–
Zinc[c]	mg/L	–	< 0.008	–	–	–
Ammonia nitrogen[b]	mg/L	2.3	1.9	2.2	2.1	2.2
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.2022	0.1773	0.1906	0.1681	0.1833
Boron[b]	mg/L	–	0.0788	0.0685	0.0722	0.0886
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	5.7597	3.7890	4.3593	4.0177	3.9809
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1177	0.1022	0.1009	0.0968	0.0991
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0090	0.0103
Nitrate[c]	mg/L	–	< 0.1	–	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	23	–	–	–
Fluoride[c]	mg/L	–	0.422	–	–	–
Sulfate[c]	mg/L	–	71	–	–	–
TOCs[c]	mg/L	11.0	11.0	11.0	13.0	13.0
TOCs[c]	mg/L	12.0	11.0	11.0	13.0	13.0
TOCs[c]	mg/L	11.0	11.0	11.0	13.0	13.0
TOCs[c]	mg/L	11.0	11.0	11.0	13.0	13.0
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 209.54 m (MSL); ground surface elevation = 227.92 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 2004

Parameter	Unit	Date of Sampling			
		1/12/2004	4/13/2004	7/14/2004	10/4/2004
Water elevation[a]	m	192.59	192.72	192.84	192.63
Temperature	º C	9.8	10.7	12.7	10.5
pH	pH	7.24	7.15	7.54	7.19
Redox	mV	-19	1	-56	0
Conductivity	µmhos/cm	820	962	1,080	880
Chloride[b]	mg/L	74	106	128	75
Sulfate[b]	mg/L	58	54	47	39
TDS[b]	mg/L	649	666	679	635
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0037	–	–
Barium[c]	mg/L	–	0.1242	–	–
Boron[c]	mg/L	–	0.1753	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	0.0814	–	–
Copper[c]	mg/L	–	< 0.015	–	–
Iron[c]	mg/L	–	1.3218	–	–
Lead[c]	mg/L	–	< 0.002	–	–
Manganese[c]	mg/L	–	0.0455	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	< 0.008	–	–
Ammonia nitrogen[b]	mg/L	1.9	1.7	1.7	2.0
Arsenic[b]	mg/L	0.0037	0.0037	0.0037	< 0.003
Barium[b]	mg/L	0.1288	0.1251	0.1253	0.1225
Boron[b]	mg/L	–	0.1581	0.1500	0.1636
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	0.0576	0.0673	0.0900	0.0808
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	1.4121	0.6618	0.9327	0.7985
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0357	0.0421	0.0478	0.0421
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0109
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	117	–	–
Fluoride[c]	mg/L	–	0.532	–	–
Sulfate[c]	mg/L	–	55	–	–
TOCs[c]	mg/L	4.1	4.5	4.5	5.1
TOCs[c]	mg/L	4.1	4.6	4.6	5.1
TOCs[c]	mg/L	4.2	4.5	4.5	5.1
TOCs[c]	mg/L	4.2	4.5	4.5	5.2
TOXs[c]	mg/L	< 0.02	< 0.02	0.022	< 0.02
TOXs[c]	mg/L	< 0.02	0.022	< 0.02	< 0.02

[a] Well point elevation = 189.47 m (MSL); ground surface elevation = 227.92 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800271, 2004

Parameter	Unit	Date of Sampling			
		1/12/2004	4/5/2004	7/6/2004	10/19/2004
Water elevation[a]	m	224.79	225.24	224.13	223.41
Temperature	º C	8.4	7.9	13.4	11.9
pH	pH	7.54	8.11	7.54	6.90
Redox	mV	-29	-83	-22	-2
Conductivity	µmhos/cm	479	586	666	702
Chloride[b]	mg/L	2	4	4	2
Sulfate[b]	mg/L	41	44	44	51
TDS[b]	mg/L	339	397	393	420
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	< 0.003
Barium[c]	mg/L	–	0.0416	–	0.0166
Boron[c]	mg/L	–	0.1093	–	0.0384
Cadmium[c]	mg/L	–	< 0.0002	–	< 0.0002
Chromium[c]	mg/L	–	< 0.024	–	< 0.024
Cobalt[c]	mg/L	–	< 0.016	–	< 0.016
Copper[c]	mg/L	–	< 0.015	–	< 0.015
Iron[c]	mg/L	–	**15.36[e]**	–	0.1646
Lead[c]	mg/L	–	0.0067	–	< 0.002
Manganese[c]	mg/L	–	**0.2221**	–	< 0.01
Mercury[c]	mg/L	–	< 0.0002	–	< 0.0002
Nickel[c]	mg/L	–	0.0224	–	< 0.02
Selenium[c]	mg/L	–	< 0.003	–	< 0.003
Silver[c]	mg/L	–	< 0.001	–	< 0.001
Zinc[c]	mg/L	–	0.0534	–	< 0.008
Ammonia nitrogen[b]	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0148	0.0173	0.0184	0.0168
Boron[b]	mg/L	–	0.0471	0.0535	0.0494
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.015	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.010	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0304	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0181
Nitrate[c]	mg/L	–	2.4	–	–
Phenols[c]	mg/L	< 0.005	0.033	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	4	–	2
Fluoride[c]	mg/L	–	0.144	–	0.397
Sulfate[c]	mg/L	–	49	–	52
TOCs[c]	mg/L	1.3	1.8	1.6	1.4
TOCs[c]	mg/L	1.3	1.7	1.8	1.5
TOCs[c]	mg/L	1.3	1.6	1.7	1.4
TOCs[c]	mg/L	1.3	1.6	1.7	1.6
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 221.65 m (MSL); ground surface elevation = 225.62 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well 800273D, 2004

Parameter	Unit	Date of Sampling				
		1/12/2004	4/5/2004	7/6/2004	10/6/2004	10/6/2004
Water elevation[a]	m	192.49	192.54	192.37	192.52	192.52
Temperature	° C	9.6	12.8	14.6	12.4	12.4
pH	pH	7.30	7.60	7.21	7.14	7.14
Redox	mV	-21	-53	-7	2	2
Conductivity	µmhos/cm	851	961	1,135	933	933
Chloride[b]	mg/L	80	87	110	88	89
Sulfate[b]	mg/L	130	128	130	137	150
TDS[b]	mg/L	665	657	745	758	773
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	–	–
Barium[c]	mg/L	–	0.0406	–	–	–
Boron[c]	mg/L	–	0.1734	–	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–	–
Chromium[c]	mg/L	–	< 0.024	–	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–	–
Copper[c]	mg/L	–	< 0.015	–	–	–
Iron[c]	mg/L	–	1.2362	–	–	–
Lead[c]	mg/L	–	< 0.002	–	–	–
Manganese[c]	mg/L	–	0.0113	–	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–	–
Nickel[c]	mg/L	–	< 0.02	–	–	–
Selenium[c]	mg/L	–	< 0.003	–	–	–
Silver[c]	mg/L	–	< 0.001	–	–	–
Zinc[c]	mg/L	–	< 0.008	–	–	–
Ammonia nitrogen[b]	mg/L	0.82	0.09	0.55	0.54	0.80
Arsenic[b]	mg/L	< 0.003	0.0036	0.0032	< 0.003	< 0.003
Barium[b]	mg/L	0.0407	0.0424	0.0442	0.0436	0.0444
Boron[b]	mg/L	–	0.1601	0.1541	0.1549	0.1599
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.7780	0.8614	0.6388	0.2668	0.6039
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0107	< 0.01	0.0102	0.0116	0.0103
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0092	0.0081
Nitrate[c]	mg/L	–	< 0.1	–	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	75	–	–	–
Fluoride[c]	mg/L	–	0.403	–	–	–
Sulfate[c]	mg/L	–	124	–	–	–
TOCs[c]	mg/L	1.2	1.6	1.4	1.9	1.6
TOCs[c]	mg/L	1.1	1.5	1.4	1.9	1.6
TOCs[c]	mg/L	1.1	1.6	1.6	1.6	1.7
TOCs[c]	mg/L	1.2	1.6	1.6	1.9	1.6
TOXs[c]	mg/L	< 0.02	< 0.02	0.036	< 0.02	0.021
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

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

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well 800281, 2004

Parameter	Unit	Date of Sampling				
		1/27/2004	4/20/2004	7/19/2004	07/19/2004	10/12/2004
Water elevation[a]	m	226.60	226.71	226.04	226.04	225.23
Temperature	º C	3.9	8.8	16.4	16.4	13.9
pH	pH	7.23	6.89	6.84	6.84	6.35
Redox	mV	-37	17	16	16	11
Conductivity	µmhos/cm	1,286	1,442	1,248	1,248	1,377
Chloride[b]	mg/L	66	86	90	97	65
Sulfate[b]	mg/L	170	98	118	117	116
TDS[b]	mg/L	809	926	948	911	893
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	0.013	< 0.01
Arsenic[c]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[c]	mg/L	0.0579	0.0684	0.0706	0.0717	0.0841
Boron[c]	mg/L	–[d]	0.2912	0.3167	0.3180	0.3598
Cadmium[c]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[c]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[c]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[c]	mg/L	< 0.015	0.0199	0.0164	< 0.015	< 0.015
Iron[c]	mg/L	0.4074	0.0505	0.0346	< 0.02	0.3158
Lead[c]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[c]	mg/L	0.0577	**0.5459[e]**	**0.8169**	**0.7927**	**1.3283**
Mercury[c]	mg/L	< 0.001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[c]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[c]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[c]	mg/L	0.0199	0.0980	0.0763	0.0782	0.0201
Ammonia nitrogen[b]	mg/L	0.08	0.06	< 0.05	0.12	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0589	0.0723	0.0762	0.0753	0.0820
Boron[b]	mg/L	–	0.2850	0.3160	0.3069	0.3489
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0468	0.5745	0.8708	0.9107	1.2509
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	0.0238	0.0212	0.0226	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0116	0.0940	0.0771	0.0833	0.0332
Nitrate[c]	mg/L	–	< 0.1	–	–	–
Phenols[c]	mg/L	0.060	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	290	269	256	238	193
Chloride[c]	mg/L	–	82	–	–	78
Fluoride[c]	mg/L	–	0.158	–	–	0.329
Sulfate[c]	mg/L	–	95	–	–	115
TOCs[c]	mg/L	1.8	2.4	2.4	2.6	3.2
TOCs[c]	mg/L	1.9	2.4	2.3	2.6	3.1
TOCs[c]	mg/L	1.9	2.3	2.4	2.6	3.3
TOCs[c]	mg/L	1.9	3.4	2.4	2.5	3.4
TOXs[c]	mg/L	0.038	0.033	0.033	0.034	0.032
TOXs[c]	mg/L	< 0.02	0.022	0.022	0.035	0.028

[a] Well point elevation = 224.00 m (MSL); ground surface elevation = 227.66 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well 800291, 2004

		Date of Sampling				
Parameter	Unit	1/19/04	4/12/2004	4/12/2004	7/7/2004	10/5/2004
Water elevation[a]	m	227.70	227.98	227.98	227.34	226.20
Temperature	º C	8.0	8.2	8.2	10.0	9.9
pH	pH	7.44	7.35	7.35	7.21	6.69
Redox	mV	-26	-8	-8	-6	-8
Conductivity	μmhos/cm	1,075	1,104	1,104	1,202	1,144
Chloride[b]	mg/L	8	7	8	9	7
Sulfate[b]	mg/L	226	215	210	226	210
TDS[b]	mg/L	802	798	780	769	771
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0107	< 0.003	–	< 0.003
Barium[c]	mg/L	–	0.0960	0.0700	–	0.0228
Boron[c]	mg/L	–	0.1076	0.1747	–	0.0424
Cadmium[c]	mg/L	–	< 0.0002	0.0002	–	< 0.0002
Chromium[c]	mg/L	–	< 0.024	< 0.024	–	< 0.024
Cobalt[c]	mg/L	–	< 0.016	< 0.016	–	< 0.016
Copper[c]	mg/L	–	0.0289	< 0.015	–	< 0.015
Iron[c]	mg/L	–	**29.27[e]**	**39.45**	–	0.3562
Lead[c]	mg/L	–	**0.0146**	**0.0169**	–	< 0.002
Manganese[c]	mg/L	–	**0.6812**	**0.896**	–	0.0960
Mercury[c]	mg/L	–	< 0.0002	< 0.0002	–	< 0.0002
Nickel[c]	mg/L	–	0.0310	< 0.02	–	< 0.02
Selenium[c]	mg/L	–	< 0.003	< 0.003	–	< 0.003
Silver[c]	mg/L	–	< 0.001	< 0.001	–	< 0.001
Zinc[c]	mg/L	–	0.0824	0.0095	–	< 0.008
Ammonia nitrogen[b]	mg/L	0.07	< 0.05	< 0.05	< 0.05	0.17
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0231	0.0233	0.0228	0.0234	0.0210
Beryllium[b]	mg/L	–	0.0323	0.0350	0.0224	0.0269
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0711	< 0.02	< 0.02	0.0671	0.0720
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1066	0.074	0.0788	0.1823	0.0964
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0082	< 0.008	< 0.008	< 0.008	0.0139
Nitrate[c]	mg/L	–	< 0.1	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	8	7	–	8
Fluoride[c]	mg/L	–	0.395	0.510	–	0.536
Sulfate[c]	mg/L	–	209	205	–	207
TOCs[c]	mg/L	2.0	2.1	2.0	2.5	2.3
TOCs[c]	mg/L	2.0	2.1	2.1	2.8	2.3
TOCs[c]	mg/L	2.1	2.1	2.0	2.5	2.2
TOCs[c]	mg/L	2.2	2.2	2.0	2.3	2.3
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 223.48 m (MSL); ground surface elevation = 230.49 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the filtered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well 800301, 2004

		Date of Sampling		
Parameter	Unit	4/20/2004	7/20/2004	10/5/2004
Water elevation[a]	m	228.4	230.11	228.36
Temperature	º C	10.0	10.6	9.5
pH	pH	7.46	7.30	6.55
Redox	mV	-50	-42	0
Conductivity	µmhos/cm	1,094	1,295	1,132
Chloride[b]	mg/L	6	7	6
Sulfate[b]	mg/L	162	315	205
TDS[b]	mg/L	741	858	770
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	0.0044	–[d]	0.0034
Barium[c]	mg/L	0.0384	–	0.0218
Boron[c]	mg/L	0.0765	–	0.0505
Cadmium[c]	mg/L	0.0014	–	< 0.0002
Chromium[c]	mg/L	< 0.0002	–	< 0.024
Cobalt[c]	mg/L	< 0.024	–	< 0.016
Copper[c]	mg/L	< 0.016	–	< 0.015
Iron[c]	mg/L	**7.946**[e]	–	1.1211
Lead[c]	mg/L	0.0031	–	< 0.002
Manganese[c]	mg/L	**0.3068**	–	**0.1723**
Mercury[c]	mg/L	< 0.0002	–	< 0.0002
Nickel[c]	mg/L	< 0.02	–	< 0.02
Selenium[c]	mg/L	< 0.003	–	< 0.003
Silver[c]	mg/L	< 0.001	–	< 0.001
Zinc[c]	mg/L	0.0299	–	< 0.008
Ammonia nitrogen[b]	mg/L	< 0.05	< 0.05	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0228	0.0235	0.0209
Boron[b]	mg/L	0.0448	0.0474	0.0385
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.2533	1.3391	1.0547
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1318	0.2051	0.1613
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	0.0119
Nitrate[c]	mg/L	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100
Chloride[c]	mg/L	6	–	6
Fluoride[c]	mg/L	0.372	–	0.472
Sulfate[c]	mg/L	144	–	198
TOCs[c]	mg/L	1.3	1.3	1.3
TOCs[c]	mg/L	1.2	1.3	1.4
TOCs[c]	mg/L	1.3	1.3	1.5
TOCs[c]	mg/L	1.3	1.2	1.4
TOXs[c]	mg/L	0.025	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	0.025	0.024

[a] Well point elevation = 224.91 m (MSL); ground surface elevation = 232.53 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the filtered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill Well 800321, 2004

		Date of Sampling			
Parameter	Unit	1/27/2004	4/20/2004	7/14/2004	10/18/2004
Water elevation[a]	m	225.45	226.16	225.71	224.35
Temperature	º C	7.3	9.5	12.4	11.6
pH	pH	7.52	7.59	6.93	6.57
Redox	mV	-29	-58	9	19
Conductivity	µmhos/cm	2,050	1,427	1,483	2,760
Chloride[b]	mg/L	37	25	38	39
Sulfate[b]	mg/L	820	445	982	1,630
TDS[b]	mg/L	1,481	1,172	1,902	2,738
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	–
Barium[c]	mg/L	–	0.0387	–	–
Boron[c]	mg/L	–	0.0881	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	< 0.015	–	–
Iron[c]	mg/L	–	**9.384**[e]	–	–
Lead[c]	mg/L	–	0.0045	–	–
Manganese[c]	mg/L	–	**0.1827**	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.0382	–	–
Ammonia nitrogen[b]	mg/L	0.58	0.15	0.11	0.11
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0157	0.0171	0.0151	0.0115
Boron[b]	mg/L	–	0.0445	0.0371	0.0410
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	0.0131	0.1628
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0166	0.0088	< 0.008	0.0192
Nitrate[c]	mg/L	–	< 0.10	–	–
Phenols[c]	mg/L	0.01	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	100	< 100
Chloride[c]	mg/L	–	26	–	–
Fluoride[c]	mg/L	–	0.453	–	–
Sulfate[c]	mg/L	–	**510**	–	–
TOCs[c]	mg/L	2.7	2.1	2.1	2.2
TOCs[c]	mg/L	2.7	2.1	2.1	2.3
TOCs[c]	mg/L	2.6	2.1	2.1	2.4
TOCs[c]	mg/L	2.7	2.1	2.1	2.1
TOXs[c]	mg/L	< 0.02	0.024	0.027	0.026
TOXs[c]	mg/L	0.045	0.027	0.024	0.022

[a] Well point elevation = 223.66 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the filtered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill Well 800331, 2004

Parameter	Unit	Date of Sampling 1/26/2004	4/21/2004	7/14/2004	10/11/2004
Water elevation[a]	m	226.98	227.13	226.51	225.38
Temperature	º C	9.2	8.0	12.0	12.3
pH	pH	7.14	7.28	7.23	6.75
Redox	mV	-33	-7	-8	-10
Conductivity	µmhos/cm	1,006	958	712	969
Chloride[b]	mg/L	5	5	6	7
Sulfate[b]	mg/L	217	147	169	144
TDS[b]	mg/L	649	617	615	634
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	–
Barium[c]	mg/L	–	0.0423	–	–
Boron[c]	mg/L	–	0.0608	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	< 0.015	–	–
Iron[c]	mg/L	–	2.236	–	–
Lead[c]	mg/L	–	< 0.002	–	–
Manganese[c]	mg/L	–	0.0824	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.0158	–	–
Ammonia nitrogen[b]	mg/L	< 0.05	< 0.05	< 0.05	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0401	0.0390	0.0388	0.0369
Boron[b]	mg/L	–	< 0.0002	0.0253	0.0397
Cadmium[b]	mg/L	< 0.0002	0.0253	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0266
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.01	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	8	–	–
Fluoride[c]	mg/L	–	0.398	–	–
Sulfate[c]	mg/L	–	143	–	–
TOCs[c]	mg/L	1.3	1.3	1.3	1.5
TOCs[c]	mg/L	1.4	1.3	1.3	1.4
TOCs[c]	mg/L	1.3	1.3	1.3	1.5
TOCs[c]	mg/L	1.3	1.3	1.3	1.5
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 222.75 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

TABLE 6.44

Groundwater Monitoring Results, Sanitary Landfill Well 800341, 2004

		Date of Sampling			
Parameter	Unit	1/19/2004	4/21/2004	7/7/2004	10/11/2004
Water elevation[a]	m	229.54	229.63	229.21	227.81
Temperature	º C	7.2	7.6	11.2	13.3
pH	pH	7.52	7.34	6.96	6.79
Redox	mV	-35	-11	7	-11
Conductivity	µmhos/cm	1,016	1,148	1,140	1,135
Chloride[b]	mg/L	12	11	14	12
Sulfate[b]	mg/L	261	210	276	267
TDS[b]	mg/L	754	735	760	770
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	–	–
Barium[c]	mg/L	–	0.0482	–	–
Boron[c]	mg/L	–	0.0625	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	0.0165	–	–
Iron[c]	mg/L	–	**6.564**[e]	–	–
Lead[c]	mg/L	–	0.0023	–	–
Manganese[c]	mg/L	–	0.1165	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	< 0.02	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.0332	–	–
Ammonia nitrogen[b]	mg/L	0.08	< 0.05	< 0.05	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0337	0.0348	0.0366	0.0388
Boron[b]	mg/L	–	0.0181	< 0.016	0.0221
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury[b]	mg/L	< 0.0001	0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0086	< 0.008	< 0.008	0.0196
Nitrate[c]	mg/L	–	0.22	–	–
Phenols[c]	mg/L	< 0.005	0.0083	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	12	–	–
Fluoride[c]	mg/L	–	0.458	–	–
Sulfate[c]	mg/L	–	216	–	–
TOCs[c]	mg/L	2.2	2.0	2.6	2.5
TOCs[c]	mg/L	2.2	2.1	2.3	2.6
TOCs[c]	mg/L	2.3	2.1	2.5	2.6
TOCs[c]	mg/L	2.5	2.1	3.2	2.7
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 226.01 m (MSL); ground surface elevation = 229.97 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the filtered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.45

Groundwater Monitoring Results, Sanitary Landfill Well 800351, 2004

Parameter	Unit	Date of Sampling			
		1/27/2004	4/7/2004	7/20/2004	10/5/2004
Water elevation[a]	m	224.60	224.80	228.66	226.83
Temperature	° C	8.3	10.2	11.5	10.6
pH	pH	7.60	7.05	7.75	6.86
Redox	mV	-35	-27	-69	-18
Conductivity	µmhos/cm	964	850	947	936
Chloride[b]	mg/L	3	4	4	3
Sulfate[b]	mg/L	62	60	60	58
TDS[b]	mg/L	566	562	551	567
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0155	–	–
Barium[c]	mg/L	–	0.1872	–	–
Boron[c]	mg/L	–	0.2340	–	–
Cadmium[c]	mg/L	–	< 0.0002	–	–
Chromium[c]	mg/L	–	0.0333	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	0.0403	–	–
Iron[c]	mg/L	–	**57.91**[e]	–	–
Lead[c]	mg/L	–	**0.0300**	–	–
Manganese[c]	mg/L	–	**1.105**	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	0.0530	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.1430	–	–
Ammonia nitrogen[b]	mg/L	0.19	< 0.05	< 0.05	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0874	0.0872	0.0878	0.0818
Boron[b]	mg/L	–	0.0983	0.0852	0.0755
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	0.0371	0.0675	0.3367
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0284	0.0260	0.0260	0.0239
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0098
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	0.0076	0.0076	0.0059
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	3	–	–
Fluoride[c]	mg/L	–	0.278	–	–
Sulfate[c]	mg/L	–	61	–	–
TOCs[c]	mg/L	1.5	1.8	1.8	2.7
TOCs[c]	mg/L	1.5	1.8	1.8	2.9
TOCs[c]	mg/L	1.5	1.8	1.8	2.3
TOCs[c]	mg/L	1.5	1.9	1.9	2.3
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	0.021	0.021	< 0.02

[a] Well point elevation = 220.86 m (MSL); ground surface elevation = 232.75 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.46

Groundwater Monitoring Results, Sanitary Landfill Well 800361, 2004

Parameter	Unit	Date of Sampling 1/26/2004	4/6/2004	8/2/2004	10/12/2004
Water elevation[a]	m	225.71	226.67	223.97	222.49
Temperature	º C	9.5	9.1	15.1	12.1
pH	pH	7.54	7.12	7.34	6.43
Redox	mV	-23	-31	-10	0
Conductivity	µmhos/cm	910	821	765	930
Chloride[b]	mg/L	10	12	15	12
Sulfate[b]	mg/L	214	151	153	161
TDS[b]	mg/L	659	603	636	628
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	0.022	< 0.01
Arsenic[c]	mg/L	–[d]	< 0.003	< 0.003	< 0.003
Barium[c]	mg/L	–	0.0426	0.0226	0.0269
Boron[c]	mg/L	–	0.0363	0.0279	0.0243
Cadmium[c]	mg/L	–	< 0.0002	< 0.0002	< 0.0002
Chromium[c]	mg/L	–	< 0.024	< 0.024	< 0.024
Cobalt[c]	mg/L	–	< 0.016	< 0.016	< 0.016
Copper[c]	mg/L	–	< 0.015	< 0.015	< 0.015
Iron[c]	mg/L	–	**5.986[e]**	0.1625	0.0295
Lead[c]	mg/L	–	0.0025	< 0.002	< 0.002
Manganese[c]	mg/L	–	**0.2302**	**0.1647**	0.1391
Mercury[c]	mg/L	–	< 0.0002	< 0.0002	< 0.0002
Nickel[c]	mg/L	–	< 0.02	< 0.02	< 0.02
Selenium[c]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[c]	mg/L	–	< 0.001	< 0.001	< 0.001
Zinc[c]	mg/L	–	0.3784	0.0664	0.0474
Ammonia nitrogen[b]	mg/L	< 0.05	< 0.05	< 0.05	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0252	0.0262	0.0252	0.0266
Boron[b]	mg/L	–	0.0197	0.0262	0.0211
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	0.0762	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1698	0.1262	0.1827	0.1415
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0290	< 0.008	0.0625	0.0597
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	0.023	< 0.005	0.014	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	12	–	12
Fluoride[c]	mg/L	–	0.332	–	0.443
Sulfate[c]	mg/L	–	153	–	156
TOCs[c]	mg/L	1.5	1.9	1.9	1.8
TOCs[c]	mg/L	1.5	1.9	1.7	1.7
TOCs[c]	mg/L	1.5	1.8	1.7	1.6
TOCs[c]	mg/L	1.5	1.8	1.7	1.6
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 220.52 m (MSL); ground surface elevation = 227.24 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

TABLE 6.47

Groundwater Monitoring Results, Sanitary Landfill Well 800371, 2004

Parameter	Unit	Date of Sampling 1/26/2004	4/7/2004	7/14/2004	10/5/2004
Water elevation[a]	m	218.84	218.79	218.79	218.66
Temperature	º C	9.2	10.7	12.3	11.9
pH	pH	7.35	7.03	6.96	6.62
Redox	mV	-21	-28	6	-4
Conductivity	µmhos/cm	1,269	1,191	947	1,258
Chloride[b]	mg/L	1	2	2	2
Sulfate[b]	mg/L	397	335	360	291
TDS[b]	mg/L	918	942	927	900
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	–[d]	0.0108	–	–
Barium[c]	mg/L	–	0.1254	–	–
Boron[c]	mg/L	–	0.1846	–	–
Cadmium[c]	mg/L	–	0.0004	–	–
Chromium[c]	mg/L	–	< 0.024	–	–
Cobalt[c]	mg/L	–	< 0.016	–	–
Copper[c]	mg/L	–	0.0318	–	–
Iron[c]	mg/L	–	**40.38**[e]	–	–
Lead[c]	mg/L	–	**0.0251**	–	–
Manganese[c]	mg/L	–	**0.9637**	–	–
Mercury[c]	mg/L	–	< 0.0002	–	–
Nickel[c]	mg/L	–	0.0346	–	–
Selenium[c]	mg/L	–	< 0.003	–	–
Silver[c]	mg/L	–	< 0.001	–	–
Zinc[c]	mg/L	–	0.1512	–	–
Ammonia nitrogen[b]	mg/L	0.12	0.08	< 0.05	0.16
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0448	0.0419	0.0357	0.0351
Boron[b]	mg/L	–	0.1150	0.1036	0.0981
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	0.0275	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0566	0.0554	0.0482	0.0333
Mercury[b]	mg/L	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Selenium[b]	mg/L	–	< 0.003	< 0.003	< 0.003
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc[b]	mg/L	0.0161	< 0.008	< 0.008	0.0143
Nitrate[c]	mg/L	–	< 0.1	–	–
Phenols[c]	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3[c]	pCi/L	< 100	< 100	< 100	< 100
Chloride[c]	mg/L	–	2	–	–
Fluoride[c]	mg/L	–	0.471	–	–
Sulfate[c]	mg/L	–	301	–	–
TOCs[c]	mg/L	1.3	1.6	1.7	1.9
TOCs[c]	mg/L	1.3	1.7	1.6	2.0
TOCs[c]	mg/L	1.2	1.6	1.6	2.1
TOCs[c]	mg/L	1.2	1.6	1.6	1.7
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TOXs[c]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02

[a] Well point elevation = 217.44 m (MSL); ground surface elevation = 227.50 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

[d] A dash indicates that no samples were collected.

[e] Bold type indicates that the unfiltered sample value exceeds the State of Illinois Groundwater Quality Standard.

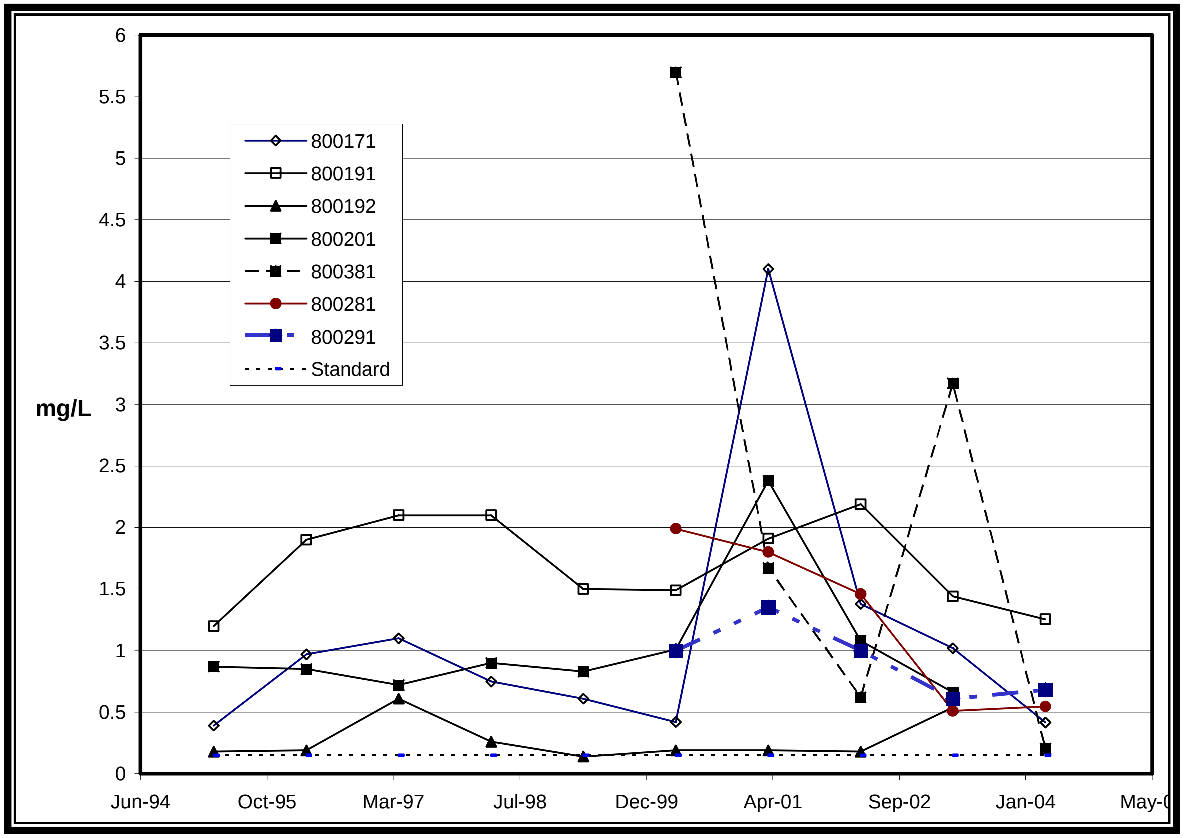


FIGURE 6.20 800 Well Manganese Results

Chloride, manganese, sulfate, and TDS were frequently noted in the deep wells. Iron was elevated during only one quarter in Well 800173D. Ammonia was elevated each quarter only in Well 800203D. Chloride was elevated each quarter in Well 800173D, during two quarters in Well 800383D, and during one quarter in Wells 800183D and 800193D. Chloride levels in these wells ranged from 8 to 542 mg/L. Manganese was elevated each quarter in Wells 800383D, 800193D, and 800203D, and during three quarters in Well 800173D. Manganese levels in these wells ranged from less than 0.010 to 0.076 mg/L. Sulfate was elevated each quarter in Well 800193D, during three quarters in Well 800183D, and during one quarter in Well 800383D. Sulfate levels in these wells ranged from 127 to 210 mg/L. TDS was elevated during two quarters in Wells 800383D, 800173D, and 800193D, and during one quarter in Well 800183D. TDS levels in these wells ranged from 780 to 1003 mg/L.

Unfiltered Routine Indicator Parameters. These parameters include cyanide, phenols (total recoverable), TOC, and TOX and are measured each quarter. All measured unfiltered routine indicator parameters were below the appropriate WQS values, where applicable.

Unfiltered Inorganic Parameters. These parameters, which are measured unfiltered only during the second quarter, include arsenic, barium, boron, cadmium, chloride, chromium, cobalt, copper, cyanide, fluoride, iron, lead, manganese, mercury, nickel, nitrate as nitrogen, selenium, silver, sulfate, and zinc. Boron, cadmium, cobalt, copper, cyanide, fluoride, mercury, nickel, nitrate as nitrogen, selenium, silver, sulfate, and zinc were all below the WQS. Iron, lead, and manganese results are similar to those noted in previous years.

Iron concentrations exceeded the WQS (5 mg/L) in Wells 800271 (upgradient), 800181, 800192, 800201, 800202, 800291, 800301, 800321, 800341, 800351, 800361, 800371, 800382, and 800383D. The iron levels ranged from 5.8 to 143 mg/L. These elevated levels are likely to be the result of suspended soil particles in the sample.

Lead concentrations exceeded the WQS (0.0075 mg/L) in Wells 800181, 800201, 800351, and 800371. Lead levels ranged from 0.008 to 0.03 mg/L. These elevated levels are also likely to be the result of suspended soil particles in the sample.

Manganese exceedances of the WQS were similar to those noted in 2003. Manganese concentrations exceeded the WQS (0.15 mg/L) in Wells 800271 (upgradient), 800171, 800181, 800191, 800192, 800201, 800281, 800291, 800301, 800321, 800351, 800361, 800371, 800381, 800382, and 800383D. Manganese levels in these wells ranged from 0.17 to 1.3 mg/L. Elevated manganese levels are common across the ANL site.

Organic Parameters. Each well was sampled quarterly and analyzed for VOCs. As in 2003, VOCs were not detected in any wells in 2004.

Radioactive Constituents. Samples collected from the 800 Area Landfill monitoring wells were also analyzed for hydrogen-3. The results are shown in Tables 6.24 to 6.47. Although the disposal of radioactive materials was prohibited in the sanitary landfill, concentrations of hydrogen-3 were detected during only one quarter in Wells 800191 and 800383D; they were detected during each quarter in Wells 800281 and 800192, which are located east and southwest of the landfill, respectively. Hydrogen-3 has been consistently noted in these two wells. In Well 800191, hydrogen-3 was detected at a level near the detection (112 pCi/L) limit and only during the second quarter. Hydrogen-3 was detected in deep Well 800383D (453 pCi/L) only during the second quarter.

As previously mentioned, the general groundwater flow direction in the shallow glacial drift is to the southeast, with a minor component to the west. Seasonal variations are known to exist, as evidenced by the inconsistent presence of water in Well 800321. The wells in the southwest corner of the landfill area are adjacent to a stream that may be influencing subsurface water flow on the western side of the landfill area. All results are summarized in the 2004 annual summary assessment of the groundwater monitoring program for the 800 Area Landfill, which was sent to the IEPA in July 2005.

6.4. CP-5 Reactor Area

The CP-5 reactor was an inactive research reactor located in Building 330 (see Figure 1.1). The CP-5 5-MW research reactor was used from 1954 until operations ceased in 1979. In addition to the reactor vessel, the CP-5 complex contained several large cooling towers and an outdoor equipment yard for storing equipment and supplies. The reactor and associated yard area have been decommissioned. A single exploratory monitoring well was installed in 1989 in the yard immediately behind the reactor building, just outside the reactor fuel storage area of the complex. Two wells were installed as part of a full characterization study of this site, which took place during 1993. The three wells have been sampled quarterly since 1995 and analyzed for radionuclides, metals, VOCs, SVOCs, pesticides, herbicides, and PCBs. A deep well was installed during June 1997 to determine whether there had been any vertical migration of hydrogen-3 to the dolomite from the CP-5 reactor.

The yard area surrounding the CP-5 reactor structure was classified as a SWMU and was therefore investigated for groundwater releases under the RCRA Part B Permit requirements. As part of this investigation, Wells 330051 and 330052 were installed in May 2000 northeast of the CP-5 complex. To improve the understanding and delineation of the CP-5 hydrogeology and groundwater flow direction, five additional wells were installed during February 2003 in the drift surrounding the CP-5 study area. Also, Well 330031 was abandoned and replaced with a new well with a shorter screen, allowing monitoring of the saturated zone within the drift. These six additional wells were incorporated into the ANL routine groundwater monitoring program during the second quarter of 2004. Data collection from the old and new wells will allow determination of groundwater flow direction within the drift and determination of the extent of potential metals and radionuclide contamination. Table 6.48 characterizes all wells in this area (see Figure 6.21 for locations).

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 6.57. 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 conductance, and temperature of water. These parameters are measured each quarter. Water from four wells (330051, 330061, 330081, and 330091) had elevated conductivity levels. The elevated conductivity levels in Wells 330051 and 330061 may be due to elevated chloride levels from road salt. The elevated levels in Wells 330081 and 330091 appear to be related to intrusion of chloride into the groundwater from a road salt storage facility near the wells.

Filtered Routine Indicator Parameters/Metals. High levels of chloride were noted in Wells 330051, 330061, 330081, and 330091. Chloride levels in these wells ranged from 724 to 13,604 mg/L. As previously mentioned, it appears that road salt intrusion from roadways and a salt storage area are responsible for the elevated chloride levels associated with the high conductivity of the water.

TABLE 6.47

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	224.2–220.98	0.05/PVC	8/89
330021	5.8	227.75	226.3–221.7	0.05/SS	9/93
330031[b]	5.2	227.13	225.6–221.0	0.05/SS	9/93
330012D	41.5	227.08	191.7–185.65	0.05/SS	6/97
330021R	11.9	227.04	216.6–215.15	0.05/PVC	2/03
330031R	9.8	227.65	219.4–217.89	0.05/PVC	2/03
330051	10.7	226.66	217.5–215.98	0.05/PVC	5/00
330052[c]	7.0	226.71	221.2–219.7	0.05/PVC	5/00
330061	9.7	227.11	218.8–217.36	0.05/PVC	2/03
330071	8.8	226.64	219.3–217.8	0.05/PVC	2/03
330081	4.5	226.60	223.5–222.03	0.05/PVC	2/03
330091	3.8	227.07	224.7–223.26	0.05/PVC	2/03

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

[b] Well abandoned and replaced with new well.

[c] Well not sampled.

Barium, iron, manganese, nickel, and zinc are the most frequently noted parameters in wells in the CP-5 vicinity. It appears that these elevated levels are associated with disturbance of silt in the well bottom during sampling, thereby increasing the turbidity of the sample. ANL has determined that the use of low-flow sampling techniques results in low-turbidity samples containing significantly reduced levels of these parameters.

Barium was noted during each quarter in each well in the CP-5 monitoring network. Levels ranged from 0.02 to 0.20 mg/L. Iron was noted during at least one quarter in six of the wells. Iron levels in all wells ranged from less than 0.02 to 4.1 mg/L. Manganese was detected during each quarter in all the wells except Well 330011, and levels ranged from less than 0.01 to 4.8 mg/L. Nickel was noted during each quarter in Wells 330021, 330031R, 330051, and 330081, and during at least one quarter in the remaining wells. Nickel levels ranged from less than 0.02 to 0.86 mg/L. Zinc was also noted at low levels in nine of the wells during at least one quarter. Zinc levels in these wells ranged from less than 0.008 to 0.01 mg/L.

Radioactive Constituents. With the exception of Well 330031R, radionuclide levels in the original well network were similar to those measured from 2000 to 2004. Hydrogen-3 was detected during each quarter in all wells except Wells 330021 and 330012D. The levels of hydrogen-3 in these wells ranged from 143 to 44,660 pCi/L. These levels exceed the WQS (20,000 pCi/L) in Well 330031R. Strontium-90 was detected during each quarter in

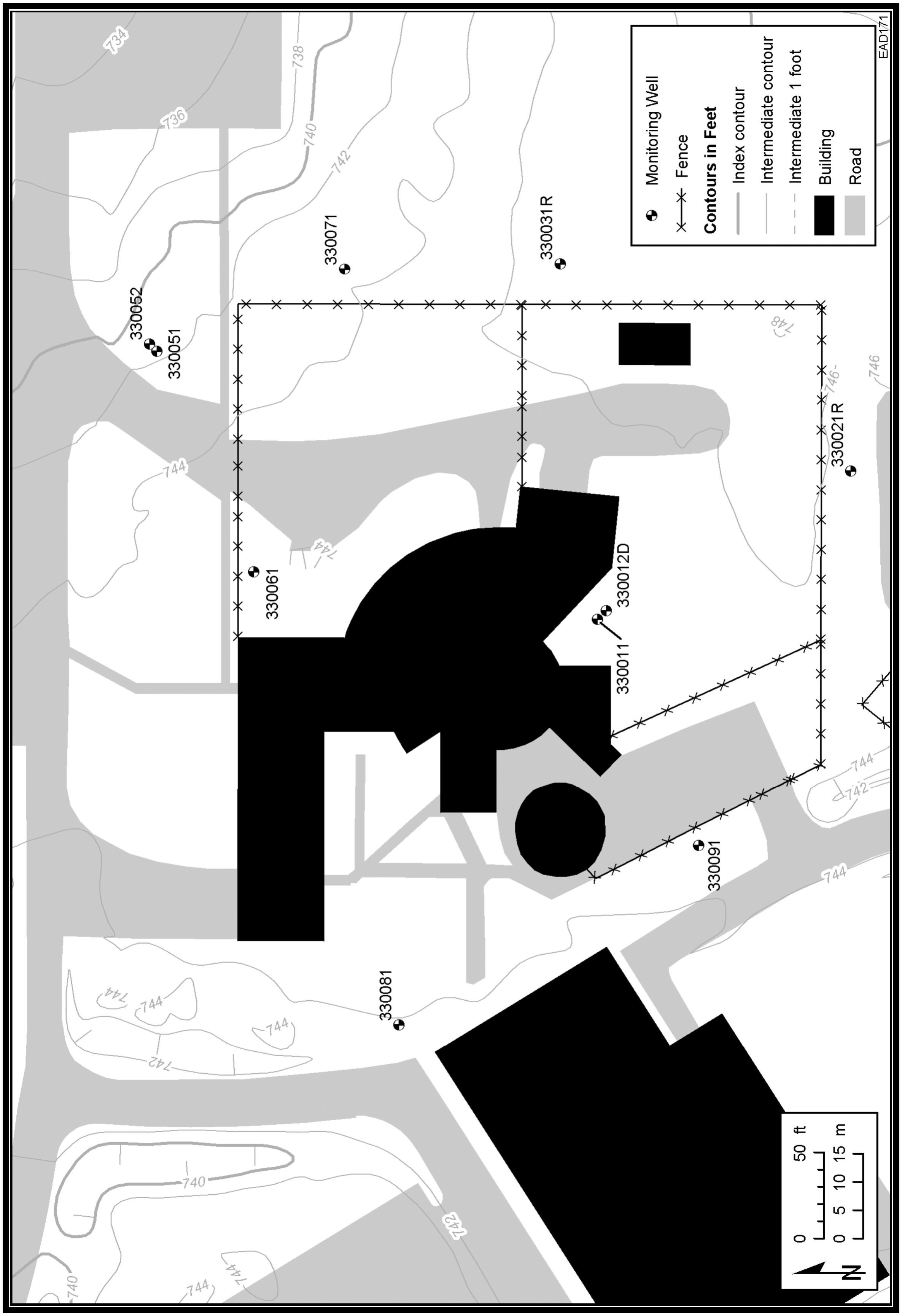


FIGURE 6.21 Monitoring Wells in the CP-5 Reactor Area

TABLE 6.49

Groundwater Monitoring Results, 300 Area Well 330011, 2004

Parameter	Unit	Date of Sampling				
		3/16/2004	6/22/2004	8/10/2004	12/9/2004	12/9/2004
Water elevation[a]	m	225.93	225.82	225.19	226.20	226.20
Temperature	º C	9.2	14.3	15.8	14.7	14.7
pH	pH	7.63	7.23	6.90	7.11	7.11
Redox	mV	-58	-5	14	4	4
Conductivity	µmhos/cm	1,002	1,210	777	942	942
Chloride[b]	mg/L	46	71	37	58	60
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0472	0.0482	0.0384	0.0468	0.0460
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.01	0.1527	0.3463	0.3664	0.3909
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.0088	0.0099	0.0084
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,165	2,001	796	1,300	1,205
Strontium-90	pCi/L	0.42	0.51	0.45	< 0.25	< 0.25

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

[b] Filtered sample.

TABLE 6.50

Groundwater Monitoring Results, 300 Area Well 330012D, 2004

Parameter	Unit	Date of Sampling			
		3/16/2004	6/22/2004	8/18/2004	12/9/2004
Water elevation[a]	m	191.04	191.01	191.23	191.29
Temperature	º C	11.4	14.3	14.5	12.7
pH	pH	7.60	7.28	7.12	7.20
Redox	mV	-49	-8	4	4
Conductivity	µmhos/cm	967	1,048	839	874
Chloride[b]	mg/L	23	28	30	40
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0492	0.0518	0.0536	0.0548
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	0.205	0.2988	0.281
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0822	0.0429	0.0463	0.0332
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0228	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0092
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	< 100	187
Strontium-90	pCi/L	0.37	0.27	< 0.25	0.29

[a] Well point elevation = 185.31 m (MSL); ground surface elevation = 227.08 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.51

Groundwater Monitoring Results, 300 Area Well 330021, 2004

Parameter	Unit	Date of Sampling			
		3/16/2004	6/22/2004	8/18/2004	12/10/2004
Water elevation[a]	m	227.55	227.14	225.52	227.66
Temperature	º C	8.5	11.2	13.3	12.3
pH	pH	7.42	7.39	7.10	7.32
Redox	mV	-49	-14	0	-5
Conductivity	µmhos/cm	887	994	1,103	946
Chloride[b]	mg/L	44	39	139	56
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0204	0.0287	0.0471	0.0303
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	0.0163	0.0183	< 0.016
Copper[b]	mg/L	< 0.15	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	0.0362	1.192	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0236	0.5068	0.7317	0.0293
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.1192	0.1525	0.1689	0.1121
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.0094	0.0109
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	< 100	< 100	129	102
Strontium-90	pCi/L	0.33	0.59	< 0.25	0.84

[a] Well point elevation = 221.95 m (MSL); ground surface elevation = 227.75 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.52

Groundwater Monitoring Results, 300 Area Well 330031R, 2004

Parameter	Unit	Date of Sampling			
		3/17/2004	6/22/2004	8/18/2004	12/10/2004
Water elevation[a]	m	223.52	223.39	222.73	223.55
Temperature	º C	9.9	13.0	12.3	11.2
pH	pH	7.49	7.33	7.33	7.70
Redox	mV	-51	-7	-11	-27
Conductivity	µmhos/cm	1,272	1,371	1,060	1,069
Chloride[b]	mg/L	103	121	144	113
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0669	0.0553	0.0580	0.0590
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.0386	< 0.02	0.0207	0.3101
Lead[b]	mg/L	< 0.002	< 0.002	0.0096	< 0.002
Manganese[b]	mg/L	0.0884	0.2359	0.0930	0.1216
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0389	0.8622	0.1593	0.1660
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.0091	0.0107
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	43,670	35,220	44,660	37,720
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.

[b] Filtered sample.

TABLE 6.53

Groundwater Monitoring Results, 300 Area Well 330051, 2004

Parameter	Unit	Date of Sampling			
		3/17/2004	6/22/2004	8/17/2004	12/9/2004
Water elevation[a]	m	224.18	223.22	222.68	223.49
Temperature	º C	11.2	12.8	13.4	13.2
pH	pH	7.11	7.29	6.93	7.23
Redox	mV	-31	-10	12	-2
Conductivity	µmhos/cm	2,720	2,930	2,300	2,390
Chloride[b]	mg/L	724	843	892	854
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0888	0.0841	0.0867	0.0818
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.2617	< 0.02	< 0.02	0.0986
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1535	0.2699	0.2346	0.1953
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.1752	0.0416	0.0586	0.0634
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.0138	0.0101
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	200	271	305	169
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 215.98 m (MSL); ground surface elevation = 226.66 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.54

Groundwater Monitoring Results, 300 Area Well 330061, 2004

Parameter	Unit	Date of Sampling			
		3/17/2004	6/22/2004	8/17/2004	12/9/2004
Water elevation[a]	m	221.47	221.72	221.32	221.42
Temperature	º C	13.9	14.9	14.9	14.3
pH	pH	7.31	7.02	7.16	7.08
Redox	mV	-42	8	-2	12
Conductivity	µmhos/cm	3,140	3,320	2,550	3,010
Chloride[b]	mg/L	778	937	999	1,031
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0666	0.0579	0.0626	0.0644
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	1.002	0.902	0.8724	4.051
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1388	0.1394	0.1865	0.1239
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	0.0830	0.0229	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.0127	0.0115
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,104	1,152	1,138	1,117
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 217.36 m (MSL); ground surface elevation = 227.11 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.55

Groundwater Monitoring Results, 300 Area Well 330071, 2004

Parameter	Unit	Date of Sampling				
		3/16/2004	3/16/2004	6/22/2004	8/18/2004	12/9/2004
Water elevation[a]	m	223.09	223.09	223.05	222.23	223.10
Temperature	ºC	10.3	10.3	12.7	12.9	11.6
pH	pH	7.41	7.41	7.09	7.47	7.70
Redox	mV	-53	-53	8	-10	-26
Conductivity	µmhos/cm	939	939	958	715	732
Chloride[b]	mg/L	7	6	7	7	8
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.0631	0.0611	0.0600	0.0619	0.0615
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.0002	< 0.0002
Manganese[b]	mg/L	0.0849	0.1051	0.1073	0.051	0.1865
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0097	0.0112
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	437	473	403	508	413
Strontium-90	pCi/L	< 0.25	< 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.

[b] Filtered sample.

TABLE 6.56

Groundwater Monitoring Results, 300 Area Well 330081, 2004

Parameter	Unit	Date of Sampling				
		3/16/2004	6/22/2004	6/22/2004	8/17/2004	12/10/2004
Water elevation[a]	m	224.32	224.41	224.41	224.03	224.59
Temperature	º C	9.7	15.0	15.0	17.6	13.6
pH	pH	7.11	7.04	7.04	7.28	7.06
Redox	mV	-32	4	4	-2	15
Conductivity	µmhos/cm	5,040	5,870	5,870	4,360	3,350
Chloride[b]	mg/L	1,560	2,166	2,092	1,422	1,315
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.1863	0.1936	0.1962	0.1642	0.0966
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.002	< 0.010	< 0.010	< 0.002	< 0.002
Manganese[b]	mg/L	0.1804	0.1472	0.1470	0.1952	0.0898
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0889	0.0291	< 0.02	0.1371	0.0846
Silver[b]	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.004	< 0.002
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	< 0.008	0.0122	0.0110
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	143	157	160	155	162
Strontium-90	pCi/L	0.83	0.55	0.79	0.64	0.40

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

[b] Filtered sample.

TABLE 6.57

Groundwater Monitoring Results, 300 Area Well 330091, 2004

Parameter	Unit	Date of Sampling			
		3/17/2004	6/22/2004	8/17/2004	12/10/2004
Water elevation[a]	m	225.96	225.26	225.77	224.95
Temperature	º C	8.4	13.8	17.4	13.4
pH	pH	6.65	6.67	6.71	6.71
Redox	mV	-5	25	24	29
Conductivity	µmhos/cm	2,170	3,120	27,800	27,800
Chloride[b]	mg/L	7,440	13,400	13,604	12,551
Arsenic[b]	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium[b]	mg/L	0.1208	0.1813	0.1989	0.1389
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.001	< 0.0002
Cadmium[b]	mg/L	< 0.0002	0.0022	0.0006	0.0018
Chromium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Cobalt[b]	mg/L	< 0.016	< 0.016	< 0.016	< 0.016
Copper[b]	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Iron[b]	mg/L	0.1188	< 0.02	< 0.02	< 0.02
Lead[b]	mg/L	< 0.010	< 0.010	< 0.006	0.004
Manganese[b]	mg/L	3.096	4.777	4.518	3.4881
Mercury[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Nickel[b]	mg/L	0.0739	< 0.02	< 0.02	< 0.02
Silver[b]	mg/L	< 0.001	< 0.001	< 0.005	< 0.001
Thallium[b]	mg/L	< 0.002	< 0.002	< 0.010	< 0.010
Vanadium[b]	mg/L	< 0.032	< 0.032	< 0.032	< 0.032
Zinc[b]	mg/L	< 0.008	< 0.008	0.0109	0.0119
Cesium-137	pCi/L	< 2.0	< 2.0	< 2.0	< 2.0
Hydrogen-3	pCi/L	1,477	1,466	1,396	975
Strontium-90	pCi/L	0.47	0.55	0.67	0.89

[a] Well point elevation = 213.26 m (MSL); ground surface elevation = 227.07 m (MSL); casing material = PVC.

[b] Filtered sample.

Wells 330081 and 330091, and during three quarters in Wells 330011, 330012D, and 330021. The levels of strontium-90 in these wells ranged from less than 0.25 to 0.89 pCi/L. These levels are well below the WQS (8 pCi/L).

The CP-5 was a heavy-water-moderated reactor. During its operational life, several incidents occurred that released small amounts of this heavy water containing high concentrations of hydrogen-3 to the environment. In addition, the normal operation released significant amounts of water vapor containing hydrogen-3 from the main ventilation system. This water may have condensed and fallen to the ground in the form of precipitation. These activities are believed to be responsible for the residual amounts of hydrogen-3 now found in the groundwater. The source of the strontium-90 is not known.

The original Well 330031 was replaced in February 2003 with Well 330031R. The screen length of the original well was from 0.6 to 6 m (2 to 20 ft) below the ground surface. This allowed for the infiltration of surface water into the well and resulted in erratic data. The replacement well was screened at 8 to 9 m (25 to 30 ft) below the surface to eliminate surface water infiltration.

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 increase. The first quarter results in 2004 revealed that hydrogen-3 concentrations increased by another factor of 10, to 43,670 pCi/L, and averaged 40,318 pCi/L for all of 2004.

The reason for the significant increase is unknown, but several factors may be responsible for the changes. First, the replacement well is screened in a different subsurface area. Results obtained before February 2003 may have been lower due to dilution by surface water infiltration. Second, the replacement well may be screened across a sand/gravel area that may intercept a source of groundwater impacted by past operations at CP-5. In addition, the well is located near Building 329, which had been used in the past for the storage of waste liquid scintillation materials. Although there was no evidence of leakage from Building 329, hydrogen-3 is typically measured using liquid scintillation mixtures. All the liquid scintillation materials were removed from Building 329 several years ago. Hydrogen-3 concentrations will continue to be monitored quarterly while an explanation of the source of the hydrogen-3 is being sought.

7. QUALITY ASSURANCE

QA plans exist for both radiological and nonradiological analyses; these QA documents were prepared in accordance with DOE Order 414.1B[27] and discuss who is responsible for QA and for auditing analyses. Both documents are supplemented by operating manuals.

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*.[25] 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. If samples for parameters such as priority pollutants are collected, field parameters for these samples (pH, specific conductance, 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 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 2004 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 (±) limit value. Unless otherwise stated, this value is the standard error at the 95% confidence level calculated from the standard deviation of the average. The ± limit value is a measure of the range in the concentrations encountered at that location; 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 ± value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

TABLE 7.1

Air and Water Detection Limits

Nuclide or Activity	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	0.0001	0.001
Plutonium-239	0.0001	0.001
Radium-226	–	0.02
Radium-228	–	0.02
Strontium-89	0.1	2
Strontium-90	0.01	0.25
Thorium-228	0.001	–
Thorium-230	0.001	–
Thorium-232	0.001	–
Uranium-234	0.001	0.01
Uranium-235	0.001	0.01
Uranium-238	0.001	0.01
Uranium - natural	0.02	0.2
Alpha	0.2	0.2
Beta	0.5	1

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

ANL participated in the March DOE Environmental Measurements Laboratory Quality Assurance Program (DOE-EML-QAP), which consists of semiannual distribution of three different sample matrices containing various combinations of radionuclides that are analyzed. Table 7.2 summarizes the March results for 2004. In the table, the EML value, which is the result of duplicate determinations by that laboratory, is compared with the average value obtained in the ANL laboratory. Information that will assist in judging the quality of the results includes the fact that typical uncertainties for ANL's analyses are 2 to 50% and that the uncertainties in the EML results are 1 to 30% (depending on the nuclide and the amount present). For most analyses for which the differences are large (> 20%), the concentrations were quite low, and the differences were within the measurement uncertainties. The EML program was terminated in March 2004.

Overall, the ANL performance in the EML intercomparison studies on the three matrices resulted in more than 84% (21 out of 25) of the analysis being in the DOE-EML-QAP

TABLE 7.2

Summary of DOE-EML-QAP Samples, 2004

Matrix	Constituent	Unit	EML	ANL	Ratio	Comments
Air filter	Cobalt-60	Bq/filter	35.4	38.0	1.07	Acceptable
	Strontium-90		1.76	1.74	0.99	Acceptable
	Cesium-134		18.2	18.0	0.99	Acceptable
	Cesium-137		26.4	28.0	1.06	Acceptable
	Uranium-234		0.086	0.089	1.04	Acceptable
	Uranium-238		0.085	0.091	1.07	Acceptable
	Plutonium-238		0.040	0.034	0.84	Warning
	Plutonium-239		0.164	0.160	0.97	Acceptable
	Americium-241		0.104	0.109	1.04	Acceptable
Soil	Potassium-40	Bq/kg	539.0	551.0	1.02	Acceptable
	Strontium-90		51.0	49.0	0.96	Acceptable
	Cesium-137		1323.0	1476.0	1.12	Acceptable
	Uranium-234		87.2	110.0	1.26	Warning
	Uranium-238		89.7	116.0	1.29	Warning
	Plutonium-238		0.82	0.90	1.10	Acceptable
	Plutonium-239		22.8	21.4	0.94	Acceptable
	Americium-241		13.0	14.6	1.12	Acceptable
Water	Hydrogen-3	Bq/L	186.6	231.0	1.24	Acceptable
	Cobalt-60		163.2	160.0	0.98	Acceptable
	Strontium-90		4.76	4.60	0.97	Acceptable
	Cesium-137		52.0	51.0	0.98	Acceptable
	Uranium-234		2.28	2.51	1.10	Acceptable
	Uranium-238		2.25	2.41	1.07	Acceptable
	Plutonium-238		1.10	1.11	1.01	Acceptable
	Plutonium-239		3.08	3.09	1.00	Acceptable
	Americium-241		1.31	1.78	1.36	Warning

acceptable range. Four samples fell within the warning category, while none of the results were not acceptable. The ANL performance on these samples indicated that, for the most part, the reported results are accurate.

In fall 2004, ANL began participation in the Mixed Analyte Performance Evaluation Program (MAPEP) administered by the Radiological and Environmental Sciences Laboratory (RESL) as a replacement for EML. The MAPEP program is very similar to the EML program in that the same three matrixes are used with essentially the same radionuclides. The results are listed in Table 7.3.

The ANL performance on the MAPEP intercomparison samples resulted in 95% (36 out of 38) of the analyses being in the MAPEP acceptable range. The two results that were not in the acceptable range were false positives.

TABLE 7.3

Summary of MAPEP Intercomparison Samples, 2004

Analyte	Matrix	Units[a]	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Am 241	Air filter	Bq/filter	0.12	0.10	0.07–0.13	Acceptable
Cs 134	Air filter	Bq/filter	2.60	2.90	2.03–3.77	Acceptable
Cs 137	Air filter	Bq/filter	2.20	1.96	1.40–2.60	Acceptable
Co 57	Air filter	Bq/filter	2.00	2.44	1.68–3.12	Acceptable
Co 60	Air filter	Bq/filter	2.60	2.35	1.61–2.99	Acceptable
Mn 54	Air filter	Bq/filter	2.60	3.03	2.10–3.90	Acceptable
Pu 238	Air filter	Bq/filter	0.15	0.13	0.09–0.17	Acceptable
Pu 239/240	Air filter	Bq/filter	0.10	0.09	0.06–0.12	Acceptable
Sr 90	Air filter	Bq/filter	0.72	0.83	0.56–1.04	Acceptable
U 233/234	Air filter	Bq/filter	0.21	0.21	0.15–0.27	Acceptable
U 238	Air filter	Bq/filter	0.22	0.22	0.15–0.29	Acceptable
Zn 65	Air filter	Bq/filter	3.20	4.11	2.80–5.20	Acceptable
Am 241	Soil	Bq/kg	66.00	67.00	46.88–87.06	Acceptable
Cs 134	Soil	Bq/kg	407.00	414.00	290.08–538.72	Acceptable
Cs 137	Soil	Bq/kg	947.00	836.00	585.34–1088	Acceptable
Co 57	Soil	Bq/kg	442.00	400.00	279.72–519.48	Acceptable
Co 60	Soil	Bq/kg	647.00	518.00	362.60–673.40	Acceptable
Mn 54	Soil	Bq/kg	580.00	485.00	339.29–630.11	Acceptable
Pu 238	Soil	Bq/kg	35.00	35.40	24.78–46.02	Acceptable
Pu 239/240	Soil	Bq/kg	40.00	41.80	29.27–54.35	Acceptable
K 40	Soil	Bq/kg	716.00	604.00	422.80–785.20	Acceptable
Sr 90	Soil	Bq/kg	1.60	ND	< 0.2	Not acceptable (false positive)
U 233/234	Soil	Bq/kg	40.00	37.00	25.90–48.10	Acceptable
U 238	Soil	Bq/kg	42.00	38.90	27.20–50.51	Acceptable
Zn 65	Soil	Bq/kg	837.00	699.00	489.51–909.09	Acceptable
Am 241	Water	Bq/L	0.58	0.59	0.42–0.78	Acceptable
Cs 134	Water	Bq/L	169.00	208.00	145.60–270.40	Acceptable
Cs 137	Water	Bq/L	242.00	250.00	175.00–325.00	Acceptable
Co 57	Water	Bq/L	183.00	185.00	129.50–240.50	Acceptable
Co 60	Water	Bq/L	167.00	163.00	114.10–211.90	Acceptable
H 3	Water	Bq/L	83.00	82.90	58.10–107.90	Acceptable
Mn 54	Water	Bq/L	262.00	267.00	186.90–347.10	Acceptable
Pu 238	Water	Bq/L	1.23	1.24	0.84–1.56	Acceptable
Pu 239/240	Water	Bq/L	0.013	ND	< 0.001	Not acceptable (false positive)
Sr 90	Water	Bq/L	7.30	7.40	4.90–9.10	Acceptable
U 233/234	Water	Bq/L	0.14	0.12	0.08–0.16	Acceptable
U 238	Water	Bq/L	0.97	0.94	0.63–1.17	Acceptable
Zn 65	Water	Bq/L	201.00	208.00	145.60–270.40	Acceptable

[a] Bq = Becquerel, kg = kilogram, L = liter, ND = not detected.

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,[28] and EPA-SW-846.[26]

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 136[20] 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 Memorandum of Understanding 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 2004 results for VOCs and SVOCs, respectively. The recoveries listed are those required by the respective methods.

7.4. NPDES Analytical Quality Assurance

ANL 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 ANL laboratory for these analyses, the EPA requires that ANL participate in the DMR-QA program. An EPA-accredited provider sends a series of intercomparison samples to ANL 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 ANL laboratory has consistently performed very well on these tests. In 2004, all results were acceptable, with the exception of biochemical oxygen demand. 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.

TABLE 7.4

Standard Reference Materials Used for Inorganic Analysis

Constituent	Reference Material[a]
Antimony	VHG-ASBH-100
Arsenic	VHG-AASN-100
Barium	VHG-PBAN-100
Beryllium	VHG-ABEN-100
Boron	VHG-PBW-100
Cadmium	VHG-ACDN-100
Chromium	VHG-ACRH-100
Cobalt	VHG-PCON-100
Copper	VHG-ACUN-100
Iron	VHG-AFEN-100
Lead	VHG-APBN-100
Manganese	VHG-AMNN-100
Mercury	VHG-AHGN-100
Nickel	VHG-ANIN-100
Selenium	VHG-ASEN-100
Silver	VHG-AAGN-100
Thallium	VHG-ATLN-100
Vanadium	VHG-PVN-100
Zinc	VHG-AZNN-100
Sulfate	HACH 891-49
Chloride	ORION 941708
Fluoride	ORION 940907

[a] VHG = VHG Labs, Inc.; NIST-SRM = National Institute of Standards and Technology – Standard Reference Materials; LABCHEM = Labchem, Inc.; ORION = Orion, Inc.

TABLE 7.5

Detection Limit for Metals Analysis, 2004

	Detection Limit (mg/L)	
Constituent	AA[a]	ICP[b]
Antimony	0.0030	NA[c]
Arsenic	0.0030	0.076
Barium	NA	0.010
Beryllium	0.0002	0.010
Boron	NA	0.016
Cadmium	0.0002	0.015
Chromium	0.015	0.024
Cobalt	NA	0.016
Copper	0.010	0.015
Hexavalent chromium[d]	0.006	NA
Iron	0.040	0.020
Lead	0.0020	0.086
Manganese	0.015	0.010
Mercury	0.0001	NA
Nickel	0.030	0.020
Selenium	0.0030	0.121
Silver	0.0010	NA
Thallium	0.0020	0.082
Vanadium	NA	0.032
Zinc	0.010	0.008

[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, 2004

Constituent	Recovery[a] (%)	Quality Limit (%)
Benzene	115	73–126
Bromobenzene	100	76–133
Bromodichloromethane	103	50–140
Bromoform	91	57–156
Butylbenzene	96	71–125
sec-Butylbenzene	98	71–145
t-Butylbenzene	100	69–134
Carbon tetrachloride	97	86–118
Chlorobenzene	99	80–137
Chloroform	111	68–120
o-Chlorotoluene	79	81–146
p-Chlorotoluene	94	73–144
1,2-Dibromo-3-chloropropane	103	36–154
Dibromochloromethane	97	68–130
1,2-Dibromoethane	108	75–149
Dibromomethane	102	65–143
1,2-Dichlorobenzene	98	59–174
1,3-Dichlorobenzene	93	84–143
1,4-Dichlorobenzene	97	58–172
1,1-Dichloroethane	117	71–142
1,2-Dichloroethane	108	70–134
1,1-Dichloroethene	103	18–209
cis-1,2-Dichloroethene	116	85–124
trans-1,2-Dichloroethene	102	67–141
1,2-Dichloropropane	102	19–179
1,3-Dichloropropane	105	73–145
1,1-Dichloropropene	105	71–133
Ethyl benzene	98	84–130
Isopropylbenzene	104	70–144
4-Isopropyltoluene	97	72–140
Methylene chloride	116	D–197[b]
n-Propylbenzene	90	78–139
1,1,1,2-Tetrachloroethane	94	88–133
Tetrachloroethene	97	84–132
Toluene	105	81–130
1,1,1-Trichloroethane	103	68–149
1,1,2-Trichloroethane	112	70–133
Trichloroethene	100	91–135
1,2,3-Trichloropropane	108	50–158
1,2,4-Trimethylbenzene	105	80–144
1,3,5-Trimethylbenzene	100	76–142
o-Xylene	93	79–141
p-Xylene	91	74–138

[a] Average of two determinations.

[b] D denotes that the compound was detected.

TABLE 7.7

Quality Check Sample Results:
Semivolatile Analyses, 2004

Constituent	Recovery[a] (%)	Quality Limit (%)
2-Fluorophenol[b]	46.9	21–100
Phenol-d5[b]	27.0	10–94
Phenol	28.0	17–100
2-Chlorophenol	70.2	36–120
1,3-Dichlorobenzene	49.1	33–95
1,4-Dichlorobenzene	47.9	37–106
n-Nitroso-n-Propylamine	37.2	24–198
Nitrobenzene-d5[b]	70.5	35–114
1,2,4-Trichlorobenzene	55.8	57–129
4-Chloro-3-Methylphenol	60.8	41–128
2-Fluorobiphenyl[b]	60.8	43–116
2-Methylnaphthalene	78.8	45–113
Acenaphthene	66.9	47–145
2,4-Dinitrotoluene	87.3	48–127
2,4,6-Tribromophenol[b]	107.0	10–123
Pentachlorophenol	74.1	38–152
Pyrene	96.0	70–100
Terphenyl-d14[b]	88.5	33–141

[a] Average of three independent determinations.

[b] Required surrogates.

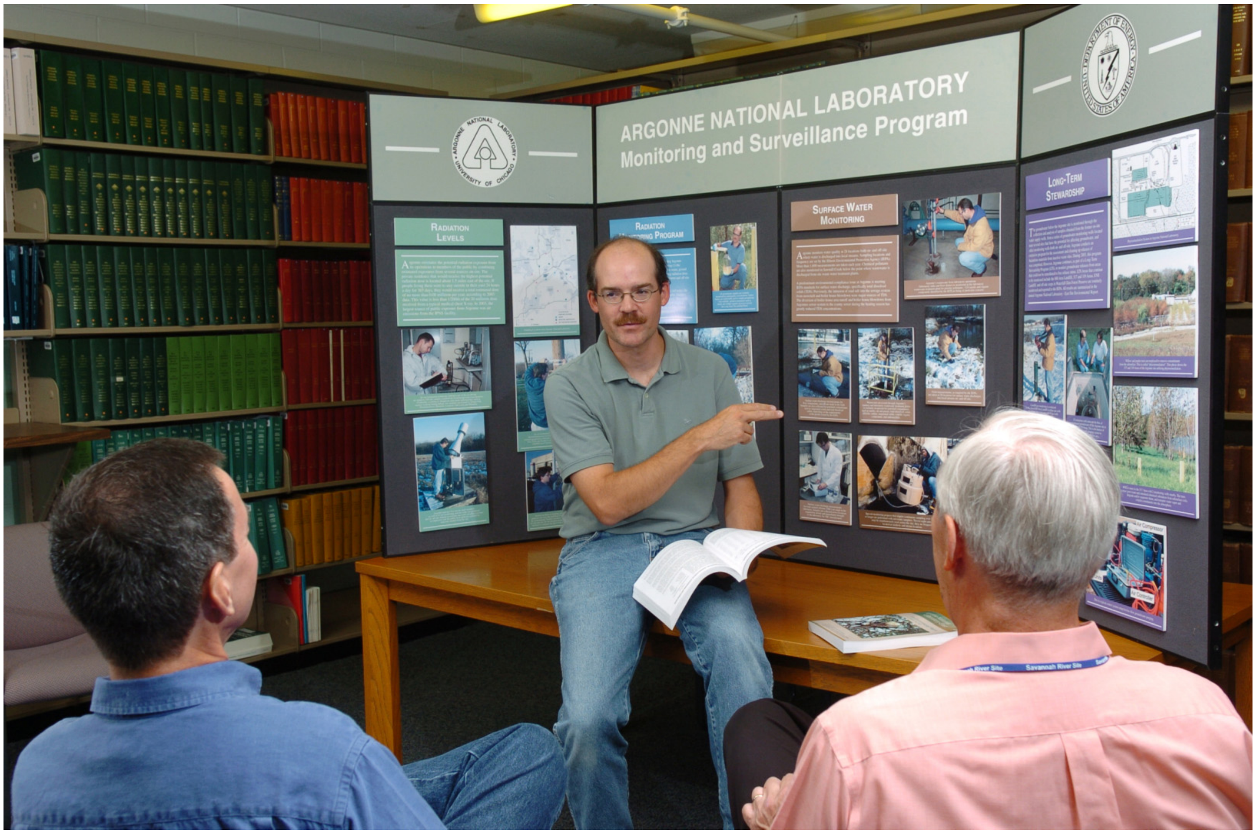
TABLE 7.8

Summary of DMR-QA Intercomparison Samples, 2004

Analyte	Units[a]	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Antimony	µg/L	401	417	289–503	Acceptable
Arsenic	µg/L	291	302	251–355	Acceptable
Barium	µg/L	615	618	531–704	Acceptable
Beryllium	µg/L	218	210	178–237	Acceptable
Boron	µg/L	696	667	541–854	Acceptable
Cadmium	µg/L	216	218	185–248	Acceptable
Chromium	µg/L	286	280	242–318	Acceptable
Cobalt	µg/L	432	409	359–459	Acceptable
Copper	µg/L	357	348	314–384	Acceptable
Iron	µg/L	458	454	398–517	Acceptable
Lead	µg/L	314	321	277–364	Acceptable
Manganese	µg/L	251	252	225–280	Acceptable
Mercury	µg/L	10.1	11.2	8.36–14.0	Acceptable
Nickel	µg/L	549	538	483–603	Acceptable
Selenium	µg/L	797	822	653–952	Acceptable
Silver	µg/L	156	151	129–173	Acceptable
Thallium	µg/L	707	704	568–816	Acceptable
Vanadium	µg/L	321	321	287–352	Acceptable
Zinc	µg/L	666	648	573–730	Acceptable
Biochemical oxygen demand	mg/L	172	91.7	46.3–137	Not acceptable
Chemical oxygen demand	mg/L	107	121	91.2–140	Acceptable
Ammonia nitrogen	mg/L	16.7	4.8	11.8–18.4	Acceptable
Total residual chlorine	mg/L	1.16	1.14	0.890–1.39	Acceptable
Total cyanide	mg/L	0.41	0.574	0.397–0.740	Acceptable
pH	S.U.	8.32	8.43	8.18–8.67	Acceptable
Total phenolics	mg/L	1.4	1.32	0.726–1.91	Acceptable
Total suspended solids	mg/L	81.9	89.9	69.8–97.1	Acceptable
Grease and oil	mg/L	19.9	24.0	14.5–29.0	Acceptable
Fathead minnow acute toxicity	LC_{50}	36.5	50.4	5.00–95.8	Acceptable
Water flea acute toxicity	LC_{50}	33	37.5	<6.25–70.3	Acceptable

[a] µg/L = micrograms/liter, mg/L = milligrams/liter, S.U. = standard units, LC_{50} = the calculated effluent concentration at which 50% of the test organisms are killed in a specified time period.

8. APPENDIX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