Argonne National Laboratory-East

Site Environmental Report
for Calendar Year 1999

ANL-00/2

By N. W. Golchert and R. G. Kolzow

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ARGONNE NATIONAL LABORATORY-EAST SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1999

by

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Environment, Safety and Health Division

September 2000

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
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This Site Environmental Report (SER) was prepared by the Environment, Safety and Health (ESH) Division at Argonne National Laboratory-East (ANL-E) for the U.S. Department of Energy. 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/1999.

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ACM	Asbestos-Containing Material
AEA	Atomic Energy Act of 1954
ANL-E	Argonne National Laboratory-East
AOC	Area of Concern
APS	Advanced Photon Source
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
CY	Calendar Year
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DPCHD	DuPage County Health Department
EA	Environmental Assessment
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EMS	Environmental Protection Data Management System
ENE	East-Northeast
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ERMS	Emissions Reduction Market System
ESA	Endangered Species Act
ESH	Environment, Safety and Health
ESH-ASCL	Environment, Safety and Health/Analytical Services, Chemical Laboratory
ESH-ASRL	Environment, Safety and Health/Analytical Services, Radiochemistry Laboratory
FFCA	Federal Facility Compliance Act
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
HSWA	Hazardous and Solid Waste Amendments
IAC	*Illinois Administrative Code*
ICRP	International Commission on Radiological Protection

IDNS	Illinois Department of Nuclear Safety
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
IHPA	Illinois Historic Preservation Agency
IPNS	Intense Pulsed Neutron Source
ISM	Integrated Safety Management
LEPC	Local Emergency Planning Committee
LLW	Low-Level Radioactive Waste
MSDS	Material Safety Data Sheet
MW	Mixed Waste
MY	Model Year
NBL	New Brunswick Laboratory
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NMOC	Nonmethane Organic Compounds
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRHP	National Register of Historical Places
O&M	Operation and Maintenance
PBT	Persistent, Bioaccumulative Toxic
PCB	Polychlorinated Biphenyl
PFS	Plant Facilities and Services
PQL	Practical Quantification Limit
PSTP	Proposed Site Treatment Plan
QA	Quality Assurance
QAP	Quality Assurance Program
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SER	Site Environmental Report
SOP	Standard Operating Procedure
SIP	Site Implementation Plan
SSI	Site Screening Investigation
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
TDS	Total Dissolved Solids
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TRI	Toxic Release Inventory
TRU	Transuranic

TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WIPP	Waste Isolation Pilot Plant
WMO	Waste Management Operations
WM&PP	Waste Minimization and Pollution Prevention
WQS	Water Quality Standard
WTP	Wastewater Treatment Plant

This report discusses the results of the environmental protection program at Argonne National Laboratory-East (ANL-E) for 1999. To evaluate the effects of ANL-E operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the ANL-E 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-E 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-E, 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. The status of ANL-E environmental protection activities with respect to the various laws and regulations that govern waste handling and disposal is discussed, along with the progress of environmental corrective actions and restoration projects.

This report summarizes the ongoing environmental protection program conducted by Argonne National Laboratory-East (ANL-E) in 1999. It includes descriptions of the site, ANL-E missions and programs, the status of compliance with environmental regulations, environmental protection and restoration activities, and the environmental surveillance program. The surveillance program conducts regular monitoring for radiation, radioactive materials, and nonradiological constituents on the ANL-E 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-E's impact on the environment. The surveillance program supports the ANL-E policy of protecting the public, employees, and the environment from harm that could be caused by ANL-E 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-E facilities are regulated under the Clean Air Act (CAA). A number of airborne radiological emission points at ANL-E are subject to National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations for radionuclide releases from U.S. Department of Energy (DOE) facilities (*Code of Federal Regulations*, Title 40, Part 61, Subpart H [40 CFR Part 61, Subpart H]). All such air emission sources were evaluated to ensure that these requirements are being addressed properly. The ANL-E individual off-site dose required to be reported by U.S. Environmental Protection Agency (EPA) regulations in 1999 was 0.0043 mrem/yr. This is 0.04% of the 10 mrem/yr standard. This dose does not include contributions from radon-220 and radon-222 emissions, as required by the regulations.

At ANL-E, asbestos-containing material (ACM) frequently is encountered during maintenance or renovation of existing facilities and equipment. Asbestos is removed and disposed of in strict accordance with NESHAP, Toxic Substances Control Act (TSCA), and Occupational Safety and Health Administration worker protection standards. Approximately 170 m^3 (6,000 ft^3) of ACM was removed and disposed of at off-site landfills in Illinois during 1999.

The ANL-E site contains several 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 (APS) and the engine test facility are also significant sources, when operational. The air pollution control operating permit for the steam plant requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only boiler equipped to burn coal. Low-sulfur coal was burned as the fuel for the steam plant for five months during 1999, whereas natural gas was used as the fuel at that boiler for the other seven months of the year. During the period coal was burned, which occurred during colder

weather to supplement the other gas-fired boilers, one exceedance for opacity was observed on April 15, 1999, due to torn filters and a leaking gasket.

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. The renewal of the ANL-E NPDES permit, effective October 30, 1994, increased the number of monitored discharge points from 9 to 28. The permit was modified on August 24, 1995, to increase temporarily to July 1, 1999, some discharge limits during the three-year compliance schedule imposed to achieve final limits. During 1999, only eight exceedances of the NPDES permit limits were reported out of approximately 1,600 measurements. An application to renew the existing permit was submitted timely to the Illinois Environmental Protection Agency (IEPA) during December 1998. The IEPA did not act to review the permit renewal application in 1999, and, therefore, as provided for in the IEPA regulations, ANL-E continues to operate under the 1994 permits, as modified, until a renewal permit is issued.

ANL-E was granted interim status under the Resource Conservation and Recovery Act (RCRA) 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. Since the issuance of the permit, two additional SWMUs have been added to the permit.

ANL-E has prepared and implemented a sitewide underground storage tank (UST) compliance plan. Thirty-nine tanks have been removed over the past several years. The ANL-E site contains 19 USTs that are in compliance with UST regulations. One UST used for fuel oil storage was removed during 1999.

The only TSCA-regulated compounds in significant quantities at ANL-E are polychlorinated biphenyls (PCBs) contained in electrical capacitors, power suppliers, and small transformers. All pole-mounted transformers and circuit breakers containing PCBs were replaced or retrofilled with non-PCB oil. All removal and disposal activities were conducted by licensed contractors specializing in such operations. PCB-contaminated sludge from the ANL-E wastewater treatment plant was characterized, containerized, and stored during 1994. The ANL-E PCB Item Inventory Program was initiated in 1995 to identify all suspect PCB-containing items.

DOE implementation of National Environmental Policy Act (NEPA) requirements has undergone significant changes since 1992. In 1999, most NEPA project reviews submitted to DOE for review and approval were determined to be categorical exclusions. Two Environmental Assessment (EA) addendums, addressing the 319 Landfill Remediation-Drainage Reroute and the Boiler House SWMU Sampling and Remediation activities, respectively, were completed in 1999.

The ANL-E Environmental Management Plan identifies funding needs for on-site rehabilitation projects, environmental restoration projects, and waste management activities. The rehabilitation projects concentrate on upgrading or replacing existing treatment facilities. ANL-E environmental restoration activities consist of projects that assess and clean up inactive waste sites. These include two inactive landfills, three French drains (i.e., dry wells used to dispose of liquid chemicals), two inactive wastewater treatment facilities, and a number of areas that may have been contaminated with small amounts of hazardous chemicals.

On-going compliance issues at ANL-E during 1999 were effluent concentrations of total dissolved solids (TDS) and total suspended solids (TSS) in excess of NPDES permit effluent limits; elevated levels of some routine indicator parameters in the groundwater at the sanitary landfill; and cleanup of environmental contamination caused by previous activities on the ANL-E site.

Environmental Surveillance Program

Airborne emissions of radioactive materials from ANL-E were monitored during 1999. The effective dose equivalents were estimated at the site perimeter and to the maximally exposed member of the public with the EPA's CAP-88 (CAA Assessment Package-1988) computer code. The estimated maximum perimeter dose was 0.063 mrem/yr in the southwest direction, while the estimated maximum dose to a member of the public was 0.015 mrem/yr. This is 0.015% of the DOE radiation protection standard of 100 mrem/yr for all pathways. Approximately 65% of this estimated dose is due to the release of 193 Ci of radon-220 in 1999. If the contribution of radon-220 is excluded from reporting, as required by 40 CFR Part 61, Subpart H, the estimated dose to the maximally exposed individual would be 0.0043 mrem/yr. The estimated population dose from releases to the approximately eight million people living within 80 km (50 mi) of the site was 0.97 man-rem.

Ambient air monitoring was conducted for total alpha activity, total beta activity, strontium-90, isotopic thorium, isotopic uranium, and plutonium-239 at the ANL-E site perimeter and at off-site locations. No statistically significant difference was identified between samples collected at the ANL-E 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-E releases was 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 0.68 Ci of hydrogen-3. The hydrogen-3 was added to the wastewater as part of normal ANL-E operations. The dose to a hypothetical individual using water from Sawmill Creek as his or her sole source of drinking water would be 0.047 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-E at Lemont. Sawmill Creek also is monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards. Iron and copper occasionally were detected above 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 0.362 pCi/g) and americium-241 (up to 0.118 pCi/g) were detected in the sediment below the outfall and are attributed to past ANL-E releases.

Dose rates from penetrating radiation (gamma-rays) were measured at 17 perimeter and on-site locations and at five off-site locations in 1999 using thermoluminescent dosimeters. The off-site results averaged 80 ± 4 mrem/yr, which is consistent with the long-term average. Above-background doses occurred at one perimeter location and were due to ANL-E operations. At the south fence, radiation from a temporary storage facility for radioactive waste resulted in an average dose of 105 ± 21 mrem/yr for 1999. The estimated dose from penetrating radiation to the nearest resident south of the site was < 0.01 mrem/yr.

The potential radiation doses to members of the public from ANL-E operations during 1999 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The inhalation pathway dominates. The highest estimated dose was approximately 0.076 mrem/yr to individuals living 500 m (1,640 ft) north of the site if they were outdoors at that location during the entire year. Estimated doses from other pathways at this location were small. The doses from ANL-E 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-E site in 1999. The former ANL-E domestic water supply is monitored by collecting quarterly samples from the three inactive supply wells. All results were less than the limits established by the Safe Drinking Water Act, except for elevated levels of TDS.

Ten monitoring wells screened in the glacial till 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 carbon tetrachloride, trichloroethene, 1,1,1-trichloroethane, 1,1-dichloroethane, and tetrachloroethene. Measurable levels of hydrogen-3, strontium-90, and cesium-137 were present in several of the wells. Remediation continued in this area using phytoremediation to remove volatile organic compounds (VOCs) and hydrogen-3 from groundwater.

Three monitoring wells are screened in the glacial till and one in the dolomite adjacent to the CP-5 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, while cesium-137 was detected occasionally. Low levels of trichlorofluoromethane were detected, in addition to a few metals.

Thirteen monitoring wells at the 800 Area sanitary landfill were sampled on a quarterly basis and analyzed for metals, cyanide, phenols, total organic carbon, total organic halogens, VOCs, semivolatiles, PCBs, pesticides and herbicides, and hydrogen-3. An additional 13 wells were added under a Supplemental Permit issued June 16, 1999. Levels above Illinois Class I Groundwater Quality Standards for chloride, iron, lead, manganese, and TDS were found in some wells. Above-background levels of hydrogen-3 were detected in several of the wells.

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 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.

ANL-E maintains a documented environmental management system that identifies responsibilities for environmental activities. ANL-E is committed to implementing that system in accordance with environmental policy.

1. INTRODUCTION

1.1. General

This annual report for 1999 on the Argonne National Laboratory-East (ANL-E) 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-E, and the amounts, if any, added to the environment by ANL-E operations. It also summarizes the compliance of ANL-E operations with applicable environmental laws and regulations and highlights significant accomplishments and problems related to environmental protection. The report was prepared in accordance with the guidelines of DOE Orders 5400.1[1] and 231.1[2] and supplemental DOE guidance.

ANL-E 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-E 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-E is a DOE research and development 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 1999 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; evaluation of heat exchangers for the recovery of waste heat from engines; and clean, efficient transportation.

Other areas of research are basic biological research, heavy-ion research into the properties of super-heavy elements, fundamental coal chemistry studies, the immobilization of radioactive waste products for safe disposal, fundamental studies of advanced computers, and the development of "chips" for the rapid assay of gene composition. 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-E 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 safeguards plutonium and uranium measurements and analytical chemistry laboratory, is located on the ANL-E site.

The principal nonnuclear activities at ANL-E in 1999 that could have measurable impacts on the environment include the use of a coal-fired boiler (No. 5) and the use of chlorine for water treatment.

1.2. Description of Site

ANL-E 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, the surrounding area, and sampling locations of the monitoring program. Much of the 907-ha (2,240-acre) Waterfall Glen Forest Preserve surrounding the site was part of the ANL-E 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-E 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-E 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). The Chicago District Pipe Line Co. and the Burlington Northern Santa Fe Railroad have rights-of-way in the southern portion of the forest preserve.

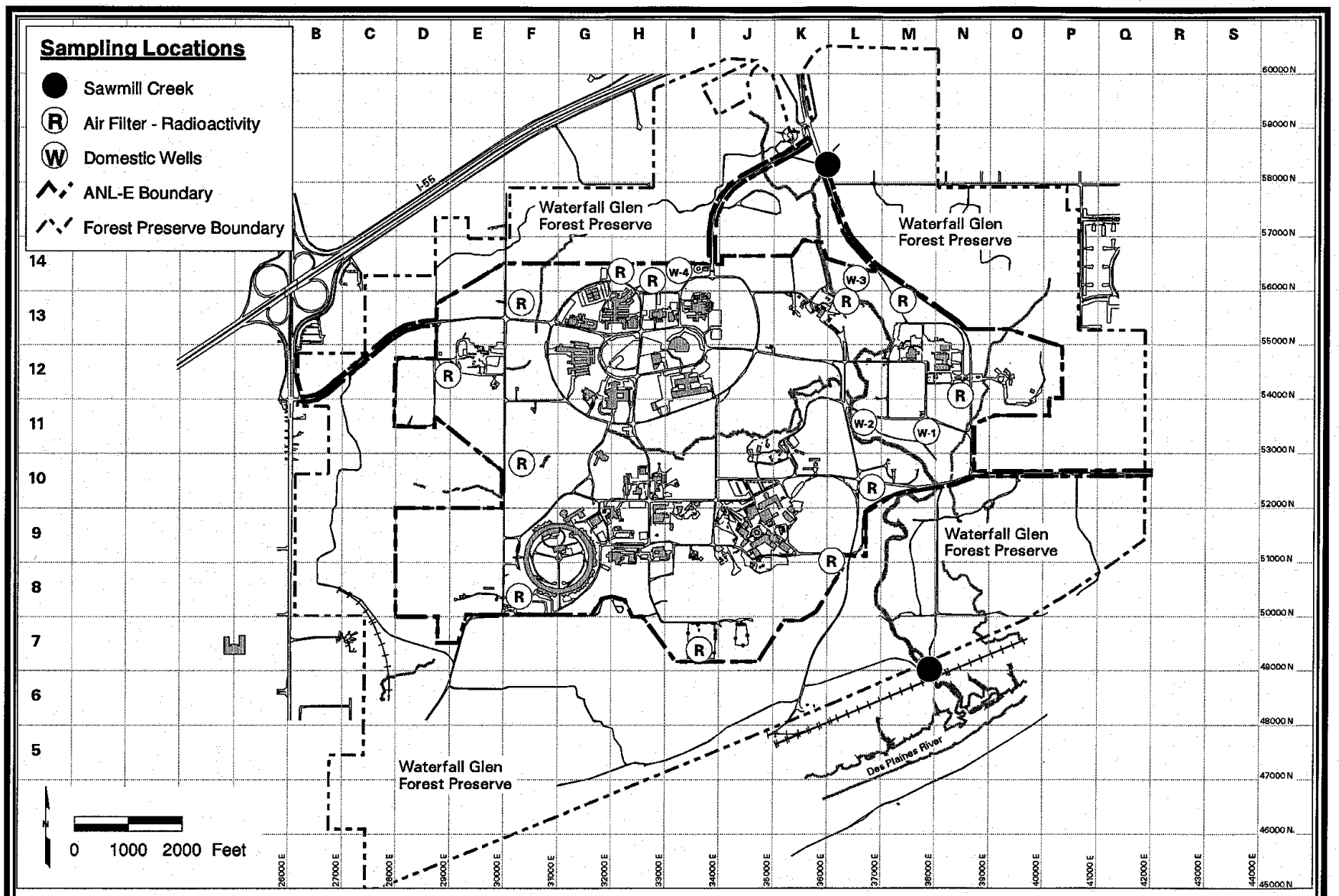

Figure 1.1 Sampling Locations at Argonne National Laboratory-East

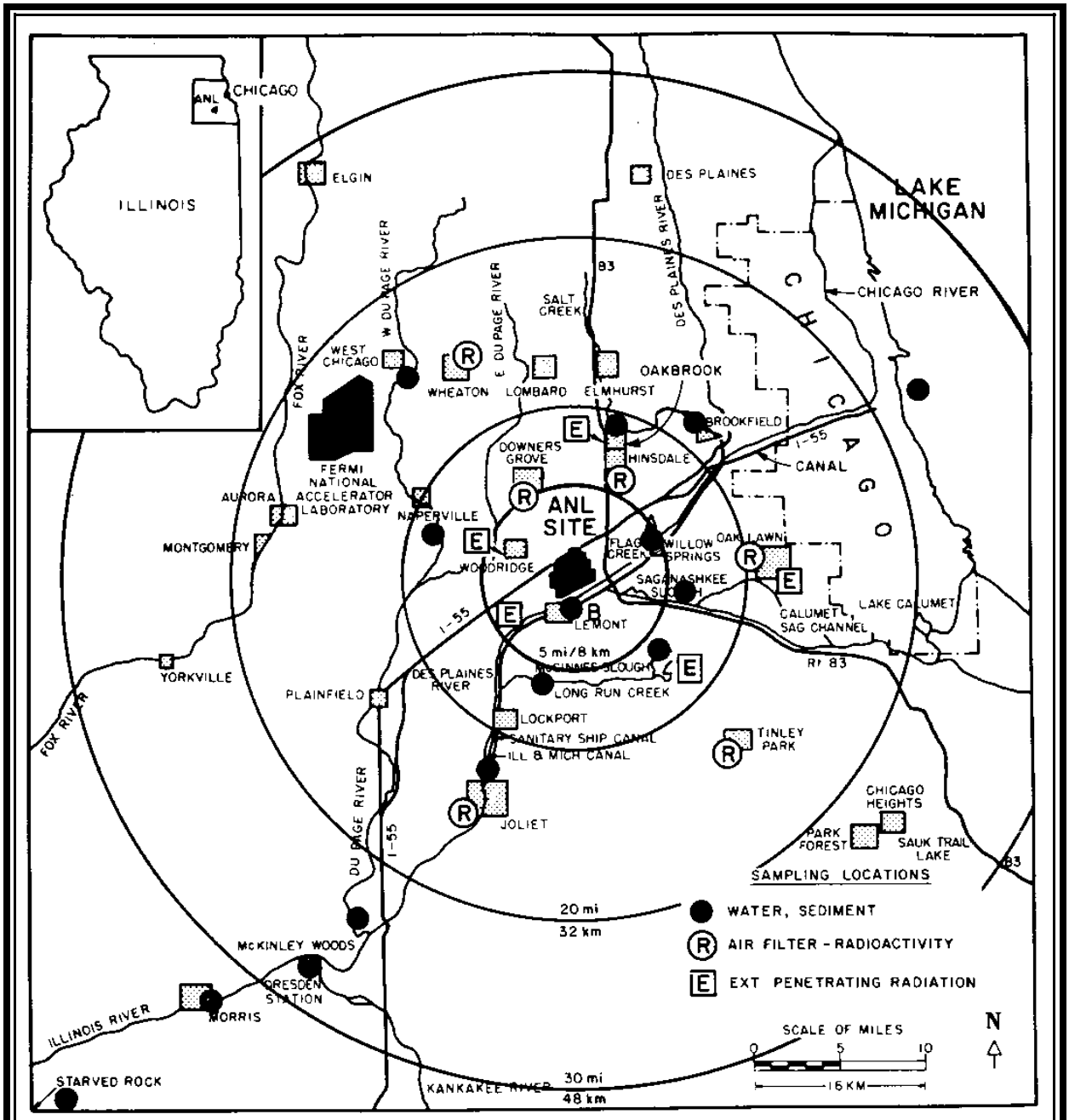

Figure 1.2 Sampling Locations near Argonne National Laboratory-East

1.3. Population

The area around ANL-E has experienced a large 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-5 (CP-5) reactor (Location 9G in Figure 1.1), was prepared by the Risk Assessment and Safety Evaluation Group of the Environmental Assessment Division at ANL-E and represents projections to 1997, on the basis of 1990 census data.

1.4. Climatology

The climate of the area is representative of the upper Mississippi Valley, as moderated by Lake Michigan. Summaries of the meteorological data collected on the site from 1950 to 1964 are available[3] and provide a historical sample of the climatic conditions. 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 1999 data were obtained from the on-site ANL-E meteorological station. The 1999 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 – 6 m/s (4.5 – 13.4 mph), 6.01 – 10 m/s (13.4 – 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 22.5^{o} intervals; each radius represents the average wind speed for the direction covering 11.25^{o} on either side of the radius.

The annual average wind rose for 1999 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 1999 precipitation and temperature data. The monthly precipitation data for 1999 showed a few differences from the average. The early part of the year had less precipitation than normal while the spring was wetter than the average. The annual average was very similar to the long-term average. The temperatures are generally higher when compared with the long-term averages.

TABLE 1.1

Population Distribution in the Vicinity of ANL-E, 1997

	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	1,120	2,884	6,245	8,613	46,331	174,570	345,014	212,982	261,504
NNE	0	898	3,573	6,846	7,168	44,197	287,496	463,950	95,266	2,047
NE	0	748	2,203	2,255	2,125	42,131	642,743	930,802	0	0
ENE	0	333	1,057	1,615	1,989	33,508	569,089	180,886	0	0
E	0	335	985	954	462	41,692	463,141	206,619	9,217	26,320
ESE	0	373	882	1,161	541	19,213	199,976	291,723	230,482	87,179
SE	0	468	900	1,192	1,109	22,696	131,492	120,061	34,063	17,926
SSE	0	521	900	937	1,418	14,904	40,179	12,562	11,807	15,974
S	0	543	900	1,007	1,275	6,807	28,223	6,226	36,775	37,107
SSW	0	497	740	898	1,063	18,028	91,686	17,430	16,371	6,348
SW	0	353	594	637	647	9,521	48,150	11,398	16,652	6,793
WSW	0	333	394	984	2,742	9,950	11,068	5,649	8,196	14,320
W	0	370	2,964	7,810	9,200	30,181	65,457	20,082	16,193	5,718
WNW	0	1,022	3,573	7,777	6,817	52,201	138,763	34,280	8,780	53,815
NW	0	1,361	2,793	7,075	8,755	46,680	83,890	101,417	24,562	17,492
NNW	0	1,361	2,756	5,798	9,150	40,435	200,789	268,137	144,672	113,070
Total	0	10,636	28,098	53,191	63,074	478,475	3,176,712	3,016,236	866,018	665,613
Cumulative total[b]	0	10,636	38,734	91,925	154,999	633,474	3,810,186	6,826,422	7,692,440	8,358,053

[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.

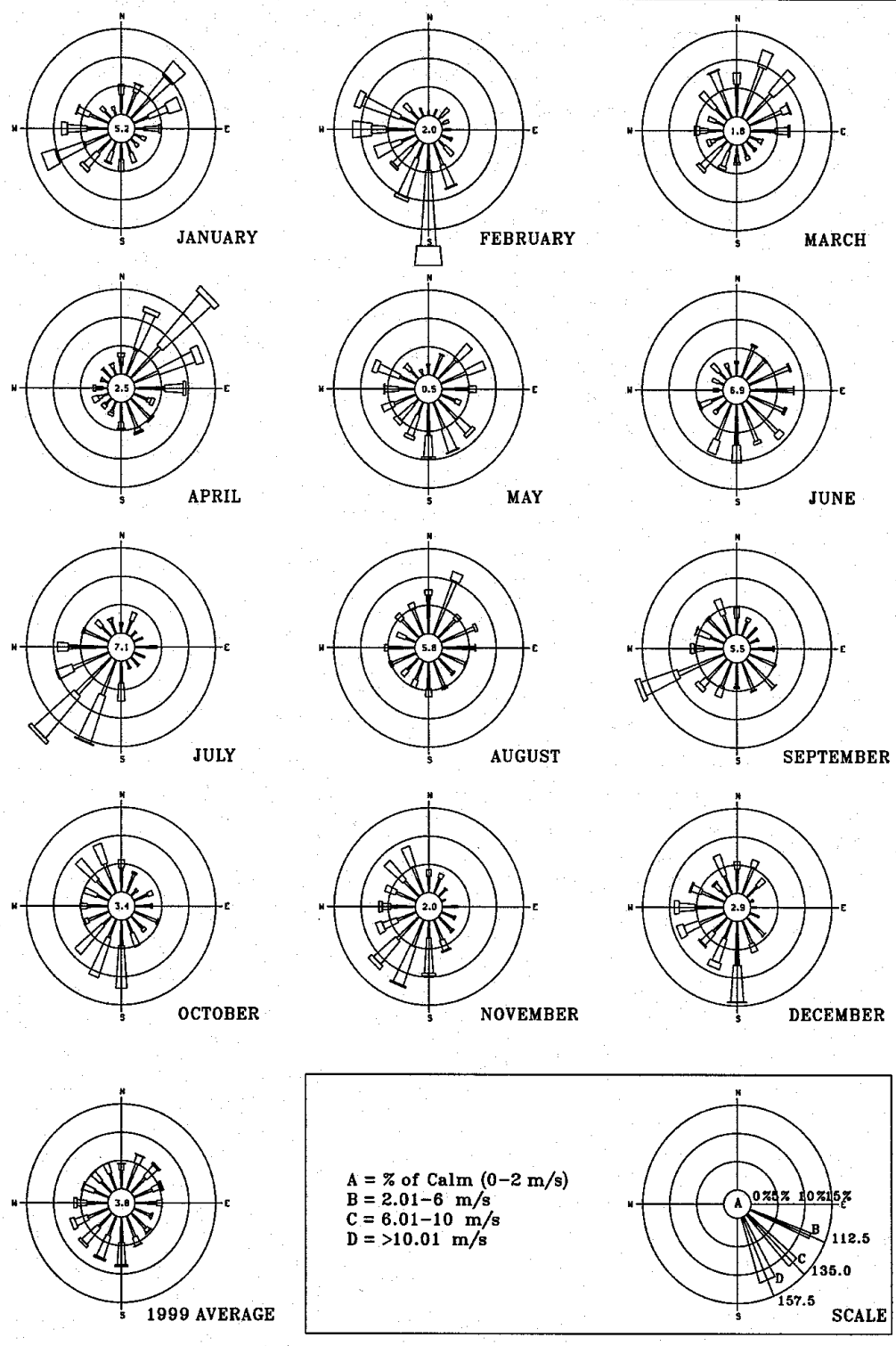

Figure 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory-East, 1999

TABLE 1.2

ANL-E Weather Summary, 1999

	Average Precipitation (cm)			Average Temperature (°C)		
Month	ANL-E 1999	ANL-E Historical[a]	Historical[b]	ANL-E 1999	ANL-E Historical[a]	Historical[b]
January	2.53	3.61	4.06	-5.8	-5.9	-5.9
February	1.22	3.38	3.33	2.6	-3.7	-3.3
March	2.77	5.56	6.58	1.8	0.6	2.2
April	18.59	9.14	9.30	10.7	8.3	9.3
May	14.96	7.82	8.00	17.1	14.5	15.1
June	9.14	9.47	10.36	21.2	19.7	20.3
July	5.43	10.97	9.22	25.5	21.7	22.8
August	7.98	8.71	8.97	21.2	20.9	22.2
September	8.31	7.14	8.51	17.9	16.8	18.2
October	2.16	6.58	5.79	11.7	11.4	11.9
November	2.24	4.37	5.23	7.7	2.9	4.3
December	6.08	3.20	5.33	-1.1	-4.2	-2.4
Total	81.41	79.95	84.68			

[a] ANL-E data obtained from Reference 3.

[b] Data obtained from the National Oceanic and Atmospheric Administration for the weather station at O'Hare International Airport. The average is for the years 1951–1980.

1.5. Geology

The geology of the ANL-E area consists of about 30 m (100 ft) of glacial till on top of bedrock, which is Niagaran and Alexandrian dolomite, underlain by shale and older dolomites and sandstones of Ordovician and Cambrian age. The beds are nearly horizontal, although the top of the dolomite may not be horizontal. Niagaran and Alexandrian dolomite is approximately 60 m (200 ft) thick and widely used in DuPage County as a source of groundwater. The shale separating the upper dolomite aquifer from the underlying sandstone and dolomite aquifers retards the hydraulic connection between them. The lower aquifer has a much lower piezometric level and does not appear to be affected by pumpage from the overlying bedrock.

The southern boundary of ANL-E follows the escarpment 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 till 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 till. Morley soils have a relatively low organic content in the surface layer, moderately slow subsoil permeability, and a large water capacity. These soils are well suited to growing crops if good erosion control practices are used. 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-E are known to be seismically active. The longest of these features 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-E. 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-E 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. Hydrology

Up until 1997, most groundwater supplies in the ANL-E 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. Because the cones of depression of ANL-E wells do not extend beyond the site and adjacent forest preserve, ANL-E water use does not affect neighboring communities. With the acquisition of Lake Michigan water in 1997, the recovery of the dolomite water table is being measured.

Two principal aquifers are used as water supplies in the vicinity of ANL-E. The upper aquifer is the Niagaran and Alexandrian dolomite, which is approximately 60 m (200 ft) thick in the ANL-E 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.

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-E 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 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-E are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. In 1999, this effluent averaged 2.9 million L/day (0.78 million gal/day), which is slightly higher than the averages for the last few years. The combined ANL-E effluent consisted of 49% laboratory wastewater and 51% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 32 million L/day (8.5 million gal/day) during 1999.

Sawmill Creek and the Des Plaines River above Joliet, about 21 km (13 mi) southwest of ANL-E, receive very little recreational or industrial use. A few people fish in these waters downstream of ANL-E, and some duck hunting takes place on the Des Plaines River. Water from the Chicago Sanitary and Ship Canal is used by ANL-E for cooling towers and by others for industrial purposes, such as hydroelectric generators and condensers, and for irrigation at the state prison near Joliet. ANL-E usage is approximately 1.1 million L/day (290,000 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-E. 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-E. In the vicinity of ANL-E, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

The principal recreational area near ANL-E 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, 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-E and the Des Plaines River. The preserves include the McGinnis and Saganashkee Sloughs (shown in Figure 1.2), 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-E site (Location 12-0 in Figure 1.1) is for the use of ANL-E and DOE employees. A local municipality has use of the park for athletic events.

1.9. Vegetation

ANL-E 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-E 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 on 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.

Early photographs of the site indicate that most of the land that ANL-E 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-E belong to Chicago Wilderness, a partnership of more than 100 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) undeveloped at the ANL-E 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 a hundred other bird species can be found in the area during migration or winter, but they do not nest on the site or in the surrounding region. An unusual species on the ANL-E 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-E site. The white-tailed and fallow deer populations are each maintained at a target density of 20 deer/mi^2 under an ongoing deer management program. Terrestrial invertebrate species and plants also reside on the ANL-E site.

Freund Brook crosses the center of the site but is impounded by a beaver dam in this area. 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-E site include additional 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-E 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 (FWS) has rated the Des Plaines River system, including ANL-E streams, as “poor” in terms of the fish species present because of domestic and industrial pollution and stream modification.

1.11. Archaeology

ANL-E, 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-E area either by professional cultural resource investigators or through interviews of local artifact collectors by ANL-E staff. A variety of site types, including mounds, quarries, lithis 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-E. 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). Three sites have been determined to be eligible for the National Register for Historic Places (NRHP); 20 sites have been determined to be ineligible; and 23 sites have not been evaluated for eligibility.

1.12. Endangered Species

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

The Hine’s emerald dragonfly (*Somatochlora hineana*), federally and state listed as endangered, occurs in locations with calcaerous seeps and wetlands along the Des Plaines River floodplain. Leafy prairie clover (*Dalea foliosa*), which is federally and state listed as endangered, is associated with dolomite prairie remnants of the Des Plaines River valley; two planted populations of this species occur in Waterfall Glen Forest Preserve. An unconfirmed capture of an Indiana bat

(*Myotis sodalis*), which is federally and state listed as endangered, indicates that this species may occur in the area. Additional state-listed species that occur in the area include the following:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax*)
  - Great egret (*Casmerodius alba*)
  - Pied-billed grebe (*Podilymbus podiceps*)
  - Red-shouldered hawk (*Buteo lineatus*)
  - River otter (*Lutra canadensis*)
  - Rough marsh cress (*Rorippa islandica* var. *hispida*)
  - Slender sandwort (*Arenaria patula*)
  - White lady's slipper (*Cypripedium candidum*)

- Threatened
  - Early fen sedge (*Carex crawei*)
  - Kirtland's snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)

Of these, rough marsh cress, Kirtland's snake, pied-billed grebe, great egret, black-crowned night heron, and red-shouldered hawk have been observed on ANL-E property.

2. COMPLIANCE SUMMARY

ANL-E is a government-owned, contractor-operated nonproduction 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 Illinois Department of Public Health (IDPH), U.S. Army Corps of Engineers (COE), and the State Fire Marshal, as well as to numerous DOE Orders and Executive Orders. A detailed listing of applicable regulations is contained in DOE Order 5400.1,[1] which establishes DOE's policy concerning environmental compliance. The status of ANL-E during 1999 with regard to these authorities is discussed in this chapter.

To ensure compliance with both the letter and spirit of these requirements, ANL-E has made a commitment to comply with all applicable environmental requirements, as described in the following policy statement:

> It is the policy of Argonne National Laboratory that its activities will be conducted in such a manner that worker and public safety, including protection of the environment, is given the highest priority. The Laboratory will comply with all applicable federal and state environmental laws, regulations, and orders.

2.1. Clean Air Act

The Clean Air Act (CAA) is a federal statute that specifies National Ambient Air Quality Standards, sets emission limits for air pollutants, and determines emission limits and operating criteria for certain hazardous air pollutants. The program for compliance with the requirements 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.

A number of major changes to the CAA were made with the passage of the Clean Air Act Amendments of 1990. Under Title V of the Clean Air Act Amendments of 1990, ANL-E was required to submit 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. This permit will supersede the state air pollution control permits that are currently in effect. All facilities designated as major emission sources for regulated air pollutants are subject to this requirement. ANL-E 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).

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-E also must evaluate emissions of carbon monoxide, particulates, volatile organic compounds (VOCs), hazardous air pollutants (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 will be allowed to emit.

When the IEPA acknowledges a CAAPP application as timely and complete, the applicant receives an application shield and is in compliance with the CAA. The ANL-E CAAPP application was submitted to the IEPA on September 19, 1995; the IEPA issued a Notice of Completeness on October 26, 1995. The Notice of Completeness also means that current air pollution control permits under which operations remain unchanged do not need to be renewed. Exceptions to this are the open burning permits used for fire training and ecological management, which must be renewed annually.

On September 22, 1999, ANL-E submitted a fifth revision to the CAAPP application. This update incorporated all changes since the prior revision, which was submitted in January 1998. On December 10, 1999, the IEPA notified ANL-E that review of the revised CAAPP application had commenced. It is anticipated that a CAAPP permit will be issued during 2000.

The ANL-E 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. By the end of 1999, a total of 35 active air pollution control permits were in place, covering all known emission points. Section 2.16 contains a list (Table 2.13) of all of the air pollution control permits at ANL-E. No IEPA air emissions inspection was conducted in 1999.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) constitute a body of federal regulations that set forth emission limits and other requirements, such as monitoring, record keeping, and operational and reporting requirements, for activities generating emissions of certain hazardous air pollutants. The only standards affecting ANL-E operations are those for asbestos and radionuclides. By the end of 1999, the IEPA had issued a total of 26 air pollution control permits to ANL-E for NESHAP sources. In 1999, two new NESHAP operating permits were issued for the Building 301 Hot Cell Decontamination and Decommissioning (D&D) project and the Building 306 Chemical Photooxidation Unit.

2.1.1.1. Asbestos Emissions

Many buildings on the ANL-E site contain large amounts of asbestos-containing material (ACM) such as thermal system insulation around pipes and tanks, spray-applied surfacing material for fireproofing, floor tile, and asbestos-cement (Transite) panels. This material is removed as

necessary during renovations or maintenance of equipment and facilities. The removal and disposal of this material are governed by the asbestos NESHAP.

ANL-E 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-E 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 NESHAP and Occupational Safety and Health Administration requirements governing worker safety at ACM removal sites.

Approximately 170 m^3 (6,000 ft^3) of ACM was removed from ANL-E buildings during 1999. The 95 small removal projects that were completed generated 48 m^3 (1,694 ft^3) of ACM waste; the remaining 119 m^3 (4,193 ft^3) generated resulted from large removal projects. Table 2.1 provides asbestos abatement information for the large removal projects. The IEPA was notified during December 1999 that no more than 100 m^3 (3,500 ft^3) of ACM waste will be generated from small-scale projects during 2000.

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-E landfill in September 1992, asbestos from small-scale projects was disposed of on site in a designated area of the landfill.

2.1.1.2. Radionuclide Emissions

The NESHAP standard for radionuclide emissions from DOE facilities (40 CFR Part 61, Subpart H) establishes the emission limits for the release of radionuclides other than radon to the air and the requirements for monitoring, reporting, and record keeping. A number of emission points at ANL-E are subject to these requirements. These points include ventilation systems for hot cell facilities for storage and handling of radioactive materials (Buildings 205 and 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-E emission sources is extremely small. The maximum off-site dose to a member of the general public for 1999 was 0.0043 mrem, which, excluding radon-220, is 0.04% of the 10 mrem/yr EPA standard. Section 4.6.1 contains a more detailed discussion of these emission points and compliance with the standard.

TABLE 2.1

Large-Scale Asbestos Abatement Projects: IEPA Notification, 1999

Completion Date	Asbestos Abatement Contractor	Notification Quantity (ft)	Notification Quantity (ft^2)	Material	Building	Disposal Quantity (ft^3)	Landfill
January 25	Champion Environmental Services	NA[a]	3,600	Transite panels	207	350	Streator[b]
April 22[c]	Holian Asbestos Removal Corporation	NA	2,500	Transite panels	108	918	Streator
May 12	Insulco Asbestos Management	NA	1,165	Transite panels	377	270	Streator
May 18	ACS, Inc.	339	NA	Pipe insulation	829	63	Streator
May 27[c]	ANL-E PFS-Waste Management	NA	280	Floor tile	350	24	Streator
September 17	National Surface Cleaning	2,200	775	Pipe and duct insulation	330	1,170	Streator
September 29[c]	ACS, Inc.	NA	1,100	Transite panels	211	48	Streator
November 29	Insul-Control, Inc.	38	310	Pipe insulation transite panels	363	1,350	Streator
					Total	4,193	

[a] NA = not applicable.

[b] Streator Area Landfill, Streator, IL.

[c] Courtesy notification, nonfriable material removed intact.

2.1.2. Conventional Air Pollutants

The ANL-E site contains a number of sources of conventional air pollutants, including a steam plant; gasoline, methanol/gasoline blend, and ethanol/gasoline blend fuel-dispensing facilities; two alkali metal reaction booths; bulk chemical tanks; a dust collection system; the engine test facility; a medical equipment sterilization unit; and fire training activities. Table 2.13 gives the emission sources that have been granted operating air pollution control permits by the IEPA. During 1999, one new air pollution control permit was issued by the IEPA (see Table 2.13) for VOC emissions from the Building 306 chemical photooxidation unit.

The operating air pollution control permit for the steam plant requires continuous opacity and SO_2 monitoring of the smoke stack from Boiler No. 5, the only one of the five boilers equipped to burn coal. The permit requires submission of a quarterly report listing any exceedances beyond emission limits for this boiler [30% opacity averaged over 6 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 1999, as well as the amount of low-sulfur coal burned. There was one opacity exceedance in 1999. On April 15, 1999, a 12-minute opacity exceedance occurred due to torn filters and a leaking gasket in the steam plant baghouse. The boiler was shut down until all repairs were completed. The IEPA was notified by phone, as required, on April 19, 1999; a written followup report was transmitted on April 30, 1999.

TABLE 2.2

Disposal of Asbestos-Containing Materials, 1999

Project Size	Landfill	Quantity (ft^3)
Small-scale	Streator[a]	1,694
Large-scale	Streator	4,301[b]
	Total	5,995

[a] Streator Area Landfill, Streator, IL.

[b] Includes 108 ft^3 of asbestos-containing floor tile from Building 207. This material was removed in 1998 but not disposed of until 1999. This was not included in Table 2.1.

The ANL-E 800 Area Landfill, which was closed in 1992, was not subject to air pollution control permitting requirements during its operation. It is not subject to 40 CFR Part 60, Subpart WWW (Standards of Performance for Municipal Solid Waste Landfills), or Subpart Cc (Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills), because it does not meet the definition of a municipal solid waste landfill. Because closed landfills are sources of emissions, in 1999, the EPA Landfill Gas Emissions Model (LandGEM)[4] was used to determine levels of methane and Nonmethane Organic Compounds (NMOC) for inclusion in the ANL-E CAAPP application and emissions inventory. For 1999, the model calculated methane emissions of approximately 59 t/yr (64.9 tons/yr) and NMOC emissions (from analysis of samples from gas monitoring wells) of approximately 0.02 t/yr (0.02 ton/yr). On the basis of the timing of initial refuse placement and closure of the landfill, the model predicts that methane emissions will decline over time.

Landfill gas monitoring is conducted quarterly at the 800 Area Landfill via the 12 gas wells placed into the waste area and the 10 gas wells at the perimeter of the 800 Area Landfill. The gas monitoring in the waste area determines the levels of methane, carbon dioxide, nitrogen, and oxygen generated by the landfill. The perimeter gas wells are monitored to determine whether or not methane is migrating from the landfill. Results indicate that methane is being generated; however, no migration of this compound has been noted.

Fuel-dispensing facilities include a commercial service station and the Building 46 Grounds and Transportation facility. Except for methanol and 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-E submits an emissions summary to the IEPA each May 1 for the previous year. The summary for 1999 is presented in Table 2.4.

TABLE 2.3

Boiler No. 5 Operation, 1999

Month	Operated (hours)	Low-Sulfur Coal Burned (tons)
January	253.5	689.8
February	620.0	1,773.3
March	445.5	1,128.6
April	68.0	131.2
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
November	0	0
December	198.0	564.7
Total	1,585.0	4,287.6

2.1.3. Clean Fuel Fleet Program

As mandated under the CAA and 35 IAC Part 241, the first annual Clean Fuel Fleet report was submitted timely to the IEPA on October 27, 1999 (September 1, 1998 – August 31, 1999), for ANL-E vehicle acquisitions for Model Year (MY) 1999. Sixteen light-duty vehicles were reported, with nonexempt vehicles exceeding the compliance requirements of at least 30% being EPA clean fuel certified. Two exempt heavy-duty vehicles also were reported. An application was submitted to the IEPA Clean Fuel Fleet credit program for overcompliance in MY 1999 in the light-duty vehicle category. September 1, 1999, marked the beginning of MY 2000; certified light-duty acquisition requirements increased from 30 to 50% for the model year (heavy-duty vehicle acquisitions remain at 50%).

2.2. Clean Water Act

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

TABLE 2.4

1999 Annual Emissions Report: Emissions Summary

Building No. and Source	CO[a]	NO_x	Particulate	SO_2	VOM	Lead
46 Ethanol/Gasoline	0	0	0	0	14.6	0
46 Methanol/Gasoline	0	0	0	0	0	0
46 10,000 Gal Gasoline	0	0	0	0	320	0
108 Boiler 1	1,701	75,766	785	471	366	0
108 Boiler 2	5	15,771	151	121	70	0
108 Boiler 3	46	45,249	456	639	213	0
108 Boiler 4	82	17,334	175	47	82	0
108 Boiler 5 (coal-fired)	21,388	115,584	324	93,041	151	0
108 Boiler 5 (gas-fired)	2,589	7,904	112	40	112	0
108 Sulfuric Acid Tank[b]	0	0	-[c]	0	0	0
200 M-Wing Hot Cells (R)	0	0	0	0	0	0
201 Ethylene Oxide Sterilizer	0	0	0	0	5.3	0
206 Alkali Reaction Booth (R)[d]	0	0	<1	0	0	0
212 Alpha Gamma Hot Cell (R)	0	0	0	0	0	0
212 Building Exhausts[b]	0	0	-	0	0	0
300 8,000 Gal Gasoline	0	0	0	0	1,148	0
300 10,000 Gal Gasoline	0	0	0	0	286	0
300 6,000 Gal Gasoline	0	0	0	0	331	0
303 Mixed Waste Storage (R)	0	0	0	0	0	0
306 Building Vents (R)	0	0	0	0	0	0
306 Bulking Sheds	0	0	0	0	429	0
306 Vial Crusher/Chemical Photooxidation Unit	0	0	0	0	0	0
308 Alkali Reaction Booth[b]	0	0	-	0	0	0
315 MACE Project (R)	100	0	<1	0	0	0
317 Lead Brick Cleaning (R)	0	0	0	0	0	<1
330 CP-5 D&D Project (R)	0	0	0	0	0	0
331 Rad Waste Storage (R)	0	0	0	0	0	0
350 NBL Pu/U Hoods (R)	0	0	0	0	0	0
363 Central Shop Dust Collector[b]	0	0	-	0	0	0
366 Grieve Oven[b]	0	0	-	0	0	0
368 Woodshop Dust Collector[b]	0	0	-	0	0	0
369 Salt Cake/Recov Elec. Plant[b]	0	0	0	0	0	0
370 Alkali Reaction Booth[b]	0	0	-	0	0	0
375 Intense Pulsed Neutron Source (R)	0	0	0	0	0	0
400 APS Facility (R)	0	69	0	0	0	0
400 APS Generator Caterpillar (1 unit)	513	2,675	95	221	72	0
400 APS Generator Kohler (2 units)	1,526	2,059	80	423	73	0
595 Lab Wastewater Plant (R)	0	0	0	0	85.8	0
Lab Rad Hoods (R)	0	0	0	0	0	0
PCB Tank Cleanout	0	0	0	0	0	0
Torch Cut Lead-Based Paint[b]	0	0	-	0	0	0
Transportation Research Facility	1,341	497	34.5	32.6	99.6	0
WMO Portable HEPA - (4) (R)	0	0	<1	0	0	0
Total (lb/yr)	29,289	282,908	2,212	95,034	3,858	0
Total (ton/yr)	14.6447	141.4539	1.1062	47.5170	1.9288	0
CAAPP Limit (ton/yr) - Typical	159.58	692.30	39.18	463.82	14.77	0.11
CAAPP Limit (ton/yr) - Alt 1	243.60	1,697.10	48.02	802.03	18.77	0.11
CAAPP Limit (ton/yr) - Alt 2	307.60	1,405.10	68.02	991.20	18.77	0.11

[a] Abbreviations: CO = carbon monoxide, HEPA = high-efficiency particulate air filter, MACE = melt attack and coolability experiment, NO_x = oxides of nitrogen, PCB = polychlorinated biphenyl, Pu = plutonium, SO_x = sulfur dioxide, U = uranium, and VOM = volatile organic material.

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

[c] A hyphen indicates no emissions for this parameter.

[d] (R) = radionuclide source regulated by NESHAP (40 CFR Part 61 Subpart H).

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 and greatly expanded the number of chemical constituents monitored in the effluent.

2.2.1. Liquid Effluent Discharge Permit

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 or 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 five years and must be renewed by the submission of a permit application at least 180 days prior to the expiration of the existing permit. Wastewater discharge at ANL-E is permitted by NPDES Permit No. IL 0034592. This permit was renewed during 1994 (effective October 30, 1994), was modified in 1995 (effective August 24, 1995), and was to expire on July 1, 1999. An application to renew the existing permit was submitted timely to the IEPA on December 28, 1998. The IEPA did not act to review the permit renewal application in 1999, and, therefore, as provided for in the IEPA regulations, ANL-E continues to operate under the existing permit until the IEPA issues a renewal permit.

Wastewater at ANL-E 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 to 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 2.1 shows their locations.

2.2.1.1. Compliance with NPDES Permit

Wastewater is processed at ANL-E 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

TABLE 2.5

Characterization of NPDES Outfalls at ANL-E, 1999

Outfall	Description	Average Flow[a]
001A	Sanitary Treatment Plant	0.40
001B	Laboratory Treatment Plant	0.39
001	Combined Outfall	0.79
003A	Swimming Pool	0.0
003B	300 Area (Condensate)	0.028
003C	Building 205 Footing Tile Drainage	0.016
003D&E	Steam Trench Drainage (Condensate)	0.008/0.004
003F	Building 201 Fire Pond Overflow Storm Water	0.005
003G	North Building 201 Storm Sewer (Condensate)	0.041
003H	Building 212 Cooling Tower Blowdown	0.013
003I	Buildings 200 and 211 Cooling Tower Blowdown	0.020
003J	Building 213 and Building 213 Parking Lot Storm Water	0.007
004	Building 203 Cooling Tower and Building 221 Footing Drainage and Storm Water	0.020
005A	Westgate Road Storm Water	Storm Water Only
005B	800 Area East Storm Water	Storm Water Only
005C	Building 200 West	0.005
005D	Storm Water	Storm Water Only
005E	Building 203 West Footing Drainage and Condensate	0.039
006	Cooling Tower Blowdown and Storm Water	0.053
007	Domestic Cooling Water for Compressor and Storm Water	0.008
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	0.051
110	Shooting Range Storm Water Discharge	Storm Water Only
111	319 Landfill and Northeast 317 Area	Storm Water Only
112A&B	Southern and Western 317 Area	Storm Water Only
113	Southern and Eastern 800 Area Landfill Storm Water Runoff	0.017
114	Northern and Western 800 Area Landfill Storm Water Runoff	0.013
115	314, 315, and 316 Cooling Water, Eastern and Southern APS Area	0.006
116	Water Treatment Plant and Storm Water	0.013

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

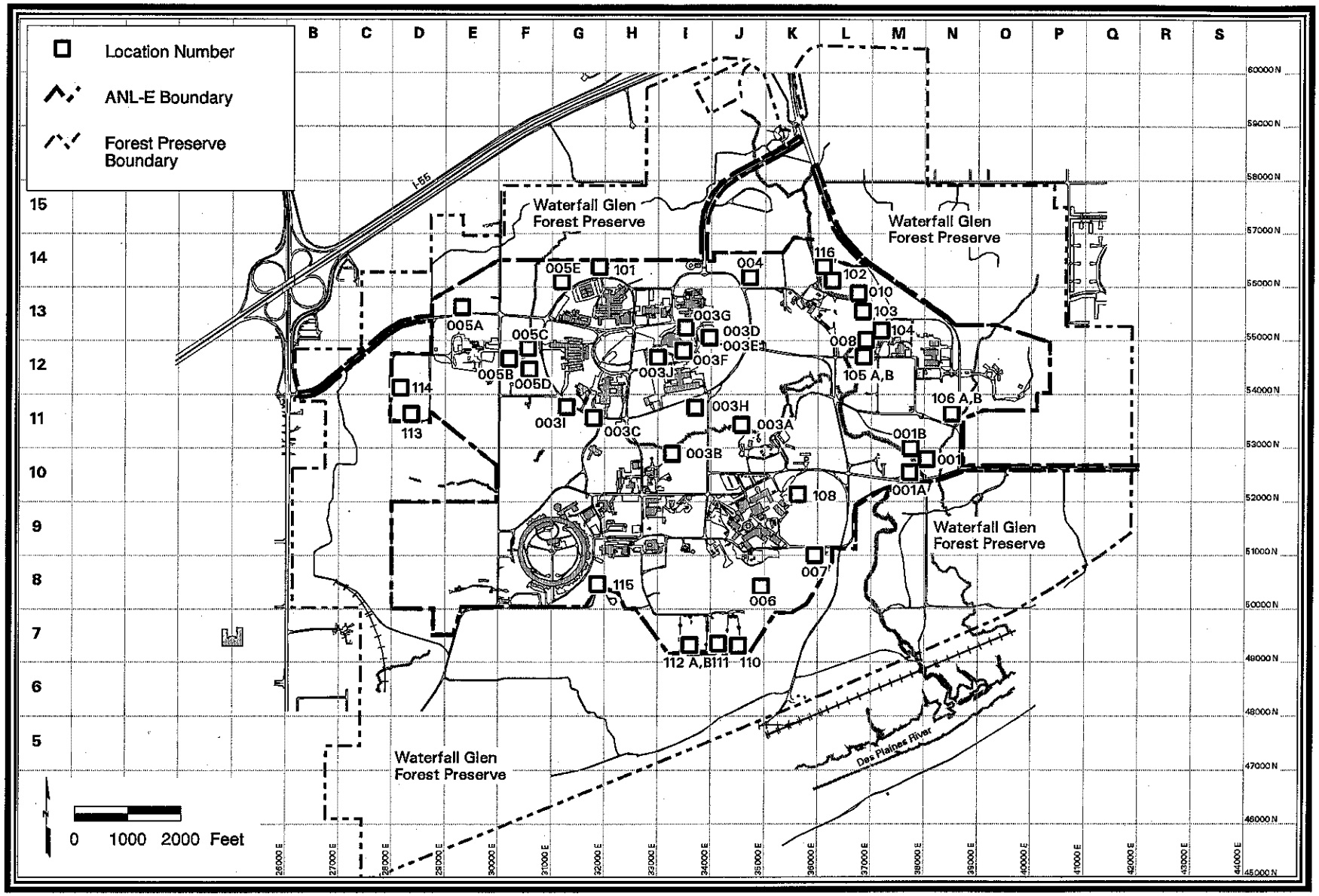

Figure 2.1 NPDES Permit Locations

wastewater treatment system consisting of primary clarifiers, trickling filters, final clarifiers, and slow sand filters. Wastewater generated by research-related activities, such as the use of laboratories and experimental equipment, flows to a series of retention tanks located in each building and subsequently discharges to the laboratory wastewater sewer after radiological analysis. Treatment in the laboratory wastewater treatment plant (WTP) consists primarily of aeration, solids-contactor clarification, and pH adjustment. Additional steps can be added, as necessary, including powder-activated carbon addition for organic removal, alum addition, and polymer addition or adjustment, if analysis demonstrates that any of these are required.

Figure 2.2 shows the two wastewater treatment systems, which are located adjacent to each other. The volume of wastewater discharged from these facilities in 1999 averaged 1.51 million L/day (0.40 million gal/day) for the sanitary wastewater and 1.48 million L/day (0.39 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 1999, there were eight exceedances of NPDES permit limits out of approximately 1,600 measurements. Total dissolved solids (TDS) and total suspended solids (TSS) permit limits at Outfalls 001 and 006, respectively, are the more persistent exceedances. The TSS limit was exceeded three times at Outfall 006 in July, August, and November. These exceedances probably were caused by summer algae growth, sediment runoff from an upstream construction project, and cooling tower drainage, respectively. The four exceedances of the TDS limit at Outfall 001 were due to road salt associated with snowmelt. A break in a chiller water line caused an unpermitted discharge at Outfall 003I in July.

Figure 2.3 presents the data for the total number of each type of exceedance over the past 10 years. In general, the total number of exceedances per year has declined steadily. The exception is 1995, when the number of exceedances increased. This increase can be attributed to the renewal of the NPDES Permit, effective October 30, 1994, which placed more restrictive limits on ANL-E discharges and increased the number of analyses required each year by approximately 600. The more restrictive limits for copper, TDS, and ammonia nitrogen resulted in a substantial increase in the number of exceedances during 1995, prior to issuance of the modified permit. The permit modification gave ANL-E a provisional variance from the existing limits for ammonia nitrogen, copper, and TDS and included a compliance schedule to bring these discharges under their respective limits. ANL-E met the compliance schedule through the upgrade of the sanitary and laboratory wastewater treatment facilities and the incorporation of Lake Michigan water as the ANL-E source water. ANL-E achieved compliance with the required discharge permit limits by July 1, 1998.

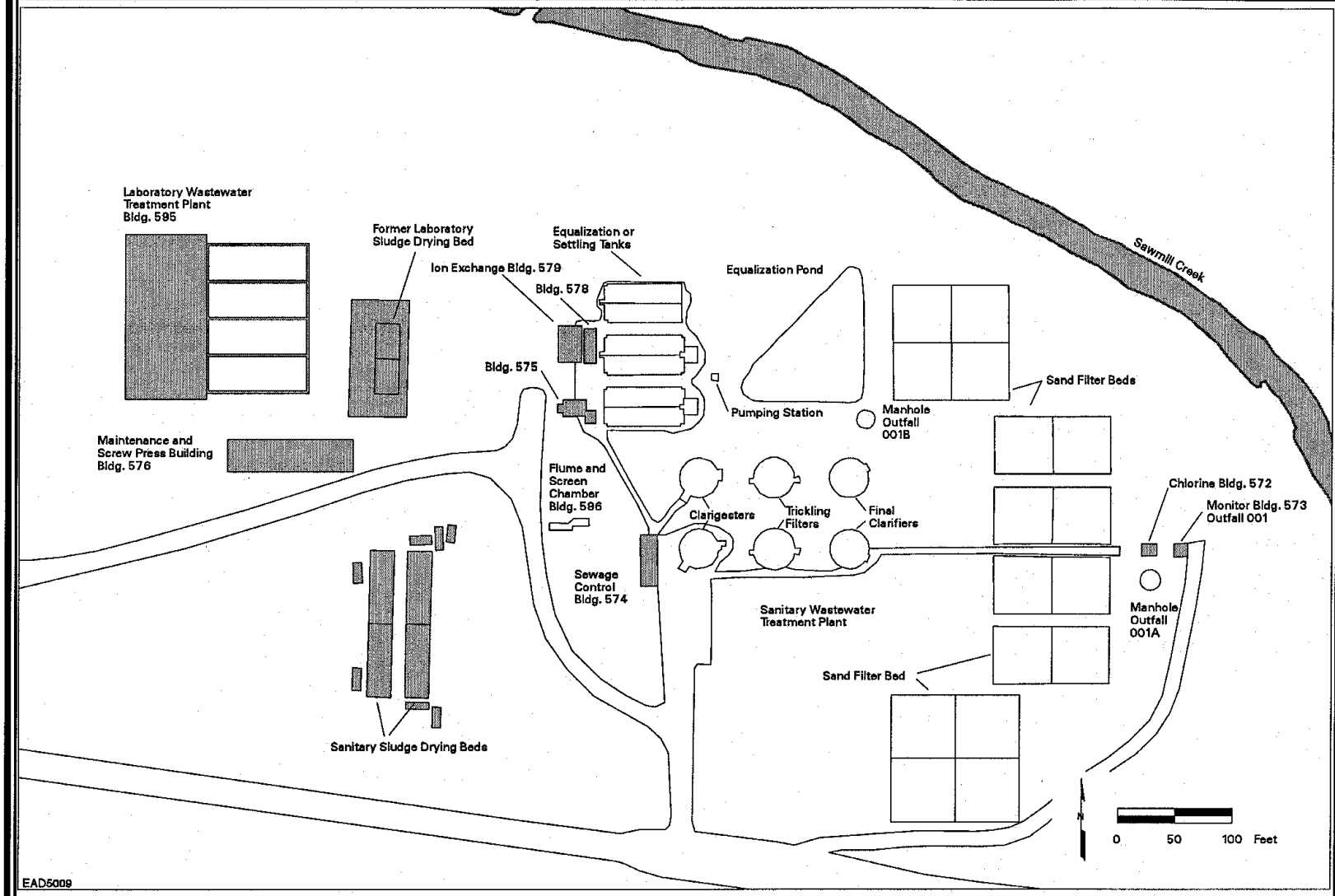

Figure 2.2 ANL-E Wastewater Treatment Plant

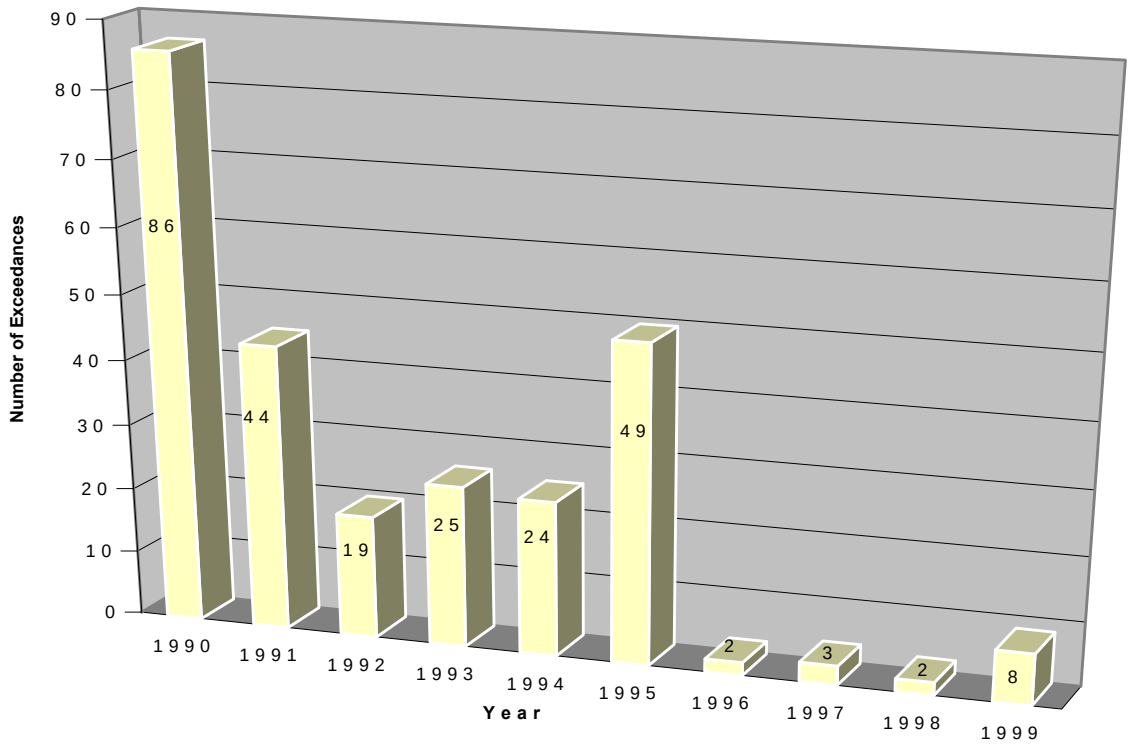

Figure 2.3 Total Number of NPDES Exceedances, 1990 to 1999

2.2.1.2. Priority Pollutant Analysis and Biological Toxicity Testing

The current permit requires semiannual testing of Outfall 001B, the laboratory WTP outfall, for all the priority pollutants — 124 metals and organic compounds identified by the IEPA as being of particular concern. During 1999, this sampling was conducted in June and December. Organic compound concentrations were very low. Chloroform (3 µg/L and 2 µg/L) was detected in both the June and December samples as was bromodichloromethane (1 µg/L and 1 µg/L) and dibromochloromethane (2 µg/L and 1 µg/L). Bromoform (5 µg/L) and methylene chloride (1 µg/L) were noted in the June sample. It is suspected that the sources of chloroform, dibromochloromethane, bromoform, and bromodichloromethane are the result of the contact of chlorinated water with organic chemicals and residues from cooling tower biocide treatment chemicals. The presence of methylene chloride is most likely a result of the discharge of small amounts of chemicals from various research and support operations. All semivolatile concentrations were below the detection limits. Low concentrations of copper (0.019 mg/L), cadmium (0.0003 mg/L), and zinc (0.149 mg/L) were detected. 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 23 through June 27, 1999. The data indicate that the effluent was not acutely toxic to either the fathead minnow or the water flea. Data from the past six years suggest that cessation of chlorination of ANL-E 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 – 30, 1999, and August 24 – 28, 1999. In addition, a special set of samples was collected from Outfall 115 from September 27, 1999, to October 1, 1999, to evaluate operational changes instituted at the cooling tower in Building 315.

A review of the data indicates that Outfalls 003I, 003J, 004, and 006 exhibited no toxicity for either the water flea or the fathead minnow. This is generally consistent with the historical data, except for an occasional isolated instance of toxicity. Outfall 003H, which had previously been in complete compliance, showed some toxicity in the July 1999 test. Before the August 1999 test, the biocide-addition procedures at the Building 212 cooling towers, which discharge to Outfall 003H, were reviewed with the operators and adjustments were instituted. The August 1999 test results for Outfall 003H showed no toxicity.

The Building 315 cooling tower discharge to Outfall 115 has exhibited recurring acute toxicity from discharges over the past two years. The water flea appears to be particularly suspectable. This tower historically has used a batch addition of biocide pellets. After the July 1999 testing, discussions with the biocide vendor resulted in the installation of a bromine-based liquid biocide using an automated dispensing system. However, the system may not have been in place in sufficient time to affect the August 1999 sampling results. Consequently, another set of samples was collected from Outfall 115 at the end of September to evaluate the effect of the new biocide system. It appears that changing to a different biocide improved the toxicity to the fathead minnow, but did not improve toxicity to the water flea. As a result of the continued toxicity to the water flea, the discharge was removed from the storm drain and rerouted to the laboratory WTP.

2.2.2. Storm Water Regulations

In November 1990, the EPA promulgated new regulations governing the permitting and discharge of storm water from industrial sites. The ANL-E site contains a large number of small-scale operations that are considered industrial activities by these regulations and, thus, are subject to these requirements. An extensive storm water characterization program was initiated in 1991, and a storm water permit application identifying 15 storm water outfalls was submitted to the IEPA in 1992.

The NPDES permit issued in October 1994 includes these 15 outfalls. In addition, the permit breaks up the watersheds for prior Outfalls 003 and 005 into smaller components and requires that their corresponding point-source discharges be analyzed and characterized for submission of a permit application, including characterization of industrial wastewater and storm water runoff discharged from these point sources. Since 1994, three additional storm water outfall locations within the subdivided watersheds were identified as requiring characterization. Wastewater and storm water characterizations were completed in 1996 for the 18 outfalls identified within the subdivided watersheds. The characterization data include quantitative data; flow measurements; analyses for certain specified pollutants; and dates, durations, and precipitation volumes for monitored storm events. The resulting permit application was completed and submitted to the IEPA on September 18, 1996. The IEPA is expected to include these 18 outfalls in the NPDES permit when it is reissued.

The NPDES permit contains two special conditions requiring Storm Water Pollution Prevention Plans (SWPPPs) for the APS construction site (Special Condition No. 12) and for the remainder of the ANL-E site (Special Condition No. 11). Both of these plans were completed by the mandated date, May 1, 1995, which was 180 days after the effective date of the permit. These special conditions also require implementation of the plans by 365 days after the effective date of the permit; this was accomplished on November 1, 1995.

The same special conditions require ANL-E to inspect and report annually on the effectiveness of the sitewide SWPPP. In 1999, the annual inspection was completed on October 29, 1999. The report was submitted to the IEPA on December 30, 1999. Changes to the plan will be required throughout the life of the permit, including any reissue or extension of the permit.

2.2.3. NPDES Inspections and Audits

The IEPA Maywood Regional Office conducted an NPDES Compliance Evaluation Inspection at ANL-E on May 19 and 20, 1999. The IEPA inspection noted an issue associated with the laboratory procedure relating to biological oxygen demand (BOD_5) holding times. In lieu of a report, the IEPA requested that ANL-E complete a quality assurance review of the laboratory procedure. This was accomplished in July 1999 and resulted in changing the laboratory analysis sheets so that holding times may be ascertained readily.

2.2.4. General Effluent and Stream Quality Standards

In addition to specific NPDES permit conditions, ANL-E 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 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 water quality standards applicable to the outfalls and discusses compliance with these standards.

2.2.5. Spill Prevention Control and Countermeasures Plan

ANL-E maintains a Spill Prevention Control and Countermeasures plan as required by the CWA and the EPA regulations in 40 CFR Part 112. This plan describes the actions to be taken in case of oil or oil product releases 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. Effective use of this plan is ensured by regular training. This plan is updated every three years and was updated last in 1998. No reportable spills occurred during 1999.

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-E and DOE on September 30, 1997. The permit became effective on November 4, 1997.

In February 1999, the IEPA issued a permit modification. The modification allows ANL-E to receive for storage the ash that results from treatment of the ANL-E mixed waste sent to the Waste Experimental Reduction Facility in Idaho, if that ash otherwise cannot be disposed of following treatment.

2.3.1. Hazardous Waste Treatment and Disposal

The nature of the research activities conducted at ANL-E 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. A small amount of these wastes also exhibits radioactivity, thereby making them

"mixed waste." The hazardous component of mixed waste is subject to RCRA regulation by the IEPA, while the radioactive component is subject to DOE regulation under the Atomic Energy Act of 1954 (AEA). ANL-E has 25 Hazardous Waste Management Units consisting of 17 container storage units, 4 miscellaneous treatment units, 1 tank storage unit, and 3 tank chemical treatment units. Table 2.6 provides descriptions of all of the units. No RCRA closures were conducted in 1999. Figure 2.4 shows the locations of the major hazardous and nonhazardous waste treatment, storage, and disposal areas at ANL-E.

ANL-E 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, treatment, and disposal. Hazardous and mixed wastes generated, treated, and stored during 1999 are described in Tables 2.7 and 2.8, respectively. ANL-E operates several RCRA-permitted storage and treatment facilities. These facilities, designed and operated in compliance with RCRA requirements, allow for accumulation and storage of waste pending off-site disposal. Off-site treatment and disposal take place at approved hazardous waste treatment and disposal facilities. Off-site treatment options for mixed waste are extremely limited.

Two ongoing treatability studies were conducted at ANL-E during 1999. A description of each study, as well as the amount of waste treated, follows.

The Neutralization of Corrosive Aqueous Waste Contaminated with Spent Solvents Study involves treating corrosive mixed waste by using a caustic solution. This study was conducted during August 1999; a total of 33 kg (73 lb) was treated. Once neutralized, the waste was solidified with sorbents approved by the DOE Waste Isolation Pilot Plant (WIPP). Treatment residues are stored in RCRA-permitted on-site units while arrangements are made to ship them to WIPP. Approximately 50 kg (110 lb) is expected to be treated during 2000.

The Amalgamation of Radioactive Elemental Mercury Waste Stream Study involves combining mercury with various powdered metals to determine the most suitable amalgamation method for ANL-E's mercury waste stream. Zinc, tin, and copper are being evaluated for the amalgams. This study was conducted in January 1999; a total of 4.5 kg (10 lb) was treated. Treatment residues are stored as low-level radioactive waste (LLW), while arrangements are made to ship them to the DOE Hanford site for disposal. Approximately 40 kg (88 lb) is expected to be treated during 2000.

2.3.2. Mixed Waste Handling

The hazardous component of mixed waste is governed by RCRA regulations, while the radioactive component is subject to regulation under the AEA as implemented by DOE Orders.

TABLE 2.6

Permitted Hazardous Waste Treatment and Storage Facilities, 1999

Description	Location	Purpose
Storage		
Concrete Storage Pad	317 Area	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 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, and solid hazardous, radiological, or MW.
	Building 331 Radioactive Waste Storage Facility	Storage of containers of flammable, toxic, corrosive, and oxidizing hazardous, radiological, and MW.
Dry Mixed Waste Storage Area	Building 374A	Storage of solid MW and radioactively contaminated lead bricks.
Mixed Waste Container Storage	Building 329	Storage of containers of bulk and lab-packed ignitable mixed waste 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).
Tank Storage	Building 306	Storage of corrosive and toxic mixed waste and radiological liquid wastes (4,000 gal; currently not used).

TABLE 2.6 (Cont.)

Description	Location	Purpose
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	317 Area	Treatment of solid MW having radionuclide and/or RCRA metal surface contamination.
Low-Level 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.
TRU Neutralization/ Precipitation Treatment Unit	Building 306	Treatment of corrosive, aqueous MW-containing transuranic radionuclides and RCRA metals.

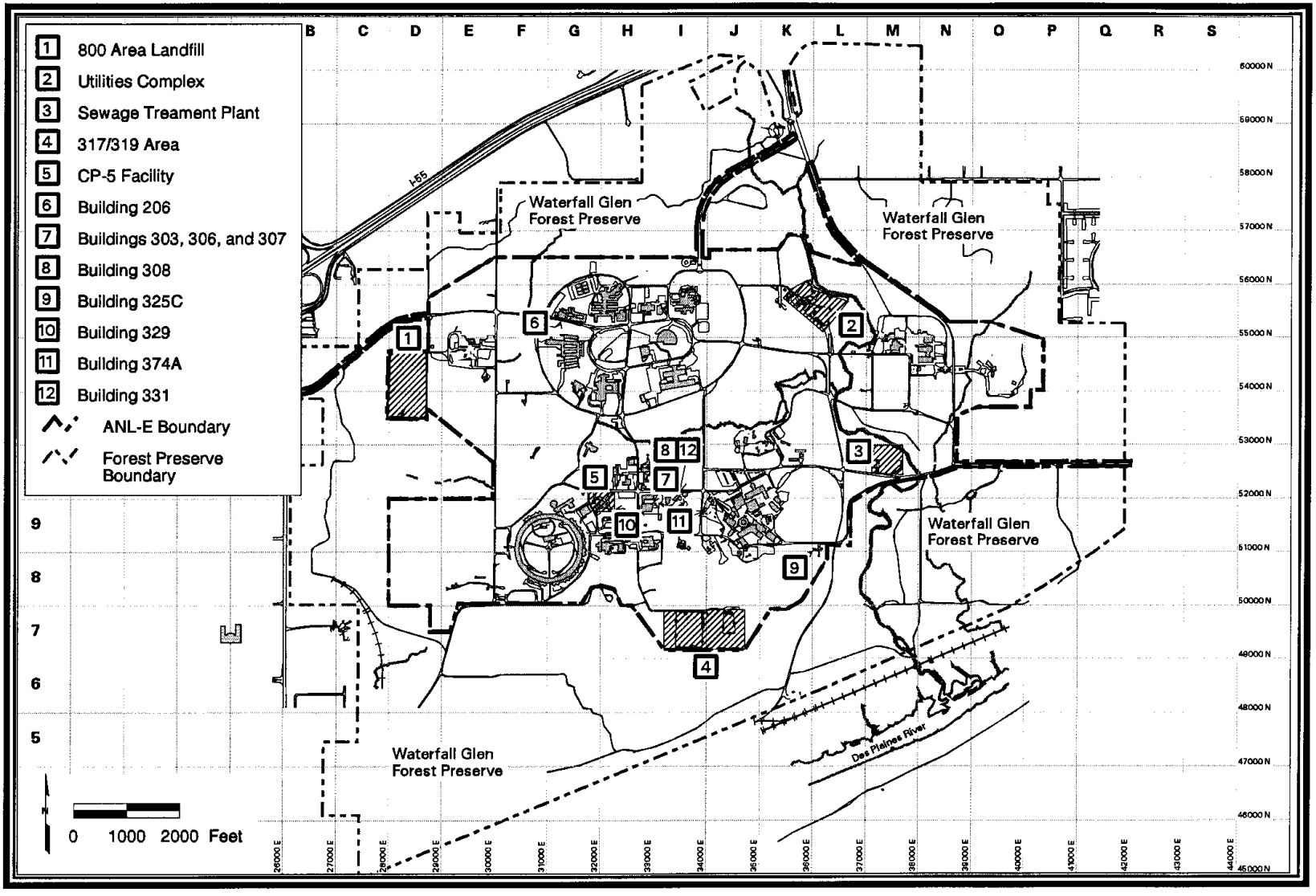

Figure 2.4 Major Treatment, Storage, and/or Disposal Areas at ANL-E

TABLE 2.7

Hazardous Waste Generation, Treatment, Disposal, or Recycle, 1999

Waste	Volume (gal)	Weight (lb)
Generated and Disposed of or Recycled		
Aerosol cans	510	1,828
Alkali metals[a]	1,910	24,647
Alkali metals	112	895
Alkaline solutions with lead	40	254
Barium-containing wastes	55	135
Brake cleaner fluid[a]	13	110
Bulked laboratory solvents	855	7,402
Cadmium-contaminated debris	55	110
Carbon filter cartridges[a]	1,000	16,200
Compressed gases	30	48
Compressed gases[a]	60	240
Cutting oils with lead and solvents	165	1,445
Ethanol solutions with silver	385	3,415
Ethyl lactate waste solution	110	989
Hydrogen peroxide waste solution	85	1,020
Immersion cleaner fluid[a]	31	248
Labpacks of liquid chemicals	2,071	16,567
Labpacks of solid chemicals	1,436	5,744
Lactic acid waste solution	110	1,100
Lead acid batteries[a]	720	14,400
Lead-contaminated debris	280	699
Mercury-contaminated debris	220	576
Metal scrap containing cadmium and lead	397	4,766
Oil-based paint wastes	140	1,046
Oil-based paint wastes with lead	85	599
Petroleum distillates	165	1,147
Plating wastes containing lead, alkaline	220	2,066
Plating wastes containing lead, acid	55	532
Silver and chromium oxide waste	30	84
Sodium nitrate waste	30	87
Xylene and methyl ethyl ketone-contaminated debris	30	50
Waste oils with solvents	1,290	9,387
Waste acidic cleaning solution	165	1,234

TABLE 2.7 (Cont.)

Waste	Volume (gal)	Weight (lb)
Generated and Disposed of or Recycled		
Water treatment chemicals	110	884
Zinc bromide solution with lead	270	3,044
Treated		
Alkali metals (passivation)	14	111
Universal Hazardous Waste		
Mercury-containing lamps[a]		20,651

[a] Recycled waste.

Accordingly, facilities storing or disposing of mixed waste must comply with both DOE requirements and RCRA permitting and facility standards. ANL-E generates several types of mixed waste, including acids, solvents, and sludges contaminated with radionuclides. The RCRA Part B Permit provides for on-site treatment in five new mixed waste treatment systems. These systems include neutralization of low-level and transuranic (TRU) corrosive aqueous wastes and the stabilization of sludge and soil. No off-site commercial treatment facility was used during 1999 to treat mixed waste.

2.3.3. Federal Facility Compliance Act Activities

The Federal Facility Compliance Act of 1992 (FFCA) amended RCRA to clarify the application of requirements and sanctions to federal facilities. The FFCA also requires that DOE prepare mixed waste treatment plans for DOE facilities that store or generate mixed waste. The Proposed Site Treatment Plan (PSTP) for mixed waste generated at ANL-E was submitted to the IEPA and the Illinois Department of Nuclear Safety (IDNS) in March 1995. Mixed waste at ANL-E has been managed in accordance with the PSTP as of October 1995. During 1999, ANL-E completed the treatment milestone for soil test samples. ANL-E's RCRA Part B Permit provides for on-site treatment of certain mixed waste as required by the PSTP.

TABLE 2.8

Mixed Waste Generation, Treatment, Storage, and Disposal, 1999

Waste	Volume (gal)	Weight (lb)
Generated		
Acidic solutions	125	1,125
Acidic solutions with heavy metals	21	189
Alkali metals	0.5	4
Aqueous solutions with heavy metals	150	1,245
Flammable liquids	0.1	0.7
Metal scrap with cadmium	425	4,500
MW debris with chromium	55	500
MW debris with heavy metals	350	1,400
MW debris with volatile organics	20	80
MW lead articles	23,000	625,000
MW sludge with heavy metals	15	150
MW soil with heavy metals	20	184
TRU acids with heavy metals	2	18
TRU lead articles	5	150
Uranyl nitrate	11	60
Treated		
Acidic solutions with heavy metals (neutralized)	95	855
Acidic solutions (neutralized)	100	900
Aqueous solutions with halogenated solvents	7.5	73
Aqueous solutions with heavy metals (neutralized)	150	125
Elemental mercury (amalgamated)	0.1	10

TABLE 2.8 (Cont.)

Waste	Volume (gal)	Weight (lb)
In Storage		
Acidic solutions	85	765
Acidic solutions with heavy metals	352	3,175
Alkali metals	224	1,788
Aqueous solutions with heavy metals	18	149
Aqueous solutions with organics	7.5	72
Cyanide solution	11	92
Flammable liquids	178	1,245
Metal scrap with cadmium	3,951	42,000
Metal scrap with heavy metals	135	1,600
MW debris with chromium	58	575
MW debris with heavy metals	1,164	4,656
MW debris with volatile organics	14.1	604
MW lead articles	23,660	650,000
MW sludges with heavy metals	281	2,825
MW soil with heavy metals	115	1,025
TRU acids	92	828
TRU cadmium	130	1,600
TRU lead	160	4,800
TRU sludge	478	4,780
Uranyl nitrate	173	3,300
In Storage - Toxic Substances Control Act (TSCA)		
MW PCB sludge and debris	18,710	152,325
MW PCB articles	5	6
Disposed of		
MW lead articles	11,190	300,000

2.3.4. RCRA Inspections: Hazardous Waste

A RCRA Compliance Inspection was conducted by the EPA on July 8 and 9, 1999. No significant issues were identified.

2.3.5. Underground Storage Tanks

The ANL-E site currently contains 19 USTs, all of which are in compliance with UST regulations; 39 tanks have been removed over the last several years. Eight of the existing tanks are being used for storage of fuel oil for emergency generators. The on-site vehicle maintenance facilities use underground diesel, gasoline, and methanol/gasoline blend tanks. The ethanol/gasoline blend is stored in an aboveground tank. A UST Compliance Inspection was conducted by the EPA on January 21, 1999. No significant issues were identified. In February 1999, during the removal of UST No. 29 near Building 306, a leak from the UST was discovered. All required notifications and followup reports to state authorities were completed, as well as cleanup of the contaminated area.

2.3.6. Corrective Action for Solid Waste Management Units

As mentioned previously, the HSWA requires that any RCRA Part B Permit issued must include provisions for corrective action to address releases of hazardous constituents from any SWMU at the site, regardless of when waste was placed in the unit. Accordingly, the ANL-E Part B Permit issued in September 1997 contains procedures and requirements to govern the corrective action of such units. The Part B Permit identifies 49 SWMUs and 5 Areas of Concern (AOCs). In January 1999, the IEPA approved an ANL-E request for no further action for SWMU Nos. 159, 161, 162, and 163. In February 1999, the IEPA approved an ANL-E request for no further action for SWMU No. 693. The majority of the remaining sites are believed to contain little or no residual contamination; however, a number will undergo some type of corrective action. Prior to issuance of the permit, ANL-E had been working proactively and on a voluntary basis to characterize, investigate, and remediate its SWMUs, with emphasis on the 800 and 317 Areas. This remediation program is continuing under the authority of the Part B Permit. The process of conducting detailed characterization studies to determine whether hazardous materials have been released from these units was begun in 1989. Chapter 3 of this report contains a summary of the characterization and remediation activities currently underway at a number of the SWMUs in accordance with IEPA-approved corrective action work plans.

2.4. Solid Waste Disposal

In September 1992, ANL-E ceased operation of its sanitary landfill, which had begun operating in 1966. The original operating permit was issued by the IEPA in 1981 in accordance with 35 IAC Part 807. Supplemental permits addressing final elevations, a groundwater monitoring program, and closure/postclosure requirements, such as gas monitoring, were issued by the IEPA on April 24, 1992; September 15, 1992; January 11, 1995; November 20, 1997; August 25, 1998; and June 16, 1999. Ground Water Quality Standards of some routine indicator parameters have been consistently exceeded. To aid in the determination of the rate and extent of contamination, in 1999, additional groundwater monitoring wells were installed around the landfill. The groundwater monitoring program is discussed in detail in Section 6.3.

ANL-E 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 2.9 gives the nonhazardous special and nonspecial wastes generated and disposed of during 1999. All nonhazardous special and nonspecial wastes generated at ANL-E in 1999 were disposed of at permitted off-site special waste landfills. The IEPA began requiring annual nonhazardous special waste reporting in 1991. The report is submitted by February 1 of each year and describes the activity of the previous year. It is a summation of all manifested nonhazardous and PCB wastes.

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 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 1999. Two EA addendums, addressing the 319 Landfill Remediation-Drainage Reroute and the Boiler House SWMU Sampling and Remediation activities, respectively, were completed in 1999.

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

TABLE 2.9

Generation and Disposal or Recycling of Special and Nonspecial Waste, 1999

Waste	Volume	Weight (lb)
Nonhazardous Special		
Contaminated soil (Bldg. 108)	448 yd^3	896,000
Contaminated soil (Bldg. 306 UST)	270 yd^3	540,000
Contaminated soil (317 Area)	10 yd^3	20,000
Medical waste	118 yd^3	609
Nonhazardous liquid chemicals	3,120 gal	21,474
Nonhazardous solid chemicals	5,390 gal	20,122
Oily water[a]	800 gal	6,640
Petroleum naptha[a] (parts washers)	1,554 gal	10,434
Used oil[a]	7,250 gal	52,265
Certified Nonspecial		
Nonspecial fly ash[a]	1,236 yd^3	1,236,163
Nonspecial laboratory sewage sludge	15 yd^3	30,000
Nonspecial oily rags	550 gal	3,278
Nonspecial sanitary sewage sludge	34 yd^3	68,000
Sanitary sewage sludge[a]	20,000 gal	180,000
Toxic Substances Control Act Special		
Asbestos	252 yd^3	252,000
PCBs	1,275 gal	9,423

[a] Recycled waste.

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-E

In January 1997, ANL-E incorporated Lake Michigan water as its domestic source water, thereby replacing the dolomite groundwater that formerly constituted its source of drinking water. The Lake Michigan water is purchased from the DuPage County Water Commission. As such, ANL-E is now a customer rather than a supplier of water. Consequently, on January 23, 1997, the DuPage County Health Department (DPCHD) notified DOE that the federal and state monitoring requirements applicable to a "non-transient, non-community" public water supply no longer are applicable. In addition, sampling, analysis, and reporting of the drinking water data to the DPCHD and the IDPH are no longer required. Nevertheless, ANL-E voluntarily provides to on-site personnel the Consumer Confidence Report on drinking water quality that ANL-E receives as a customer of the DuPage County Water Commission.

2.6.2. Water Supply Monitoring

During 1999, ANL-E 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 1999, all exterior pesticides and herbicides were applied by licensed contractors who provide the chemical used and who remove any unused portions. ANL-E ensures that the chemical is EPA-approved, that it is used properly, and that any residue is disposed of in accordance with applicable regulations. These ANL-E activities are carried out by oversight inspections and maintenance of records.

In addition, routine applications of pesticides are performed within buildings, as needed. Indoor pesticide applications are provided by IDPH-licensed contractors under the direction of Plant Facilities and Services (PFS)-Custodial Services and Marriott Management. The indoor applications involve EPA "Restricted Use" products. In 1999, approximately 16,480 L (4,337 gal) of commercial-grade herbicide and 555 L (146 gal) of pesticide were applied throughout the ANL-E site. Fertilizer with weed control is included in this 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-E sites are included in the NPL.

On December 21, 1999, the EPA published interim guidance redefining under CERCLA "federally permitted releases." This action may have a significant impact on ANL-E 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 restrictive definition of how CERCLA substances released to the air would be exempted from reporting as a federally permitted release. To date, the EPA has announced it would hold implementation of the guidance in abeyance until the guidance is revised, or until August 25, 2000, whichever comes first.

2.8.1. CERCLA Program at ANL-E

In early 1990, the EPA requested that DOE submit SSI reports for 6 of 13 ANL-E sites for which PA reports previously had been submitted. Upon further discussions between the EPA and DOE, one of the six sites was eliminated from consideration, and three adjacent units (317/319/East-Northeast [ENE]) were treated as a single site. As a result, three SSI reports were submitted to the EPA in January 1991. Table 2.10 lists the sites for which a PA report was submitted.

Inquiries into waste disposal practices during the 1950s and 1960s have identified a number of smaller waste disposal sites, some of which could contain hazardous materials. These sites are under investigation; however, their potential to affect groundwater is thought to be minimal.

2.8.2. CERCLA Remedial Actions

Remedial actions to clean up any release of hazardous materials from these sites could occur in a number of different ways. All but one of the CERCLA sites (see Table 2.10) are on the ANL-E site, and most are included as SWMUs in the RCRA Part B Permit. The RCRA Part B Permit, effective November 4, 1997, contains procedures and requirements that govern the corrective action of these sites. However, several of these SWMUs also contain radiological contamination that

TABLE 2.10

List of Inactive Waste Disposal Sites at ANL-E
Described in Various CERCLA Reports

Site Name
On Current ANL-E Property
319 Area Landfill and French Drain[a,b]
800 Area Landfill and French Drain[a,b]
810 Area Paint Shop
Compressed Gas Cylinder Disposal Area, 318 Area[a,b]
Decommissioned Reactor CP-5, Building 330[a,b]
French Drain, 317 Area[a,b]
Gasoline Spill, Gasoline Station
Landfill East-Northeast of the 319 Area[a,b]
Liquid Waste Treatment Facility, Building 34[b]
Mixed Waste Storage Vaults, 317 Area[a]
Shock Treatment Facility, 317 Area[a]
Wastewater Holding Basin, Sewage Treatment Plant[b]
On Former ANL-E Property, Currently Waterfall Glen Forest Preserve
Reactive Waste Disposal, Underwriters Pond

[a] SSI report submitted to the EPA in 1991.

[b] RCRA SWMU.

is not regulated under RCRA. Therefore, the SWMUs that are both radiologically and chemically contaminated will be cleaned up under RCRA, as well as other authorities pertinent to radiological contamination, as appropriate.

2.8.3. 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-E may be required to submit reports pursuant to Sections 302, 304, 311, 312, and 313.

• EPCRA 302:	Planning Notification	Required
• EPCRA 304:	Extremely Hazardous Substances Release Notification	Required
• EPCRA 311-312:	Material Data Safety Sheet/Chemical Inventory	Required
• EPCRA 313:	Toxic Release Inventory (TRI) Reporting	Required

Section 302 of SARA Title III requires notification to the State Emergency Response Commission when an extremely hazardous substance is present at a facility in excess of the threshold planning quantity.

Section 304 of SARA Title III requires that the Local Emergency Planning Committee (LEPC) and state emergency planning agencies be notified of accidental or unplanned releases of Section 302 hazardous substances to the environment. The procedures for notification are described in the Argonne Comprehensive Emergency Management Plan. No incidents occurred during 1999 that required notification of the LEPC and the Illinois Emergency Management Agency.

Under EPCRA Section 311, ANL-E is required to provide applicable emergency response agencies with Material Safety Data Sheets (MSDSs), or a list of MSDSs, for each hazardous chemical stored on site. In addition, pursuant to EPCRA Section 312, ANL-E is required to report certain information regarding inventories and the locations of hazardous chemicals to state and local emergency authorities upon request. Petroleum products need to be reported. However, chemicals used in research laboratories under the direct supervision of a technically qualified individual are exempt from reporting. This report was updated and provided to DOE on February 19, 1999. Table 2.11 lists the hazardous chemicals reported.

Section 313 of EPCRA requires facilities to prepare an annual report entitled “Toxic Chemical Release Inventory, Form R” if annual usage quantities of listed toxic chemicals exceed certain thresholds. ANL-E is not within the range of Standard Industrial Codes specified in the statute. ANL-E reports this information, however, because DOE, which is subject to Executive Order 12856 and participates in the EPA 33/50 program, directs ANL-E to do so. No report was filed in 1999 for 1998, because no listed chemicals exceeded reporting thresholds for that year. On the basis of information provided by the ANL-E Chemical Management System (CMS), it is not anticipated that a report will be filed in 2000 for 1999.

TABLE 2.11

ANL-E, SARA, Title III, Section 312, Chemical List, 1999

	Physical Hazard			Health Hazard	
Compound	Fire	Pressure	Reactivity	Acute	Chronic
Aluminum sulfate	-[a]	-	-	X	-
Chlorodifluoromethane	-	-	-	-	X
Diesel fuel/heating oil	X	-	-	-	-
Gasoline	X	-	-	-	-
Lubricating oils	X	-	-	-	-
Methanol/gasoline	X	-	-	-	-
NALCO 356 amine corrosion inhibitor	X	-	-	X	-
Sulfuric acid	-	-	-	X	-
Trichlorofluoromethane	-	-	-	-	X

[a] A hyphen indicates that the compound does not fall within the particular hazard class.

In October 1999, the EPA issued the final rule on the persistent bioaccumulative toxic (PBT) list developed under Section 313. The rule, which took effect on January 1, 2000, significantly reduces the Section 313 reporting threshold, from 25,000 lb/yr (manufacture or process) or 10,000 lb/yr (otherwise use), to 10 lb/yr or 100 lb/yr, depending upon the chemical or chemical class. Dioxins also were added to the Section 313 list, with a manufacturing reporting threshold of 0.1 g/yr. Furthermore, the *de minimis* exemption, which exempted reporting of listed chemicals in mixtures at less than 1% (0.1% in the case of carcinogens), was eliminated from the PBT list. This change in Section 313 reporting will have a significant impact on how ANL-E tracks PBT chemical usage on a sitewide basis; it may result in reporting on PBT chemicals for activities in 2000.

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. Of these specially regulated substances, only asbestos and PCBs are found at the ANL-E site. The ANL-E safety training program addresses asbestos handling. Suspect PCB-containing items are identified through the ANL-E PCB Item Inventory Program.

2.9.1. PCBs in Use at ANL-E

PCB items in use or in storage for reuse are tracked by the ANL-E 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-E Annual PCB Report, which describes the location, quantity, manufacturer, and unique identification number for all PCBs on site. The PCBs in use at ANL-E are contained in capacitators and power supplies. In addition, Waste Management Operations (WMO) still receives PCB-contaminated equipment and oil from unknown sources. 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-E operations includes materials lab-packed and bulked and aggregated solids shipped off site through WMO. Table 2.9 gives the amount of PCBs and PCB-contaminated materials shipped by ANL-E during 1999.

2.9.3. Storage of Radioactive PCB-Contaminated Material

Contamination from historical PCB spills has 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. Because a disposal option has not been available, it is stored for future disposal. A total of 71,096 L (18,710 gal) of PCB-contaminated sludge and debris is being kept in storage.

2.10. Endangered Species Act

The Endangered Species Act of 1973 (ESA) is designed to protect plant and animal resources from the adverse effects of development. Under the Act, the Secretaries of the Interior and Commerce are directed to establish programs to ensure the conservation of endangered or threatened species and the critical habitat of such species. The FWS has been delegated authority to implement the requirements of the ESA.

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 these species. If no such species or habitat are present, this fact is to be documented in a letter to the FWS. If such species or habitat are found to exist, the FWS is to be notified, and a series of

consultations and studies then will be carried out to determine the extent of impact and any special actions that must be taken to minimize this impact.

At ANL-E, the provisions of the ESA are implemented 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 Evaluation Notification Form. If the potential exists for an adverse impact, this impact will be assessed further and will be evaluated through the preparation of a more detailed NEPA document, such as an EA or EIS.

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

The Hine's emerald dragonfly (*Somatochlora hineana*), federally and state listed as endangered, occurs in locations with calcareous seeps and wetlands along the Des Plaines River floodplain. Leafy prairie clover (*Dalea foliosa*), which is federally and state listed as endangered, is associated with dolomite prairie remnants of the Des Plaines River valley; two planted populations of this species occur in Waterfall Glen Forest Preserve. An unconfirmed capture of an Indiana bat (*Myotis sodalis*), which is federally and state listed as endangered, indicates that this species may occur in the area.

Additional state-listed species that occur in the area include the following:

- Endangered
  - Black-crowned night heron (*Nycticorax nycticorax*)
  - Great egret (*Casmerodius alba*)
  - Pied-billed grebe (*Podilymbus podiceps*)
  - Red-shouldered hawk (*Buteo lineatus*)
  - River otter (*Lutra canadensis*)
  - Rough marsh cress (*Rorippa islandica* var. *hispida*)
  - Slender sandwort (*Arenaria patula*)
  - White lady's slipper (*Cypripedium candidum*)

- Threatened
  - Early fen sedge (*Carex crawei*)
  - Kirtland's snake (*Clonophis kirtlandi*)
  - Marsh speedwell (*Veronica scutellata*)

Of these, rough marsh cress, Kirtland's snake, pied-billed grebe, great egret, black-crowned night heron, and red-shouldered hawk have been observed on ANL-E property. Impacts to these species also would be assessed during the NEPA process. No project at ANL-E has ever had to be stopped, delayed, or modified as a result of a potential impact to an endangered species. In February 1997, the FWS concluded that a groundwater remediation project in the 800 and 317/319 Areas most likely would not affect the hydrology of the breeding area of the Hine's emerald dragonfly *(Somatochlora hineana)*. To confirm that a seep in the surrounding Waterfall Glen Forest Preserve had not been contaminated by some other activity at the ANL-E site, or by a third party, the FWS requested that ANL-E take water quality and sediment samples from the seep, a potential breeding area for the Hine's emerald dragonfly. Samples collected in 1998 verified that the seep area was not contaminated.

2.11. National Historic Preservation Act

The National Historic Preservation Act (NHPA) 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 sites, 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 Illinois Historic Preservation Agency (IHPA) and the Advisory Council on Historic Preservation, as appropriate, when proposed actions would adversely affect properties that are eligible for listing on the NRHP.

The NHPA is implemented at ANL-E through the NEPA review process, as well as through the ANL-E digging permit process. All proposed actions must consider the potential impact to historic or culturally important artifacts and document this consideration on the Environmental Evaluation Notification Form. If the proposed site has not been surveyed for the presence of such artifacts, a cultural resources survey is conducted, and any artifacts found are documented and removed carefully. Prior to disturbing the soil, an ANL-E digging permit must be obtained from the PFS Division. This permit must be signed by an individual who is familiar with the location of archaeological sites at ANL-E to document the fact that no significant cultural resources will be affected. DOE consults with the IHPA and the Advisory Council on Historic Preservation, as appropriate, if proposed actions would adversely affect properties eligible for listing on the NRHP.

A draft Cultural Resources Management Plan (CRMP) was prepared in 1998 to fulfill DOE's responsibilities under the NHPA. This draft CRMP describes the management of cultural resources at ANL-E pursuant to the NHPA and identifies a strategy toward good faith stewardship of cultural resources. Management goals for cultural resources at ANL-E reflect current issues, interests, and problems identified through internal assessment. They include protecting and preserving significant resources, establishing outreach programs, and continuing the integrity of the Cultural Resource Program.

Cultural resources include both historic structures and archaeological sites. Much of the focus at ANL-E has been on evaluating archaeological sites, rather than structures. Phase I archaeological surveys have been completed for the entire ANL-E facility, and 46 archaeological sites have been recorded. Of these, 23 sites have been tested to determine eligibility for inclusion on the NRHP. Three of these 23 sites tested are potentially eligible for the NRHP. The other 23 recorded sites have not been evaluated formally to determine whether they are eligible for inclusion under the NRHP.

A sitewide inventory of all building structures is necessary to identify those buildings that may have housed activities of historic significance, such that the building potentially may be eligible for listing on the NRHP. This sitewide inventory of building structures was initiated in 1998. DOE has determined that four structures — Buildings 301, 315/316, 330, and 331 — are eligible for listing on the NRHP. The CP-5 reactor, Building 301,and the Argonne Thermal Source Reactor in Building 315/316 were documented.

2.12. Floodplain Management

Federal policy on managing floodplains is contained in Executive Order 11988 (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this Executive Order. The Executive Order 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-E site is located approximately 46 m (150 ft) above the nearest large body of water (Des Plaines River) and, thus, is not subject to major flooding. A number of small areas associated with Sawmill Creek and other small streams or low-lying areas are subject to local flood conditions following extremely heavy precipitation. 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 are fully assessed in a floodplain assessment, and, as appropriate, documented in the NEPA documents prepared for a proposed project.

In 1999, an electrical upgrade project involved crossing a creek bed. To accomplish the work, the duct bank was located under the creek bed; additional concrete was placed in the creek bed, which disrupted the normal water course. Initially, this action did not meet the requirements of the applicable COE Nationwide Permit. However, thereafter, corrective actions were taken to restore the intercourse to its original configuration, thereby fulfilling the terms of the Nationwide Permit.

2.13. Protection of Wetlands

Federal policy on wetland protection is contained in Executive Order 11990 (May 24, 1977). In addition, 10 CFR Part 1022 describes DOE's implementation of this Executive Order. This Order requires federal agencies to identify potential impacts to wetlands resulting from proposed activities and to minimize these impacts. Where impacts cannot be avoided, action must be taken to mitigate the damage 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. The goal of the current federal policy in the Clean Water Action Plan is to increase the amount of wetlands by 40,486 ha (100,00 acres) each year.

Because of its topography and the nature of the soil at ANL-E, the site contains a significant number of natural and man-made wetlands. These range from small storm water ditches overgrown with cattails to natural depressions, beaver ponds, and man-made ponds. Potential impacts to those areas from proposed actions are assessed in wetlands assessments and NEPA documentation as appropriate.

During 1993, an ANL-E sitewide wetlands delineation was completed. A survey was conducted to identify and delineate all jurisdictional wetlands present on site in accordance with the 1987 U.S. Army *Corps of Engineers Wetlands Delineation Manual.*[5] The results of the survey were delineated on a site map that indicates the aerial extent of all wetlands present at ANL-E down to 500 m^2 (1/8th acre). The findings were documented in an accompanying report that describes in detail the soil, vegetation, and hydrology of each wetland area delineated on the map. Thirty-five individual wetland areas were identified; their total area is approximately 18 ha (45 acres). The wetland areas also were digitized onto a computer-aided design file to provide ANL-E engineers with scale maps for planning and designing projects. This delineation also is useful for determining project impacts under NEPA review. The site wetlands map will be updated to reflect significant changes in wetland boundaries that may occur over time.

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-E. 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 had been 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 a fourth wetland, Wetland C, during APS construction activities.

The COE inspected Wetlands R and C on October 3, 1996, and on October 10, 1996, issued a cease and desist order alleging that the ANL-E project was in noncompliance with the COE permit. In response to the order, DOE submitted a management plan to the COE for Wetland R and committed to mitigating Wetland C.

In 1999, ANL-E prepared a report identifying mitigation alternatives for Wetland C. Two potential sites were selected as mitigation candidates. These sites will be investigated during 2000.

Acting on ANL-E's COE-approved management plan, several Wetland R management activities were conducted during 1999. A herbicide treatment to control weeds around the wetland was initiated in May 1999. To increase sunlight within the wetland area, cattails in the wetland were removed by treatment with herbicide. Rootstock and seed from natural prairies in the area were planted. In the fall, seeds were purchased, as well as collected on site, and the seeds were planted in the winter. Two burns of the wetland were planned, but could not be performed due to weather conditions. The wetland burn is a priority for spring 2000.

2.14. Wildlife Management and Related Monitoring

DOE manages the site white-tailed and fallow deer herds through an interagency agreement with the U.S. Department of Agriculture. Each species is managed to a target density of 20 deer/mi^2. 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 – 1996, and more than 80 deer were removed the following winter. Smaller numbers of deer have been removed each year since 1997. DOE and the Forest Preserve District of DuPage County coordinate deer management efforts in order to preserve and enhance biodiversity at ANL-E 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. Forty-nine white-tailed deer were removed in November 1999 to achieve a target density of 20 deer/mi^2. No fallow deer were removed in 1999.

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 December 1997 were analyzed for gamma-ray-emitting radionuclides and hydrogen-3. Naturally occurring potassium-40 was the only gamma-ray-emitting radionuclide identified above detection limits. Hydrogen-3 was not detected in any sample.

2.14.4. Vegetation Damage

Vegetation is monitored periodically to determine the effects of browsing by deer on woody vegetation. This monitoring is conducted to meet conditions of Deer Population Control Permits and to help make deer management decisions. Horizontal vegetation densities and tree species richness at ANL-E are compared with previous ANL-E data and with data from Herrick Lake Forest Preserve, which has had a lower density of deer than ANL-E. Data collected in 1993 and 1997 indicated very heavy or extremely heavy adverse effects on ANL-E vegetation. Data for 1999 show improved tree species richness.

2.15. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 1999. Table 2.12 lists all air and water effluent exceedances reported during 1999. Ongoing remedial action work is described in Section 3.2. Exceedances of the Ground Water Quality Standards at the 800 Area Landfill Area are discussed in Chapter 6.

2.15.1. Clean Water Act - NPDES

The most significant ongoing issue encountered at ANL-E during 1999 involved wastewater discharges at some outfalls, which affects compliance with existing NPDES wastewater discharge permit requirements. ANL-E has not consistently been able to meet the permit limits for TDS at Outfall 001 and for TSS at Outfall 006. With regard to TDS exceedances, plans are underway to evaluate the use of road salt and the final disposition of boiler blowdown during the winter months. With regard to TSS exceedances, plans are also in progress to divert Building 377 cooling tower drainage to the sewage system and to upgrade the Outfall 006 discharge monitoring area to reduce erosion.

TABLE 2.12

Summary of 1999 Air and Water Effluent Exceedances

Month	Location of Exceedance	Parameter	Assessment
January	001	TDS	Road salt associated with snowmelt.
February	001	TDS	Road salt associated with snowmelt.
March	001	TDS	Road salt associated with snowmelt.
March	001	TDS	Road salt associated with snowmelt.
April	Boiler No. 5	Opacity	Torn bags and leaking gaskets.
July	006	TSS	Algae growth.
July	003I	Unpermitted discharge	Break in chiller water line.
August	006	TSS	Sediment runoff from upstream construction.
November	006	TSS	Drainage of Building 377 cooling tower.

2.15.2. Solid Waste Disposal

The IEPA-approved sanitary landfill groundwater monitoring program continues to indicate that the Ground Water Quality Standards of some routine indicator parameters are consistently being exceeded. Expansion of the groundwater monitoring well network during 1999 should aid in determining the rate and extent of any contamination. The groundwater monitoring program is discussed in detail in Section 6.3

2.15.3. Remedial Actions

Remediation of waste management units is an ongoing compliance issue. These activities are described in detail in Section 3.2.

2.16. Environmental Permits

Table 2.13 lists all the environmental permits in effect at the end of 1999. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements. The monitoring results required by these permits are discussed in those sections, as well as in Chapters 5 and 6.

TABLE 2.13

ANL-E Environmental Permits in Effect December 31, 1999

Type	Source	Building	Issued	Expiration Date[a]
Air	ALEX Alkali Metal Scrubber[b]	370	12/05/91	12/03/96
Air	Alkali Metal Reaction Booth[b]	308	02/15/89	11/18/98
Air	APS Emergency Generators (3)	400	05/16/94	03/15/99
Air	Argonne Service Station	300	01/09/91	10/04/00
Air	Boiler No. 5 Low NO_x Gas Burner[c]	108	06/21/96	12/28/98
Air	Central Heating Plant	108	12/28/93	12/28/98
Air	Central Shops Dust Collector[b]	363	03/12/91	01/08/01
Air	Ethylene Oxide Sterilizer	201	03/27/91	01/08/01
Air	Gasoline Dispensing Facility[d]	46	02/01/93	05/22/00
Air	Grieve Oven[b,e]	366	08/08/91	08/06/96
Air	Hazardous Waste Storage Facility[e]	307	05/24/95	04/26/00
Air	Methanol/Gasoline Storage Tank	46	09/24/91	09/23/96
Air	Open-Burning Permit - Fire Dept.[b]	333	01/22/98	04/16/99
Air	Open Burning - Vegetation	Sitewide	11/29/99	11/29/00
Air	Paint Spray Booth[e,f]	306	07/03/95	06/27/00
Air	Salt Cake/Recovery Electrodialysis Plant	369	08/10/98	08/10/03
Air	Sulfuric Acid Storage Tank[b]	108	01/17/91	12/01/99
Air	Title V (CAAPP)	Sitewide	Pending	-[g]
Air	Torch Cutting (Welding) Fumes[b]	Sitewide	07/20/95	07/20/00
Air	Transportation Research Facility	376	07/25/96	07/25/01
Air	Wood Shop Dust Collector[b]	368	12/16/93	10/17/96
Air	Waste Bulking Sheds[b]	306	06/14/94	07/25/96
Hazardous Waste	RCRA Part B	Sitewide	09/30/97	11/04/07
Miscellaneous	Deer Population Control Permit	Sitewide	11/15/99	02/12/00
Miscellaneous	Nuisance Wildlife Control	Sitewide	01/01/00	01/31/01
NESHAP	Advanced Photon Source	400	12/21/93	07/26/98
NESHAP	Alkali Metal Reaction Booth	206	06/09/93	06/09/97
NESHAP	Alpha Gamma Hot Cell Facility	212	03/25/91	08/09/00
NESHAP	Building Exhausts[b,h]	212	07/30/91	07/23/96
NESHAP	Building Rehab - Phase 1[i]	306	03/13/95	07/25/96
NESHAP	Building Vents	306	08/06/91	07/25/96
NESHAP	Chemical Photooxid. Vial Crusher[j]	306	01/06/99	01/06/04
NESHAP	Continuous Wave Deuterium Demonstration[e]	369	05/09/91	12/28/99

TABLE 2.13 (Cont.)

Type	Source	Building	Issued	Expiration Date[a]
NESHAP	CP-5 D&D Project	330	05/10/91	12/08/96
NESHAP	Cyclotron[e]	211	05/10/91	12/01/99
NESHAP	D&D HEPA Filter System[e]	317	05/10/94	05/10/99
NESHAP	French Drain Soil Vapor Extraction	317 Area	05/08/97	05/08/02
NESHAP	Hot Cell D&D Project	301	01/05/99	01/05/04
NESHAP	Intense Pulsed Neutron Source	375	03/25/91	08/09/00
NESHAP	Janus D&D Project[e]	202	06/12/96	06/12/01
NESHAP	Lab Wastewater Treatment Plant	575	08/29/95	08/29/00
NESHAP	Lead Brick Cleaning (carbon dioxide)	200/317	06/20/95	06/19/00
NESHAP	Melt Attack/Coolability Experiment	315	03/22/96	03/22/01
NESHAP	Mixed Waste Storage Facility	303	05/18/95	04/26/00
NESHAP	M-Wing Hot Cells	200	03/25/91	08/09/00
NESHAP	New Brunswick Lab Hoods	350	04/25/91	04/19/96
NESHAP	PCB Tank Cleanout[j]	Sitewide	08/16/95	09/28/99
NESHAP	Rad Hoods	Sitewide	07/09/92	07/09/97
NESHAP	Rad Waste Storage Facility	331	05/18/95	04/26/00
NESHAP	WMO HEPA Filter Systems (4)	Sitewide	09/28/94	09/28/99
NESHAP	WMO Portable HEPA Filters[k]	306	06/04/97	-
Solid Waste	Landfill	800 Area	03/31/82	-
Solid Waste	Landfill	800 Area	03/30/89	-
Solid Waste	Landfill	800 Area	04/12/89	-
Solid Waste	Landfill Groundwater Assessment	800 Area	09/30/91	-
Solid Waste	Landfill Leachate Characterization	800 Area	09/30/91	-
Solid Waste	Landfill Leachate Test Wells	800 Area	08/31/90	-
Solid Waste	Landfill Revised Closure Plan	800 Area	04/24/92[l]	-
Solid Waste	Landfill Supplemental Closure Plan	800 Area	09/15/92	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	04/19/94	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	01/11/95	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	11/20/97	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	08/25/98	-
Solid Waste	Landfill Supplemental Permit Groundwater	800 Area	06/16/99	-
Water	APS Wetland	400 Area	02/02/89	-
Water	Landfill Wetlands	800 Area	05/20/81	-
Water	Lime Sludge Application - Land Application	Sitewide	10/30/98	10/31/02
Water	NPDES Permitted Outfalls[m]	Sitewide	10/31/94	07/01/99
Water	NPDES Storm Water Outfalls[m]	Sitewide	10/31/94	07/01/99

TABLE 2.13 (Cont.)

[a] The expiration dates on NESHAP and air pollution permits are no longer valid (except for open burning), since the Notice of Completeness for the CAAPP application was received (see Section 2.1).

[b] These units have been designated as insignificant sources in the ANL-E Title V permit application.

[c] Construction permit issued; operated under Central Heating Plant permit.

[d] Includes ethanol/gasoline tank.

[e] Inactive.

[f] Permit originally issued for Building 815.

[g] A hyphen indicates no expiration date.

[h] Plasma spray booth added to permit 05/27/94.

[i] Construction permit issued; operated under Building 306 permit.

[j] Vial Crusher originally issued under Building 306 permit.

[k] Construction permit issued; operated under WMO HEPA permit.

[l] Revised September 15, 1992, and October 22, 1992.

[m] Revised permit application under IEPA review.

3. ENVIRONMENTAL PROGRAM INFORMATION

3.1. Environmental Programs

DOE and ANL-E 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 always given the highest priority. A number of programs and organizations exist at ANL-E to ensure compliance with these authorities and to monitor and minimize the impact of ANL-E operations on the environment.

The site remediation, environmental compliance, and environmental monitoring programs are within the Environment, Safety and Health (ESH) Division. The ANL-E Remedial Actions Project is responsible for achieving compliance with all applicable environmental authorities related to assessing and cleaning up releases of hazardous materials from inactive waste sites. The primary regulatory vehicle is the corrective action requirements specified in the RCRA Part B Permit. The environmental compliance and environmental monitoring programs are responsible for the actions conducted at ANL-E to ensure the safety of the public; protection of the environment; and compliance with applicable federal, state, and local environmental regulations and DOE orders.

3.2. Remedial Actions Progress in 1999

In 1999, ANL-E continued implementing its plan for accelerated remediation of waste management units. The current plan calls for completion of the planned remedial actions by the end of Fiscal Year (FY) 2003. The current plan for the ANL-E site is described in the document entitled *Environmental Restoration Program (EM-40) Baseline for Argonne National Laboratory-East.*[6] In early 1999, ANL-E completed the 1999 baseline document. This document describes in detail the activities required to complete the planned actions by the end of FY 2003.

Several significant remedial actions were completed in 1999. The most significant involved deployment of a state-of-the-art remediation technology to clean up soil and groundwater in the 317 Area French Drain. In the 1950s, spent solvents were poured into a gravel-filled trench (French drain) as a means of disposal. These solvents did not evaporate or degrade, as intended, but slowly were released to underlying soil and groundwater. To remove this accumulation of solvent, in 1997 and 1998, ANL-E deployed a process known as soil mixing with thermally enhanced soil vapor extraction. A specially designed soil auger assembly was used to break up and blend a column of soil while a stream of steam, hot air, and zero-valent iron was injected into the column. Some of the VOCs were stripped from the soil and captured in an off-gas treatment system, while others reacted with the iron particles and were decomposed. This process was successful in removing about 80% of the source of soil and groundwater contamination in the 317 French Drain area. However, a significant volume of contaminated groundwater and some untreated soils were left in place.

The remaining contamination is being treated with a newly developed remediation technology known as phytoremediation. This technology uses trees and other deep-rooted plants to extract contaminants from the groundwater and soil and processes them in the plant's tissue to render them harmless. In 1999, over 800 poplar and willow trees were planted in the 317 French Drain area to remove contamination from groundwater and soil. Tree roots planted to remediate groundwater were planted at depths up to 11 m (35 ft), while tree roots planted to treat soil were planted up to 6 m (20 ft) deep. ANL-E estimates that it will require about three growing seasons until the trees are mature.

A second remedial action project completed in 1999 involved placing an engineered cap over the 319 Area Landfill and upgrading the landfill's leachate and groundwater extraction system to function over the long term. The landfill cap work included placing a geosynthetic clay liner (equivalent in effectiveness against water intrusion to 0.61 m [2 ft] of compacted clay), an impervious geomembrane, a drainage medium, and 0.91 m (3 ft) of clay and top soil to support a vegetative cover over the waste mound. Native grasses then were planted over the cap surface.

Other work included consolidating scattered debris next to the 800 Area Landfill and extending the existing cap north of the landfill to cover the exposed debris on the landfill's north slope. The new cap extension received 0.61 m (2 ft) of compacted clay and 0.15 m (0.5 ft) of top soil. The top soil was seeded with a mixture of grasses similar to that used on the remainder of the 800 Area Landfill cover.

Four other SWMUs were remediated in 1999 in the 100 Area; these SWMUs were associated with the Building 108 Boiler House operations. They were remediated by excavating the contaminated soil and gravel, thus demonstrating that the IEPA Tier 1 cleanup objectives had been met; the previously contaminated soil area was then replaced with a layer of concrete. The concrete then was sealed to prevent ongoing operations from recontaminating the underlying soils. As a result of these actions, ANL-E submitted a request to the IEPA for No Further Action.

Routine operation and maintenance (O&M) of two groundwater extraction systems, one south of the 319 Landfill and the second south of the 317 Area French Drain, was carried out. Monitoring of these systems has indicated that they are capturing the groundwater as intended.

3.3. Environmental Support Programs

3.3.1. Self-Assessment

In line with the principles of Integrated Safety Management (ISM), line management is responsible for internal self-assessment. The process focuses on the activities of an individual

organization, and the results are reported to those who have the authority and responsibility for the organization's performance. At the beginning of each calendar year, each organization develops an agenda of activities to be reviewed that year. A schedule is prepared, and assignments are made to manage the organization's self-assessment program. The results and conclusions of the assessment program are summarized annually and submitted to the Director of ESH/Quality Assurance Oversight (EQO). The actual performance during the year is monitored by oversight organizations to assist senior management in fulfilling its responsibilities.

For 1999, the annual summary self-assessment was documented in the form of an ISM gap analysis. The overall ANL-E self-assessment combined the division analyses that identified specific gaps between expectations and actual execution, as well as corrective actions to address these gaps.

3.3.2. Environmental Training Programs

ANL-E has a comprehensive environmental protection training program that includes mechanisms to identify, track, and document requirements for every employee. Environmental protection training for ANL-E personnel is provided primarily by the ESH Training Section, although some training may be delivered by subject-matter experts from other organizations. Personnel training requirements address various requirements, such as those contained in DOE Orders, or EPA or U.S. Department of Transportation regulations. These requirements are identified by a Job Hazards Checklist form that is completed by every employee and that is reviewed by each employee's supervisor. A positive answer to any one of a battery of specific questions triggers the training requirements specific to that question. Options also exist for division-required training, recommended training, and elective training.

Activities 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 representatives, the ESH Training Section, or Human Resources.

3.3.3. Waste Minimization and Pollution Prevention

During 1999, ANL-E received two prestigious pollution prevention awards. In April, ANL-E received the DOE 1999 Pollution Prevention Award for Waste Reduction and Recycling. In November, ANL-E received the Illinois Governor's Pollution Prevention Award for Continuous Improvement.

ANL-E has a formal Waste Minimization and Pollution Prevention (WM&PP) Program. The program's long-term strategy is identified in the ANL-E WM&PP Strategic Plan dated

November 1995. In April 1997, ANL-E finalized a Pollution Prevention Program Plan that identifies ANL-E's short-term (three-year cycle) pollution prevention goals and describes the strategies that will be employed to achieve those goals. The pollution prevention goals outlined in the ANL-E Pollution Prevention Program Plan are the same as the 1999 DOE Pollution Prevention Goals that were established in 1996, which were derived from the 1993 baseline.

The following paragraphs present the seven DOE Pollution Prevention Goals, brief descriptions of ANL-E's progress toward each goal in 1999, and future strategies for achieving each goal.

Goal 1. Reduce by 50% the generation of radioactive waste. Annual Radioactive Waste Generation, 1993–1999 (ft^3 [1,000])

	1993	1994	1995	1996	1997	1998	1999
Generation	10.5	16.9	19.5	12.3	9.1	10.9	2.5
Goal							5.2

In 1999, generation of LLW at ANL-E decreased compared with 1998. ANL-E experienced an increase in LLW in 1998 because a waste management strategy was implemented that focuses on more expedient identification and removal of waste from the facility. This strategy is being carried out in an effort to avoid the extended accumulation and deferred disposal of archived wastes and represents a proactive approach to waste management activities.

During the past year, PFS-WMO developed data management tools that improved the tracking of "routine" and "nonroutine" LLW. Through the use of these tools, PFS-WMO can track the amount of routine LLW disposed of by ANL-E more accurately.

Depletion of existing LLW, in conjunction with the implementation of proactive waste management activities, is projected to result in the continued reduction of ANL-E LLW in the future.

Goal 2. Reduce by 50% the generation of radioactive mixed waste. Radioactive Mixed Waste Generation 1993 –1999 (ft^3 [1,000])

	1993	1994	1995	1996	1997	1998	1999
Generation	5.0	0.67	0.71	0.16	0.3	0	0.44
Goal							2.5

Generation of mixed waste at ANL-E has continued to remain below the 1999 DOE Pollution Prevention Goal established from the 1993 baseline. The goal of reducing mixed wastes by 2.5 ft^3 has been surpassed. This goal for mixed waste has been achieved through a combination of treatment and source reduction. Current generation levels should be maintained by continuing to execute and improve current waste reduction activities and by implementing additional planned activities.

Goal 3. Reduce by 50% the generation of hazardous waste.
Annual Hazardous and State-Regulated Special Waste Generation (metric tons)

	1993	1994	1995	1996	1997	1998	1999
Generation	5,588	2,509	1,246	1,226	1,452	396	46.7
Goal							1,842

Hazardous waste generation levels in 1999 continue to be well below the 1999 DOE Pollution Prevention Goals derived from the 1993 baseline. ANL-E continues to encourage the use of microscale techniques within laboratories as a waste prevention strategy. In addition, ANL-E has reduced the volume of RCRA-related waste by implementing more efficient packaging procedures for chemical wastes and by implementing a proactive waste management strategy that incorporates alternatives to disposal, such as recycling and reuse of materials and chemicals.

ANL-E also has addressed state-regulated waste by taking advantage of new IEPA regulations that allow waste streams, such as wastewater sludges and coal combustion fly ash, to be certified as “nonspecial” waste. These waste streams are now tracked under the sanitary waste category. In addition, all coal combustion fly ash generated at ANL-E is being recycled at this time.

Goal 4. Reduce by 33% the generation of sanitary waste.
Annual Sanitary Waste Generation, 1993 –1999 (metric tons)

	1993	1994	1995	1996	1997	1998	1999
Generation	1,260	2,670	1,753	1,228	970	804	539
Goal							870

During 1999, ANL-E continued the downward trend of routine sanitary waste generation, with levels below the 1999 DOE Pollution Prevention Goals. ANL-E has developed and is implementing aggressive waste prevention and recycling programs that will be used to maintain and

improve upon these levels. Through the continuous improvement of recycling programs and improved data management, ANL-E will continue to achieve this goal.

Goal 5. Reduce by 50% total releases and off-site transfers for treatment and disposal of toxic chemicals. Annual Toxic Release Inventory, 1993 –1999 (metric tons)

	1993	1994	1995	1996	1997	1998	1999
Treatment or Disposal	1.78	0	0	0	0	0	0
Goal							0.89

Since 1993, when 1.78 t (1.96 tons) of toxic releases was recorded, ANL-E has focused on eliminating all forms of toxic releases. From 1994 through 1999, ANL-E has maintained zero generation levels.

Goal 6. Recycle 33% of sanitary waste from all operations, including cleanup and stabilization activities.

During 1999, ANL-E generated a total of 7,799 t (8,579 tons) of sanitary waste and materials from all operations, including cleanup and stabilization activities. ANL-E was able to recycle (reuse) 5,699 t (6,269 tons) of these materials. This amounts to a 73% level of recycling of sanitary waste from all ANL-E operations. To improve this recycling level, ANL-E is developing and implementing a variety of additional recycling programs for sanitary waste and materials originating from environmental restoration, D&D, and facility construction and demolition activities. Programs have been successful in recycling fill material, roadway materials, and wood and scrap metal from routine and nonroutine activities. ANL-E will continue to work to develop, implement, and document waste stream diversion, material recycling, and other pollution prevention initiatives.

Goal 7. Affirmative Procurement: Increase procurement of EPA-designated recycled products to 100%, except where they are not commercially available competitively at a reasonable price or do not meet performance standards.

As a result of 1999 ANL-E Affirmative Procurement Program efforts, purchasing of recycled-content products has been made easier for employees, tracking purchases is less difficult, and the overall awareness level for buying recycled material products is at an all-time high. As evidence of the effectiveness of the ANL-E Affirmative Procurement Program, the ANL-E percentage for purchases of EPA-designated recycle-content products dramatically increased during FY 1999 to 70%, as compared with 42% in FY 1998, and 31% in FY 1997. Justification for the balance of product purchases was based on their not being available competitively within a reasonable time frame, not meeting appropriate performance standards, or being available but only

at an unreasonable price. ANL-E is working toward this goal through a combination of an Affirmative Procurement Awareness Program, the development of an upgraded procurement tracking system, and the development and execution of ANL-E recycled product procurement procedures.

3.3.4. Site Environmental Performance Measures Program

Effective June 1, 1995, the prime contract between DOE and the University of Chicago to operate ANL-E made provisions for a performance fee, based on the performance of various research and operations activities, including ESH and Projects and Infrastructure Management performance. Performance objectives and supporting metrics have been developed to administer the contract and determine the performance fee. Each performance expectation is weighted; at the end of the performance period, a rating (outstanding, excellent, good, or marginal) is assigned for each. The performance fee is based on these ratings.

For the period of the performance-based contract October 1998 to September 1999, the environmental measurements were included in two Critical Few categories. One category was identified as the ESH category, and the other as Projects and Infrastructure Management. The ratings of the measurements in the Critical Few categories directly affected the performance-based fee. The environmental measurements included improvements in the environmental review process (outstanding), compliance with environmental permit conditions (outstanding), compliance with air and water effluent limits (outstanding), compliance with environmental project schedule (excellent), compliance with environmental project cost (outstanding), and waste minimization/pollution prevention (outstanding), for an overall rating of outstanding. This rating was later lowered to excellent in the final rating. In addition, the overall rating of the Projects and Infrastructure Management categories within Critical Few, based on a roll-up of the individual expectation performance ratings during the contract period, also was outstanding.

3.3.5. Environmental Management System

It is ANL-E policy to conduct its operations in an environmentally safe and sound manner. Protection of the environment and the public are responsibilities of paramount importance and concern to ANL-E. To that end, ANL-E is firmly committed to ensuring the incorporation of national environmental protection goals in the formulation and implementation of ANL-E programs. It is committed as well to the goals of restoring and enhancing environmental quality and protecting public health. Accordingly, it is ANL-E policy to conduct its operations in compliance with the letter and spirit of applicable environmental statutes, regulations, and standards. To manage these commitments, ANL-E has structured its activities to focus on these goals. Line organizations have primary responsibility for environmental management and are supported by professional staff from

the core ESH organizations, including specialists in air, water, RCRA, CERCLA, and NEPA. The ESH/QA organization provides oversight.

3.3.6. Ecological Restoration Program

DOE and ANL-E recognize the importance of enhancing and preserving biodiversity and have committed to supporting the Biodiversity Recovery Plan prepared by Chicago Wilderness partnership organizations. Ongoing ecological restoration activities include enhancing oak woodland, savanna, wetland, and prairie habitats in the undeveloped areas on the ANL-E site. Six acres of vacant land that was formerly 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 administrative building is being used to demonstrate the use of native plants for landscaping after invasive weedy plants have been removed and replaced by native species.

ANL-E is implementing, where practical, Executive Order 13112 (Invasive Species) and Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds (60 FR 40837).

3.4. Environmental Monitoring Program Description

As required by DOE Orders 5400.1[1] and 231.1, ANL-E conducts a routine environmental monitoring program. This program is designed to determine the effect of ANL-E operations on the environment surrounding the site. This section describes this monitoring program. In 1999, a total of 1,962 samples were collected and 22,489 analyses were performed. A general description of the techniques used to sample each environmental medium is provided. This is followed by the collection procedures, the sampling schedule, and the analytical techniques used. Greater detail is provided in the ANL-E Environmental Monitoring Plan.

3.4.1. Air Sampling

ANL-E 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 14 locations around the ANL-E perimeter and at 6 off-site locations, approximately 8 km (5 mi) from ANL-E, 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. The filters on perimeter samplers are changed by ANL-E staff, and the filters on off-site samplers are changed and mailed to ANL-E by cooperating local agencies. Additional samples of particles in air, used for radiochemical analysis of plutonium and other radionuclides, are collected at two perimeter locations and at one off-site location. These samples are collected on special filter media that are changed every 10 days by ANL-E staff. 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, the initial flow rate, the date and time when the sample was collected, and the final flow rate are recorded on a label attached to the sample container. The samples are then transported to ANL-E where this information is then transferred to the Environmental Protection Data Management System (EMS).

Each air filter sample collected for alpha, beta, and gamma-ray analysis 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.

Stack monitoring is conducted continuously at those emission points that have a probability of releasing measurable radionuclides. The results of these measurements are used for estimating the annual off-site dose using the required EPA CAP-88 (Clean Air Act Assessment Package-1988)[7] atmospheric dispersion computer code and dose conversion method.

3.4.2. Water Sampling

Water samples are collected to determine what, if any, radionuclides or selected hazardous chemicals used or generated at ANL-E enter the environment by the water pathway. Surface water samples are collected from the wastewater outfall and from Sawmill Creek below the point at which ANL-E discharges its treated wastewater. The results of radiological analysis of water samples at these locations are compared with upstream and off-site results to determine the ANL-E contribution. The results of the chemical analyses are compared with the applicable IEPA stream quality standards

to determine whether the site is degrading the quality of the creek. These results are discussed in more detail in Chapters 4 and 5.

Surface water samples are collected from Sawmill Creek and combined into a single weekly composite sample. A continuous sampling device has been installed at this location to improve sample collection representativeness. To provide control samples, Sawmill Creek is sampled upstream of ANL-E once a month. The Des Plaines River is sampled twice a month below, and monthly above, the mouth of Sawmill Creek to determine whether radionuclides in the creek are detectable in the river.

In addition to surface water, subsurface water samples also are collected at 41 locations. These samples are collected from monitoring wells located near areas that have the potential for adversely impacting groundwater. These areas are the 800 Area Landfill, the 317/319 waste management area, and the site of the inactive CP-5 reactor. Samples from the three on-site wells that formerly provided domestic water also are collected and analyzed for hazardous and radioactive constituents.

Subsurface water samples are collected quarterly from the monitoring wells located in the 317/319 Area, the 800 Area Sanitary Landfill, and the CP-5 reactor. The monitoring wells are purged, and samples are collected from the recharged well water. These samples are analyzed for both chemical and radiological constituents, as discussed in Chapter 6. Samples are collected quarterly from the wellheads of the three ANL-E wells that formally provided the domestic water supply. The water is pumped to the surface and collected in appropriate containers, depending on the required analysis.

At the time of sample collection for radiological analysis, the sampling location, time, date, and collector identification number are recorded on a label attached to the sample container. Upon return to the laboratory, the information is transferred to the EMS system. Each sample is assigned a unique number that accompanies it through all analyses. After the sample has been logged in, an aliquot is removed for hydrogen-3 analysis; 20 mL (1 oz) of concentrated nitric acid is added per gallon of water as a preservative, and the sample is filtered through Whatman No. 2 filter paper to remove any sediment present in the sample. Appropriate aliquots are then taken, depending on the analysis.

For nonradiological analysis, samples are collected and preserved using EPA-prescribed procedures. Cooling is used for organic analysis, and nitric acid is used to preserve samples to be analyzed for metals. Specific collection procedures are used for other components, and EPA methods are used. All samples are analyzed within the required holding period, or noncompliance is documented. The quality control requirements of either SW-846[8] or the Contract Laboratory Program (CLP) must be met, or deviations are documented. All samples are assigned a unique number that

serves as a reference source for each sample. When duplicate samples are obtained, unique numbers are assigned, and an indication that duplicates exist is entered in the data management system.

3.4.3. Bottom Sediment

Bottom sediment accumulates small amounts of radionuclides that may be present from time to time in a stream and, as a result, acts as an accumulator of the radionuclides that were present in the water. The sediment provides evidence of radionuclides in the surface water system. These samples are not routinely analyzed for chemical constituents. Bottom sediment samples are collected annually from Sawmill Creek above, at, and from several locations below the point at which ANL-E discharges its treated wastewater. Sediment is collected from each location with a stainless-steel scoop and is transferred to a glass bottle.

At the time of sample collection, the date, time, and sample collector identification are recorded on sample labels affixed to the sample container. Upon return to the laboratory, the information is transferred to the EMS system. Each sample is assigned a unique number that accompanies it through the process.

Each sample is dried for several days at 110°C (230°F), ball milled, and sieved through a No. 70 mesh screen. The material that does not pass the No. 70 screen is discarded. A 100-g (4-oz) portion is taken for gamma-ray spectrometric measurement, and other appropriate aliquots are used for specific radiochemical analyses.

3.4.4. External Penetrating Radiation

Measurements of direct penetrating radiation emanating from several sources within ANL-E are taken by using aluminum oxide thermoluminescent dosimeters (TLDs) provided by a commercial vendor. Each measurement is the average of two chips exposed in the same packet. Dosimeters are exposed at 17 locations at the site perimeter and on site and at five off-site locations. All dosimeters are changed quarterly. At the time of dosimeter collection, the date, time, and collector identification number are recorded on a preprinted label affixed to the container. Each sample is assigned a unique number that accompanies it through the process. After completion of the exposure period, the TLDs are mailed to the vendor for reading. When the dose information is provided to the on-site laboratory by the vendor, it is entered into the EMS system.

3.4.5. Data Management

ANL-E manages the large amount of data assembled in the environmental monitoring program in a structured manner that allows a number of reports to be generated. Basic data management, including sample record keeping, is implemented with the EMS computerized record-keeping system. All sample and analytical data are maintained in the EMS for eventual output in formats required for either regulatory compliance reports or for annual reports. In addition, reports are provided for trend analysis, statistical analysis, and tracking.

The ANL-E–developed EMS is the basic data management tool; it generates sampling schedules, all other tracking and calculation routines, and the final analytical result tabulations. The EMS is set up for the radiological portion of the monitoring program and for nonradiological monitoring for groundwater and NPDES surface water effluents.

The starting point for effluent monitoring and environmental surveillance is establishing a set of sampling locations and a sample schedule. On the basis of regulatory parameters, pathway analysis, or professional judgment, sample locations for the various media are identified and entered into the EMS. For each sample location, nine categories of data are entered into the EMS: geographic code, location description, sampling frequency, sample type, exact sampling position, last date sampled, sampling priority (same location with multiple samples), size of sample to collect, and analytes.

Once the data are entered, the EMS is used to generate a sampling schedule. Every week a schedule for the next week is printed out, along with uniquely numbered, preprinted labels for the sample containers. These items are provided to the staff who conduct the sampling in the field. Field data are entered into the EMS. At the time the samples are submitted to the analytical laboratory, chain of custody documents are generated. The EMS distributes sample data electronically (via diskette) to the ESH data management system and accepts back the analytical data (via diskette or e-mail).

As the laboratory results are compiled, the data are entered into the EMS. This permits up-to-date tracking of all samples currently in process. When the analysis for each sample is completed and the results electronically entered into the EMS, the completed final results sample card is retained in a file as an additional QA measure.

Complete data sets for all samples are maintained by the EMS. When all results have been completed and entered into the EMS, a final result card is generated that lists all data related to each sample. The electronic files are backed up by the ESH computer network server. The printed final result card is filed after review, then ultimately put in DOE's archives in Chicago. Final results are thus available both on line via the network and in hard copy.

3.5. Compliance with DOE Order 5820.2A

DOE Order 5820.2A, "Radioactive Waste Management," Section III-3 (k),[9] requires that an environmental monitoring and surveillance program be conducted to determine any releases or migration from LLW treatment, storage, or disposal sites. Compliance with these requirements is an integral part of the ANL-E sitewide monitoring and surveillance program. Waste management operations in general are covered by relying on the perimeter air monitoring network and monitoring of the liquid effluent streams and Sawmill Creek. The analytical results are presented in Chapter 4 of this report.

Of particular interest is monitoring of the waste management activities conducted in the 317 Area. These include air monitoring for total alpha, total beta, and gamma-ray emitters and radiochemical determinations of plutonium, uranium, thorium, and strontium-90; direct radiation measurements with TLDs; surface water discharges for hydrogen-3 and gamma-ray emitters; and subsurface water samples at all the monitoring wells with analyses for hydrogen-3, strontium-90, and gamma-ray emitters, plus selected monitoring for VOCs. The results are presented in Chapters 4 and 6 of this report.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1. Description of Monitoring Program

The radioactivity of the environment around ANL-E in 1999 was determined by measuring radionuclide concentrations in naturally occurring materials and by measuring the external penetrating radiation dose. 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.[10] 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 man-rems.

DOE has provided guidance[11] for effective dose equivalent calculations for members of the public based on International Commission on Radiological Protection (ICRP) Publications 26 and 30.[12,13] 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 factors[14] and were compared with the annual dose limits for uncontrolled areas. The CEDEs were calculated from the DOE Derived Concentration Guides (DCGs)[11] for members of the public on the basis of a radiation dose of 100 mrem/yr. The numerical values of the CEDE factors used in this report are provided later in this chapter (Table 4.26). Although the CEDE factors apply only to concentrations above natural levels, for comparative purposes, the calculated dose is sometimes given in this report for radioactivities that are primarily of natural origin. 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. Separate collections were made for specific radiochemical analyses and for gross alpha, gross beta, and gamma-ray spectrometry. The latter measurements were taken from samples collected continuously on laminated glass fiber filters (changed weekly) at 12 locations at the ANL-E site perimeter by using PM_{10} units (particles less than 10 micrometers) and at 5 off-site locations.

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-E, provided that the perimeter samples are greater than the background samples 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 total alpha and beta activities in the individual weekly samples. 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 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.

The alpha activity, principally due to naturally occurring nuclides, averaged the same as in the past several years and was within its normal range. The perimeter beta activity averaged 20 fCi/m^3, which is similar to the average value for the past five years. The gamma-ray emitters listed in Table 4.2 are those that have been present in the air for the past five 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 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

TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 1999
(concentrations in fCi/m^3)

			Alpha Activity			Beta Activity		
Month	Location	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	25	0.8	0.1	1.7	23.7	11.6	41.7
	Off-Site	19	1.7	0.5	3.5	29.2	16.7	57.6
February	Perimeter	44	0.7	0.2	1.1	19.0	9.6	27.6
	Off-Site	14	0.8	0.4	1.5	18.4	14.4	23.8
March	Perimeter	60	0.9	0.3	1.5	18.8	9.6	26.7
	Off-Site	17	1.1	0.7	1.6	16.2	11.3	26.8
April	Perimeter	46	0.8	0.2	1.5	15.4	7.0	23.7
	Off-Site	14	0.9	0.5	1.2	12.9	9.9	16.1
May	Perimeter	46	0.9	0.3	1.8	14.4	6.1	21.0
	Off-Site	16	0.9	0.3	2.1	12.6	8.2	24.5
June	Perimeter	60	0.7	0.1	1.6	15.0	5.6	30.3
	Off-Site	20	0.6	0.2	1.2	12.2	1.2	24.7
July	Perimeter	47	1.1	0.1	2.4	18.2	4.0	29.5
	Off-Site	12	1.3	0.2	2.2	13.1	0.3	25.3
August	Perimeter	44	0.7	0.1	1.2	16.5	8.9	31.7
	Off-Site	14	0.9	0.2	1.6	16.8	2.2	30.5
September	Perimeter	58	0.9	0.4	2.1	21.2	9.6	42.3
	Off-Site	16	1.1	0.1	3.2	16.5	1.6	32.9
October	Perimeter	47	0.8	0.3	1.6	18.7	8.4	29.8
	Off-Site	14	1.1	0.1	2.5	19.1	6.0	34.4
November	Perimeter	48	1.6	0.7	3.4	29.6	16.5	50.9
	Off-Site	12	1.7	0.5	2.5	29.7	13.4	43.6
December	Perimeter	46	1.0	0.3	2.2	22.8	13.9	39.4
	Off-Site	13	1.6	0.4	3.1	27.3	8.9	45.4
Annual	Perimeter	571	0.9 ± 0.2	0.1	3.4	19.4 ± 2.8	4.0	50.9
summary	Off-Site	181	1.1 ± 0.2	0.1	3.5	18.7 ± 4.1	0.3	57.6

TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 1999
(concentrations in fCi/m^3)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	69	21
	Off-Site	70	23
February	Perimeter	89	17
	Off-Site	73	12
March	Perimeter	110	15
	Off-Site	80	11
April	Perimeter	111	12
	Off-Site	81	8
May	Perimeter	107	11
	Off-Site	75	6
June	Perimeter	95	13
	Off-Site	66	8
July	Perimeter	89	13
	Off-Site	68	7
August	Perimeter	88	14
	Off-Site	69	11
September	Perimeter	87	17
	Off-Site	56	10
October	Perimeter	62	17
	Off-Site	55	14
November	Perimeter	62	26
	Off-Site	64	23
December	Perimeter	46	21
	Off-Site	56	21
Annual	Perimeter	85 ± 13	16 ± 2
Summary	Off-Site	68 ± 5	13 ± 3
Dose(mrem)	Perimeter	(0.00021)	(1.87)
	Off-Site	(0.00017)	(1.48)

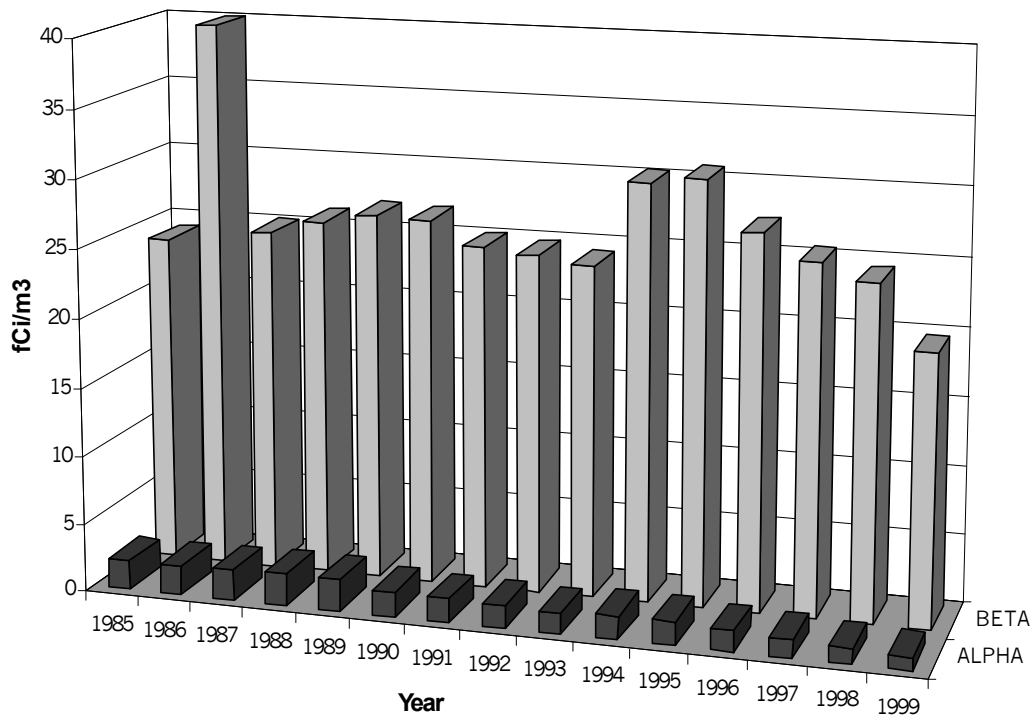

Figure 4.1 Comparison of Total Alpha and Beta Activities in Air Filter Samples

attributed to the Chernobyl incident are subtracted from the annual beta average of 40 fCi/m^3, the 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 started to decrease. The changes in the beryllium-7 air concentrations have been observed worldwide by the DOE Environmental Laboratory's Surface Air Sampling Program and are attributed to changes in solar activity.[15]

Samples for radiochemical analyses were collected at perimeter locations 12N and 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 600°C (1,100^{o}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

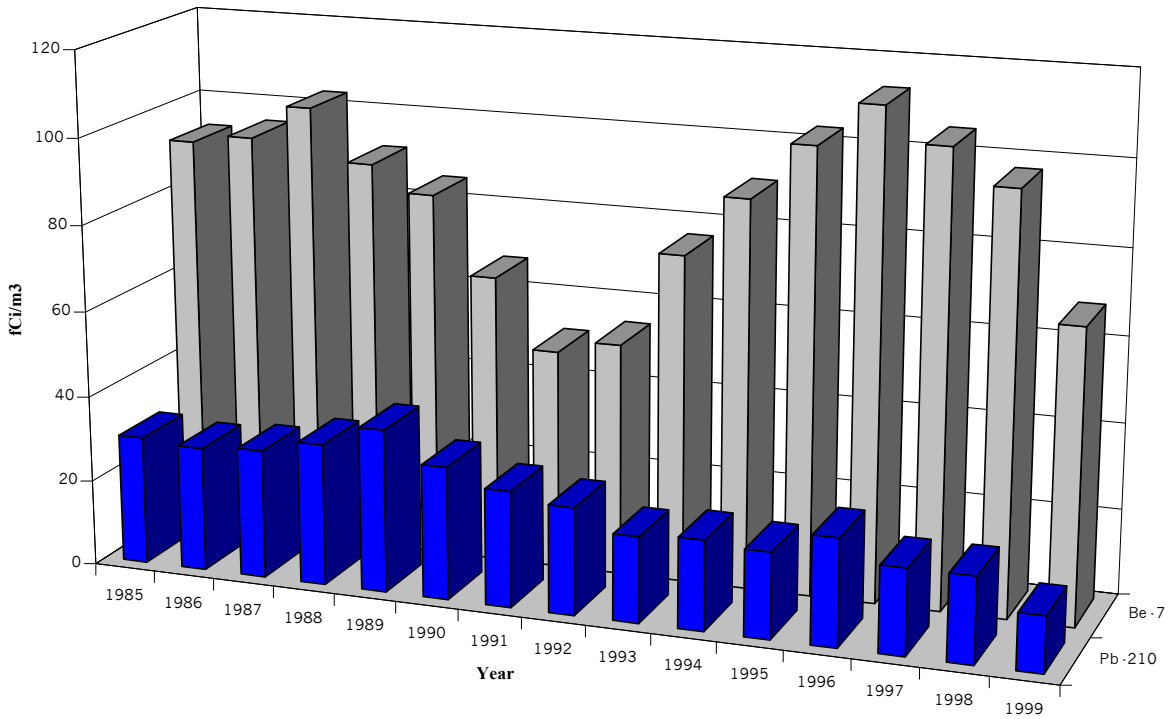

Figure 4.2 Comparison of Gamma-Ray Activity in Air Filter Samples

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.

The strontium-90 concentrations have decreased over the past several years; consequently, during 1999, all of the results were less than the detection limit of 10 aCi/m^3, except for two results in December. 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.

The major airborne effluents released at ANL-E during 1999 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, have been greatly reduced. The hydrogen-3 emitted from Building 212 is from hydrogen-3 recovery studies, while short-lived 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

TABLE 4.3

Strontium, Thorium, Uranium, and Plutonium Concentrations
in Air Filter Samples, 1999
(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	52 ± 6	39 ± 5	39 ± 5	47 ± 5	48 ± 5	2.1 ± 1.1
	12N	< 10	23 ± 3	27 ± 3	19 ± 3	32 ± 3	32 ± 3	0.8 ± 0.5
	Off-Site	< 10	4 ± 1	5 ± 1	3 ± 1	8 ± 2	7 ± 2	0.2 ± 0.2
February	7I	< 10	7 ± 2	5 ± 1	4 ± 1	7 ± 2	8 ± 2	0.2 ± 0.4
	12N	< 10	13 ± 3	14 ± 3	11 ± 2	18 ± 4	19 ± 4	2.2 ± 1.2
	Off-Site	< 10	2 ± 1	2 ± 1	1 ± 1	5 ± 2	4 ± 1	< 0.1
March	7I	< 10	5 ± 2	5 ± 1	3 ± 1	8 ± 2	7 ± 2	0.3 ± 0.2
	12N	< 10	11 ± 2	12 ± 3	8 ± 2	17 ± 2	17 ± 2	0.4 ± 0.2
	Off-Site	< 10	6 ± 2	7 ± 2	4 ± 2	13 ± 4	8 ± 3	0.7 ± 0.6
April	7I	< 10	7 ± 2	7 ± 2	5 ± 1	8 ± 2	8 ± 2	0.3 ± 0.3
	12N	< 10	6 ± 1	6 ± 1	4 ± 1	7 ± 1	7 ± 1	0.3 ± 0.2
	Off-Site	< 10	2 ± 1	2 ± 1	1 ± 1	2 ± 1	2 ± 1	2.3 ± 0.7
May	7I	< 10	7 ± 2	7 ± 2	5 ± 1	9 ± 1	12 ± 1	0.3 ± 0.3
	12N	< 10	9 ± 2	9 ± 2	6 ± 1	11 ± 1	10 ± 1	-
	Off-Site	< 10	4 ± 2	5 ± 1	2 ± 1	7 ± 1	5 ± 1	0.5 ± 0.4
June	7I	< 10	3 ± 1	6 ± 2	3 ± 1	4 ± 1	4 ± 1	0.4 ± 0.2
	12N	< 10	7 ± 2	8 ± 2	6 ± 1	8 ± 1	8 ± 1	0.2 ± 0.1
	Off-Site	< 10	5 ± 2	5 ± 1	3 ± 1	6 ± 1	7 ± 1	0.2 ± 0.2
July	7I	< 10	3 ± 1	3 ± 1	1 ± 1	3 ± 1	4 ± 1	0.2 ± 0.2
	12N	< 10	8 ± 2	8 ± 2	6 ± 1	9 ± 1	10 ± 1	0.1 ± 0.1
	Off-Site	< 10	6 ± 2	5 ± 1	4 ± 1	6 ± 1	5 ± 1	0.3 ± 0.2
August	7I	< 10	5 ± 2	4 ± 1	3 ± 1	4 ± 1	5 ± 1	0.2 ± 0.2
	12N	< 10	5 ± 1	6 ± 1	4 ± 1	6 ± 1	5 ± 1	< 0.1
	Off-Site	< 10	3 ± 1	2 ± 1	1 ± 1	3 ± 1	3 ± 1	0.3 ± 0.2
September	7I	< 10	5 ± 2	4 ± 1	3 ± 1	5 ± 2	5 ± 1	< 0.1
	12N	< 10	7 ± 2	8 ± 2	5 ± 1	8 ± 1	8 ± 1	0.2 ± 0.2
	Off-Site	< 10	7 ± 2	8 ± 2	6 ± 1	7 ± 2	8 ± 2	0.3 ± 0.3
October	7I	< 10	3 ± 1	4 ± 1	2 ± 1	4 ± 1	4 ± 1	0.3 ± 0.3
	12N	< 10	8 ± 2	9 ± 2	7 ± 2	11 ± 2	10 ± 2	0.1 ± 0.1
	Off-Site	< 10	5 ± 2	5 ± 2	3 ± 1	5 ± 1	5 ± 1	0.2 ± 0.2
November	7I	< 10	2 ± 1	4 ± 1	2 ± 1	3 ± 1	4 ± 1	0.3 ± 0.3
	12N	< 10	9 ± 2	11 ± 2	8 ± 2	9 ± 1	10 ± 1	0.1 ± 0.2
	Off-Site	< 10	3 ± 1	3 ± 1	2 ± 1	3 ± 1	4 ± 1	0.3 ± 0.3
December	7I	16 ± 5	17 ± 7	17 ± 5	15 ± 5	16 ± 5	16 ± 5	1.7 ± 0.9
	12N	70 ± 16	14 ± 3	15 ± 2	10 ± 2	14 ± 2	15 ± 2	0.3 ± 0.3
	Off-Site	< 10	3 ± 1	5 ± 1	3 ± 1	5 ± 2	6 ± 2	0.4 ± 0.2
Annual Summary	7I	< 10	10 ± 31	9 ± 22	7 ± 23	10 ± 27	10 ± 27	0.5 ± 1.5
	12N	< 10	10 ± 11	11 ± 13	8 ± 9	12 ± 16	12 ± 16	0.4 ± 1.4
	Off-Site	< 10	4 ± 3	4 ± 4	3 ± 3	6 ± 6	5 ± 4	0.5 ± 1.3
Dose (mrem)	7I	< (0.00011)	(0.0238)	(0.0172)	(0.071)	(0.00049)	(0.00051)	(0.0013)
	12N	< (0.00011)	(0.0245)	(0.0221)	(0.078)	(0.00062)	(0.00062)	(0.0011)
	Off-Site	< (0.00011)	(0.0099)	(0.0089)	(0.027)	(0.00029)	(0.00026)	(0.0012)

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

TABLE 4.4

Summary of Monitored Airborne Radioactive Emissions from ANL-E Facilities, 1999

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	193.0	7.1×10^{12}
205	Hydrogen-3 (tritiated water [HTO])	12.3 yr	0.53	1.9×10^{10}
212 (Alpha Gamma Hot Cell Facility)	Hydrogen-3 (HTO)	12.3 yr	10.9	4.0×10^{11}
	Hydrogen-3 (tritiated hydrogen gas [HT])	12.3 yr	131.4	4.8×10^{12}
	Krypton-85	10.7 yr	1.35	5.0×10^{10}
	Radon-220	56 s	0.14	5.2×10^{9}
350 (NBL)	Uranium-234	2.4×10^{5} yr	3.2×10^{-5}	1.2×10^{1}
	Uranium-238	4.5×10^{9} yr	3.2×10^{-5}	1.2×10^{1}
	Plutonium-238	87.7 yr	1.5×10^{-9}	5.5×10^{0}
	Plutonium-239	2.4×10^{4} yr	5.8×10^{-9}	2.1×10^{1}
	Plutonium-240	6.6×10^{4} yr	8.5×10^{-9}	3.1×10^{1}
	Plutonium-241	14.4 yr	2.2×10^{-7}	8.1×10^{3}
	Plutonium-242	3.76×10^{5} yr	1.8×10^{-9}	6.6×10^{0}
	Plutonium-244	8.0×10^{7} yr	3.3×10^{-13}	1.2×10^{-3}
375 (IPNS)	Carbon-11	20 m	118.1	4.3×10^{12}
	Argon-41	1.8 h	1.6	5.9×10^{10}
411/415 (APS)	Carbon-11	20 m	0.07	2.6×10^{9}
	Nitrogen-13	10 m	3.22	1.2×10^{11}
	Oxygen-15	122 s	0.35	1.3×10^{10}

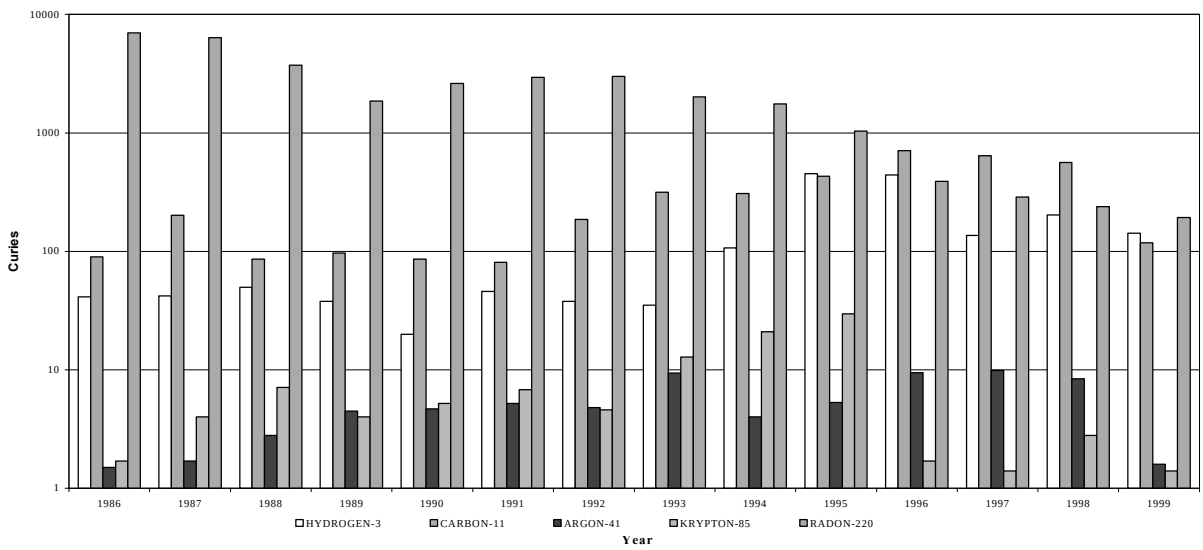

Figure 4.3 Selected Airborne Radionuclide Emissions

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.

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 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 are 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. 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 BAT as required by DOE Order 5400.5.[11]

Another component of the radiological effluent monitoring program, which was instituted in 1999, 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 5.10). The same 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 1999. The results show that the radionuclides hydrogen-3 and strontium-90 detected in the effluent water can be attributed to ANL-E operations. The concentrations are very low and a small fraction of the DOE limits; these findings reinforce ANL-E 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 (1.08×10^9 L) is computed. These results are given in Table 4.6, along with similar data from concentrations measured in Sawmill Creek.

ANL-E wastewater is discharged into Sawmill Creek at Location 7M (Figure 1.1). The creek runs through the ANL-E 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-E wastewater outfall. Sawmill Creek was sampled upstream from the ANL-E site and downstream from the wastewater outfall to determine whether radioactivity was added to the stream by ANL-E wastewater or surface drainage. The sampling locations are shown in Figure 1.1. Below the wastewater outfall, daily samples were collected. 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 4.7 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-E operations: hydrogen-3, strontium-90, plutonium-239, and americium-241; and occasionally neptunium-237, plutonium-238, and curium-244 and/or californium-249. The percentage of individual samples containing activity attributable to ANL-E was 65% for hydrogen-3, 92% for

TABLE 4.5

Radionuclides in Effluents from the ANL-E Wastewater Treatment Plant, 1999

Activity	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
		Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	52	0.5 ± 0.7	< 0.1	1.4	-[a]	-	-
Beta	52	15 ± 5	9	21	-	-	-
Hydrogen-3	52	626 ± 3652	< 100	12780	0.0287	< 0.0046	0.5866
Strontium-90	52	0.77 ± 1.10	0.45	3.76	0.073	0.043	0.357
Cesium-137	52	< 1.0	< 1.0	< 1.0	< 0.04	< 0.04	< 0.04
Uranium-234	52	0.261 ± 0.358	0.083	0.714	0.050	0.016	0.136
Uranium-238	52	0.233 ± 0.326	0.067	0.712	0.039	0.011	0.120
Neptunium-237	52	< 0.0010	< 0.0010	0.0033	< 0.0028	< 0.0028	0.0094
Plutonium-238	52	< 0.0010	< 0.0010	0.0048	< 0.0028	< 0.0028	0.0134
Plutonium-239	52	< 0.0010	< 0.0010	0.0068	< 0.0031	< 0.0031	0.0214
Americium-241	52	< 0.0010	< 0.0010	0.0029	< 0.0033	< 0.0033	0.0097
Curium-242 and/or Californium - 252	52	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium - 249	52	< 0.0010	< 0.0010	0.0010	< 0.0034	< 0.0034	0.0034

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

strontium-90, 24% for plutonium-239, and 67% for americium-241. The concentrations of all these nuclides are low and at a small fraction of DOE limits.

At location 7M, below the ANL-E outfall, the annual average concentrations of most measured radionuclides were similar to recent annual averages. All the annual averages were well below the applicable standards. The annual total radioactive effluent discharged to the creek in ANL-E wastewater can be estimated from the average net concentrations and the volume of water carried by the creek. These totals are presented in Table 4.6. Comparison of the total quantity released, as calculated from measurements at the Outfall 001 and in Sawmill Creek, indicate

significant differences. The differences in volume between the two locations is about 10, while the concentrations differ by a factor of 2. It is speculated that the measurement of the Sawmill Creek flow has the greatest uncertainty.

TABLE 4.6

Total Radioactivity Released to Sawmill Creek, 1999

Radionuclide	Outfall (Ci)	Creek (Ci)
Hydrogen-3	0.68	4.44
Strontium-90	0.0006	0.0037
Plutonium-239	<0.0001	<0.0001
Americium-241	<0.0001	<0.0001
Total	0.68	4.44

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 and strontium-90 and by gamma-ray spectrometry. The results are presented in Table 4.8.

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.

Because Sawmill Creek empties into the Des Plaines River, data on the radioactivity in this river is important in assessing the contribution of ANL-E 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 quite 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.

TABLE 4.7

Radionuclides in Sawmill Creek Water, 1999

			Concentrations in pCi/L			Dose (mrem)		
Activity	Location[a]	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	16K	12	1.1 ± 1.0	0.3	2.2	-[b]	-	-
(Nonvolatile)	7M	49	1.2 ± 1.1	0.2	2.7	-	-	-
Beta	16K	12	7 ± 5	4	12	-	-	-
(Nonvolatile)	7M	49	12 ± 6	6	20	-	-	-
Hydrogen-3	16K	12	< 100	< 100	109	< 0.0046	< 0.0046	0.0050
	7M	49	418 ± 3608	< 100	12700	0.0192	< 0.0046	0.5829
Strontium-90	16K	12	< 0.25	< 0.25	0.32	< 0.024	< 0.024	0.031
	7M	49	0.56 ± 0.93	< 0.25	3.25	0.053	< 0.024	0.308
Cesium-137	16K	12	< 1.0	< 1.0	< 1.0	< 0.04	< 0.04	< 0.04
	7M	49	< 1.0	< 1.0	< 1.0	< 0.04	< 0.04	< 0.04
Uranium-234	16K	12	0.574 ± 0.573	0.275	0.976	0.109	0.052	0.185
	7M	49	0.450 ± 0.517	0.114	1.044	0.086	0.022	0.198
Uranium-238	16K	12	0.537 ± 0.561	0.241	1.004	0.090	0.040	0.169
	7M	49	0.401 ± 0.481	0.087	0.928	0.067	0.015	0.156
Neptunium-237	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	7M	49	< 0.0010	< 0.0010	0.0011	< 0.0028	< 0.0028	0.0032
Plutonium-238	16K	12	< 0.0010	< 0.0010	0.0019	< 0.0028	< 0.0028	0.0051
	7M	49	< 0.0010	< 0.0010	0.0019	< 0.0028	< 0.0028	0.0053
Plutonium-239	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	7M	49	< 0.0010	< 0.0010	0.0019	< 0.0031	< 0.0031	0.0059
Americium-241	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	7M	49	0.0014 ± 0.0018	< 0.0010	0.0046	0.0045	< 0.0033	0.0150
Curium-242 and/or	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Californium-252	7M	49	< 0.0010	< 0.0010	0.0011	< 0.0007	< 0.0007	0.0007
Curium-244 and/or	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
Californium-249	7M	49	< 0.0010	< 0.0010	0.0011	< 0.0034	< 0.0034	0.0037

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

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

TABLE 4.8

Radionuclides in Storm Water Outfalls, 1999
(concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
January 27	<100	0.63	<1	373
April 16	<100	0.63	<1	646
August 25	278	0.86	<1	Dry
October	Dry	Dry	Dry	Dry

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 soil. Results are given in terms of the oven-dried (110EC [230EF]) weight.

A set of sediment samples was collected on October 27, 1999, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which ANL-E 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 7M outfall are similar to those of the off-site samples collected in past years. The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, which indicates that their origin is in ANL-E 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 the dynamic nature of the sediment material in this area.

4.5. External Penetrating Radiation

Levels of external penetrating radiation at and in the vicinity of the ANL-E site were measured with aluminum oxide 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

TABLE 4.9

Radionuclides in Des Plaines River Water, 1999

			Concentrations in pCi/L			Dose (mrem)		
Activity	Location[a]	No. of Samples	Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha	A	12	0.9 ± 0.7	0.5	1.5	-[b]	-	-
(Nonvolatile)	B	24	1.1 ± 1.5	0.3	4.2	-	-	-
Beta	A	12	16 ± 13	8	25	-	-	-
(Nonvolatile)	B	24	16 ± 11	7	25	-	-	-
Hydrogen-3	A	12	< 100	< 100	107	< 0.0046	< 0.0046	0.0049
	B	24	< 100	< 100	107	< 0.0046	< 0.0046	0.0049
Strontium-90	A	12	0.27 ± 0.14	< 0.25	0.37	0.025	< 0.024	0.036
	B	24	0.28 ± 0.13	< 0.25	0.39	0.027	< 0.024	0.037
Uranium-234	A	12	0.496 ± 0.434	0.271	0.893	0.094	0.051	0.170
	B	24	0.476 ± 0.437	0.122	0.824	0.090	0.023	0.157
Uranium-238	A	12	0.405 ± 0.387	0.227	0.735	0.068	0.038	0.124
	B	24	0.396 ± 0.404	0.089	0.748	0.066	0.015	0.126
Neptunium-237	A	12	< 0.0010	< 0.0010	0.0033	< 0.0028	< 0.0028	0.0094
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
Plutonium-238	A	12	< 0.0010	< 0.0010	0.0033	< 0.0028	< 0.0028	0.0090
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
Plutonium-239	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
	B	11	< 0.0010	< 0.0010	< 0.0010	< 0.0031	< 0.0031	< 0.0031
Americium-241	A	12	< 0.0010	< 0.0010	0.0034	< 0.0033	< 0.0033	0.0110
	B	12	< 0.0010	< 0.0010	0.0046	< 0.0033	< 0.0033	0.0151
Curium-242 and/or	A	12	< 0.0010	< 0.0010	0.0013	< 0.0007	< 0.0007	0.0009
Californium-252	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or	A	12	< 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 hyphen indicates no CEDEs for alpha and beta.

TABLE 4.10

Radionuclides in Bottom Sediment, 1999[a]

Location	Concentrations (pCi/g)					Concentrations (fCi/g)		
	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241
Sawmill Creek 25 m above Outfall	8.66 ± 0.48	0.02 ± 0.02	0.50 ± 0.05	0.36 ± 0.04	0.24 ± 0.07	< 0.1	1.5 ± 0.7	0.8 ± 0.3
Sawmill Creek at Outfall	5.23 ± 0.40	0.37 ± 0.03	0.68 ± 0.06	0.55 ± 0.04	0.44 ± 0.08	47.2 ± 3.8	361.8 ± 20.5	117.5 ± 6.4
Sawmill Creek 50 m below Outfall	9.50 ± 0.49	0.10 ± 0.02	0.54 ± 0.06	0.44 ± 0.04	0.28 ± 0.07	0.4 ± 0.3	9.4 ± 1.6	3.4 ± 0.8
Sawmill Creek 100 m below Outfall	< 0.01	0.10 ± 0.02	0.49 ± 0.05	0.31 ± 0.03	0.26 ± 0.07	0.4 ± 0.3	6.1 ± 1.3	2.0 ± 0.5
Sawmill Creek at Des Plaines River	12.69 ± 0.56	0.24 ± 0.03	0.63 ± 0.06	0.58 ± 0.04	0.43 ± 0.08	1.4 ± 0.6	21.3 ± 2.5	5.7 ± 1.0

[a] All samples were collected on October 27, 1999.

(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 80 ± 4 mrem/yr and were identical to last year's off-site average of 80 ± 3 mrem/yr.[16] To compare boundary results for individual sampling periods, the standard deviation of the 19 individual off-site results is useful. This value is 8 mrem/yr; thus, individual results in the range of 80 ± 16 mrem/yr may be considered to be the average natural background with a 95% probability.

The site boundary location at 7I had dose rates consistently above the average background. This was the result of radiation from ANL-E's 317 Area in the northern half of grid 7I. Waste is packaged and temporarily stored in this area before removal for permanent disposal off site. In 1999, the dose at this perimeter fence location was 105 ± 21 mrem/yr. Approximately 300 m (960 ft) south of the fence in grid 6I, the measured dose dropped to 88 ± 11 mrem/yr, which is within the normal background range.

TABLE 4.11

Environmental Penetrating Radiation at Off-Site Locations, 1999

	Dose Rate (mrem/year) Period of Measurement				
Location	Jan. 7 – April 1	April 1 – July 6	July 6 – Oct. 6	Oct. 6 – Jan. 6	Average
Lemont	77	89	90	64	80 ± 12
Oak Brook	80	89	100	77	87 ± 10
Orland Park	76	80	64	-[a]	73 ± 9
Woodridge	90	91	76	77	84 ± 8
Willow Springs	79	70	78	65	73 ± 7
Average	80 ± 5	84 ± 8	82 ± 12	71 ± 7	80 ± 4

[a] Sample lost.

TABLE 4.12

Environmental Penetrating Radiation at ANL-E, 1999

	Dose Rate (mrem/year) Period of Measurement				
Location[a]	Jan. 7 – April 1	April 1 – July 6	July 6 – Oct. 6	Oct. 6 – Jan. 6	Average
14G - Boundary	101	98	94	73	92 ± 12
14I - Boundary	89	54	79	78	75 ± 15
14L - Boundary	77	65	94	72	77 ± 12
6I - 200 m N of Quarry Road	98	89	93	73	88 ± 11
7I - Center, Waste Storage Area Facility 317	3,614	2,467	3,051	2,676	2,952 ± 493
7I - Boundary	117	79	126	96	105 ± 21
8H - Boundary	96	97	85	70	87 ± 12
8H - 65 m S of Building 316	89	71	97	69	82 ± 13
8H - 200 m NW of Waste Storage Area (Heliport)	89	81	111	75	89 ± 15
8H - Boundary, Center, St. Patrick Cemetery	85	86	75	-[b]	82 ± 7
9H - 50 m SE of CP-5	129	232	540	121	256 ± 192
9 H/I - 50 m E of Building 331	176	68	720	504	367 ± 294
9/10 I - E of D306	75	75	77	96	81 ± 10
9/10 I - 65 m NE of Building 350, 230 m NE of Building 316	66	78	81	73	75 ± 6
9/10 IF - Boundary	106	61	103	81	88 ± 21
9J - 50 m W of 398A Area	772	699	859	1,625	989 ± 421
10/11 K - Facilities	89	186	84	66	106 ± 53

[a] See Figure 1.1

[b] This sample was lost.

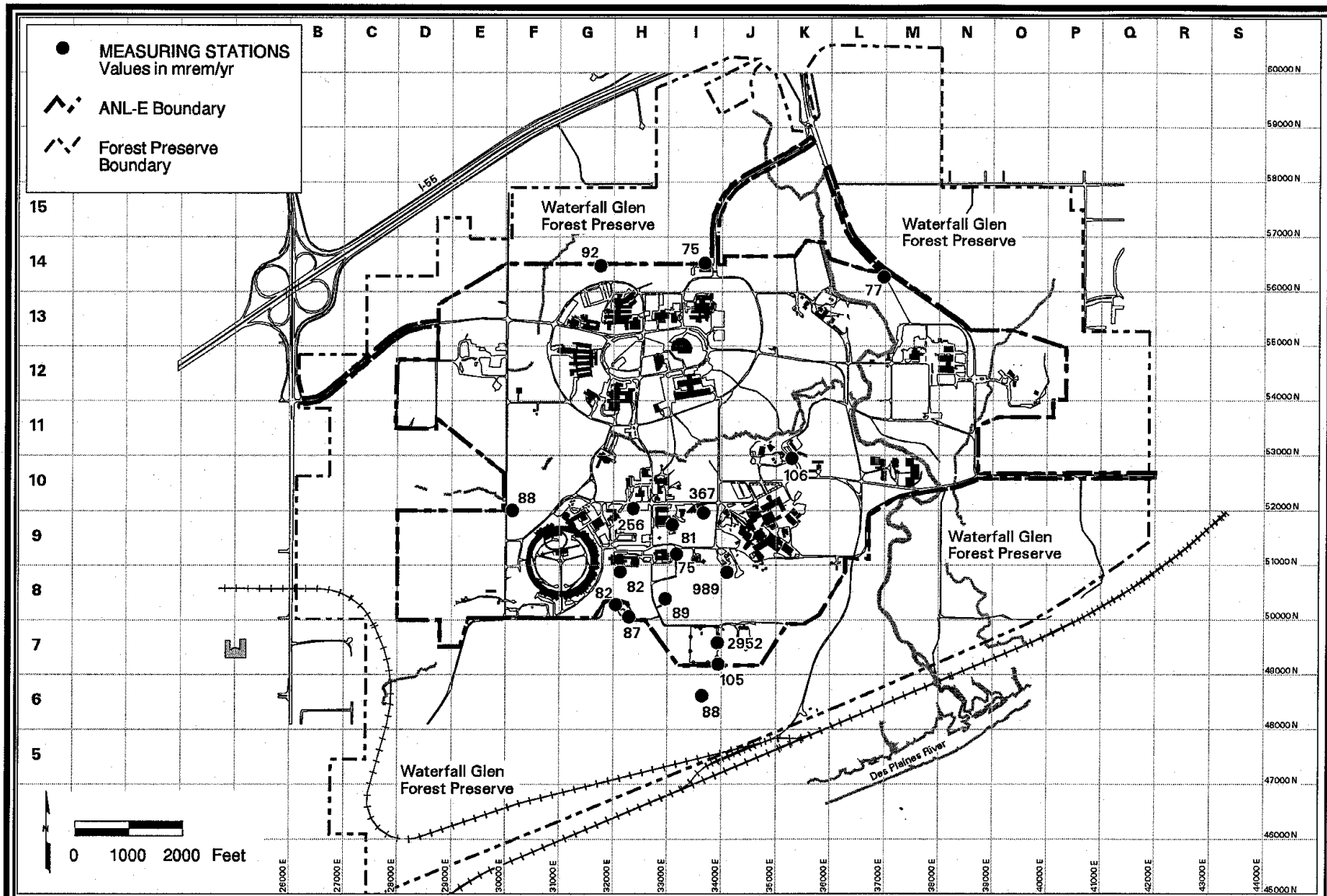

Figure 4.4 Penetrating Radiation Measurements at the ANL-E Site, 1999

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 CP-5 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 256 mrem/yr in 1999. The cleanup of the yard was completed in 1994; the residual dose is from sources in the building, which is currently undergoing D&D, and the use of the yard to stage radioactive waste from the D&D, pending shipment off site.

The 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. Current plans call for evacuating the 317 Area so that it can be remediated. Although some waste is repacked in Building 306 (Location 9/10 I), the dose from these operations could not be distinguished from 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 large number of radioactive waste shipments were made during the second half of 1999, as reflected by the elevated dose rates. Much of this waste came from the D&D of the CP-5 reactor, as indicated by the elevated doses in the second and third quarters when waste was stored in the CP-5 yard pending transfer to the Building 331 yard for shipment. The second quarter result of 186 mrem/yr at location 10/11 K appears to be an outlier.

4.6. 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.

4.6.1. Airborne Pathway

Guidance issued by DOE[11] stipulates that DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,[17] which requires the use of the EPA's CAP-88 code[8] to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 1999 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 1999, 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 six release points. The wind speed and direction data shown in Figure 1.3 were used for these calculations. In the past, the wind stability classes had been determined by the temperature differences between the 10-m (33-ft) and 60-m (197-ft) levels. To improve the determination of stability levels, the categories were obtained from daytime measurements of solar radiation and nighttime measurements of the standard deviation of the horizontal wind speed. Doses were calculated for an area extending out to 80 km (50 mi) from ANL-E. 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 4.13 and 4.14), Building 205 (Tables 4.15 and 4.16), Building 212 (Tables 4.17 and 4.18), Building 350 (Tables 4.19 and 4.20), Building 375 (Tables 4.21 and 4.22), and Building 411 (Tables 4.23 and 4.24). The doses given in these tables are the committed whole body effective dose equivalents.

A significant D&D program was completed 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, was completed in 1995. This has resulted in a decrease of radon-220 emissions: 3,000 Ci in 1992; 2,023 Ci in 1993; 1,750 Ci in 1994; 1,033 Ci in 1995; 388 Ci in 1996; 286.6 Ci in 1997; 239.2 Ci in 1998; and 193.0 Ci in 1999. The present radon-220 emissions will be reduced 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. The highest perimeter dose was in the southwest direction with a maximum dose of 0.063 mrem/yr (location 7H in Figure 1.1). The major component of this dose is air immersion of carbon-11 (0.032 mrem/yr).

The full-time resident who would receive the largest annual dose (0.015 mrem/yr) is located approximately 0.8 km (0.5 mi) north-northwest of the site boundary. The major contributor to the whole body dose is the inhalation dose from lead-212 (0.009 mrem/yr). If radon-220 plus daughters were excluded from the calculation, as required by NESHAP,[17] the maximally exposed resident would receive a dose of 0.0043 mrem/yr, primarily carbon-11 from the IPNS facility (Building 375).

TABLE 4.13

Radiological Airborne Releases from Building 200, 1999

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	500	4.1×10^{-2}	1,000	1.2×10^{-2}
NNE	600	3.3×10^{-2}	1,100	1.0×10^{-2}
NE	750	1.9×10^{-2}	2,600	2.0×10^{-3}
ENE	1,700	4.0×10^{-3}	3,100	1.4×10^{-3}
E	2,400	2.9×10^{-3}	3,500	1.5×10^{-3}
ESE	2,200	2.4×10^{-3}	3,600	1.0×10^{-3}
SE	2,100	2.0×10^{-3}	4,000	6.8×10^{-4}
SSE	2,000	2.9×10^{-3}	4,000	9.1×10^{-4}
S	1,500	2.4×10^{-3}	4,000	5.0×10^{-4}
SSW	1,000	1.3×10^{-2}	2,500	2.7×10^{-3}
SW	800	2.7×10^{-2}	2,200	5.6×10^{-3}
WSW	1,100	8.5×10^{-3}	1,500	4.9×10^{-3}
W	750	1.5×10^{-2}	1,500	5.0×10^{-3}
WNW	800	9.8×10^{-3}	1,300	4.6×10^{-3}
NW	600	1.5×10^{-2}	1,100	5.6×10^{-3}
NNW	600	2.1×10^{-2}	800	1.2×10^{-2}

[a] Source term: radon-220 = 193.0 Ci (plus daughters).

TABLE 4.14

Maximum Perimeter and Individual Doses
from Building 200 Air Emissions, 1999
(dose in mrem/yr)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	5.9×10^{-14}	2.2×10^{-14}
Inhalation	4.1×10^{-2}	1.2×10^{-2}
Air immersion	2.8×10^{-4}	7.5×10^{-5}
Ground surface	2.0×10^{-5}	7.4×10^{-6}
Total	4.1×10^{-2}	1.2×10^{-2}
Radionuclide		
Thallium-208	2.5×10^{-4}	6.3×10^{-5}
Bismuth-212	4.9×10^{-3}	1.7×10^{-3}
Lead-212	2.4×10^{-2}	8.7×10^{-3}
Radon-220	1.2×10^{-2}	1.7×10^{-3}
Total	4.1×10^{-2}	1.2×10^{-2}

TABLE 4.15

Radiological Airborne Releases from Building 205, 1999

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	850	3.3×10^{-5}	1,300	1.6×10^{-5}
NNE	1,000	2.6×10^{-5}	2,100	7.5×10^{-6}
NE	1,200	1.7×10^{-5}	2,700	4.5×10^{-6}
ENE	2,400	5.2×10^{-6}	3,000	3.6×10^{-6}
E	2,200	7.9×10^{-6}	2,400	3.9×10^{-6}
ESE	2,000	6.5×10^{-6}	3,500	2.6×10^{-6}
SE	1,800	6.1×10^{-6}	3,900	1.7×10^{-6}
SSE	1,500	1.1×10^{-5}	4,000	2.2×10^{-6}
S	1,300	7.3×10^{-6}	3,900	1.3×10^{-6}
SSW	1,100	2.6×10^{-5}	2,400	7.1×10^{-6}
SW	900	5.9×10^{-5}	2,100	1.8×10^{-5}
WSW	1,100	1.9×10^{-5}	1,800	8.5×10^{-6}
W	1,300	1.3×10^{-5}	1,800	9.5×10^{-6}
WNW	1,100	1.5×10^{-5}	1,700	7.6×10^{-6}
NW	1,100	1.4×10^{-5}	1,500	8.4×10^{-6}
NNW	900	2.2×10^{-5}	1,500	9.3×10^{-6}

[a] Source term: hydrogen-3 = 0.53 Ci.

TABLE 4.16

Maximum Perimeter and Individual Doses from Building 205 Air Emissions, 1999 (dose in mrem/yr)

Pathway	Perimeter (900 m SW)	Individual (2,100 m SW)
Ingestion	1.4×10^{-5}	4.4×10^{-6}
Inhalation	4.5×10^{-5}	1.4×10^{-5}
Air immersion	-[a]	-
Ground surface	-	-
Total	5.9×10^{-5}	1.8×10^{-5}
Radionuclide		
Hydrogen-3	5.9×10^{-5}	1.8×10^{-5}

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

TABLE 4.17

Radiological Airborne Releases from Building 212, 1999

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	800	5.7×10^{-3}	2,000	1.4×10^{-3}
NNE	1,000	4.2×10^{-3}	2,500	9.9×10^{-4}
NE	1,300	2.5×10^{-3}	2,000	1.3×10^{-3}
ENE	1,500	1.9×10^{-3}	2,500	8.6×10^{-4}
E	1,600	2.2×10^{-3}	2,800	9.3×10^{-4}
ESE	1,200	2.6×10^{-3}	2,500	7.9×10^{-4}
SE	1,400	1.5×10^{-3}	3,500	3.6×10^{-4}
SSE	1,400	2.1×10^{-3}	4,500	3.4×10^{-4}
S	1,500	9.4×10^{-4}	5,000	1.6×10^{-4}
SSW	1,600	2.3×10^{-3}	5,000	4.1×10^{-4}
SW	1,400	4.2×10^{-3}	2,400	2.0×10^{-3}
WSW	1,300	2.4×10^{-3}	2,300	9.8×10^{-4}
W	1,700	1.6×10^{-3}	2,200	1.1×10^{-3}
WNW	1,500	1.4×10^{-3}	2,000	9.3×10^{-4}
NW	1,300	1.6×10^{-3}	2,000	8.6×10^{-4}
NNW	1,000	2.9×10^{-3}	2,000	9.9×10^{-4}

[a] Source terms: hydrogen-3 (HT) = 131.4 Ci
hydrogen-3 (HTO) = 10.9 Ci
krypton-85 = 1.35 Ci
radon-220 = 0.14 Ci.

TABLE 4.18

Maximum Perimeter and Individual Doses
from Building 212 Air Emissions, 1999
(dose in mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,400 m SW)
Ingestion	1.3×10^{-3}	4.8×10^{-4}
Inhalation	4.3×10^{-3}	1.5×10^{-3}
Air immersion	4.5×10^{-7}	1.6×10^{-7}
Ground surface	3.8×10^{-8}	1.0×10^{-8}
Total	5.7×10^{-3}	2.0×10^{-3}
Radionuclide		
Hydrogen-3	5.7×10^{-3}	2.0×10^{-3}
Krypton-85	6.7×10^{-7}	2.4×10^{-7}
Radon-220	2.0×10^{-6}	1.6×10^{-8}
Total	5.7×10^{-3}	2.0×10^{-3}

TABLE 4.19

Radiological Airborne Releases from Building 350, 1999

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,700	4.7×10^{-4}	2,200	3.3×10^{-4}
NNE	1,800	4.6×10^{-4}	3,200	2.0×10^{-4}
NE	2,200	3.0×10^{-4}	3,100	1.9×10^{-4}
ENE	2,000	3.4×10^{-4}	3,100	1.8×10^{-4}
E	1,700	5.3×10^{-4}	2,500	2.4×10^{-4}
ESE	900	9.5×10^{-4}	3,000	1.8×10^{-4}
SE	900	6.5×10^{-4}	3,000	1.5×10^{-4}
SSE	700	1.3×10^{-3}	2,700	2.1×10^{-4}
S	600	4.7×10^{-4}	2,700	1.0×10^{-4}
SSW	400	1.7×10^{-3}	2,500	3.3×10^{-4}
SW	600	2.0×10^{-3}	2,700	4.0×10^{-4}
WSW	800	9.6×10^{-4}	2,100	3.0×10^{-4}
W	900	5.8×10^{-4}	2,200	2.5×10^{-4}
WNW	1,000	4.1×10^{-4}	2,100	1.9×10^{-4}
NW	1,900	2.1×10^{-4}	2,400	1.6×10^{-4}
NNW	1,900	2.9×10^{-4}	2,200	2.4×10^{-4}

[a] Source terms:
uranium-234 = 3.2×10^{-5} Ci
uranium-238 = 3.2×10^{-5} Ci
plutonium-238 = 1.5×10^{-9} Ci
plutonium-239 = 5.8×10^{-9} Ci
plutonium-240 = 8.5×10^{-9} Ci
plutonium-241 = 2.2×10^{-7} Ci
plutonium-242 = 1.8×10^{-9} Ci
plutonium-244 = 3.3×10^{-13} Ci.

TABLE 4.20

Maximum Perimeter and Individual Doses
from Building 350 Air Emissions, 1999
(dose in mrem/yr)

Pathway	Perimeter (600 m SW)	Individual (2,700 m SW)
Ingestion	1.5×10^{-5}	3.1×10^{-6}
Inhalation	2.0×10^{-3}	4.0×10^{-4}
Air immersion	1.2×10^{-12}	2.5×10^{-13}
Ground surface	2.8×10^{-7}	5.6×10^{-8}
Total	2.0×10^{-3}	4.0×10^{-4}
Radionuclide		
Uranium-234	1.1×10^{-3}	2.1×10^{-4}
Uranium-238	9.5×10^{-4}	1.9×10^{-4}
Plutonium-238	1.2×10^{-7}	2.4×10^{-8}
Plutonium-239	5.0×10^{-7}	9.9×10^{-8}
Plutonium-240	7.4×10^{-7}	1.5×10^{-7}
Plutonium-241	2.9×10^{-7}	5.8×10^{-8}
Plutonium-242	1.5×10^{-7}	2.9×10^{-8}
Plutonium-244	2.7×10^{-11}	5.3×10^{-12}
Total	2.0×10^{-3}	4.0×10^{-4}

TABLE 4.21

Radiological Airborne Releases from Building 375 (IPNS), 1999

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,600	5.8×10^{-3}	3,200	1.6×10^{-3}
NNE	1,700	6.1×10^{-3}	3,100	1.8×10^{-3}
NE	1,700	5.4×10^{-3}	2,700	2.1×10^{-3}
ENE	1,500	5.7×10^{-3}	2,500	2.2×10^{-3}
E	600	3.3×10^{-2}	2,500	3.1×10^{-3}
ESE	600	2.6×10^{-2}	2,500	2.2×10^{-3}
SE	600	1.8×10^{-2}	2,500	1.6×10^{-3}
SSE	600	2.6×10^{-2}	3,000	1.5×10^{-3}
S	800	7.5×10^{-3}	3,000	7.7×10^{-4}
SSW	800	2.1×10^{-2}	3,500	1.5×10^{-3}
SW	800	2.8×10^{-2}	4,000	1.4×10^{-3}
WSW	1,500	5.6×10^{-3}	2,700	1.9×10^{-3}
W	2,200	3.2×10^{-3}	2,700	2.0×10^{-3}
WNW	1,500	4.0×10^{-3}	2,600	1.5×10^{-3}
NW	2,200	1.8×10^{-3}	2,500	1.4×10^{-3}
NNW	1,800	3.2×10^{-3}	2,200	2.2×10^{-3}

[a] Source terms: carbon-11=118.1 Ci
argon-41 =1.6 Ci.

TABLE 4.22

Maximum Perimeter and Individual Doses from Building 375 (IPNS) Air Emissions, 1999 (dose in mrem/yr)

Pathway	Perimeter (600 m E)	Individual (2,400 m E)
Ingestion	-[a]	-
Inhalation	1.4×10^{-3}	1.4×10^{-4}
Air immersion	3.0×10^{-2}	2.8×10^{-3}
Ground surface	1.2×10^{-3}	1.3×10^{-4}
Total	3.3×10^{-2}	3.1×10^{-3}
Radionuclide		
Carbon-11	3.2×10^{-2}	3.1×10^{-3}
Argon-41	5.6×10^{-4}	6.3×10^{-5}
Total	3.3×10^{-2}	3.1×10^{-3}

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

TABLE 4.23

Radiological Airborne Releases from Building 411/415 (APS), 1999

Direction	Distance to Perimeter (m)	Dose[a] (mrem/yr)	Distance to Nearest Resident (m)	Dose[a] (mrem/yr)
N	1,500	1.6×10^{-4}	2,000	8.5×10^{-5}
NNE	1,600	1.5×10^{-4}	2,100	8.4×10^{-5}
NE	2,200	6.7×10^{-5}	3,100	3.1×10^{-5}
ENE	2,500	4.5×10^{-5}	3,300	2.4×10^{-5}
E	1,600	1.6×10^{-4}	3,400	3.1×10^{-5}
ESE	1,500	1.3×10^{-4}	3,500	2.2×10^{-5}
SE	400	1.2×10^{-3}	3,000	2.0×10^{-5}
SSE	400	1.6×10^{-3}	3,000	2.8×10^{-5}
S	350	8.8×10^{-4}	2,500	2.2×10^{-5}
SSW	400	2.1×10^{-3}	2,800	4.2×10^{-5}
SW	550	1.6×10^{-3}	3,000	4.3×10^{-5}
WSW	800	4.7×10^{-4}	1,400	1.6×10^{-4}
W	800	4.7×10^{-4}	1,500	1.4×10^{-4}
WNW	500	7.3×10^{-4}	1,400	1.1×10^{-4}
NW	350	1.2×10^{-3}	1,600	7.5×10^{-5}
NNW	1,500	1.0×10^{-4}	2,000	5.6×10^{-5}

[a] Source terms: carbon-11 = 0.07 Ci (estimated)
nitrogen-13 = 3.22 Ci (estimated)
oxygen-15 = 0.35 Ci (estimated).

TABLE 4.24

Maximum Perimeter and Individual Doses
from Building 411/415 (APS) Air Emissions, 1999
(dose in mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	-[a]	-
Inhalation	6.1×10^{-5}	4.6×10^{-6}
Air immersion	2.0×10^{-3}	1.5×10^{-4}
Ground surface	3.6×10^{-5}	3.1×10^{-6}
Total	2.1×10^{-3}	1.6×10^{-4}
Radionuclide		
Carbon-11	4.6×10^{-5}	4.0×10^{-6}
Nitrogen-13	1.9×10^{-3}	1.5×10^{-4}
Oxygen-15	1.3×10^{-4}	4.8×10^{-6}
Total	2.1×10^{-3}	1.6×10^{-4}

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

The individual doses to the maximally exposed member of the public and the maximum fence line dose are shown in Figure 4.5. The decreases in individual and population doses since 1988 are due in part to the decrease of radon-220 emissions as a result of the cleanup of the Building 200 M-Wing hot cells. The decrease from 1998 to 1999 is principally due to reduced emissions from IPNS because of lower operating time.

The population data in Table 1.1 were used to calculate the cumulative population dose from gaseous radioactive effluents from ANL-E operations. The results are given in Table 4.25, 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.[18] 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-E operations since 1987 is shown in Figure 4.6.

TABLE 4.25

Population Dose within 80 km, 1999

Radionuclide	Man-rem
Hydrogen-3	0.24
Carbon-11	0.15
Nitrogen-13	<0.01
Oxygen-15	<0.01
Argon-41	<0.01
Krypton-85	<0.01
Thallium-208	<0.01
Lead-212	0.44
Bismuth-212	0.04
Radon-220	<0.01
Uranium-234	0.05
Uranium-238	0.04
Plutonium-238	<0.01
Plutonium-239	<0.01
Plutonium-240	<0.01
Plutonium-241	<0.01
Plutonium-242	<0.01
Plutonium-244	<0.01
Total	0.97
Natural	2.5×10^6

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.[11] 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.[19] This annual intake is then multiplied by the CEDE for the appropriate lung retention class.[11] Because the CEDE factors are in units of rem/µCi, this calculation gives the 50-year CEDE. Table 4.26 lists the applicable CEDE factors.

The calculated doses in Tables 4.2 and 4.3 were derived by using this procedure. Because they are all essentially at perimeter locations, these doses represent the fence-line values for those radionuclides measured. In most cases, these doses also 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 factors for such measurements.

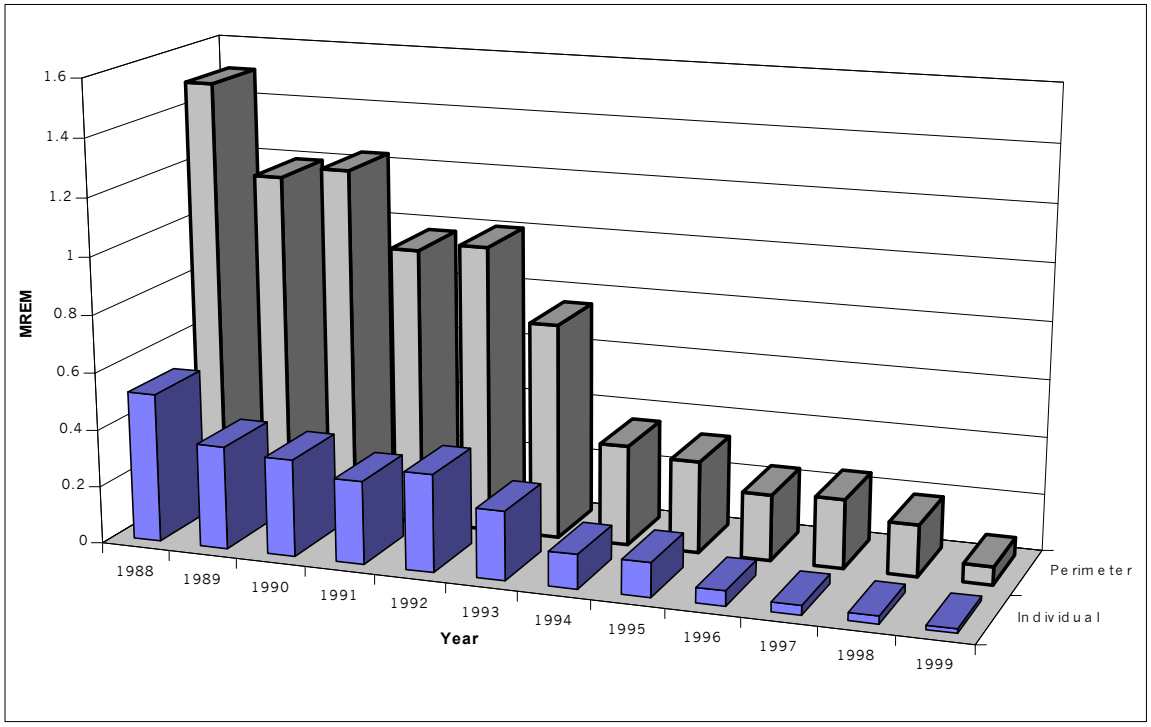

Figure 4.5 Individual and Perimeter Doses from Airborne Radioactive Emissions

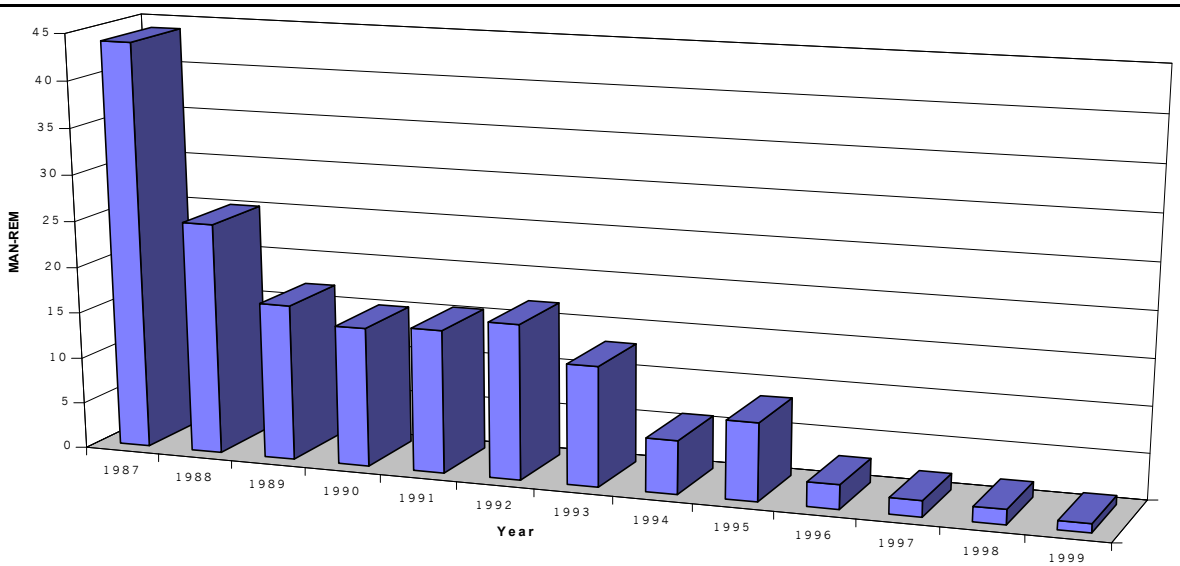

Figure 4.6 Population Dose from Airborne Radioactive Emissions

4.6.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5,[11] 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 factor for ingestion (Table 4.26) 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.

TABLE 4.26

50-Year Committed Effective Dose Equivalent (CEDE) 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	-	1,100
Uranium-234	0.26	130
Uranium-235	0.25	120
Uranium-238	0.23	120
Neptunium-237	3.90	-
Plutonium-238	3.80	-
Plutonium-239	4.30	330
Americium-241	4.50	-
Curium-242	0.11	-
Curium-244	2.30	-
Californium-249	4.60	-
Californium-252	0.94	-

[a] A hyphen indicates value not required.

The only significant location where radionuclides attributable to ANL-E 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-E 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) are given in Table 4.27. The dose rates were all well below the standards for the general population. It should be emphasized that Sawmill Creek is not used for drinking, swimming, or boating. Inspection of the area shows that there are fish in the stream; however, they do not constitute a significant source of food for any individual. Figure 4.7 is a plot of the estimated dose an individual would receive if ingesting Sawmill Creek water.

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

TABLE 4.27

Radionuclide Concentrations and Dose Estimates for Sawmill Creek Water, 1999

Radionuclide	Total Released (Ci)	Net Avg. Concentration (pCi/L)	Dose (mrem)
Hydrogen-3	4.44	370	0.0170
Strontium-90	0.0037	0.31	0.0294
Plutonium-239	0.000001	0.0001	0.00003
Americium-241	0.000005	0.0004	0.00013
Total	4.44		0.0466

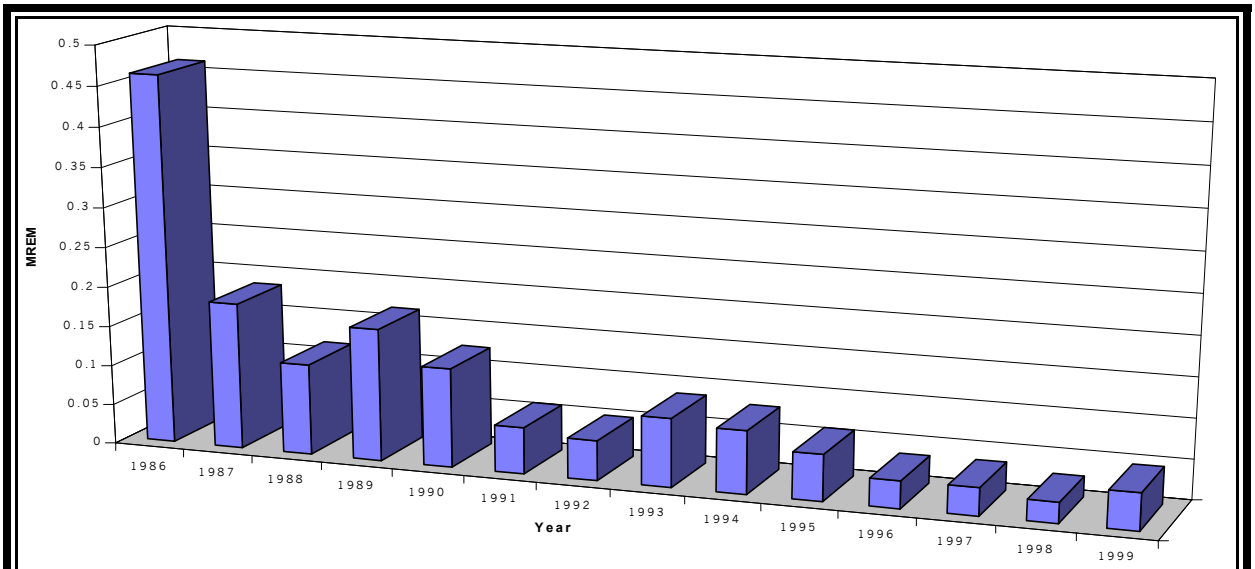

Figure 4.7 Comparison of Dose Estimate from Ingestion of Sawmill Creek Water

radionuclides more commonly found in creek water; this method of averaging, however, probably overestimates the true concentration. Annual doses range from 3×10^{-3} to 6×10^{-5} mrem/yr for these radionuclides.

DOE Order 5400.5[11] 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-E 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). A dose can be estimated by using the annual average concentrations of the radionuclides listed in Table 4.7. The sum of the exposure from these radionuclides is estimated to be about 0.01 rad/yr, which is well within the DOE standard. This value, therefore, demonstrates compliance with that portion of the order.

The EPA has established drinking water standards on the basis of a maximum dose of 4 mrem/yr for man-made beta particle and photon-emitting radio nuclides.[20] The EPA standard is 2×10^4 pCi/L for hydrogen-3 and 8 pCi/L for strontium-90. The net concentrations in Table 4.27 correspond to 1.8% (hydrogen-3) and 3.9% (strontium-90) of the EPA standards. No specific EPA standards exist for the transuranic nuclides.

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-E is about 25 m^3/s (900 ft^3/s). Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.27, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.0005 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} man-rem.

4.6.3. External Direct Radiation Pathway

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

At Location 7I, the fence-line dose from ANL-E was 105 ± 21 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 88 ± 11 rem/yr, slightly higher than the off-site average (80 ± 4 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 was 0.001 mrem/yr, if the energy of the radiation were that of a 0.66-MeV cesium-137 gamma-ray, and approximately 0.003 mrem/yr, if the energy were 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-E 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 0.003 mrem/yr at the 317 Area fence (location 7I) from ANL-E operations.

4.6.4. Dose Summary

The total effective dose equivalent received by off-site residents during 1999 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 0.015 mrem/yr to individuals living north of the site if they were outdoors at that location during the entire year. The total annual population dose to the entire area within an 80-km (50-mi) radius was 0.97 man-rem. The dose pathways are presented in Table 4.28 and compared with the applicable standards.

To receive the maximum public dose, an individual would need to live north of the site at the point of maximum air and direct radiation exposure and use only water from Sawmill Creek below the ANL-E wastewater outfall. This is a very conservative and unlikely situation. To put the maximum individual dose of 0.076 mrem/yr attributable to ANL-E operations into perspective, comparisons can be made with annual average doses received by the public from natural or accepted sources of radiation. These values are listed in Table 4.29. The magnitude of the doses received from ANL-E operations is insignificant compared with these sources. Therefore, the monitoring program results establish that the radioactive emissions from ANL-E are very low and do not endanger the health or safety of those living in the vicinity of the site.

TABLE 4.28

Summary of the Estimated Dose to the Public, 1999
(mrem/yr)

Pathway	ANL-E Estimate	Applicable Standard
Air (less radon)	0.0043	10 (EPA)
Air total	0.0154	100 (DOE)
Water	0.046	100 (DOE)
Direct radiation	0.010	100 (DOE)
Maximum public	0.076	100 (DOE)

TABLE 4.29

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	
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.[18]

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

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The nonradiological monitoring program 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-E is extremely small, except for the boiler house, which is equipped with dedicated monitoring equipment for sulfur dioxide and opacity. One exceedance for opacity was noted during 1999 over a period of 1,600 hours of coal-burning operation of Boiler No. 5, the coal-burning boiler. Chapter 3 provides a detailed discussion of the environmental monitoring program.

Surface water samples for nonradiological chemical analyses are collected from NPDES-permitted outfalls and Sawmill Creek.[21] 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.[22]

5.1. National Pollutant Discharge Elimination System Monitoring Results

5.1.1. Influent Monitoring

Since 1989, analyses of the laboratory wastewater influent have shown the presence of a variety of VOCs with variable concentrations. Although the practice is not authorized, it is suspected that limited quantities of VOCs are disposed of in the laboratory drain through laboratory sinks located throughout the site. In addition, VOCs are known to be discharged into the laboratory sewer from the 317/319 Lift Station, which pumps contaminated groundwater generated by ANL-E's RCRA corrective actions. The results of the analysis of laboratory wastewater influent are shown in Table 5.1.

The 1999 results for laboratory influent wastewater are quite similar to those for 1997 and 1998. Table 5.1 gives the 1999 results for the most common compounds detected. Bromoform, bromodichloromethane, chloroform, and dibromochloromethane are halomethanes that are produced

TABLE 5.1

Laboratory Influent Wastewater, 1999
(concentrations in µg/L)

Month	Acetone	Chloroform	Bromodi-chloroethane	Dibromo-chloromethane	Bromoform
January	168	3	2	1	<1
February	26	21	12	4	<1
March	3	5	3	1	<1
April	61	7	1	1	<1
May	<1	17	4	2	4
June	14	3	2	3	1
July	29	7	2	5	8
August	18	7	2	3	1
September	8	1	2	9	32
October	8	3	3	8	24
November	2	3	4	6	5
December	16	4	2	2	<1

as the result of contact of the chlorinated water supply with organic chemicals. Research activity probably accounts for the presence of other volatiles.

Historically, the more persistent VOCs were consistently noted but at lower ranges of concentration. Acetone was detected in 11 samples and levels ranged up to 168 µg/L, which is higher than the 1998 maximum value of 76 µg/L, but the yearly average was lower than the 1998 average (Figure 5.1). Infrequent trace levels of other chemicals, that is, acetonitrile, 2-butanone, carbon tetrachloride, methylene chloride, tetrahydrofuran, 1,1-dichloroethane, cis-1,2-dichloromethene, and 1,1,1-trichloroethane, were also noted.

Figures 5.1 and 5.2 present comparisons of the 1992 through 1999 laboratory influent wastewater results for the two more persistent VOCs. The persistent 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-E. ANL-E 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.

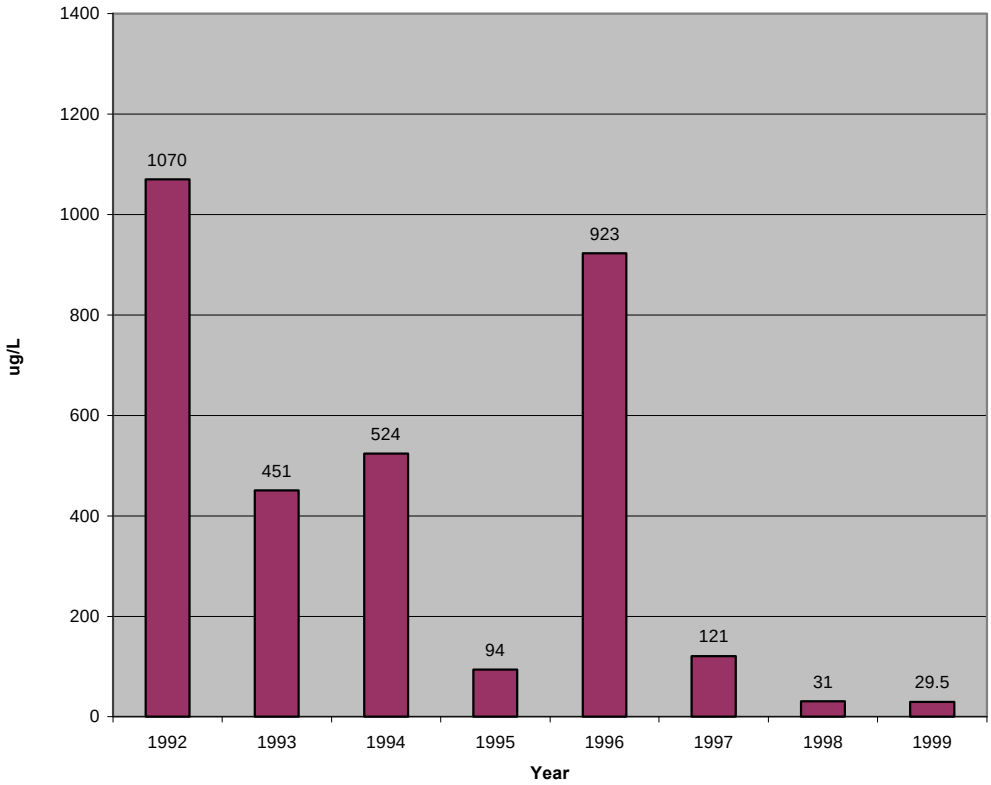


Figure 5.1 Average Acetone Levels in Laboratory Influent Wastewater, 1992 to 1999

5.1.2. Effluent Monitoring

Effluent samples are collected from ANL-E 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.[23]

A small amount of process wastewater, primarily cooling tower blowdown and cooling water, is discharged directly to a number of 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.

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,

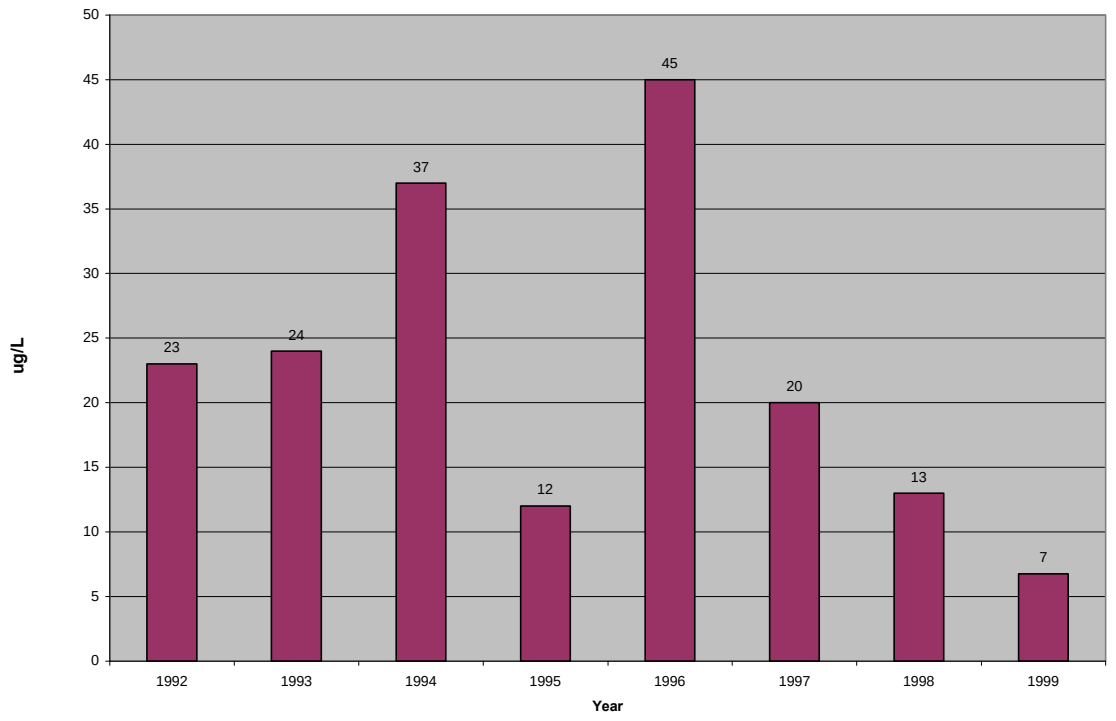


Figure 5.2 Average Chloroform Levels in Laboratory Influent Wastewater, 1992 to 1999

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.

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."[23] Six metal analyses were performed by using flame atomic absorption spectroscopy. Mercury was

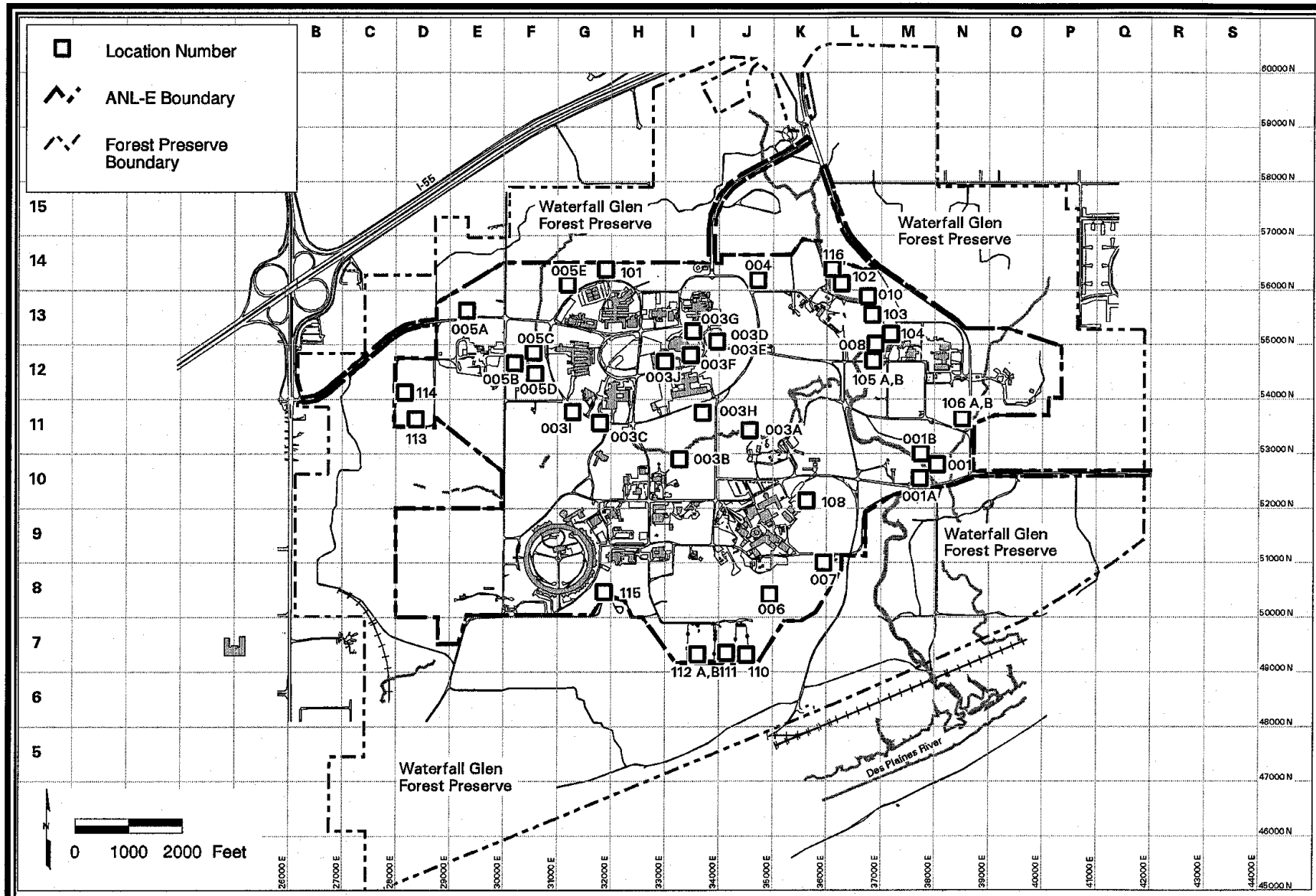


Figure 5.3 NPDES Outfall Locations

determined by cold vapor atomic absorption spectroscopy. Hexavalent chromium determination and chemical oxygen demand (COD) were performed by using a colorimetric technique. Five-day 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. Ammonia nitrogen was determined by distillation, followed by an ion-selective electrode finish. Five 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 flame atomic absorption spectroscopy. Cyanide and phenol were determined by distillation, followed by a spectrophotometric finish.

NPDES Outfall 001 is sampled and analyzed annually for acute aquatic toxicity parameters. NPDES Outfalls 003H, 003I, 003J, 004, 006, and 115 are tested in July and August for aquatic toxicity. An off-site contractor laboratory performs both the sample collection and analyses. The testing is performed by diluting a series of ANL-E 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 1999, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits, as compared with 1991 through 1998, when rates ranged from 96 to 99%. 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. Outfalls

Outfall 001A. This outfall consists of treated sanitary wastewater and various wastewater streams from the boiler house area, including coal pile storm water runoff. 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. All samples collected and analyzed for these parameters during 1999 were within the permit limits.

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 that may discharge to the sanitary sewage system. No limits were exceeded during 1999.

Outfall 001B. This outfall consists of processed wastewater from the laboratory wastewater system. The permit requires that weekly samples be collected and analyzed for BOD_5, TSS, mercury, pH, and COD.

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 limit for TSS is 24 mg/L; the 30-day average is 12 mg/L. The TSS mass loading limits are 62 and 31 kg/day (136 and 68 lb/day), respectively. No exceedances of the TSS or BOD_5 loading and concentration limits were noted in 1999.

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 1999
(concentrations in mg/L)

Constituent	Minimum	Average	Average Limit	Maximum	Maximum Limit
Chromium	-[a]	<0.02	1.00	<0.02	2.00
Copper	0.011	0.025	0.50	0.052	1.00
Iron	<0.025	0.123	2.00	0.345	4.00
Lead	-	<0.10	0.20	<0.10	0.40
Manganese	<0.015	<0.020	1.00	0.059	2.00
Zinc	0.054	0.125	1.00	0.275	2.00
Oil and grease	-	<5.0	15.0	<5.0	30.0

[a] A hyphen indicates no minimum values.

The daily maximum concentration limit for mercury is 6 µg/L; the 30-day average is 3 µg/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 1999.

No concentration limits have been established for COD. The once-per-week grab samples give a rough indication of the organic and inorganic contents of this stream. The values obtained in 1999 ranged from less than 10 to 19 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 22, 1999, and December 7, 1999, 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-E treated drinking water. The samples contained some VOCs at very low levels. The majority of compounds detected were halomethanes. Table 5.3 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 5.4 gives the results, limits, and number of exceedances.

TABLE 5.3

Outfall 001B Effluent Priority Pollutant Monitoring Results, 1999
(concentrations in µg/L)

Compound	Concentration in June Sample	Concentration in December Sample
Bromodichloromethane	1	1
Bromoform	5	<1
Chloroform	3	2
Dibromochloromethane	2	1
Methylene chloride	1	<1

TABLE 5.4

Outfall 001 Monitoring Results and Effluent Limits, 1999
(concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Limit		Exceedances
Copper	0.011	0.021	0.039	0.051		0
TDS	469	713	1,346	1,000		4
Ammonia nitrogen	<0.1	0.9	2.0	10.0	(November–March)	0
				3.0	(April–October)	

Elevated TDS levels during the 1999 heating season are believed to be related to the combination of reduced flows, with increases in TDS concentrations from discharges from boiler blowdown, road salt, and cooling tower blowdown. 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 1996 through 1999. Elevated TDS levels prior to 1997 are attributed to high TDS levels (800 ppm) in ANL-E'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 ppm), became ANL-E's domestic source water. Figure 5.5 shows the substantial decrease in average TDS levels at Outfall 001 since the introduction of Lake Michigan water. Figure 5.5 shows weekly TDS levels at Outfall 001 and the seasonal variation associated with heating and road salt usage. Four exceedances of the TDS limit were noted during 1999, and these were primarily due to road salt associated with snowmelt (see Figure 5.5).

Copper levels have decreased since 1997. The changeover in the domestic water supply from groundwater to Lake Michigan water during 1997 appears to have played a role in reducing the amount of copper in the wastewater. Lake Michigan water causes less corrosion of domestic water distribution copper piping than the previously used groundwater source. The addition of this water source, combined with the proper balance of chemical treatment additives, has reduced copper concentrations in the discharge to below permit limits. Figure 5.6 shows the 1996 through 1999 monthly average copper levels at Outfall 001. No copper exceedances occurred during 1999.

The upgrade of the sanitary WTP, completed in 1996, has enhanced the treatment of ammonia nitrogen. Figure 5.7 shows a decrease in the monthly average ammonia nitrogen levels prior to and after the sanitary WTP upgrade. Improved mechanical operation of the trickling filters results in a more even dispersion of the wastewater. Also, dome covers on the trickling filters allow the trickling filters to hold a constant temperature and aerobic conditions by providing a constant flow of air across the filter area. No ammonia nitrogen exceedances occurred during 1999.

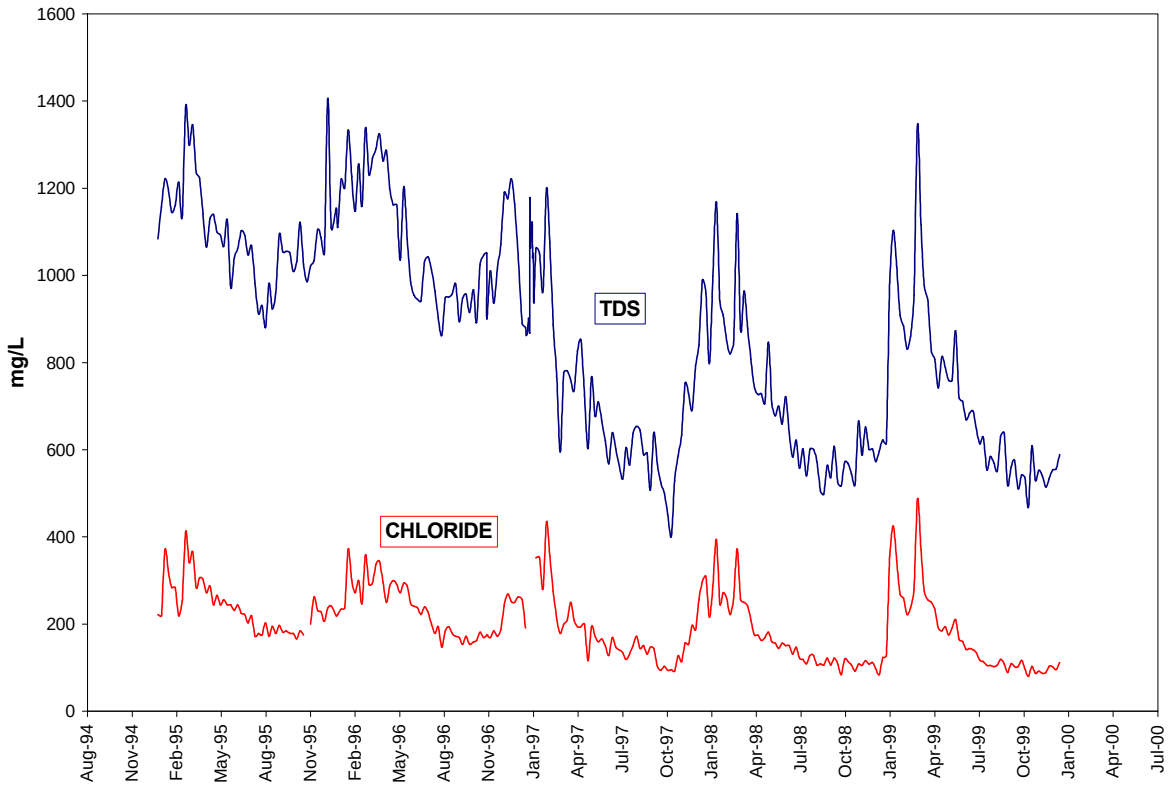


Figure 5.4 Total Dissolved Solids and Chloride in Outfall 001 Water, 1996 to 1999

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 1999 testing was conducted on samples collected June 23 – 27; the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*) were used.

No toxicity was observed to the fathead minnows or to the water flea. The concentration of wastewater that produces 50% mortality in the test population (i.e., the LC_{50}) for both species is greater than 100%; that is, concentrations higher than those found in the effluent would be required for half to be killed. Table 5.5 summarizes the results from the toxicity tests for 1999. Table 5.6 summarizes the test results from 1991 to 1999.

The permit also requires that weekly pH, ammonia nitrogen, dissolved iron, manganese, and zinc measurements be made. No exceedances of these parameters were noted in 1999. Monthly monitoring for lead, hexavalent and trivalent chromium, and beta radioactivity is required.

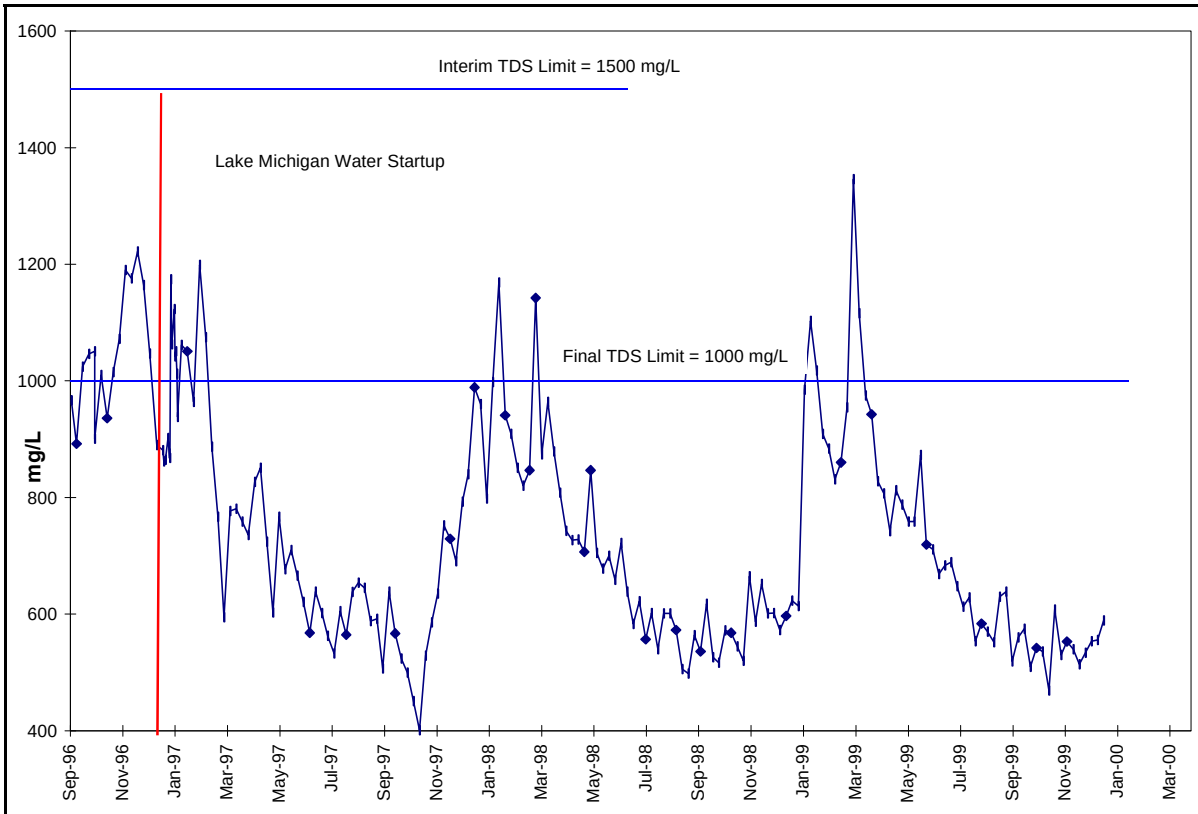


Figure 5.5 Total Dissolved Solids NPDES Outfall 001

TABLE 5.5

Outfall 001 Aquatic Toxicity Test Results, 1999

Test	End Point	96/48-Hour LC_{50} (%)
96-hour fathead minnow acute toxicity	Survival	>100.0
48-hour water flea acute toxicity	Survival	>100.0

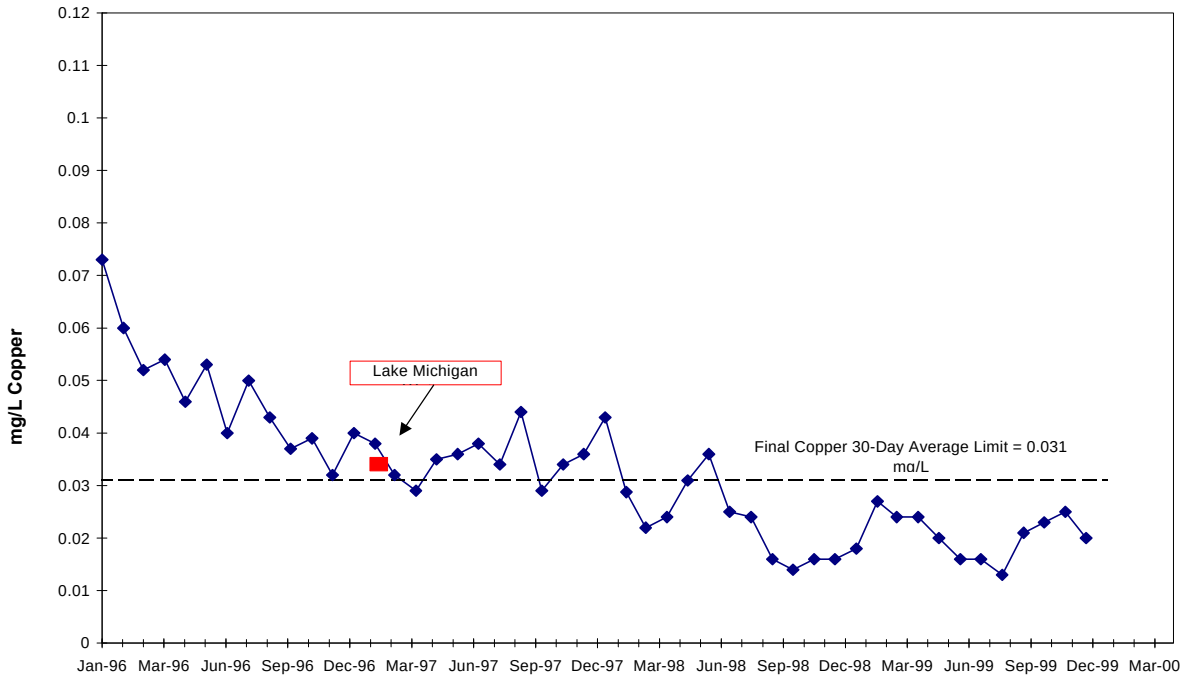


Figure 5.6 NPDES Outfall 001 30-Day Average Copper Results, 1996 to 1999

TABLE 5.6

Outfall 001 Aquatic Toxicity Test Results, 1991 to 1999

Test	1991 (%)	1992 (%)	1993 (%)	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)	1999 (%)
Minnow, acute, LC_{50}	61.6	<6.2	100.0	100.0	>100	>100	>100	>100	>100
Water flea, acute, LC_{50}	17.1	35.4	100.0	100.0	>100	>100	>100	>100	>100
Minnow, chronic, survival, NOEC[a]	50.0	100.0	50.0	100.0	-[b]	-	-	-	-
Minnow, chronic, survival, LOEC[c]	100.0	100.0	100.0	100.0	-	-	-	-	-
Minnow, chronic, growth, NOEC	50.0	100.0	50.0	100.0	-	-	-	-	-
Water flea, chronic, survival, NOEC	50.0	50.0	50.0	100.0	-	-	-	-	-
Water flea, chronic, survival, LOEC	100.0	100.0	100.0	100.0	-	-	-	-	-
Water flea, chronic, reproduction, NOEC	50.0	50.0	25.0	100.0	-	-	-	-	-
Algal growth, LOEC	6.2	6.2	100.0	100.0	-	-	-	-	-
Algal growth, NOEC	3.1	<6.25	100.0	100.0	-	-	-	-	-

[a] NOEC = no observable effect concentration; the highest concentration of the effluent at which no adverse effect is observed.

[b] A hyphen indicates that no analysis was performed because of a change in the permit.

[c] LOEC = lowest observable effect concentration; the lowest concentration of the effluent at which an adverse effect is observed.

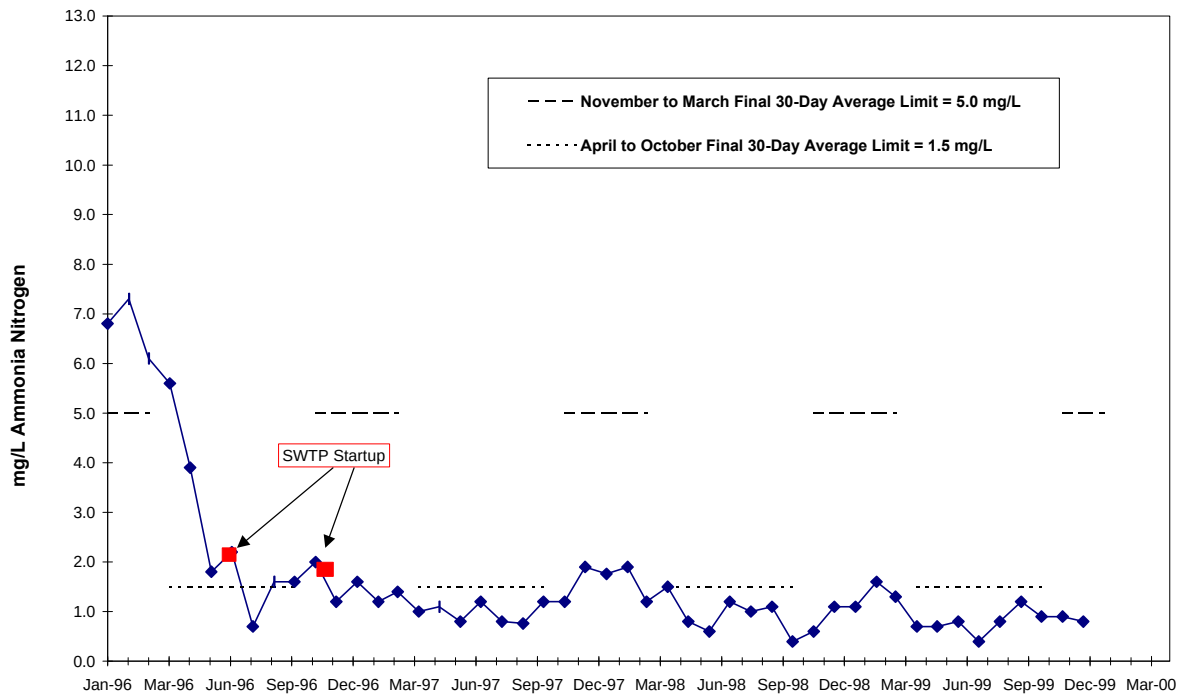


Figure 5.7 NPDES Outfall 001 30-Day Average Ammonia Nitrogen Results, 1996 to 1999

Outfall 003A. This potential discharge is located approximately 25 m (75 ft) north of the swimming pool and is a vitrified clay pipe that was originally used as the discharge point for all the swimming pool activities (filter backwash, draining, and overflow). Table 5.7 presents the sampling requirements and effluent limits.

By July 1995, discharge of chlorinated water from Outfall 003A had been completely eliminated by installation of a sump collection system that captures all the flow and discharges into the sanitary drain system.

Outfall 003B. This outfall is located approximately 150 m (500 ft) northeast of Building 308 and is composed of storm water runoff and condensate from the buildings in the watershed of the outfall. The discharge point is a 1-m (3-ft) concrete pipe to a tributary brook flowing north to the Freund Brook. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Outfall 003C. The discharge from this outfall is made up of footing tile drainage and storm water runoff. The discharge point is a 0.65-m (2-ft) concrete pipe discharging into Freund Brook approximately 50 m (150 ft) upstream of the gas station, south of Building 205. The sampling requirements and effluent limits are given in Table 5.7. No exceedances occurred during 1999.

TABLE 5.7

NPDES Effluent Summary, 1999

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	<2.8EC rise		0
003C	12	Flow	None		0
		pH	6 – 9		0
003D	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
003E	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
003F	11	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
		TDS	Monitor only		NA[b]
003G	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
003H	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
		TDS	Monitor only		NA

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit: 30-Day Average	Limit: Daily Maximum	No. Exceeding Limit
003I[c]	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
		TDS	Monitor only		NA
		Oil and grease	Monitor only		NA
003J	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC rise		0
		TDS	Monitor only		NA
004	12	Flow	None		0
		pH	6 – 9		0
		TSS	15	30	0
005C	12	Flow	None		0
		pH	6–9		0
		Temperature	<2.8EC rise		0
		Oil and grease	Monitor only		NA
005E	12	Flow	None		0
		pH	6 – 9		0
006	12	Flow	None		0
		pH	6 – 9		0
		TSS	15	30	3
		TDS	Monitor only		NA
		Temperature	<2.8EC rise		0
007	12	Flow	None		0
	12	pH	6 – 9		0
	12	Temperature	<2.8EC rise		0
	36	TRC	0.05		0
	12	Oil and grease	Monitor only		NA
008	10	Flow	None		0
		pH	6 – 9		0
		VOC	Monitor only		NA

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	No. Exceeding Limit
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	<2.8EC rise		0
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	5	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA
114	5	Flow	None		0
		Hydrogen-3	Monitor only		NA
		PCB 1260	Monitor only		NA
		Lead, copper, nickel, zinc	Monitor only		NA

TABLE 5.7 (Cont.)

Discharge Location	No. of Samples	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	No. Exceeding Limit
115	12	Flow	None		0
		pH	6 – 9		0
		Temperature	<2.8EC 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.

[c] An unpermitted discharge occurred at Outfall 003I due to a break in a chiller water line.

Outfalls 003D and 003E. These two discharge points are from the steam trench around Inner Circle Drive and discharge into the north fork of Freund Brook approximately 150 m (500 ft) east of the intersection of Inner Circle Drive and Eastwood Extension. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Outfall 003F. This outfall is intended to discharge excess water from the fire pond during storm events. The building discharges cooling tower water to the fire pond; the rate is generally insufficient to result in a discharge at this outfall. When the rate is sufficient, the discharge is through a cement raceway to the south fork of the north branch of Freund Brook. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Outfall 003G. Footing tile drainage from the Inner Circle steam trench is pumped to the storm sewer passing around the northeastern portion of Building 201 and discharges into the northern fork of the southern branch of Freund Brook. Condensate leaks in the steam trench produce discharge on a regular basis to the storm sewer. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Outfall 003H. This discharge originates from the footing tile drainage around Building 212 and storm water collected from around Buildings 212 and 214 and their associated parking lots. The cooling tower located on the south roof of Building 212 discharges into the tile drainage system and is the source of the industrial discharge. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

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 on a biannual basis during the months of July and August. These outfalls were sampled during the periods of July 26 – 30 and August 24 – 28, 1999. Outfall 003H was acutely toxic to the fathead minnow and the water flea during the July test (see Section 2.2.1.2). Adjustments to the Building 212 cooling tower biocide addition were made after the July test. The August 1999 test results showed no toxicity. The results are summarized in Tables 5.8 and 5.9.

TABLE 5.8

Acute Toxicity Results: Fathead Minnow, 1999

NPDES Outfall	96-Hour LC_{50} July 26 – 30, 1999 (%)	96-Hour LC_{50} August 24 – 28, 1999 (%)	96-Hour LC_{50} September 27 – October 1, 1999 (%)	Comments
003H	<60	>100	NA	Acutely toxic/not acutely toxic
003I	>100	>100	NA	Not acutely toxic
003J	>100	>100	NA	Not acutely toxic
004	>100	>100	NA	Not acutely toxic
006	>100	>100	NA	Not acutely toxic
115	>100	84.2	>100	Acutely toxic

TABLE 5.9

Acute Toxicity Results: Water Flea, 1999

NPDES Outfall	48-Hour LC_{50} July 26 – 30, 1999 (%)	48-Hour LC_{50} August 24 – 28, 1999 (%)	48-Hour LC_{50} September 27 – October 1, 1999 (%)	Comments
003H	<60	>100	NA	Acutely toxic
003I	>100	>100	NA	Not acutely toxic
003J	>100	>100	NA	Not acutely toxic
004	>100	>100	NA	Not acutely toxic
006	>100	>100	NA	Not acutely toxic
115	<60	<60	42.7	Acutely toxic

Outfall 003I. This outfall collects storm water from Buildings 200 and 211 and the western portion of Building 205 areas and also accumulates cooling tower discharge from the cooling tower located behind Building 200. Table 5.7 gives the sampling requirements and effluent limits. One unpermitted discharge occurred in July due to a break in a chiller water line. Results of acute toxicity tests for Outfall 003I are presented in Tables 5.8 and 5.9. Outfall 003I was not acutely toxic to the fathead minnow or water flea.

Outfall 003J. This outfall collects storm water from the Building 213 area and parking lot. The storm water passes through a storm sewer around Building 201. Cooling tower blowdown is the industrial discharge to this system. The sampling requirements and effluent limits are given in Table 5.7. No exceedances were noted during 1999. Results of acute toxicity tests for Outfall 003J are presented in Tables 5.8 and 5.9. Outfall 003J was not acutely toxic to the fathead minnow or water flea.

Outfall 004. This outfall discharges storm water from the Buildings 202, 203, and 221 areas and cooling water from Building 221. The discharge is to a drainage ditch and sewer system that pass around the northeastern portion of Outer Circle Drive and to a ditch leading north to the fence line, east of the Visitor's Center. Table 5.7 gives the sampling requirements and effluent limits. No exceedances were noted during 1999. Results of acute toxicity tests for Outfall 004 are presented in Tables 5.8 and 5.9. Outfall 004 was not acutely toxic to the fathead minnow or water flea.

Outfall 005A. This outfall discharges runoff from the northwestern portion of the 800 Area. The flow passes under Westgate Road, east of the West Gate, and flows toward the northwestern fence line. This is a storm water only outfall.

Outfall 005B. The outfall for this watershed discharges runoff collected from the major portion of the 800 Area. The flow is collected from the parking lots and roadways and flows by storm sewers to the east, where it is discharged to the marsh located on the eastern side of Kearney Road. This is a storm water only outfall.

Outfall 005C. This outfall collects storm water from the northern side and the loading dock area of Building 200. The Building 200 once-through cooling water systems discharge to this outfall, which passes through sewers to the west of the loading dock and to the beaver pond west of Building 200. The sampling requirements and effluent limits are given in Table 5.7. No exceedances occurred during 1999.

Outfall 005D. The Building 200 M-Wing loading dock area storm water runoff is collected in a storm sewer and passes west to a beaver pond located west of Building 200. The discharge is through a 1-m (3-ft) corrugated pipe into the pond. This is a storm water only discharge.

Outfall 005E. This outfall discharges footing tile drainage from the west sides of Buildings 203 and 208. It also discharges storm water collected from the same area. The industrial discharge arises from cup drains and compressors discharging into the footing tile sumps. The sampling requirements and effluent limits are given in Table 5.7. No exceedances occurred during 1999.

Outfall 006. Cooling towers at Building 350 and the 377 Area discharge into the drainage ditch that flows south of the Canal Water Treatment Plant, bends south, and flows to the south fence line. The permit requires monthly sampling for pH, TSS, and temperature. The limits are given in Table 5.7. Three exceedances of the TSS limit occurred in 1999. The exceedances were due to summer algae growth (July), sediment runoff from an upstream construction project (August), and cooling tower drainage sediment (November). Results of acute toxicity tests for Outfall 006 are presented in Tables 5.8 and 5.9. Unlike 1995, 1996, and 1998, Outfall 006 was not acutely toxic to water fleas. As in 1996, 1997, and 1998, it was not acutely toxic to the fathead minnow.

Outfall 007. The watershed for Outfall 007 includes the southeastern section of the 300 Area and extends from Building 370 east to Building 366 and north to Building 367. Water is collected in catchment basins and conveyed toward the southeast to a point approximately 30 m (100 ft) southeast of Building 366, where it is discharged into a ditch on the south side of Old Bluff Road. This ditch runs along the roadside for 15 m (50 ft), at which point it turns south and runs to the fence line where it is discharged to the forest preserve. The once-through cooling water of compressors is the industrial component of this outfall. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Outfall 008. The watershed for this outfall includes the area around the new Vehicle Maintenance and Grounds Building 46. Runoff is collected in storm water grates and catchments and conveyed through sewers to the discharge point in Sawmill Creek, which is located directly west of Building 24. Industrial activity in this small watershed involves operations associated with the maintenance of all facility vehicles; grounds, maintenance, and storage of the equipment associated with these activities; and fueling for the vehicles. Five VOCs are monitored once a month. Low levels (5 to 74 µg/L) of tetrachloroethylene are consistently noted at this outfall. A characterization study will be performed in this area to determine the source and extent of contamination. The only NPDES limit that applies at this point is pH. No exceedances were noted during 1999.

Outfall 010. This outfall is for the coal pile storage area runoff collection system overflow line. The collection system consists of a trench on the north and west sides of the coal pile; a sump is located at the extreme southern end of the western trench line. The overflow line comes into use only when the runoff reaches the level at which the trench system would overflow; the line was put into place to ensure against overflow conditions. During normal operations, the water is pumped to the equalization basin located in the western part of the 100 Area. The industrial activity associated

with this outfall is solely the coal pile operation. The berm and trench system in place to collect runoff has been improved to eliminate discharge from the outfall.

This outfall is sampled once per day when flow occurs. Analyses are performed for pH, TSS, TDS, iron, lead, zinc, manganese, trivalent and hexavalent chromium, copper, and oil and grease. No flow occurred at this site during 1999.

Outfall 101. The drainage to this outfall is through ditches along the streets and sewer conduits from the parking lot to a marsh located between Outer Circle Drive and the fence line to the outfall; the conduits consist of a 0.65-m (2-ft) corrugated metal pipe with a Palmer-Bowlus flume. The drainage then discharges on the other side of the fence line into the forest preserve. The sources of storm water runoff to the outfall are the Building 203 parking lot and loading dock and the excess equipment storage area on the north side of Outer Circle Drive. This is a storm water only discharge.

Outfall 102. This watershed includes portions of the 100 Area. Large amounts of paved areas are associated with the industrial activities for the production of steam such as those areas associated with the water treatment plant, the lime sludge pond, and the tarmac around the boiler house. The contributing runoff flows are collected from storm water inlet grates and catch basins, through storm sewers to a discharge point consisting of a 0.30-m (1-ft) corrugated metal pipe extending out of the bank of Sawmill Creek. This is a storm water only discharge.

Outfall 103. The watershed for Outfall 103 includes the southern and southeastern extreme portions of the 100 Area and the area south of the coal pile. These areas drain into a storm sewer that runs due east of the coal pile toward Sawmill Creek. The outfall is located at the outlet of a 0.35-m (1.2-ft) corrugated metal pipe culvert located approximately 50 m (150 ft) from the creek. Activities that are industrial in nature take place in and around the utilities area and consist of boiler house steam generation, storage of plastic and metal, loading dock activities, a flue gas scrubber and cooling pond (no longer in use), steam condensate return storage (two tanks), and the southern access road to the coal pile storage area. This is a storm water only discharge.

Outfall 104. This outfall includes the buildings and parking areas remaining in the East Area, excluding Buildings 40 and 46. Buildings 4, 5, and 6 and their smaller attendant buildings are included. The area is served by a number of roadways leading to and from these buildings; contributing storm grate inlets are located on the roadways and parking areas. This is a storm water only discharge.

Outfalls 105A and 105B. Two discharge points are located within this watershed. The contributing sources of storm water for this watershed include runoff from the Building 40 area, elevated water tower tanks, and scrub vegetation areas on the west side of Tech Road. Industrial

activity within this watershed includes receiving, loading, parking and storage areas, and oil-containing transformers. These are storm water only discharges.

Outfalls 106A and 106B. The watershed for these outfalls encompasses the largest portion of the East Area, most of which is now demolished and the buildings razed. A portion of the eastern end of the Shipping and Receiving Area is part of this watershed, that is, Building 33, which has electrical transformers located outside of it, and a portion of Argonne Park. Like Outfall 105 above, this watershed is served by two distinct outfalls. The industrial activities within this watershed involve the receiving and shipping areas with loading docks and the transformer area. These are storm water only discharges.

Outfall 108. This watershed encompasses a portion of the 300 Area. The drainage area includes the parking areas north of Building 360, the buildings in and around Building 360, excluding Buildings 370 and 390 and the southern and western ends of the 300 Area, and the paved parking and loading dock areas in and around the eastern portions of the 300 Area (surrounding Building 363). Ongoing industrial activities in this watershed are shipping and receiving, a metals reclaim dumpster (Building 363), loading dock activities, and numerous outdoor equipment storage areas. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Outfall 110. The watershed for this outfall includes the 320 Area shooting range (inactive since March 1993) and the area just south of the range. No other industrial activities take place within this watershed at present. Past industrial activity involved use of the shooting range for practice by the security force. This is a storm water only discharge.

Outfall 111. This outfall is located on the south fence line of the site due south of the old, closed 319 Area Landfill, between the watershed for Outfall 110 and the watershed for Outfalls 112A and 112B. This watershed encompasses the 319 Area Landfill, the 318 Area (landfill area for compressed gases), and portions of the 317 Area, primarily the paved area. In addition, the roadways for access to these areas drain to this outfall through a small ditch running along the southern extreme of the 319 Area Landfill, turning south to the fence line, and then to the outfall location, which is a 0.65-m (2-ft) corrugated metal pipe culvert that passes under the fence and discharges into the forest preserve. Industrial activities within this watershed consist of 317 Area radioactive waste storage and remediation activities, the 319 Area Landfill, and associated roadways for access. This outfall is sampled semiannually for flow and hydrogen-3 and has no permit limits. Hydrogen-3 results were 115 pCi/L during January 1999 and 288 pCi/L during August 1999.

Outfalls 112A and 112B. The contributing sources of storm water within this watershed receive runoff from the southern and western sections of the 317 Area radioactive waste storage. Runoff flow is generally toward the south in sheet flow from the source areas; the eastern portions consolidate at the fence line at the southeastern corner of the 317 Area and pass under the fence

through rough concrete fill. The western and central portions of the drainage area sheet flow consolidate in the same manner and pass under the fence through the same material, approximately 50 m (150 ft) to the west. Both flows discharge into large gullies in the forest preserve and form one flow approximately 100 m (328 ft) south of the ANL-E fence line. Industrial activity within this watershed consists of 317 Area radioactive waste storage and remediation activities, loading activities at Building 350, and the associated roadways for access. These outfalls are sampled semiannually for flow and hydrogen-3 and have no permit limits. Hydrogen-3 results were less than 100 pCi/L during January. There was no flow from these outfalls during the last two quarters of 1999.

Outfall 113. This outfall is the discharge point for runoff from the eastern, southern, and southwestern sections of the closed 800 Area Landfill. The outfall is located in a ditch on the extreme southern end of the landfill, approximately 50 m (150 ft) from the southwestern corner of the landfill fence line. This discharge flows under the fence in the ditch and empties into the creek that flows south from the wetland marsh west of the site. The marsh is the headwaters of one leg of the Freund Brook system that runs through the middle of the ANL-E site and discharges into Sawmill Creek. Industrial activity within this watershed is limited to the landfill. This outfall was sampled monthly when discharging and has no permit limits. Flow occurred during five months in 1999.

Outfall 114. This outfall is the discharge point for runoff coming from the northern and northwestern sections of the closed 800 Area Landfill. The outfall is located in a ditch on the extreme western side of the landfill, approximately halfway between the northern and southern boundaries of the landfill. The flow proceeds along the western edge of the landfill where water is added from the marsh. The flow eventually combines with the ditch from the Outfall 113 flow and then passes into the creek that flows south from the wetland marsh west of the ANL-E site. Industrial activity within this watershed is limited to the landfill. This outfall was sampled monthly when discharging and has no permit limits. Flow occurred during five months in 1999.

Outfall 115. This watershed encompasses the APS site and the southern areas around the Building 314, 315, and 316 complex. The APS flow drains into ditches that discharge through a cement culvert into a collection pond located on the southeastern portion of the APS site. The 0.65-m (2-ft) sewer conduit from the Building 314, 315, and 316 complex discharges into the same collection pond approximately 10 m (30 ft) east of the ditch culvert. The flow from this pond discharges south through a culvert into another pond, flows through this pond, and discharges through a 1-m (3-ft) corrugated metal pipe culvert under the south fence line into the forest preserve. Industrial activities within the watershed involve the APS; all roadways associated with APS; loading docks in the APS buildings; and the Building 314, 315, and 316 complex storage, loading areas, and cooling water discharges. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

Results of acute toxicity tests for Outfall 115 are presented in Tables 5.8 and Table 5.9. Outfall 115 was acutely toxic to the water flea and fathead minnow. The toxicity appears to come from the Building 315 cooling tower, which historically used a batch addition of biocide pellets. Installation of a bromine-based liquid biocide using an automated dispensing system appears to have improved the toxicity to the fathead minnow but not to the water flea. Therefore, this discharge was removed from the storm drain system (Outfall 115) and rerouted to the WTP.

Outfall 116. This outfall was originally intended as a storm water discharge point only; however, it also contains non-storm–water discharges as well. The source of the discharge was traced back and found to be potable water from the domestic water treatment plant located uphill from the rest of the main utilities area. This source was investigated for corrective action and the flow stopped. The watershed for this outfall contains sections of the domestic water treatment plant, including the garage and storage area, the area around Well 5, and the associated access roads for the domestic water treatment plant. Flow is conducted through storm water sewers and discharged at the outfall, which is a 0.25-m (0.82-ft) vitrified clay pipe with a cement raceway into Sawmill Creek. Industrial activities for this watershed include parking, loading, and materials storage around the domestic water treatment plant; domestic water treatment plant operation, including bulk chemical storage (brine tank) and transformers (Building 129); outdoor equipment storage area and four flammable materials storage cabinets (Building 130); outdoor materials storage (Buildings 107 and 163); well operation and maintenance (Building 160); and the associated roadways for these activities. Table 5.7 gives the sampling requirements and effluent limits. No exceedances occurred during 1999.

5.2. Additional Effluent Monitoring

To characterize the wastewater from the ANL-E site more fully, composite samples of the combined effluent from the WTP were collected each week and analyzed for the constituents shown in Table 5.10. The results were then compared with IEPA General Effluent Limits found in 35 IAC, Subtitle C, Part 304.[24]

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.

TABLE 5.10

Chemical Constituents in Effluents from the ANL-E Wastewater Treatment Plant, 1999

Constituent	No. of Samples	Concentrations (mg/L) Average	Minimum	Maximum	Limit
Arsenic	52	0.0024	<0.0020	0.0026	0.25
Barium	52	0.0212	0.0180	0.0261	2.0
Beryllium	52			<0.0002[a]	-[b]
Cadmium	52			<0.0002	0.15
Chromium	52			<0.0440	1.0
Cobalt	52			<0.0260	-
Copper	52	0.0196	<0.0170	0.0300	0.5
Fluoride	52	0.8736	0.6000	1.1600	15.0
Iron	52	0.0598	0.0370	0.1490	2.0
Lead	52			<0.0020	0.2
Manganese	52	0.0171	0.0170	0.0259	1.0
Mercury	52	0.0001	<0.0001	0.0002	0.0005
Nickel	52			<0.0400	1.0
Silver	52	0.0008	<0.0005	0.0050	0.1
Thallium	52	0.0015	<0.0015	0.0018	-
Vanadium	52			<0.0240	-
Zinc	52	0.1237	0.0542	0.2528	1.0
pH (units)	49	NA[c]	7.00	7.84	6.0 – 9.0

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

[b] A hyphen indicates no effluent limit for this constituent.

[c] NA = not applicable.

5.2.2. Results

Fifteen metals were determined by inductively coupled plasma emission spectroscopy, flame atomic absorption 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 5.10 gives the results for 1999. None of the annual average results exceeded General Effluent Limits.[24]

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-E has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of ANL-E wastewater and discharges to assorted storm drains. To determine the impact ANL-E wastewaters have on Sawmill Creek, samples of the creek downstream of all ANL-E 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.[25]

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-E 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 5.10.

Fifteen metals were determined by inductively coupled plasma emission spectroscopy, flame atomic absorption 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 are shown in Table 5.11. As in 1998, the annual average concentration for copper did not exceed the Water Quality Standard (WQS). Since the conversion to Lake Michigan water, copper levels have declined due to a gradual reduction in leaching of copper from the domestic water distribution system. The maximum concentrations for copper and iron exceeded

TABLE 5.11

Chemical Constituents in Sawmill Creek, Location 7M,[a] 1999

Constituent	No. of Samples	Concentrations (mg/L) Average	Minimum	Maximum	Limit
Arsenic	49	0.0027	0.0025	0.0041	0.36[b]
Barium	49	0.0427	0.0222	0.0681	5.0
Beryllium	49			<0.0002[c]	-[d]
Cadmium	49	0.0004	0.0002	0.0014	0.03[b]
Chromium	49			<0.0440	3.6[b]
Cobalt	49			<0.0260	
Copper	49	0.0228	0.0170	0.0476	0.041[b]
Fluoride	49	0.5808	0.2620	1.02	1.4
Iron	49	1.0	0.07	3.1	1.0
Lead	49	0.0058	0.0011	0.0165	0.3[b]
Manganese	49	0.1714	0.0170	0.5040	1.0
Mercury	49			<0.0001	0.0026[b]
Nickel	49			<0.0400	1.0
Silver	49			<0.0010	0.005
Thallium	49			<0.0015	-
Vanadium	49			<0.0240	-
Zinc	49	0.1453	0.0165	0.3842	1.0
pH (units)	49	NA[e]	6.89	8.20	6.5 – 9.0

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

[b] The acute standard for the chemical constituent is listed.

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

[d] A hyphen indicates no effluent limit for this constituent.

[e] NA = not applicable.

the WQS. Overall, the levels of copper are declining since the introduction of Lake Michigan water as ANL-E's domestic water source. Between 1996 and 1999, the average levels have ranged from 0.38, 0.31, 0.21, and 0.23 mg/L, respectively. The elevated iron levels are probably associated with inadequate retention time during periods of high wastewater flow that are known to contain increased coal pile runoff discharges.

6. GROUNDWATER PROTECTION

The groundwater below the ANL-E site is monitored through the collection and analysis of samples obtained from the former on-site water supply wells and from a series of groundwater monitoring wells located near several sites that have the potential for affecting groundwater. Regulations establishing comprehensive water quality standards for the protection of groundwater have been enacted — IEPA Groundwater Quality Standards, 35 IAC, Subtitle F, Part 620.[26] In addition, demonstration of compliance with the groundwater protection requirements in DOE Order 5400.1,[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.

6.1. Former Potable Water System

Domestic water for ANL-E 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 to where 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 of approximately 200 mg/L. In addition, Lake Michigan water is lower in bicarbonate, which makes it less corrosive on the piping system.

6.1.1. Regulatory Required Monitoring

The supplier of the domestic water is responsible for conducting any regulatory required monitoring. Because ANL-E water is provided by the DuPage Water Commission, it is responsible for any monitoring. Therefore, ANL-E did not conduct any required monitoring in 1999.

6.1.2. Informational Monitoring

Samples were collected quarterly at the wellhead, except for Well 2, which is no longer operational, and were analyzed to determine the presence of several types of radioactive constituents and VOCs in ANL-E 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 a gas-flow–proportional counting technique. Hydrogen-3 was determined by distillation followed by a beta liquid scintillation counting technique. Strontium-90 was determined by ion-exchange separations followed by proportional counting. The results are presented in Table 6.2. If these wells constituted the ANL-E

TABLE 6.1

ANL-E 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	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.

drinking water source, the following EPA limits established for the nuclides measured in Table 6.2 would apply:

Gross alpha particle activity	=	15 pCi/L
Gross beta particle activity	=	50 pCi/L
Hydrogen-3	=	2×10^4 pCi/L
Strontium-90	=	8 pCi/L

VOC samples were collected quarterly. Samples were analyzed for SDWA volatile compounds and quantified by EPA Method 524.2[27], which includes purge and trap pretreatment, followed by gas chromatography-mass spectroscopy detection. The detection limit is the Practical Quantification Limit (PQL), which is defined as 10 times the method detection limit. The lack of measurable concentrations of VOCs supports the determination that no VOCs have migrated from remediation sites.

6.1.3. Dolomite Well Monitoring

Past analytical data were used to track the presence of hydrogen-3 in ANL-E 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 tritiated water appears to have migrated through the glacial till to the dolomite aquifer and was drawn into the wells. Well 1, which is about 200 m (650 ft) north of the

TABLE 6.2

Radioactivity in ANL-E Former Water Supply Wells, 1999
(concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Average	Minimum	Maximum
Alpha (nonvolatile)	Well 1	4	3.6	2.5	4.7
	Well 3	4	2.6	1.6	3.2
	Well 4	4	3.2	2.1	4.8
Beta (nonvolatile)	Well 1	4	10.5	10.1	11.4
	Well 3	4	11.5	10.9	12.4
	Well 4	4	12.4	11.5	12.9
Hydrogen-3	Well 1	4	<100	<100	<100
	Well 3	4	<100	<100	<100
	Well 4	4	<100	<100	<100
Strontium-90	Well 1	4	<0.25	<0.25	<0.25
	Well 3	4	<0.25	<0.25	<0.25
	Well 4	4	<0.25	<0.25	<0.25
Radium-226	Well 1	1	-[a]	-	0.90
	Well 3	1	-	-	2.24
	Well 4	1	-	-	1.76
Radium-228	Well 1	1	-	-	0.40
	Well 3	1	-	-	1.15
	Well 4	1	-	-	0.32
Uranium-234	Well 1	1	-	-	1.00
	Well 3	1	-	-	0.23
	Well 4	1	-	-	0.23
Uranium-235	Well 1	1	-	-	0.03
	Well 3	1	-	-	<0.01
	Well 4	1	-	-	<0.01
Uranium-238	Well 1	1	-	-	0.68
	Well 3	1	-	-	0.11
	Well 4	1	-	-	0.10

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

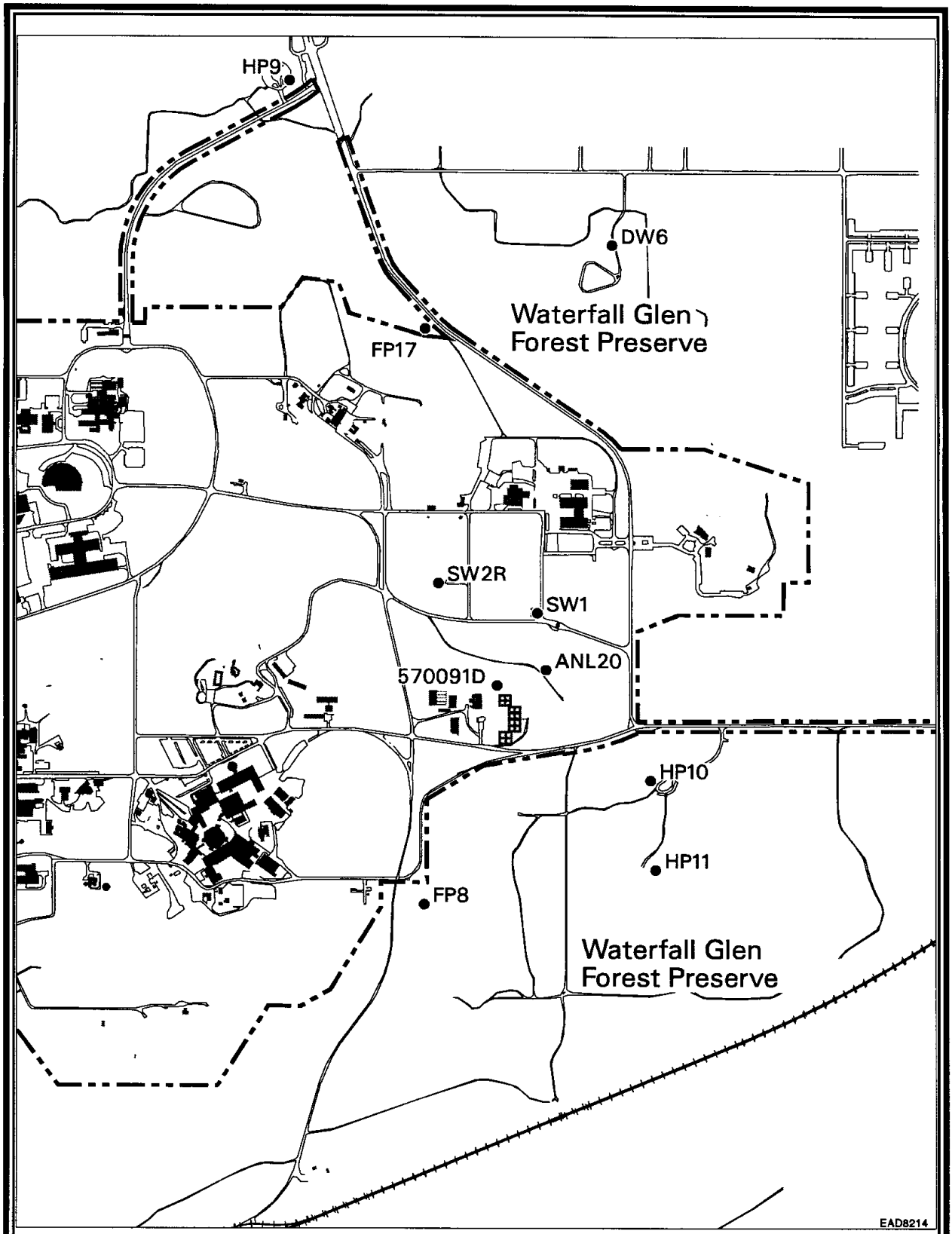


Figure 6.1 East Area/Forest Preserve Monitoring Wells

wastewater treatment area, had higher hydrogen-3 concentrations than Well 2, which is about 300 m (1,000 ft) from the treatment area. Although the normal subsurface water flow gradient is toward the south-southeast, the cone of depression created by pumping these wells 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. A concern was raised that potentially the subsurface migration of radionuclides, particularly hydrogen-3, could change direction because of the lack of the influence of pumping. Since hydrogen-3 from the 570 Area Pond was already known to have migrated to the dolomite, a monitoring network of three ANL-E and six forest preserve wells was established to monitor the magnitude and direction of any hydrogen-3 movement. 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 1999. Hydrogen-3 results from Well 570091D, which is directly below the 570 Pond, continue to show low concentrations of hydrogen-3. The results from HP No. 11 are just above the detection limit and will require continued surveillance. This sampling network is now part of the monitoring program.

6.2. Groundwater Monitoring at Waste Management Sites

ANL-E has occupied its current site since 1948. Since that time, waste generated by ANL-E was placed in a number of on-site disposal units; these ranged from ditches filled with construction

TABLE 6.3

Hydrogen-3 in Dolomite Wells, 1999
(concentrations in pCi/L)

	Date Collected			
Well	February 24	April 22	July 13	October 19
Waterfall Glen				
DW No. 6	<100	<100	<100	<100
HP No. 9	<100	<100	<100	<100
HP No. 10	<100	<100	<100	<100
HP No. 11	157	127	<100	<100
FP No. 8	<100	<100	<100	<100
FP No. 17	<100	<100	<100	<100
Ranger House	-[a]	-	<100	<100
ANL-E				
570091D	186	160	<100	<100
ANL-20	<100	<100	<100	<100
SW2R	<100	<100	<100	<100

[a] A hyphen indicates that no samples were collected.

and demolition debris during the 1950s, to a modern 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 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.

6.2.1. 317 and 319 Areas

The 317 and 319 Areas contain 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 consists of a series of in-ground and aboveground concrete structures used for storage of containers of dry radioactive or mixed (radioactive and chemically hazardous) waste. It also contains a small building used for decontamination of metal objects, such as lead bricks, tools, metal objects, etc. 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 northern half of the 317 Area. The contaminants are primarily VOCs such as cleaning solvents. The groundwater below this area also contains low concentrations of these chemicals. General features in the 317/319 Area are identified in Figure 6.2.

The 319 Area contains an inactive landfill that was used for disposal of a variety of solid wastes generated on site prior to 1969. It was not intended for disposal of radioactive waste; however, a small amount of radioactive material was detected during sampling activities completed several years ago. The only radionuclide found to be migrating from the landfill is hydrogen-3, a radioactive isotope of hydrogen. 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 are 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 very 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

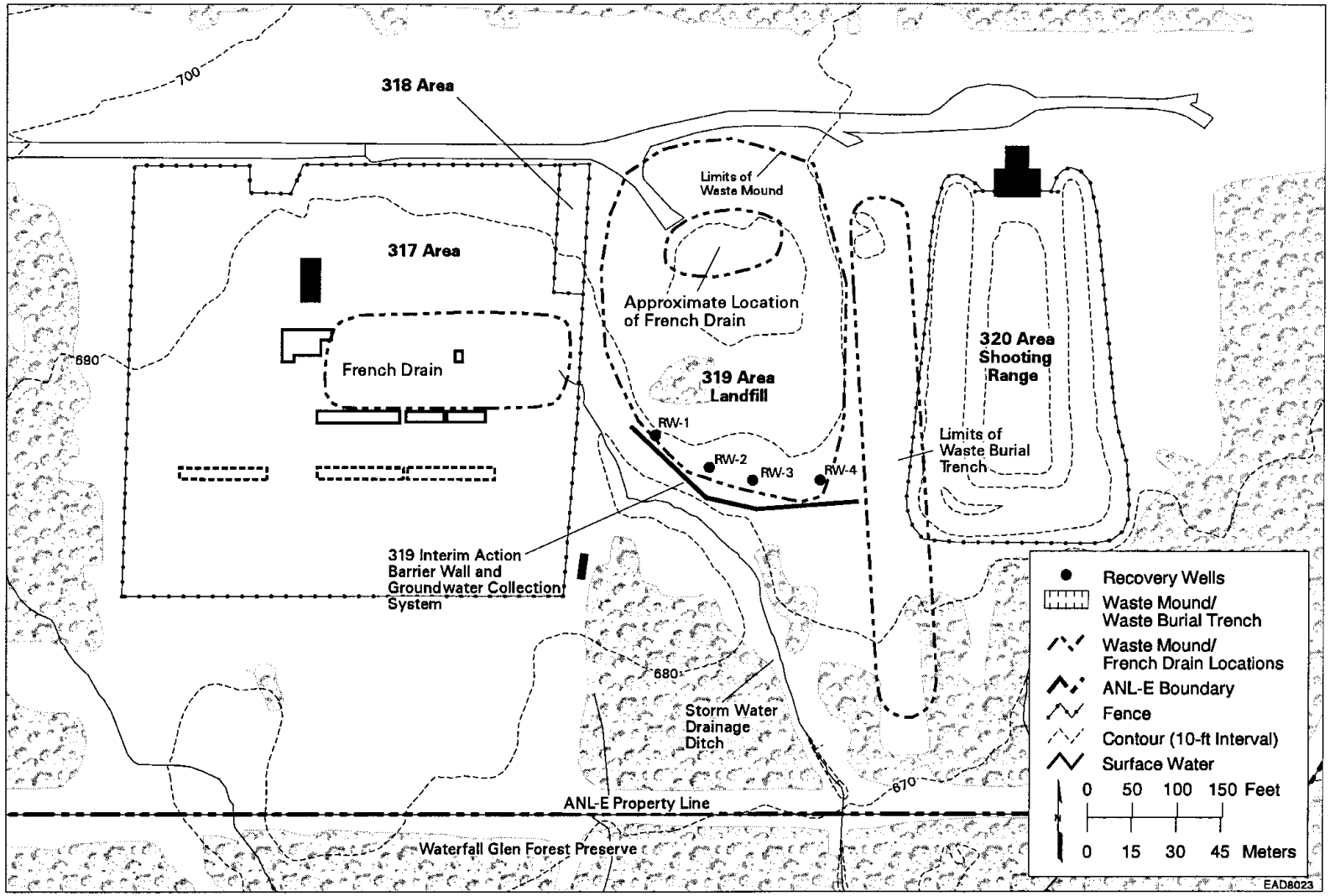


Figure 6.2 Locations of Components within the 317/319/ENE Area

applicable standards. Since their discovery, these seeps have been monitored on a regular basis (see Section 6.5). A characterization study was completed in 1998 to identify the source and 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 measured on site. The source of VOCs was not clearly discerned, though it is likely that they also emanated from some past waste disposal activities in the 319 or 317 Area. The current region of VOC-contaminated groundwater is limited to a small area immediately northeast of the contaminated seeps.

Cleanup of the 317 and 319 Areas has been underway since the late 1980s. It is being carried out as a series of interrelated actions that will ultimately remove or contain 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, removal of four waste storage vaults contaminated with radioactive materials, sealing of an underground drainage sewer, installation of 13 groundwater extraction wells south of the 317 Area, and construction of a concrete cover over a region containing buried compressed gas cylinders (318 Area). In addition, routine sampling and analysis of groundwater and surface water have continued. These actions have been discussed in previous annual reports. The remedial actions continued during 1999. A project to remove VOCs from the soil in the 317 French Drain area was completed. This project utilized innovative remedial technologies to remove approximately 80% of the VOCs from several locations within the French drain area.

The IEPA approved the design of a phytoremediation system in the 317 Area. Phytoremediation involves the use of green plants (trees, grasses, and flowering plants) to remove by evapotranspiration or 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 downstream of the 317 French Drain and the former 319 Landfill took place during 1999.

Construction activities for the upgrade of the existing leachate and groundwater collection system at the 319 Landfill took place during 1999. Four additional wells were installed and equipment was purchased for converting the aboveground piping system to a belowground system. A composite cap was installed over the landfill mound.

The results of the routine O&M of the groundwater collection systems in the 317 and 319 Areas and the monitoring of the off-site groundwater seeps were transmitted to the IEPA on a quarterly basis through the submittal of Quarterly Progress Reports. The results of this monitoring are also summarized in this report.

6.2.2. Groundwater Monitoring at the 317 and 319 Areas

Ten active monitoring wells (some of which are clustered or nested) were installed at the locations shown in Figure 6.3. Well data are listed in Table 6.4. The wide range in water level elevations shown in Table 6.4 is not unusual and results from some of the wells being screened at different depths. This variation in water level also may be indicative of "perched" (i.e., discontinuous) groundwater conditions within the glacial till. Samples are collected quarterly following EPA sampling protocols listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[28]

Groundwater monitoring in the 317 and 319 Areas has been conducted since 1986. Wells 319011, 317021, and 319031 were installed in September 1986; Well 317061 in August 1987; Wells 317101 and 317111 in September 1988; and Wells 319032 and 317052 were installed in June 1989. These wells were all completed in the glacial till. Well 317061 was sampled only two quarters due to construction damage to the well casing. In addition, Wells 317121D and 319131D were installed in November 1989 and reach the dolomite aquifer at about 25 m (80 ft) below the surface.

Wells 317101 and 317111 are upgradient of the 317 storage 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 by Well 317052 and 319032. This layer is also intercepted by Well 317101.

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.

6.2.2.1. Sample Collection

The monitoring wells are sampled using the protocol listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[28] The volume of the 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 till 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 by bailing with a dedicated Teflon bailer. The field parameters for these samples (pH, specific conductance, redox potential, and temperature) are measured statically. For those samples in the porous, saturated zone that recharges rapidly, three well volumes are purged using dedicated submersible pumps, while the field parameters are measured continuously. These 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,

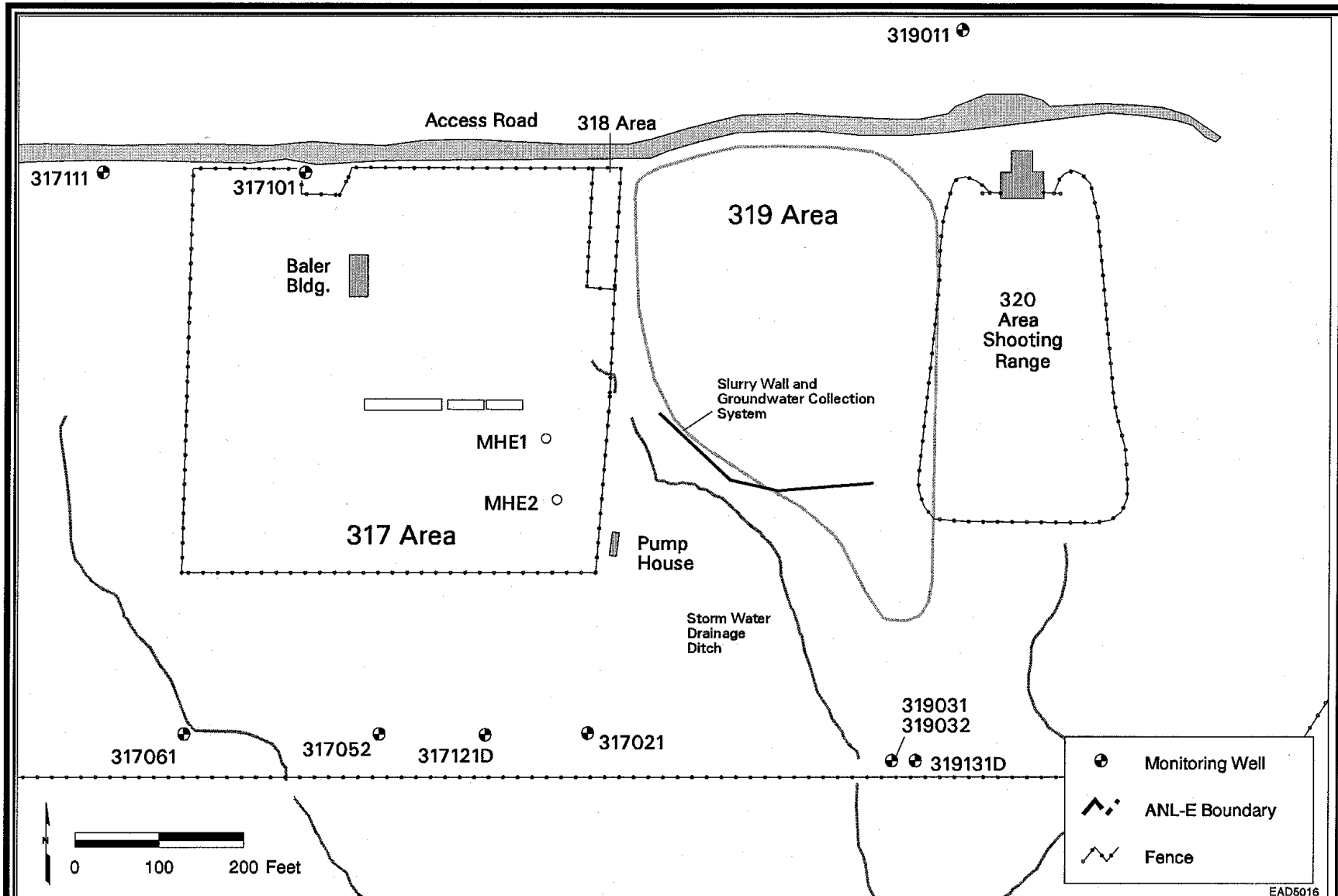


Figure 6.3 Active Monitoring and Characterization Wells in the 317 and 319 Areas, 1999

TABLE 6.4

Groundwater Monitoring Wells: 317 and 319 Areas

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	8/89
317051	6.10	208.3	205.3 – 202.2	0.05/PVC	7/87
317053	6.71	208.3	203.1 – 201.6	0.05/PVC	8/89
317052	4.27	208.3	207.1 – 204.0	0.05/PVC	8/89
317061	12.19	207.5	196.9 – 195.3	0.05/PVC	7/87
317101	11.89	211.0	202.2 – 199.1	0.05/PVC	8/89
317111	11.89	210.3	201.4 – 198.4	0.05/PVC	8/89
317121D[b]	24.08	207.6	185.0 – 183.5	0.15/CS	9/88
319131D	21.03	203.5	184.0 – 182.5	0.15/CS	9/88

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

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

SVOCs, PCBs and pesticides, metals, nonmetals, and radioactivity 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 obtained.

6.2.2.2. Sample Analyses - 317 and 319 Areas

The 317 and 319 Area groundwater chemical analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of ESH-Analytical Services, Chemistry Laboratory (ESH-ASCH). These SOPs reference protocols in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*.[8] Fifteen metals were routinely determined and were

measured using flame atomic absorption spectroscopy, inductively coupled plasma atomic emission spectrometry, and graphite furnace atomic absorption spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy. Chloride was determined by titrimetry. VOCs were determined by using a purge and trap sample pretreatment followed by gas chromatography-mass spectroscopy detection. SVOCs were determined by solvent extraction followed by gas chromatography-mass spectrometry detection. PCBs and pesticides were determined by solvent extraction followed by gas chromatography-electron capture detection. In the case of organic compound analyses, efforts were made to identify compounds that were present but not included on the method list. This was accomplished, and standard solutions of these compounds were prepared and analyzed.

The 317 and 319 Area groundwater radiological analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of ESH-Analytical Services, Radiochemistry Laboratory (ESH-ASRL). Cesium-137 was determined by gamma-ray spectrometry. Hydrogen-3 was determined by distillation followed by a beta liquid scintillation counting technique. Strontium-90 was determined by an 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 and 319 Areas are contained in Tables 6.5 through 6.14. All radiological and inorganic analytical results are shown in these tables. The analytical methods used for organic compounds could 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. 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, and 319031 usually dry up after one well volume is removed. Therefore, field parameters were measured on one well volume. As in past years, Well 319031 was dry during the third and fourth quarters. It is unlikely that any nearby residents use water from the measured aquifers for domestic use.

TABLE 6.5

Groundwater Monitoring Results, 300 Area Well 317021, 1999

Parameter	Unit	Date of Sampling				
		03/23/99	06/10/99	09/02/99	11/15/99	11/15/99
Water elevation[a]	m	200.24	202.38	200.33	198.94	198.94
Temperature	°C	11.1	11.8	13.9	12.6	12.6
pH	pH	7.92	7.58	7.94	7.40	7.40
Redox	mV	-45	-30	-37	-12	-12
Conductivity	µmhos/c	906	749	613	823	823
Chloride[b]	mg/L	32	13	17	32	32
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0370	0.0322	0.0338	0.0366	0.0405
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	0.0007	< 0.0005	0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0575	0.0284	< 0.011	0.0169	0.0118
Cesium-137	pCi/L	< 1.0	1.1	< 1.0	< 1.0	< 1.0
Hydrogen-3	pCi/L	101	< 100	125	109	< 100
Strontium-90	pCi/L	< 0.25	1.055	< 0.25	< 0.25	< 0.25
1,1,1-Trichloroethane	µg/L	8	5	7	9	8
1,1-Dichloroethane	µg/L	2	2	2	5	4
Methylene chloride	µg/L	< 1	< 1	1	< 1	< 1

[a] Well point elevation = 197.27 m mean sea level (MSL); Ground surface elevation = 209.17 m (MSL); casing material = PVC.

[b] Filtered sample.

TABLE 6.6

Groundwater Monitoring Results, 300 Area Well 317052, 1999

Parameter	Unit	Date of Sampling			
		03/23/99	06/10/99	09/03/99	11/15/99
Water elevation[a]	m	205.85	205.29	204.69	204.16
Temperature	°C	8.1	11.0	14.7	13.0
pH	pH	7.51	7.79	7.87	7.32
Redox	mV	-21	-42	-34	-8
Conductivity	µmhos/cm	733	745	606	778
Chloride[b]	mg/L	3	4	3	5
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0199	0.0260	0.0372	0.0410
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	0.0402
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	0.001	0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0554	0.0235	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	pCi/L	< 100	< 100	100	< 100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

[a] Well point elevation = 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, 1999

Parameter	Unit	Date of Sampling 03/23/99	Date of Sampling 06/10/99
Water elevation[a]	m	199.86	200.63
Temperature	ºC	10.9	12.3
pH	pH	7.27	7.51
Redox	mV	-10	-26
Conductivity	µmhos/cm	1,115	1,115
Chloride[b]	mg/L	76	81
Arsenic[b]	mg/L	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0477	0.0514
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	0.0463	0.0592
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	0.0016	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	0.0190	0.0244
Cesium-137	pCi/L	< 1.0	< 1.0
Hydrogen-3	pCi/L	124	116
Strontium-90	pCi/L	< 0.25	< 0.25

[a] Well point elevation = 195.35 m (MSL); ground surface elevation = 207.54 m (MSL); casing material = PVC

[b] Filtered sample.

TABLE 6.8

Groundwater Monitoring Results, 300 Area Well 317101, 1999

Parameter	Unit	Date of Sampling			
		03/22/99	06/09/99	09/02/99	11/15/99
Water elevation[a]	m	203.89	204.81	202.93	202.29
Temperature	°C	11.9	12.1	12.1	11.7
pH	pH	7.07	7.13	7.14	7.19
Redox	mV	-2	-6	7	0
Conductivity	µmhos/cm	3,190	2,740	1,558	1,358
Chloride[b]	mg/L	725	606	369	162
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0897	0.0750	0.0659	0.0406
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0197	0.0202	0.0259	0.0372
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	0.0006	< 0.0005	0.0007	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0496	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	1.9
Hydrogen-3	pCi/L	< 100	112	< 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, 1999

Parameter	Unit	Date of Sampling			
		03/22/99	06/10/99	09/02/99	11/15/99
Water elevation[a]	m	204.27	205.24	203.22	202.46
Temperature	°C	11.4	13.1	12.3	12.2
pH	pH	7.16	7.39	6.82	7.20
Redox	mV	-6	-25	36	-5
Conductivity	µmhos/cm	1,601	1,454	1,059	1,411
Chloride[b]	mg/L	312	244	269	244
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0758	0.0845	0.0833	0.0817
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0297	0.0335	0.0345	0.0723
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	0.0005	< 0.0005	0.0010	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
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, 1999

Parameter	Unit	Date of Sampling				
		03/23/99	03/23/99	06/10/99	09/03/99	11/15/99
Water elevation[a]	m	186.42	186.42	186.41	186.38	186.38
Temperature	°C	11.3	11.3	12.0	12.1	11.0
pH	pH	11.85	11.85	11.49	10.70	10.65
Redox	mV	-255	-255	-242	-187	-199
Conductivity	µmhos/cm	892	892	676	368	497
Chloride[b]	mg/L	35	39	41	36	42
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.1419	0.1081	0.1149	0.1113	0.0481
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	0.1458	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	0.0018	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0	1.2
Hydrogen-3	pCi/L	144	127	144	154	138
Strontium-90	pCi/L	< 0.25	< 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, 1999

Parameter	Unit	Date of Sampling				
		03/22/99	06/09/99	09/02/99	09/02/99	11/15/99
Water elevation[a]	m	200.13	202.75	200.06	200.06	198.83
Temperature	ºC	10.8	13.0	13.4	13.4	11.5
pH	pH	7.12	7.33	7.45	7.45	7.21
Redox	mV	-2	-19	-10	-10	-1
Conductivity	µmhos/cm	1,154	1,109	815	815	1,066
Chloride[b]	mg/L	44	40	38	36	34
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0369	0.0381	0.0379	0.0372	0.038
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0204	0.0234	0.0355	0.0243	0.0209
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	0.0415	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0906	0.0384	< 0.0110	< 0.0110	0.0114
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0	1.05
Hydrogen-3	pCi/L	< 100	107	< 100	134	117
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Methylene chloride	µg/L	< 1	< 1	1	1	< 1

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

[b] Filtered sample.

TABLE 6.12

Groundwater Monitoring Results,
300 Area Well 319031, 1999

Parameter	Unit	Date of Sampling 03/22/99	Date of Sampling 06/10/99
Water elevation[a]	m	193.14	193.12
Temperature	ºC	11.3	11.8
pH	pH	7.26	7.39
Redox	mV	-9	-21
Conductivity	µmhos/cm	983	979
Chloride[b]	mg/L	31	27
Arsenic[b]	mg/L	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0503	0.0526
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	0.0448	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	0.0231	0.2129
Cesium-137	pCi/L	< 1.0	< 1.0
Hydrogen-3	pCi/L	877	685
Strontium-90	pCi/L	0.36	0.40
1,1,1-Trichloroethane	µg/L	2	2
4-Methyl-2-pentanone	µg/L	< 1	2
Acetone	µg/L	< 1	5
Trichloroethene	µg/L	3	4

[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, 1999

Parameter	Unit	Date of Sampling			
		03/22/99	06/10/99	09/02/99	11/15/99
Water elevation[a]	m	198.42	198.53	197.59	197.05
Temperature	ºC	10.7	11.4	11.4	11.0
pH	pH	7.24	7.39	7.53	7.15
Redox	mV	-7	-20	-13	0
Conductivity	µmhos/cm	1,053	1,067	745	1,023
Chloride[b]	mg/L	16	27	17	17
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0642	0.0740	0.0702	0.0692
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	0.0008	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0157	0.028	0.0115	< 0.011
Americium-241	fCi/L	-[c]	-	< 1.0	-
Curium-244	fCi/L	-	-	< 1.0	-
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	1.0
Hydrogen-3	pCi/L	373	770	487	456
Neptunium-237	fCi/L	-	-	2.2	-
Plutonium-238	fCi/L	-	-	< 1.0	-
Plutonium-239	fCi/L	-	-	5.4	-
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	0.27
1,1,1-Trichloroethane	µg/L	< 1.0	1.0	1.0	< 1.0
1,1-Dichloroethane	µg/L	< 1.0	1.0	< 1.0	< 1.0

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

[b] Filtered samples.

[c] A hyphen indicates that no samples were collected.

TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 319131D, 1999

Parameter	Unit	Date of Sampling				
		03/22/99	06/10/99	06/10/99	09/02/99	11/15/99
Water elevation[a]	m	184.70	184.84	184.84	184.43	184.28
Temperature	ºC	11.1	13.8	13.8	14.2	10.7
pH	pH	7.15	7.31	7.31	7.76	7.27
Redox	mV	-6	-21	-21	-30	-6
Conductivity	µmhos/cm	1,116	1,026	1,026	840	1,092
Chloride[b]	mg/L	49	43	49	49	51
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0656	0.0669	0.0694	0.0733	0.0702
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.0170	0.0621	0.0485	< 0.0170	< 0.0170
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.0110	0.0415	0.0388	< 0.0110	< 0.0110
Americium-241	fCi/L	-[c]	< 1	-	-	-
Curium-242	fCi/L	-	< 1	-	-	-
Curium-244	fCi/L	-	< 1	-	-	-
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0	1.2
Hydrogen-3	pCi/L	1,227	1,250	986	1,398	1,358
Neptunium-237	fCi/L	-	< 1	-	-	-
Plutonium-238	fCi/L	-	< 1	-	-	-
Plutonium-239	fCi/L	-	< 1	-	-	-
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Carbon tetrachloride	µg/L	< 1	1	1	< 1	< 1
Methylene chloride	µg/L	< 1	< 1	< 1	1	< 1

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

[b] Filtered samples.

[c] A hyphen indicates that no samples were collected.

Inorganic Parameters. ANL-E 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. In 1999, all samples for metals analyses were field-filtered prior to preservation with acid (an IEPA requirement for the IEPA-approved groundwater monitoring program at the 800 Area Landfill, Section 6.3.2.3).

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

As noted in previous years, no elevated levels, with respect to the WQS for inorganics, were noted with the exception of pH at dolomite Well 317121D and chloride at Wells 317101 and 317111. Historically, elevated pH values at Well 317121D have been reported. The pH changes drastically between the purging of two to five volumes of water. In each case, the last value obtained was recorded. Well 317111 exceeded the WQS for chloride each quarter, and Well 317101 exceeded the chloride WQS three quarters. Chloride levels ranged from 162 to 725 mg/L. Several wells had elevated levels of barium and manganese, but they were considerably below the WQS. Barium concentrations ranged from 0.02 to 0.14 mg/L, and manganese concentrations ranged from less than 0.017 to 0.072 mg/L. The source of the elevated barium and manganese levels is unknown. Elevated levels of barium and manganese have been reported in previous annual reports.[16]

Organic Parameters. Each well was sampled quarterly and analyzed for VOCs. In 1996 and 1997, VOCs were noted in nine wells. In 1998, VOCs were detected in three wells — 317021, 317061, and 319031 — and in 1999, VOCs were detected in five wells — 317021, 319011, 319031, 319032, and 319131D. Except for Well 319011, these wells are located south of the 317 Area and the 319 Area, near the south perimeter fence. The

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		

concentrations of VOCs in the wells were very low. Well 317021 showed persistent VOC levels, as in the past. Well 319031 is frequently dry but contains organic constituents when water is present. Well 319031 was dry during the third and fourth quarters. VOCs were detected in 319011 only during the third quarter at the detection limit. No organic WQSs were exceeded. The reduction in the frequency and concentration of VOCs may be due to the extensive Soil Treatment Project in the 317 Area completed during 1998 as well as the 319 Landfill expanded groundwater collection system. Over 6,500 m^3 (8,500 yd^3) of VOC-contaminated soil was treated using an innovative treatment approach developed by ANL-E for reduction of VOCs. The 319 Landfill leachate and groundwater collection system was upgraded and expanded with four additional wells for pumping contaminated groundwater to the wastewater treatment system.

Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, pesticides, and herbicides. None of these parameters were found in 1999.

Figure 6.4 shows the results for Well 317021. The major components are 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane; 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 remarkably consistent until 1991, at which time a substantial increase is seen. The consistent levels prior to 1991 would indicate that this well is sampling a large area of contaminated water that is unaffected by seasonal water level changes. The large increase in the summer and fall of 1991 is clearly related to a period of intense drought and also could be related to restricted flow of normal dilution water. In 1999, a trace level of methylene chloride was also found in this well but at levels well below the WQS and only during one quarter. The well is immediately below a former sewer line that was known to be contaminated. The sewer line was permanently closed in 1986 and sealed in 1997.

Manholes E1 and E2, in the 317 Area were sampled monthly and analyzed for VOCs. The results are presented in Table 6.17. Contributors of groundwater into Manholes E1 and E2 include an average of 3,529 L/day (932 gal/day) from the 319 Area groundwater collection system, an average of 29,840 L/day (7,880 gal/day) from the 317 Area groundwater collection system, and groundwater from existing foundation drains around storage vaults. This represents a substantial increase in flow from 1997 and 1998. In May 1997, grouting and sealing a footing drain system in the southeastern portion of the 317 Area to prevent the migration of contaminated groundwater off site was completed. Approximately 183 m (600 ft) of underground pipe and bedding material was sealed in the 317 Area south of the deactivated South Vault system. At a future date, all underground piping immediately south of the Deep Vault, Map Tube Vault, and North Vault will be grouted and sealed.

In general, volatile constituent concentrations decreased from levels noted in previous years (see Figure 6.5). In addition, the ratios of the decreases in concentrations between Manhole E1 and

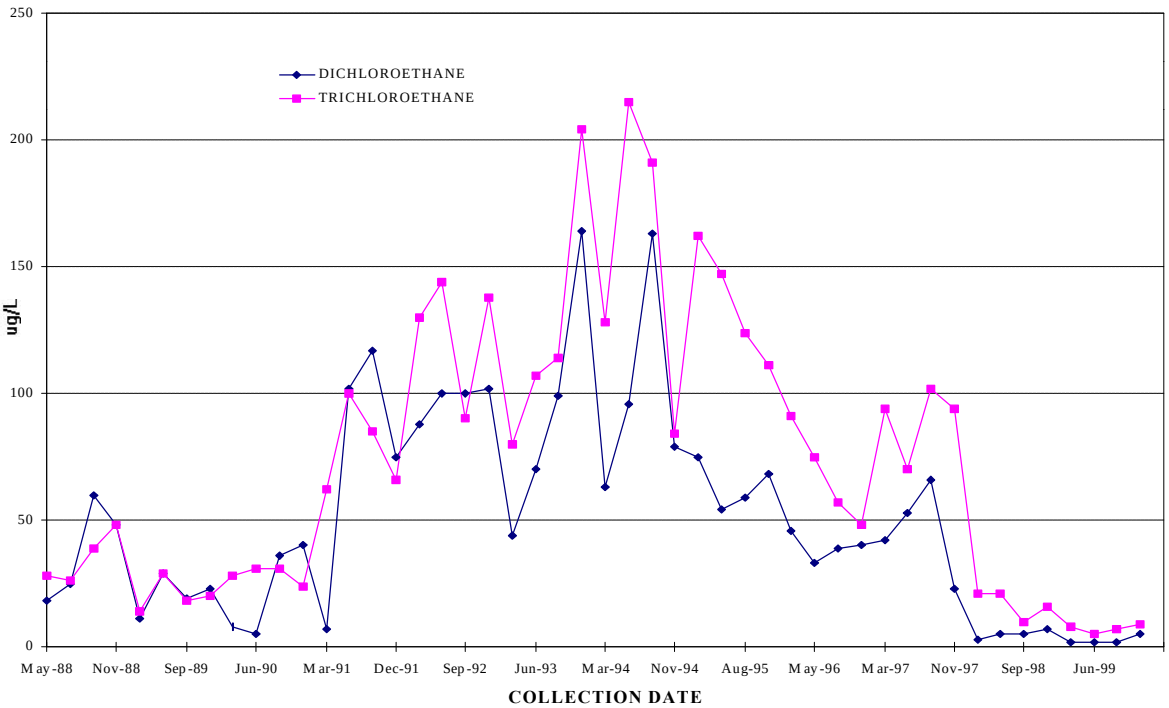


Figure 6.4 Concentration of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

Manhole E2 (see Figure 6.6 and Table 6.17) have changed significantly since 1998; most likely these changes can be attributed to the dilution of Manhole E2 water. Remediation activities in the 317 and 319 Areas has resulted in Manhole E2 receiving increased groundwater flows from these areas. Starting in October 1997, as part of the 317 Area remediation project, 317 Area groundwater was pumped at a rate of over 4,542 L/day (1,200 gal/day) to Manhole E2, increasing to 29,840 L/day (7,880 gal/day) in 1999.

Chloroform is a degradation product of carbon tetrachloride. Cis-1,2-dichloroethene (1,2-DCE) is a degradation product of TCE. The fact that both the original and breakdown products are present in most samples indicates an ongoing release of these compounds into the groundwater, such as from highly contaminated soils. Trace levels of acetone, dichlorofluoromethane, methylene chloride, trans-1,2-DCE, tribromoethene, 1,2-dibromoethene, 1,2-dichloroethane, vinyl chloride, tetrahydrofuran, and 4-methyl-2-pentanone have been detected, but at low levels and not on a consistent basis. The source of these compounds is believed to be the French drains previously described in Section 6.2.1. Extensive characterization activities continue to better define the nature, rate, and extent of contamination at this location.

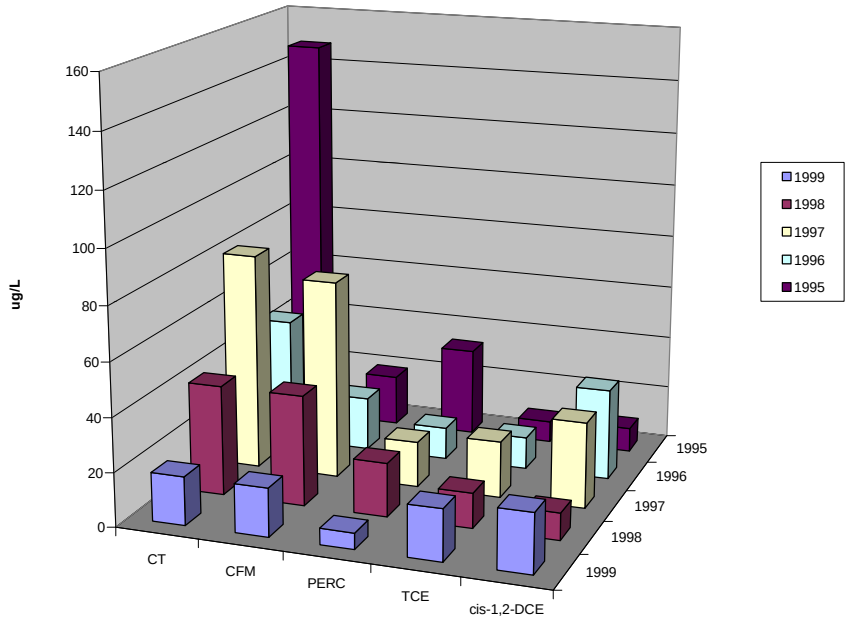
TABLE 6.17

Volatile Organic Compounds in the 317 Area: Manholes E1 and E2, 1999
(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 13	5	5	< 1	2	2	3	5	6	22	24	7	4	13	14
February 11	53	7	27	5	12	13	32	33	3	4	153	14	3	14
March 9	38	9	7	5	7	7	10	12	31	16	43	16	29	18
April 16	188	114	34	28	46	34	14	15	14	25	169	101	13	23
May 10	99	9	19	3	38	57	30	8	38	142	93	13	51	261
June 3	343	19	57	8	54	10	18	4	31	50	342	22	25	37
July 8	610	2	57	< 1	41	10	38	27	30	4	463	< 1	33	1
August 8	216	8	26	2	33	22	26	24	76	100	123	5	58	99
September 14	196	1	26	< 1	21	10	18	14	17	26	235	2	23	43
October 14	171	1	23	1	23	8	22	7	33	33	157	2	47	50
November 10	116	3	18	2	23	25	20	84	53	43	127	4	113	88
December 9	206	39	42	10	40	34	27	25	68	111	261	35	141	248

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. An annual sample for alpha-emitters was collected from Wells 317021, 319031, 319032, and 319131D. 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, cesium-137, strontium-90, and alpha-emitters in wells located near the south perimeter fence in the 317 and 319 Areas. Hydrogen-3 was detected in Wells 317021, 317052, 317061, and 317121D, located south of the 317 Area. It was detected during one quarter in upgradient Well 317101. Hydrogen-3 was also detected in Wells 319011, 319031, 319032, and 319131D, which (except for Well 319011) are located near the south 319 Area perimeter fence. Cesium-137 was detected in Wells 317021, 317052, 317061, and 317121D located south of the 317 Area near the south perimeter fence. Cesium-137 was also detected in Wells 317101 and 317111, which are upgradient of the 317 Area. A small amount of cesium-137 was also detected in Well 319131D, which is south of the 319 Area near the south perimeter fence. It was also detected one quarter in upgradient Well 319011. Strontium-90 was detected in Wells 319031 and 319032, which are near the south perimeter fence. Alpha-emitters were monitored and detected in Well 319032. Wells 319031, 319032, and 319131D are directly below a small drainage swale from the 319 Area that has contained water intermittently with measurable concentrations of hydrogen-3 and strontium-90. All concentrations are well below any applicable standards.

Water from the 317 Area and 319 Area groundwater collection systems is pumped to Manhole 2E. Manhole 1E is connected to the footing drain system around the operating vaults. In



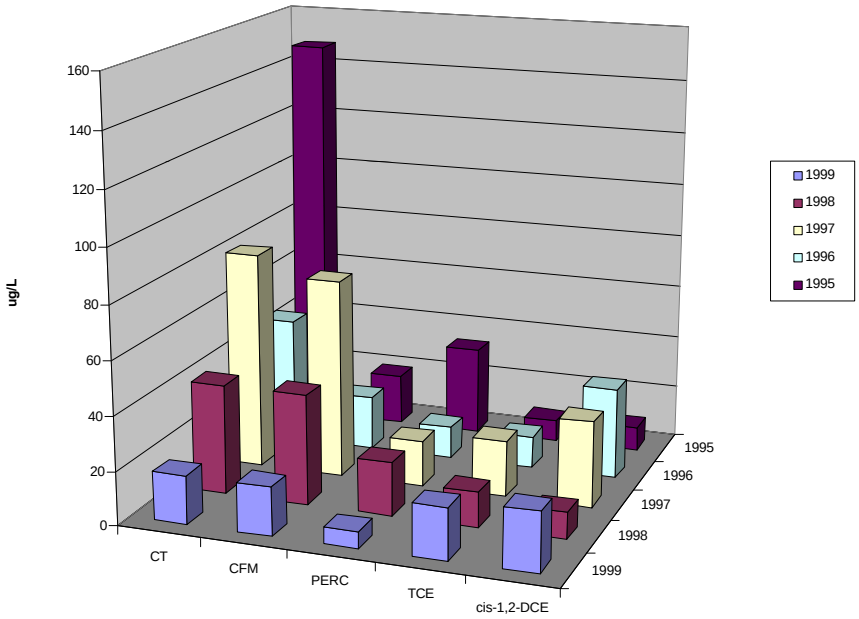
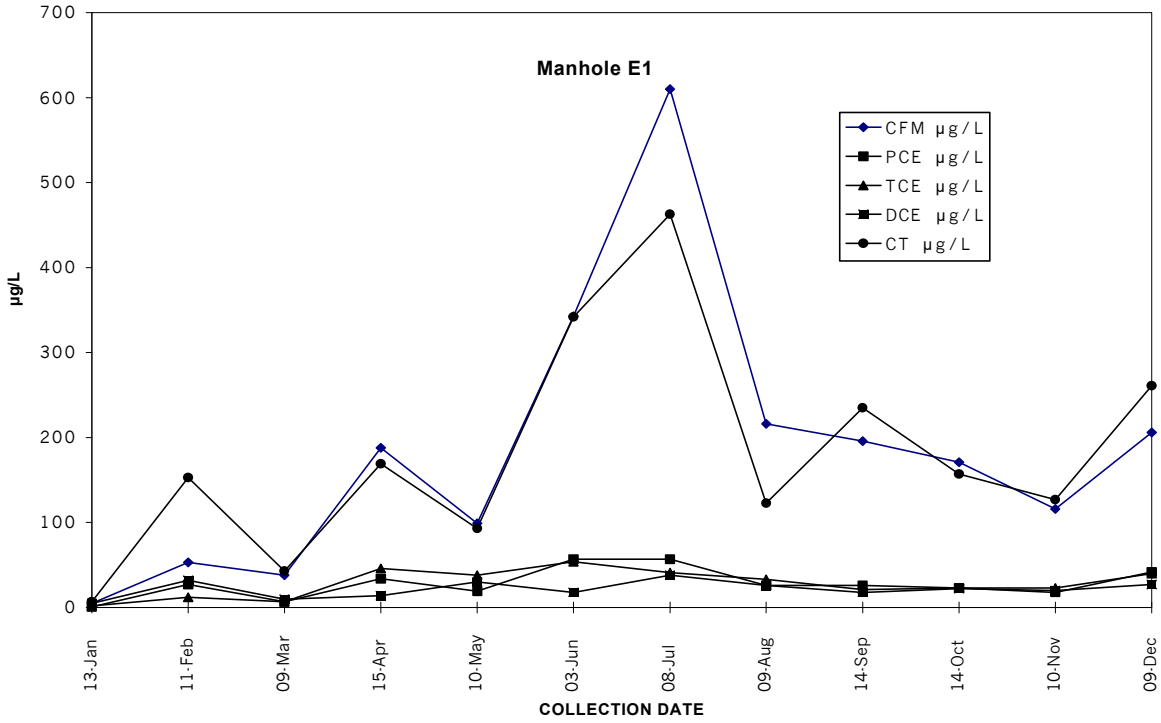


Figure 6.5 Manhole E1 and Manhole E2 Average Groundwater Concentrations, 1995 to 1999



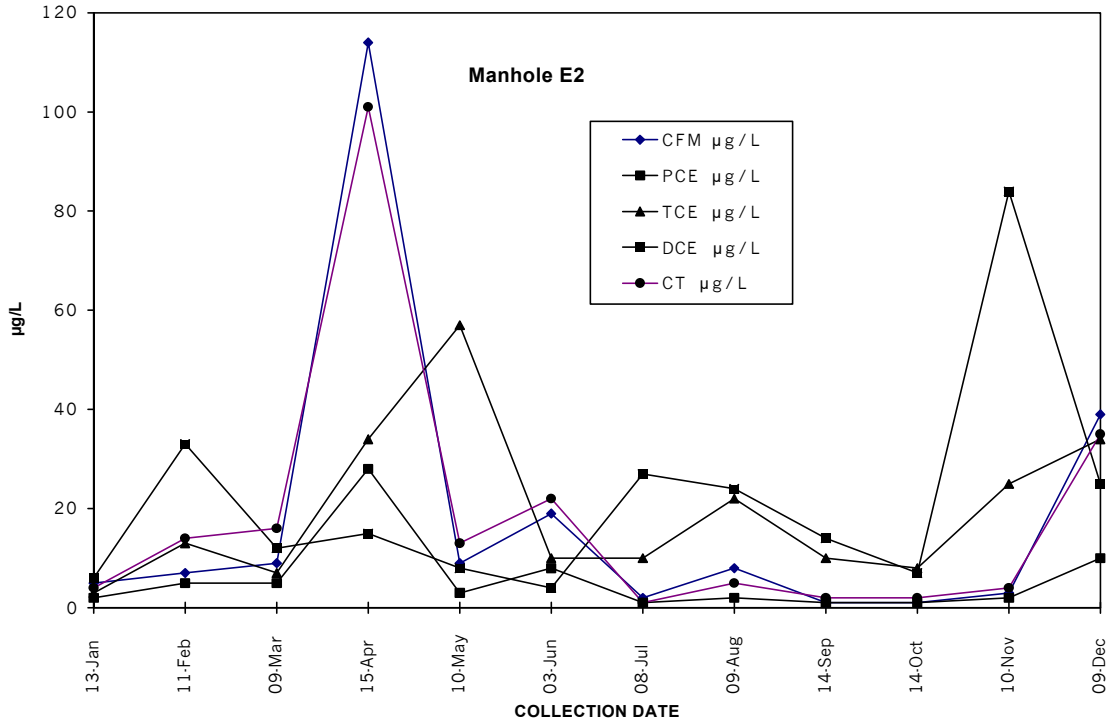


Figure 6.6 Trends of Selected Organics in 317 Area Manholes, 1999

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. Since hydrogen-3 concentrations are generally higher in Manhole 2E, the source of the hydrogen-3 appears to be from the groundwater pumping system. In contrast, the VOCs, see Table 6.17, are generally higher in Manhole 1E, which implies that the main source of the VOCs is the 317 Area French Drain. No gamma-ray–emitting radionuclides were detected in any samples.

TABLE 6.18

Hydrogen-3 Concentrations in Manhole Water Samples, 1999
(Concentrations in pCi/L)

Date Collected	Manhole 1E	Manhole 2E
January 13	13,710	14,190
February 11	76,190	85,370
March 9	14,870	16,730
April 16	4,441	11,190
May 10	103,100	14,780
June 3	873	3,366
July 8	75,960	63,000
August 9	27,070	22,430
September 14	20,660	14,950
October 14	26,960	8,636
November 10	19,000	56,880
December 9	11,620	16,230

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 less than the detection limit of 100 pCi/L. This indicates that any subsurface contaminant movement has not extended to this location and indicates a western limit to movement.

6.3. Sanitary Landfill

The 800 Area is the site of the ANL-E sanitary landfill. The 8.8-ha (21.8-acre) landfill is located on the western edge of ANL-E property (Figure 1.1). The landfill has received waste since 1966 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 until September 1992. The landfill is now being closed pursuant to Permit No. 1992-002-SP and Supplemental Permit Nos. 1994-506-SP, 1997-295-SP, 1998-017-SP, and 1999-107-SP.

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 thence into the soil and fill material.

Available documentation indicates that 109,000 L (29,000 gal) of liquid waste was placed in this drain. Some of the wastes disposed of in this manner are now defined as hazardous wastes. The presence of volatile and other toxic organic compounds has been confirmed by soil gas surveys and leachate sampling conducted at the landfill. Measurable amounts of these materials were identified in soil vapor leachate but not groundwater near the landfill.

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 6.7 and Table 6.19). Wells 800241 and 800243D, installed during 1995, were formally incorporated into the 800 Area Landfill Groundwater Monitoring Program by IEPA Supplemental Permit No. 1998-017-SP, effective August 25, 1998. The analytical data collected from these wells is being evaluated in order to determine their appropriateness for use as upgradient wells for the shallow and deep series wells. Informational monitoring of these wells commenced during July 1998.

IEPA Supplemental Permit No. 1999-107-SP, effective June 16, 1999, provided for (1) the installation and addition of three new upgradient groundwater monitoring wells, Nos. 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 6.19 provides information on these wells, and Figure 6.7 shows their locations. Wells 800272, 800311, and 800321 have been dry since installation.

In late spring of 1999, an environmental remediation project was completed that resulted in the extension of the north portion of the landfill to cover some recently identified waste material. As part of this project, the fence was moved 15 m (50 ft) north, and monitoring wells Nos. 800161, 800162, and 800163D were also relocated. During the first two quarters of 1999, results are for Wells 800161, 800162, and 800163D, while for the last quarters, the replacement wells, Nos. 800381, 800382, and 800383D, were sampled.

6.3.2.1. Sample Collection

The same procedure for well water sample collection previously described for the 300 Area was used for this area. Each well is sampled annually for semivolatiles, PCBs, pesticides, and

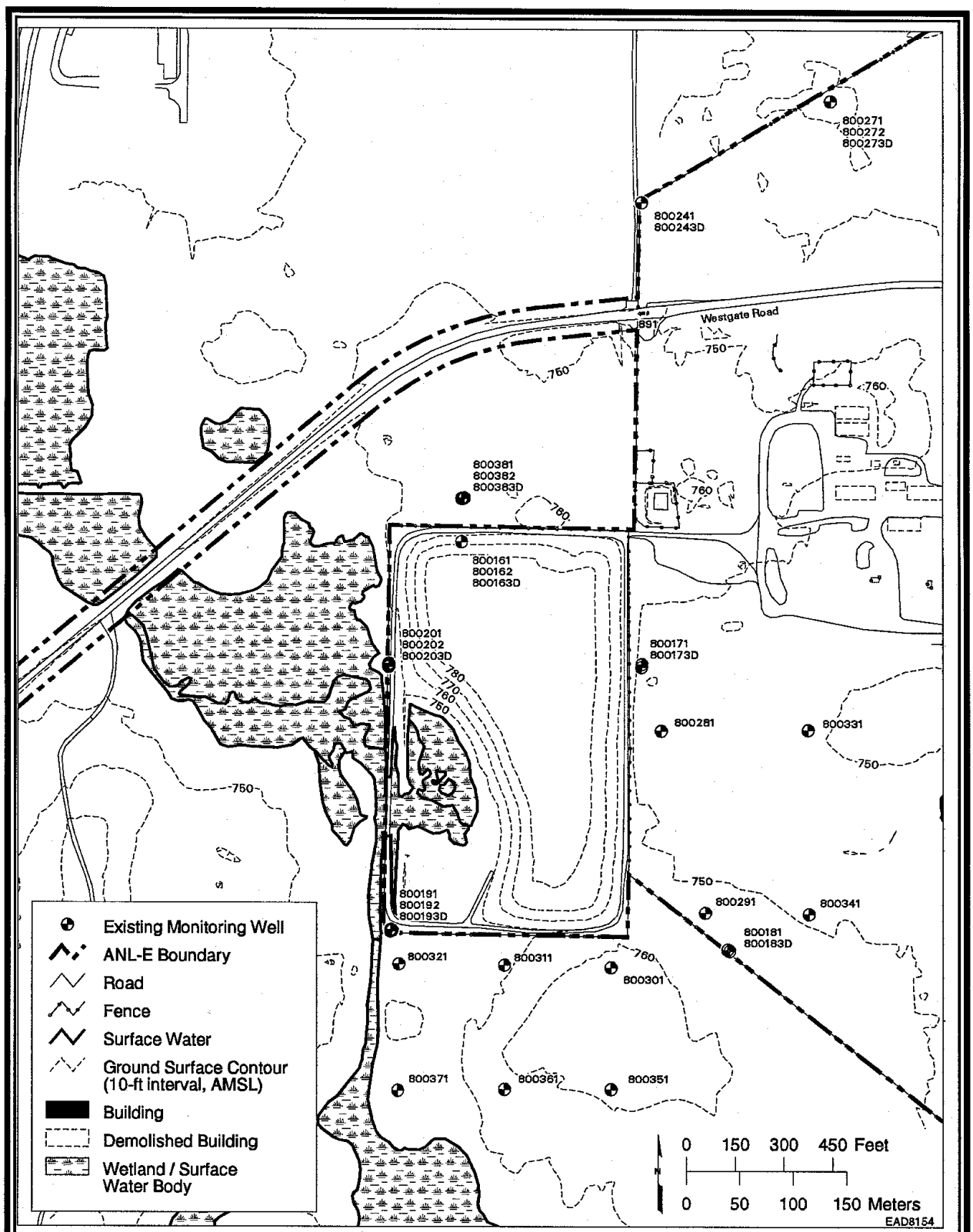


Figure 6.7 Active Monitoring Wells in the 800 Area Landfill

TABLE 6.19

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
800161	7.94	230.8	224.3 – 222.8	0.05/SS	10/92
800162	20.76	230.7	211.5 – 210.0	0.05/SS	10/92
800163D	47.00	230.8	186.8 – 183.8	0.05/SS	9/92
800171	7.71	228.4	222.2 – 220.7	0.05/SS	10/92
800173D	39.08	228.4	192.4 – 189.3	0.05/SS	10/92
800181	11.01	230.5	221.0 – 219.5	0.05/SS	10/92
800183D	49.68	230.4	183.7 – 180.7	0.05/SS	10/92
800191	4.62	227.4	224.3 – 222.8	0.05/SS	10/92
800192	18.67	227.4	210.2 – 208.7	0.05/SS	10/92
800193D	45.48	227.4	185.0 – 181.9	0.05/SS	10/92
800201	10.74	227.9	218.7 – 217.2	0.05/SS	10/92
800202	18.52	227.9	210.9 – 209.4	0.05/SS	10/92
800203D	38.47	227.9	192.5 – 189.5	0.05/SS	9/92
800241	4.90	226.1	224.3 – 221.3	0.05/SS	3/95
800243D	35.50	226.1	193.9 – 190.8	0.05/SS	4/95
800271	3.98	225.7	193.4 – 222.5	0.05/SS	8/99
800272	13.77	225.7	214.2 – 212.7	0.05/SS	8/99
800273D	36.72	225.7	192.8 – 189.7	0.05/SS	8/99
800281	3.98	227.7	226.2 – 224.6	0.05/SS	9/99
800291	7.34	230.5	225.5 – 224.0	0.05/SS	9/99
800301	7.04	232.6	227.7 – 226.2	0.05/SS	9/99
800311	12.85	227.5	218.5 – 215.4	0.05/SS	9/99
800321	3.67	228.0	227.4 – 225.9	0.05/SS	9/99
800331	5.20	228.0	225.2 – 223.7	0.05/SS	9/99
800341	3.67	230.0	228.6 – 227.1	0.05/SS	9/99
800351	11.63	232.8	225.2 – 222.2	0.05/SS	9/99
800361	7.04	227.6	222.8 – 221.3	0.05/SS	9/99
800371	9.79	227.6	220.0 – 218.5	0.05/SS	9/99
800381[c]	7.65	231.2	226.8 – 225.2	0.05/SS	6/99
800382[c]	19.89	231.2	214.5 – 213.0	0.05/SS	6/99
800383D[c]	44.38	231.3	190.0 – 188.5	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.

herbicides. Also, during the second quarter, in accordance with the IEPA-approved groundwater monitoring plan, both filtered and unfiltered samples for numerous parameters (e.g., metals, chloride, sulfate) are required. Volatile organics are monitored each quarter, although only required by permit during the second quarter.

6.3.2.2. Sample Analyses - 800 Area

The 800 Area sample analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of ESH-ASCL, PFS-Utilities Laboratory, and ESH-ASRL. These SOPs reference protocols in SW-846.[8] Fifteen metals were routinely determined and analyzed by using flame atomic absorption spectroscopy, inductively coupled plasma atomic emission spectroscopy, and graphite furnace atomic absorption spectroscopy. Mercury was determined by 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 solvent extraction followed by gas chromatography-mass spectroscopy detection. PCBs and pesticides were determined by solvent extraction followed by gas chromatography-electron capture detection. In the case of organic compound analyses, efforts were made to identify compounds that were present but not included on the method list. This was accomplished, and standard solutions of these compounds were prepared and analyzed. TDS were determined gravimetrically. Sulfate determination was performed by using a turbidimetric technique, while chloride was determined by 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. SW-846[8] procedures were specified and used. Cyanide and phenol were determined by distillation followed by a spectrophotometric finish. Total organic carbon (TOC) and total organic halogen (TOX) were determined by 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 chromotography techniques, respectively.

The 800 Area groundwater radiological analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of ESH-ASRL. Hydrogen-3 was determined by distillation followed by a beta liquid scintillation counting technique.

6.3.2.3. 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 6.20 to 6.47. All radiological and inorganic analysis results are shown in these tables. The

analytical methods used for organic compounds could 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. Figures 6.8 to 6.22 show the trends for exceedances of the WQS for wells monitored as part of the IEPA-approved groundwater monitoring program for the sanitary landfill. Results represent filtered samples only because filtered samples are collected each quarter for the constituents presented.

ANL-E chose a conservative approach for evaluating the inorganic monitoring results by selecting as the standard of comparison the Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater, 35 IAC Part 620.410. The most common constituents at levels above the WQS (see Table 6.15) are chloride, iron, TDS, and manganese. This is consistent with results reported in prior years using the previous well monitoring network. In general, data for the shallow wells indicate exceedances of the manganese, iron, TDS, and chloride WQSs in a number of wells. These results are consistent with results reported in prior years. The intermediate wells have fewer exceedances except for manganese, which exceeded the WQS in each intermediate well. The iron WQS was exceeded in two wells. The results for the deep wells show only manganese exceedances.

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. No standards exist for comparative purposes, with the exception of pH. However, results are consistent from quarter to quarter and 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. Ammonia, arsenic, cadmium, lead, and mercury were all less than the WQS. Sulfate exceeded the WQS (400 mg/L) in Well 800381 during one quarter. Chloride exceeded the WQS (200 mg/L) in Well 800241 during three quarters, and the chloride levels ranged from 481 to 531 mg/L. Well 800241 is considered an upgradient well. TDS exceeded the WQS (1,200 mg/L) in Well 800241 also during three quarters, and the TDS levels ranged from 1,347 to 1,499 mg/L. Chloride and TDS in Well 800241 are due to road salt runoff, since the well is located within 100 m (300 ft) of a main road and is screened only 2 m (6 ft) below the surface. The other upgradient well, 800271, had no exceedances of the WQS.

Iron concentrations exceeded the WQS (5 mg/L) at least once during the year in Wells 800191, 800192, 800201, 800202, and 800241. Iron levels in these wells ranged from 5 to 143 mg/L.

Manganese concentrations exceeded the WQS (0.15 mg/L) during at least one quarter in Wells 800161, 800381, 800162, 800163D, 800171, 800181, 800191, 800192, 800201, 800202, 800241, 800243D, 800281, 800291, 800301, 800331, and 800341. Manganese levels in these wells ranged from 0.16 to 1.78 mg/L. Manganese appears to be elevated over the entire 800 Landfill area, and

TABLE 6.20

Groundwater Monitoring Results, Sanitary Landfill
Well 800161, 1999

Parameter	Unit	Date of Sampling 01/21/99	Date of Sampling 04/06/99
Water elevation[a]	m	227.49	228.66
Temperature	ºC	11.3	9.7
pH	pH	7.37	7.04
Redox	mV	-11	-9
Conductivity	µmhos/cm	1,379	1,384
Chloride[b]	mg/L	65	135
Sulfate[b]	mg/L	142	132
TDS[b]	mg/L	858	848
Cyanide (total)[c]	mg/L	< 0.01	< 0.01
Arsenic[c]	mg/L	-d	0.0204
Barium[c]	mg/L	-	0.2726
Boron[c]	mg/L	-	0.1955
Cadmium[c]	mg/L	-	0.0006
Chromium[c]	mg/L	-	< 0.044
Cobalt[c]	mg/L	-	< 0.026
Copper[c]	mg/L	-	0.0481
Iron[c]	mg/L	-	37.78
Lead[c]	mg/L	-	0.0275
Manganese[c]	mg/L	-	1.281
Mercury[c]	mg/L	-	< 0.0001
Nickel[c]	mg/L	-	0.0435
Selenium[c]	mg/L	-	< 0.003
Silver[c]	mg/L	-	< 0.0005
Zinc[c]	mg/L	-	0.2723
Chlordane	µg/L	-	< 0.5
Ammonia nitrogen[b]	mg/L	0.1	0.2
Arsenic[b]	mg/L	< 0.0025	0.0043
Barium[b]	mg/L	0.1507	0.0552
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	0.4142	1.817
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	0.7304	0.0492
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1
Phenols	mg/L	< 0.005	0.011
Cesium-137	pCi/L	-	< 1.0
Hydrogen-3	pCi/L	325	138
Chloride	mg/L	-	81
Fluoride	mg/L	-	0.306
Sulfate	mg/L	-	129
TOCs	mg/L	13.8	4.1
TOCs	mg/L	12.0	4.0
TOCs	mg/L	13.8	4.2
TOCs	mg/L	14.0	4.2
TOXs	mg/L	0.012	0.071
TOXs	mg/L	0.011	0.079

[a] Well point elevation = 222.83 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.21

Groundwater Monitoring Results, Sanitary Landfill
Well 800162, 1999

Parameter	Unit	Date of Sampling	
		01/21/99	04/06/99
Water elevation[a]	m	218.63	219.06
Temperature	°C	10.5	10.6
pH	pH	7.26	6.98
Redox	mV	-5	-2
Conductivity	µmhos/cm	1,059	1,070
Chloride[b]	mg/L	54	61
Sulfate[b]	mg/L	74	34
TDS[b]	mg/L	641	645
Cyanide (total)[c]	mg/L	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	< 0.0025
Barium[c]	mg/L	-	0.062
Boron[c]	mg/L	-	0.1362
Cadmium[c]	mg/L	-	< 0.0002
Chromium[c]	mg/L	-	< 0.044
Cobalt[c]	mg/L	-	< 0.026
Copper[c]	mg/L	-	< 0.017
Iron[c]	mg/L	-	1.438
Lead[c]	mg/L	-	< 0.002
Manganese[c]	mg/L	-	0.2584
Mercury[c]	mg/L	-	< 0.0001
Nickel[c]	mg/L	-	< 0.04
Selenium[c]	mg/L	-	< 0.003
Silver[c]	mg/L	-	< 0.0005
Zinc[c]	mg/L	-	0.0149
Ammonia nitrogen[b]	mg/L	0.3	0.2
Arsenic[b]	mg/L	0.0027	< 0.0025
Barium[b]	mg/L	0.0644	0.0593
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	1.249	1.149
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	0.27	0.254
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1
Phenols	mg/L	< 0.005	< 0.005
Hydrogen-3	pCi/L	< 100	< 100
Chloride	mg/L	-	60
Fluoride	mg/L	-	0.252
Sulfate	mg/L	-	34
TOCs	mg/L	4.7	3.8
TOCs	mg/L	4.6	3.6
TOCs	mg/L	4.5	3.6
TOCs	mg/L	4.6	3.7
TOXs	mg/L	0.039	0.045
TOXs	mg/L	0.035	0.022

[a] Well point elevation = 183.79 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.22

Groundwater Monitoring Results, Sanitary Landfill
Well 800163D, 1999

Parameter	Unit	Date of Sampling 01/21/99	Date of Sampling 04/06/99
Water elevation[a]	m	192.97	192.77
Temperature	ºC	11.2	11.1
pH	pH	7.25	7.13
Redox	mV	-4	-12
Conductivity	µmhos/cm	1,339	1,354
Chloride[b]	mg/L	134	61
Sulfate[b]	mg/L	190	187
TDS[b]	mg/L	881	871
Cyanide (total)[c]	mg/L	< 0.01	0.012
Arsenic[c]	mg/L	-[d]	0.0097
Barium[c]	mg/L	-	0.0768
Boron[c]	mg/L	-	0.1911
Cadmium[c]	mg/L	-	< 0.0002
Chromium[c]	mg/L	-	< 0.044
Cobalt[c]	mg/L	-	< 0.026
Copper[c]	mg/L	-	< 0.017
Iron[c]	mg/L	-	6.754
Lead[c]	mg/L	-	< 0.002
Manganese[c]	mg/L	-	0.0609
Mercury[c]	mg/L	-	< 0.0001
Nickel[c]	mg/L	-	< 0.04
Selenium[c]	mg/L	-	< 0.003
Silver[c]	mg/L	-	0.0008
Zinc[c]	mg/L	-	0.3128
Ammonia nitrogen[b]	mg/L	0.7	1.0
Arsenic[b]	mg/L	0.0051	< 0.0025
Barium[b]	mg/L	0.0551	0.1321
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	1.984	0.5192
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	0.0505	0.6039
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	0.0239
Nitrate	mg/L	-	< 0.1
Phenols	mg/L	< 0.005	< 0.005
Hydrogen-3	pCi/L	< 100	< 100
Chloride	mg/L	-	139
Fluoride	mg/L	-	0.376
Sulfate	mg/L	-	184
TOCs	mg/L	2.8	2.5
TOCs	mg/L	2.7	2.4
TOCs	mg/L	2.8	2.4
TOCs	mg/L	2.8	2.4
TOXs	mg/L	0.026	0.076
TOXs	mg/L	0.037	0.059

[a] Well point elevation = 183.79 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.23

Groundwater Monitoring Results, Sanitary Landfill
Well 800381, 1999

Parameter	Unit	Date of Sampling	
		08/10/99	10/01/99
Water elevation[a]	m	227.31	226.77
Temperature	°C	12.2	12.9
pH	pH	7.05	7.06
Redox	mV	7	10
Conductivity	µmhos/c	1,399	2,150
Chloride[b]	mg/L	37	110
Sulfate[b]	mg/L	161	456
TDS[b]	mg/L	854	959
Cyanide (total)	mg/L	< 0.01	< 0.01
Ammonia	mg/L	< 0.1	< 0.1
Arsenic[b]	mg/L	0.0136	0.0043
Barium[b]	mg/L	0.1007	0.0509
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	0.6839	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	0.2097	0.2293
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011
Phenols	mg/L	0.006	0.010
Hydrogen-3	pCi/L	< 100	< 100
TOCs	mg/L	3.9	3.8
TOCs	mg/L	3.6	3.9
TOCs	mg/L	4.1	3.8
TOCs	mg/L	3.6	4.2
TOXs	mg/L	0.019	0.040
TOXs	mg/L	0.018	0.041

[a] Well point elevation = 225.20 m (MSL); ground surface elevation = 232.00 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.24

Groundwater Monitoring Results, Sanitary Landfill
Well 800382, 1999

Parameter	Unit	Date of Sampling	
		08/10/99	10/01/99
Water elevation[a]	m	219.83	219.31
Temperature	°C	11.2	13.9
pH	pH	7.14	7.54
Redox	mV	-5	-22
Conductivity	µmhos/cm	998	985
Chloride[b]	mg/L	58	80
Sulfate[b]	mg/L	52	69
TDS[b]	mg/L	665	652
Cyanide (total)	mg/L	< 0.01	< 0.01
Ammonia nitrogen[b]	mg/L	0.4	0.3
Arsenic[b]	mg/L	< 0.0025	< 0.0025
Barium[b]	mg/L	0.1160	0.1115
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	0.1726	0.0727
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	0.0837	0.0627
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011
Phenols	mg/L	0.014	0.014
Hydrogen-3	pCi/L	< 100	< 100
TOCs	mg/L	3.5	2.8
TOCs	mg/L	3.4	3.0
TOCs	mg/L	3.5	2.5
TOCs	mg/L	3.9	2.4
TOXs	mg/L	0.019	0.037
TOXs	mg/L	0.024	0.034
Methylene chloride	µg/L	1	< 1

[a] Well point elevation = 213.00 m (MSL); ground surface elevation = 232.10 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.25

Groundwater Monitoring Results, Sanitary Landfill
Well 800383D, 1999

Parameter	Unit	Date of Sampling	
		08/10/99	10/01/99
Water elevation[a]	m	193.23	192.94
Temperature	°C	13.6	12.5
pH	pH	7.29	7.54
Redox	mV	-10	-11
Conductivity	µmhos/cm	1,267	1,302
Chloride[b]	mg/L	117	129
Sulfate[b]	mg/L	130	150
TDS[b]	mg/L	863	851
Cyanide (total)	mg/L	< 0.01	< 0.01
Ammonia nitrogen[b]	mg/L	0.7	0.6
Arsenic[b]	mg/L	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0825	0.0778
Beryllium[b]	mg/L	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017
Iron[b]	mg/L	0.6598	0.8966
Lead[b]	mg/L	< 0.002	< 0.002
Manganese[b]	mg/L	0.1478	0.0872
Mercury[b]	mg/L	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011
Phenols	mg/L	< 0.005	0.009
Hydrogen-3	pCi/L	< 100	< 100
TOCs	mg/L	2.2	1.4
TOCs	mg/L	2.1	1.4
TOCs	mg/L	2.1	1.4
TOCs	mg/L	3.0	1.4
TOXs	mg/L	0.027	0.028
TOXs	mg/L	0.041	0.025
Dibromomethane	µg/L	1	< 1

[a] Well point elevation = 188.50 m (MSL); ground surface elevation = 232.20 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.26

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 1999

Parameter	Unit	Date of Sampling				
		01/18/99	04/07/99	07/13/99	07/13/99	10/04/99
Water elevation[a]	m	226.20	226.17	225.75	225.75	225.69
Temperature	ºC	11.3	11.1	13.3	13.3	12.4
pH	pH	6.97	6.73	6.67	6.67	7.21
Redox	mV	11	13	19	19	-3
Conductivity	µmhos/cm	1,516	1,420	1,414	1,414	1,398
Chloride[b]	mg/L	32	29	22	22	22
Sulfate[b]	mg/L	190	191	201	205	197
TDS[b]	mg/L	976	941	921	914	925
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	< 0.0025	-	-	-
Barium[c]	mg/L	-	0.1131	-	-	-
Boron[c]	mg/L	-	0.1378	-	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-	-
Chromium[c]	mg/L	-	< 0.044	-	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-	-
Copper[c]	mg/L	-	< 0.017	-	-	-
Iron[c]	mg/L	-	5.979	-	-	-
Lead[c]	mg/L	-	0.004	-	-	-
Manganese[c]	mg/L	-	0.6105	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	< 0.04	-	-	-
Selenium[c]	mg/L	-	< 0.003	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.0832	-	-	-
Ammonia nitrogen[b]	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	0.0030
Barium[b]	mg/L	0.0702	0.0715	0.0670	0.0652	0.0690
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.2513	0.1942	0.4032	0.4001	0.2372
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	0.0005	< 0.0005	< 0.0005	0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0129	0.0330	< 0.0110	< 0.0110	0.0115
Nitrate	mg/L	-	< 0.1	-	-	-
Phenols	mg/L	< 0.005	0.007	< 0.005	< 0.005	0.008
Cesium-137	pCi/L	-	< 1.0	-	-	-
Hydrogen-3	pCi/L	155	108	< 100	< 100	< 100
Chloride	mg/L	-	29	-	-	-
Fluoride	mg/L	-	0.186	-	-	-
Sulfate	mg/L	-	199	-	-	-
TOCs	mg/L	3.1	2.3	3.6	3.1	2.5
TOCs	mg/L	3.4	2.4	3.6	3.1	2.5
TOCs	mg/L	3.2	2.3	3.5	3.1	2.5
TOCs	mg/L	3.2	2.4	3.3	3.1	2.6
TOXs	mg/L	0.037	0.028	0.023	0.035	0.018
TOXs	mg/L	0.030	0.025	0.029	0.038	0.014
Trichloroethene	µg/L	1	1	1	1	1

[a] Well point elevation = 220.71 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 1999

Parameter	Unit	Date of Sampling				
		01/18/99	01/18/99	04/07/99	07/13/99	10/04/99
Water elevation[a]	m	192.70	192.70	192.64	192.53	192.15
Temperature	ºC	10.3	10.3	12.9	12.5	10.7
pH	pH	7.3	7.3	7.07	7.09	7.35
Redox	mV	-5	-5	-6	-5	-8
Conductivity	µmhos/cm	1,445	1,445	1,307	1,354	1,297
Chloride[b]	mg/L	197	181	178	159	156
Sulfate[b]	mg/L	109	90	103	100	89
TDS[b]	mg/L	897	888	857	898	826
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	-	0.0055	-	-
Barium[c]	mg/L	-	-	0.0922	-	-
Boron[c]	mg/L	-	-	0.1733	-	-
Cadmium[c]	mg/L	-	-	< 0.0002	-	-
Chromium[c]	mg/L	-	-	< 0.044	-	-
Cobalt[c]	mg/L	-	-	< 0.026	-	-
Copper[c]	mg/L	-	-	< 0.017	-	-
Iron[c]	mg/L	-	-	3.656	-	-
Lead[c]	mg/L	-	-	< 0.002	-	-
Manganese[c]	mg/L	-	-	0.0754	-	-
Mercury[c]	mg/L	-	-	< 0.0001	-	-
Nickel[c]	mg/L	-	-	< 0.04	-	-
Selenium[c]	mg/L	-	-	< 0.003	-	-
Silver[c]	mg/L	-	-	< 0.0005	-	-
Zinc[c]	mg/L	-	-	< 0.011	-	-
Ammonia nitrogen[b]	mg/L	0.9	0.9	0.5	0.4	0.6
Arsenic[b]	mg/L	0.0062	0.0068	0.0054	0.0041	0.0030
Barium[b]	mg/L	0.0862	0.0824	0.0818	0.0850	0.0630
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	3.345	3.403	3.148	2.700	1.403
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0720	0.0732	0.0727	0.0891	0.0826
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	0.0006	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.008
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride	mg/L	-	-	175	-	-
Fluoride	mg/L	-	-	0.352	-	-
Sulfate	mg/L	-	-	107	-	-
TOCs	mg/L	5.0	5.1	3.3	3.7	3.0
TOCs	mg/L	5.0	4.9	3.2	3.4	3.1
TOCs	mg/L	4.8	4.9	3.3	3.6	3.0
TOCs	mg/L	4.8	4.9	3.3	3.8	3.1
TOXs	mg/L	0.025	0.037	0.038	0.029	0.034
TOXs	mg/L	0.049	0.039	0.051	0.025	0.030

[a] Well point elevation = 189.34 m (MSL); ground surface elevation = 228.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 1999

Parameter	Unit	Date of Sampling			
		01/18/99	04/08/99	07/13/99	10/04/99
Water elevation[a]	m	222.67	223.07	222.75	221.55
Temperature	ºC	10.0	10.8	11.1	9.8
pH	pH	8.03	6.75	7.07	7.49
Redox	mV	-38	8	-4	-8
Conductivity	µmhos/cm	1,404	1,182	1,155	1,161
Chloride[b]	mg/L	4	5	6	4
Sulfate[b]	mg/L	206	215	221	205
TDS[b]	mg/L	773	773	817	749
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0038	-	-
Barium[c]	mg/L	-	0.1605	-	-
Boron[c]	mg/L	-	0.1229	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	13.06	-	-
Lead[c]	mg/L	-	0.005	-	-
Manganese[c]	mg/L	-	0.216	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0487	-	-
Ammonia nitrogen[b]	mg/L	<0.1	< 0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0848	0.0877	0.0737	0.0773
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	< 0.0002	0.0006	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0309	< 0.011	0.0403	0.0331
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.011
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Chloride	mg/L	-	5	-	-
Fluoride	mg/L	-	0.256	-	-
Sulfate	mg/L	-	211	-	-
TOCs	mg/L	1.9	1.3	1.7	1.4
TOCs	mg/L	1.9	1.3	1.9	1.3
TOCs	mg/L	2.0	1.4	1.6	1.3
TOCs	mg/L	2.0	1.3	1.7	1.7
TOXs	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
TOXs	mg/L	< 0.01	< 0.01	< 0.01	< 0.01

[a] Well point elevation = 219.52 m (MSL); ground surface elevation = 230.52 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 1999

Parameter	Unit	Date of Sampling			
		01/18/99	04/08/99	07/13/99	10/04/99
Water elevation[a]	m	192.71	192.69	192.52	192.14
Temperature	ºC	9.7	12.1	11.8	10.9
pH	pH	7.38	7.09	7.34	7.52
Redox	mV	-10	-5	-16	-13
Conductivity	µmhos/cm	1,285	1,278	1,269	1,253
Chloride[b]	mg/L	112	120	94	115
Sulfate[b]	mg/L	186	203	205	197
TDS[b]	mg/L	843	802	850	814
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0028	-	-
Barium[c]	mg/L	-	0.0436	-	-
Boron[c]	mg/L	-	0.1778	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	1.417	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	< 0.017	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	< 0.011	-	-
Ammonia nitrogen[b]	mg/L	1.0	0.4	0.5	0.8
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0465	0.0390	0.0476	0.0496
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	0.8128	0.7509	0.6550	0.6624
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0007
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Chloride	mg/L	-	116	-	-
Fluoride	mg/L	-	0.27	-	-
Sulfate	mg/L	-	211	-	-
TOCs	mg/L	2.5	1.8	2.3	2.2
TOCs	mg/L	2.4	1.8	2.3	2.4
TOCs	mg/L	2.3	1.9	2.3	2.3
TOCs	mg/L	2.3	1.9	2.4	2.2
TOXs	mg/L	0.015	< 0.010	0.023	0.028
TOXs	mg/L	0.017	0.012	0.023	0.029
Chloroform	µg/L	< 1	< 1	< 1	1

[a] Well point elevation = 180.44 m (MSL); ground surface elevation = 230.37 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800191, 1999

Parameter	Unit	Date of Sampling			
		01/19/99	04/07/99	07/14/99	10/01/99
Water elevation[a]	m	225.73	225.69	225.19	224.97
Temperature	ºC	9.6	10.5	12.1	12.7
pH	pH	6.98	6.75	7.03	6.81
Redox	mV	10	10	7	19
Conductivity	µmhos/cm	2,010	1,939	1,785	1,563
Chloride[b]	mg/L	172	125	87	101
Sulfate[b]	mg/L	202	199	208	181
TDS[b]	mg/L	1,481	1,491	1,364	1,022
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0041	-	-
Barium[c]	mg/L	-	0.1615	-	-
Boron[c]	mg/L	-	0.1484	-	-
Cadmium[c]	mg/L	-	0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.019	-	-
Iron[c]	mg/L	-	34.24	-	-
Lead[c]	mg/L	-	0.0088	-	-
Manganese[c]	mg/L	-	1.536	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0887	-	-
Ammonia nitrogen[b]	mg/L	0.5	0.4	0.5	0.5
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0822	0.0654	0.0713	0.0638
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	3.470	5.474	3.767	2.397
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	1.635	1.364	1.426	1.467
Mercury[b]	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0192	0.0234	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.039
Cesium-137	pCi/L	-	< 1.0	-	-
Hydrogen-3	pCi/L	110	< 100	< 100	< 100
Chloride	mg/L	-	122	-	-
Fluoride	mg/L	-	0.196	-	-
Sulfate	mg/L	-	203	-	-
TOCs	mg/L	6.3	7.1	6.5	6.7
TOCs	mg/L	6.0	7.2	6.7	7.3
TOCs	mg/L	6.1	7.0	6.6	7.6
TOCs	mg/L	6.1	7.0	6.5	7.6
TOXs	mg/L	0.040	0.041	0.021	0.028
TOXs	mg/L	0.023	0.048	0.026	0.027

[a] Well point elevation = 222.77 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800192, 1999

Parameter	Unit	Date of Sampling				
		01/19/99	04/07/99	07/14/99	10/01/99	10/01/99
Water elevation[a]	m	222.25	222.21	221.64	220.22	220.22
Temperature	ºC	10.8	11.6	11.5	11.6	11.6
pH	pH	6.98	6.96	7.32	6.70	6.70
Redox	mV	13	1	-17	30	30
Conductivity	µmhos/cm	1,477	1,464	1,474	1,446	1,446
Chloride[b]	mg/L	75	74	69	71	67
Sulfate[b]	mg/L	111	129	140	130	132
TDS[b]	mg/L	1,098	1,014	1,150	1,008	1,028
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0134	-	-	-
Barium[c]	mg/L	-	0.6524	-	-	-
Boron[c]	mg/L	-	0.1033	-	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-	-
Chromium[c]	mg/L	-	< 0.044	-	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-	-
Copper[c]	mg/L	-	< 0.017	-	-	-
Iron[c]	mg/L	-	21.02	-	-	-
Lead[c]	mg/L	-	0.005	-	-	-
Manganese[c]	mg/L	-	0.137	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	< 0.04	-	-	-
Selenium[c]	mg/L	-	< 0.003	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.0196	-	-	-
Ammonia nitrogen[b]	mg/L	1.0	0.6	0.6	0.9	1.0
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.3691	0.3427	0.4194	0.4092	0.0198
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	5.914	4.576	5.548	6.899	8.958
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.2621	0.1237	0.1318	0.1720	0.1947
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	0.14	-	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.005	0.010
Cesium-137	pCi/L	-	< 1.0	-	-	-
Hydrogen-3	pCi/L	384	358	333	400	454
Chloride	mg/L	-	75	-	-	-
Fluoride	mg/L	-	0.398	-	-	-
Sulfate	mg/L	-	129	-	-	-
TOCs	mg/L	14.5	9.1	9.1	11.9	11.6
TOCs	mg/L	14.3	9.2	9.0	11.1	12.0
TOCs	mg/L	14.4	9.1	9.1	12.7	12.3
TOCs	mg/L	14.3	9.0	9.2	11.1	11.9
TOXs	mg/L	0.033	< 0.010	0.024	0.033	0.025
TOXs	mg/L	0.034	< 0.010	0.026	0.026	0.031

[a] Well point elevation = 208.71 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 1999

Parameter	Unit	Date of Sampling			
		01/19/99	04/07/99	07/14/99	10/01/99
Water elevation[a]	m	192.57	192.60	192.52	192.18
Temperature	ºC	10.6	12.3	11.8	11.3
pH	pH	7.22	7.03	7.38	6.88
Redox	mV	-3	-6	-20	11
Conductivity	µmhos/cm	1,325	1,321	1,310	1,296
Chloride[b]	mg/L	114	114	111	116
Sulfate[b]	mg/L	175	211	213	189
TDS[b]	mg/L	870	857	921	852
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0031	-	-
Barium[c]	mg/L	-	0.0732	-	-
Boron[c]	mg/L	-	0.2163	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	2.384	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	0.029	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0274	-	-
Ammonia nitrogen[b]	mg/L	0.8	0.5	0.4	0.5
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0562	0.0547	0.0615	0.0568
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	1.027	0.8139	0.6487	0.9495
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0453	0.0403	0.032	0.025
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	0.018	< 0.005	< 0.005	< 0.005
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Chloride	mg/L	-	110	-	-
Fluoride	mg/L	-	0.312	-	-
Sulfate	mg/L	-	218	-	-
TOCs	mg/L	2.9	3.5	3.6	2.9
TOCs	mg/L	2.9	3.4	3.4	3.1
TOCs	mg/L	3.0	3.4	3.0	3.0
TOCs	mg/L	3.0	3.4	3.2	3.0
TOXs	mg/L	0.024	0.032	0.016	< 0.010
TOXs	mg/L	0.014	0.045	0.011	0.027

[a] Well point elevation = 181.91 m (MSL); ground surface elevation = 227.38 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 1999

Parameter	Unit	Date of Sampling			
		01/21/99	04/06/99	07/14/99	10/01/99
Water elevation[a]	m	224.05	224.59	224.14	223.34
Temperature	ºC	10.7	11.1	11.4	11.1
pH	pH	7.08	6.61	7.03	7.06
Redox	mV	4	10	-1	6
Conductivity	µmhos/cm	1,110	1,142	1,117	1,083
Chloride[b]	mg/L	8	8	11	9
Sulfate[b]	mg/L	64	66	80	74
TDS[b]	mg/L	722	731	749	747
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0152	-	-
Barium[c]	mg/L	-	0.3431	-	-
Boron[c]	mg/L	-	0.106	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	0.0191	-	-
Iron[c]	mg/L	-	19.44	-	-
Lead[c]	mg/L	-	0.0079	-	-
Manganese[c]	mg/L	-	0.8301	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0719	-	-
Ammonia nitrogen[b]	mg/L	3.5	2.5	3.5	2.5
Arsenic[b]	mg/L	0.0063	0.0058	0.0051	0.0050
Barium[b]	mg/L	0.2453	0.2552	0.2612	0.2409
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	2.385	2.814	2.220	1.419
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.5609	0.4670	0.5571	0.5495
Mercury[b]	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0215	0.0250	< 0.0110	0.0137
Nitrate	mg/L	-	0.84	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	0.018
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Chloride	mg/L	-	10	-	-
Fluoride	mg/L	-	0.22	-	-
Sulfate	mg/L	-	70	-	-
TOCs	mg/L	3.7	29.7	28.7	32.1
TOCs	mg/L	3.8	30.4	28.8	34.6
TOCs	mg/L	3.7	29.3	28.6	32.6
TOCs	mg/L	3.7	29.1	28.6	32.5
TOXs	mg/L	0.014	0.010	< 0.010	0.014
TOXs	mg/L	0.020	< 0.010	0.012	0.010

[a] Well point elevation = 217.20 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800202, 1999

Parameter	Unit	Date of Sampling			
		01/21/99	04/06/99	07/14/99	10/01/99
Water elevation[a]	m	217.97	218.32	218.57	217.88
Temperature	ºC	10.4	11.1	11.3	11.2
pH	pH	7.20	7.03	7.11	7.14
Redox	mV	-1	-4	-5	-
Conductivity	µmhos/cm	1,014	1,078	1,080	1,030
Chloride[b]	mg/L	16	16	15	19
Sulfate[b]	mg/L	74	83	79	73
TDS[b]	mg/L	668	669	687	662
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0061	-	-
Barium[c]	mg/L	-	0.2101	-	-
Boron[c]	mg/L	-	0.1104	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	5.085	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	0.1693	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	< 0.011	-	-
Ammonia nitrogen[b]	mg/L	2.0	1.5	2.0	1.5
Arsenic[b]	mg/L	0.0082	0.0088	0.0070	0.0051
Barium[b]	mg/L	0.1716	0.1833	0.1764	0.1871
Beryllium[b]	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium[b]	mg/L	0.0012	< 0.0002	< 0.0002	< 0.0002
Chromium[b]	mg/L	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	4.501	5.107	4.755	5.049
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1851	0.1901	0.1622	0.1477
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	0.046	< 0.005
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Chloride	mg/L	-	17	-	-
Fluoride	mg/L	-	0.25	-	-
Sulfate	mg/L	-	86	-	-
TOCs	mg/L	30.1	12.7	12.5	15.1
TOCs	mg/L	29.7	12.7	12.4	15.4
TOCs	mg/L	29.8	12.6	12.5	15.3
TOCs	mg/L	29.9	30.4	12.6	15.9
TOXs	mg/L	0.013	< 0.01	< 0.01	< 0.01
TOXs	mg/L	< 0.01	0.01	< 0.01	< 0.01

[a] Well point elevation = 217.20 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 1999

Parameter	Unit	Date of Sampling				
		01/21/99	04/06/99	04/06/99	07/14/99	10/01/99
Water elevation[a]	m	192.66	192.71	192.71	192.59	192.24
Temperature	ºC	10.8	11.0	11.0	11.5	11.6
pH	pH	7.42	7.14	7.14	7.20	7.25
Redox	mV	-5	-11	-11	-12	-5
Conductivity	µmhos/cm	1,108	1,066	1,066	1,119	1,017
Chloride[b]	mg/L	80	79	75	81	65
Sulfate[b]	mg/L	64	63	64	68	65
TDS[b]	mg/L	675	667	662	673	648
Cyanide (total)[c]	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic[c]	mg/L	-[d]	0.0055	0.0053	-	-
Barium[c]	mg/L	-	0.1324	0.1260	-	-
Boron[c]	mg/L	-	0.1947	0.1932	-	-
Cadmium[c]	mg/L	-	< 0.0002	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	< 0.044	-	-
Cobalt[c]	mg/L	-	0.0355	< 0.0260	-	-
Copper[c]	mg/L	-	< 0.017	< 0.017	-	-
Iron[c]	mg/L	-	3.779	3.095	-	-
Lead[c]	mg/L	-	0.002	< 0.002	-	-
Manganese[c]	mg/L	-	0.0597	0.0408	-	-
Mercury[c]	mg/L	-	< 0.0001	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	< 0.0005	-	-
Zinc[c]	mg/L	-	0.1678	0.0120	-	-
Ammonia nitrogen[b]	mg/L	2.5	1.0	1.0	1.5	1.5
Arsenic[b]	mg/L	0.0054	0.0052	0.0054	0.0043	0.0035
Barium[b]	mg/L	0.1193	0.1211	0.1153	0.1116	0.1143
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	0.0267	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	1.933	2.200	2.160	1.201	1.032
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0405	0.0339	0.0333	0.0326	0.0312
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	< 0.1	-	-
Phenols	mg/L	0.008	< 0.005	< 0.005	< 0.005	0.020
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride	mg/L	-	74	80	-	-
Fluoride	mg/L	-	0.416	0.376	-	-
Sulfate	mg/L	-	66	67	-	-
TOCs	mg/L	4.9	4.1	4.0	5.4	5.3
TOCs	mg/L	4.9	4.2	4.0	5.1	4.8
TOCs	mg/L	4.9	4.1	4.0	5.2	5.2
TOCs	mg/L	5.0	4.1	4.0	5.4	5.2
TOXs	mg/L	0.020	0.037	0.026	0.035	0.028
TOXs	mg/L	0.026	0.027	0.012	0.036	0.021
Chloroform	µg/L	< 1	< 1	< 1	< 1	2

[a] Well point elevation = 189.47 m (MSL); ground surface elevation = 227.93 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800241, 1999

Parameter	Unit	Date of Sampling				
		01/21/99	04/12/99	07/15/99	10/04/99	10/04/99
Water elevation[a]	m	224.46	225.12	223.86	223.54	223.54
Temperature	ºC	8.8	8.4	12.8	13.3	13.3
pH	pH	7.48	7.16	7.29	7.63	7.63
Redox	mV	-16	-10	-14	-14	-14
Conductivity	µmhos/cm	2,230	2,410	2,310	1,248	1,248
Chloride[b]	mg/L	481	512	531	175	181
Sulfate[b]	mg/L	151	148	161	159	157
TDS[b]	mg/L	1,401	1,347	1,499	826	847
Cyanide (total)[c]	mg/L	0.018	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic[c]	mg/L	-[d]	0.0117	-	-	-
Barium[c]	mg/L	-	0.3412	-	-	-
Boron[c]	mg/L	-	0.4073	-	-	-
Cadmium[c]	mg/L	-	0.001	-	-	-
Chromium[c]	mg/L	-	0.7406	-	-	-
Cobalt[c]	mg/L	-	0.0542	-	-	-
Copper[c]	mg/L	-	0.1447	-	-	-
Iron[c]	mg/L	-	143.2	-	-	-
Lead[c]	mg/L	-	0.089	-	-	-
Manganese[c]	mg/L	-	2.349	-	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-	-
Nickel[c]	mg/L	-	0.2723	-	-	-
Selenium[c]	mg/L	-	< 0.003	-	-	-
Silver[c]	mg/L	-	< 0.0005	-	-	-
Zinc[c]	mg/L	-	0.4735	-	-	-
Ammonia nitrogen[b]	mg/L	0.1	0.1	0.1	< 0.1	< 0.1
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0737	0.0576	0.0784	0.0559	0.0530
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	< 0.044	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	0.7457	1.1010	0.1662	1.3330	1.0090
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.2653	0.3214	0.2618	0.2458	0.1934
Mercury[b]	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	0.2258	0.2197	< 0.0400	0.8620	0.6572
Silver[b]	mg/L	0.0005	0.0006	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	-	-	-
Phenols	mg/L	0.013	< 0.005	< 0.005	< 0.005	0.005
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100	< 100
Chloride	mg/L	-	512	-	-	-
Fluoride	mg/L	-	0.188	-	-	-
Sulfate	mg/L	-	151	-	-	-
TOCs	mg/L	< 5.0	1.5	< 1.0	1.3	1.2
TOCs	mg/L	< 5.0	1.6	< 1.0	1.3	1.5
TOCs	mg/L	< 5.0	1.5	< 1.0	1.3	1.3
TOCs	mg/L	< 5.0	1.4	< 1.0	1.3	1.4
TOXs	mg/L	0.057	0.170	0.150	0.052	0.190
TOXs	mg/L	0.077	0.110	0.170	0.061	0.270

[a] Well point elevation = 221.15 m (MSL); ground surface elevation = 226.10 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800243D, 1999

Parameter	Unit	Date of Sampling			
		01/21/99	04/12/99	07/15/99	10/06/99
Water elevation[a]	m	192.27	192.15	192.16	191.81
Temperature	ºC	9.9	10.5	11.5	10.4
pH	pH	7.35	7.08	7.28	7.41
Redox	mV	-8	-5	-13	-13
Conductivity	µmhos/cm	874	831	873	739
Chloride[b]	mg/L	18	12	15	14
Sulfate[b]	mg/L	42	39	44	158
TDS[b]	mg/L	531	516	537	477
Cyanide (total)[c]	mg/L	0.019	< 0.010	< 0.010	< 0.010
Arsenic[c]	mg/L	-[d]	< 0.0025	-	-
Barium[c]	mg/L	-	0.1646	-	-
Boron[c]	mg/L	-	0.2429	-	-
Cadmium[c]	mg/L	-	< 0.0002	-	-
Chromium[c]	mg/L	-	< 0.044	-	-
Cobalt[c]	mg/L	-	< 0.026	-	-
Copper[c]	mg/L	-	< 0.017	-	-
Iron[c]	mg/L	-	2.868	-	-
Lead[c]	mg/L	-	< 0.002	-	-
Manganese[c]	mg/L	-	0.6396	-	-
Mercury[c]	mg/L	-	< 0.0001	-	-
Nickel[c]	mg/L	-	< 0.04	-	-
Selenium[c]	mg/L	-	< 0.003	-	-
Silver[c]	mg/L	-	< 0.0005	-	-
Zinc[c]	mg/L	-	0.0235	-	-
Ammonia nitrogen[b]	mg/L	0.3	0.2	0.2	0.3
Arsenic[b]	mg/L	< 0.0025	0.0026	< 0.0025	< 0.0025
Barium[b]	mg/L	0.1588	0.1439	0.1524	0.1398
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	1.129	1.226	0.1291	0.8222
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.7145	0.5098	0.4663	0.5142
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0166	< 0.011	< 0.011	< 0.011
Nitrate	mg/L	-	< 0.1	-	-
Phenols	mg/L	< 0.005	< 0.005	< 0.005	< 0.005
Hydrogen-3	pCi/L	< 100	< 100	< 100	< 100
Chloride	mg/L	-	17	-	-
Fluoride	mg/L	-	0.326	-	-
Sulfate	mg/L	-	40	-	-
TOCs	mg/L	1.9	1.4	1.9	1.7
TOCs	mg/L	1.8	1.4	1.7	1.7
TOCs	mg/L	2.0	1.4	1.8	1.6
TOCs	mg/L	1.9	1.5	1.9	1.7
TOXs	mg/L	< 0.010	< 0.010	0.013	0.013
TOXs	mg/L	< 0.010	< 0.010	< 0.010	0.011

[a] Well point elevation = 190.56 m (MSL); ground surface elevation = 226.10 m (MSL); casing material = stainless steel.

[b] Filtered sample.

[c] Unfiltered sample.

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

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill
Well 800271, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	223.05
Temperature	ºC	14.2
pH	pH	7.41
Redox	mV	-17
Conductivity	µmhos/cm	676
Chloride[b]	mg/L	3
Sulfate[b]	mg/L	41
TDS[b]	mg/L	431
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	< 0.1
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.1004
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	0.0985
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.0969
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0617
Phenols	mg/L	0.009
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	2.4
TOCs	mg/L	2.5
TOCs	mg/L	2.4
TOCs	mg/L	2.3
TOXs	mg/L	< 0.01
TOXs	mg/L	< 0.01

[a] Well point elevation = 191.84 m (MSL); ground surface elevation = 226.48 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill
Well 800273D, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	192.29
Temperature	ºC	11.1
pH	pH	7.8
Redox	mV	-38
Conductivity	µmhos/cm	1,042
Chloride[b]	mg/L	102
Sulfate[b]	mg/L	117
TDS[b]	mg/L	638
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	0.7
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.1134
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.0206
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0462
Phenols	mg/L	0.008
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	6.6
TOCs	mg/L	4.8
TOCs	mg/L	5.4
TOCs	mg/L	4.4
TOXs	mg/L	0.019
TOXs	mg/L	0.036
Acetone	µg/L	10
Dibromomethane	µg/L	2

[a] Well point elevation = 189.70 m (MSL); ground surface elevation = 226.48 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill
Well 800281, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	224.85
Temperature	ºC	12.6
pH	pH	7.03
Redox	mV	7
Conductivity	µmhos/cm	1,612
Chloride[b]	mg/L	101
Sulfate[b]	mg/L	66
TDS[b]	mg/L	1,042
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	< 0.1
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.1357
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	0.2542
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	1.775
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0194
Phenols	mg/L	0.01
Hydrogen-3	pCi/L	588
TOCs	mg/L	4.2
TOCs	mg/L	4.2
TOCs	mg/L	4.2
TOCs	mg/L	4.3
TOXs	mg/L	0.082
TOXs	mg/L	0.066

[a] Well point elevation = 224.60 m (MSL); ground surface elevation = 228.56 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill
Well 800291, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	226.59
Temperature	ºC	10.7
pH	pH	7.31
Redox	mV	-9
Conductivity	µmhos/cm	1,132
Chloride[b]	mg/L	7
Sulfate[b]	mg/L	138
TDS[b]	mg/L	758
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	< 0.1
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.0733
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.1786
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0368
Phenols	mg/L	0.007
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	2.8
TOCs	mg/L	2.8
TOCs	mg/L	2.6
TOCs	mg/L	2.7
TOXs	mg/L	< 0.01
TOXs	mg/L	0.01

[a] Well point elevation = 223.97 m (MSL); ground surface elevation = 231.37 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.42

Groundwater Monitoring Results, Sanitary Landfill
Well 800301, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	227.58
Temperature	ºC	10.6
pH	pH	7.35
Redox	mV	-9
Conductivity	µmhos/cm	1,060
Chloride[b]	mg/L	8
Sulfate[b]	mg/L	103
TDS[b]	mg/L	692
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	0.1
Arsenic[b]	mg/L	0.0031
Barium[b]	mg/L	0.0697
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	0.0966
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.1653
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	0.0012
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0455
Phenols	mg/L	0.007
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	2.7
TOCs	mg/L	2.7
TOCs	mg/L	2.3
TOCs	mg/L	2.2
TOXs	mg/L	0.011
TOXs	mg/L	< 0.01

[a] Well point elevation = 226.11 m (MSL); ground surface elevation = 233.42 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.43

Groundwater Monitoring Results, Sanitary Landfill
Well 800331, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	225.12
Temperature	ºC	12.1
pH	pH	7.31
Redox	mV	-10
Conductivity	µmhos/cm	1,103
Chloride[b]	mg/L	8
Sulfate[b]	mg/L	138
TDS[b]	mg/L	755
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	0.1
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.0768
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.3053
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0118
Phenols	mg/L	0.008
Hydrogen-3	pCi/L	117
TOCs	mg/L	2.4
TOCs	mg/L	2.4
TOCs	mg/L	2.6
TOCs	mg/L	2.5
TOXs	mg/L	0.012
TOXs	mg/L	< 0.01

[a] Well point elevation = 223.66 m (MSL); ground surface elevation = 228.80 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.44

Groundwater Monitoring Results, Sanitary Landfill
Well 800341, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	227.23
Temperature	ºC	12.5
pH	pH	7.44
Redox	mV	-14
Conductivity	µmhos/cm	1,173
Chloride[b]	mg/L	11
Sulfate[b]	mg/L	163
TDS[b]	mg/L	800
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	< 0.1
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.0752
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	0.0431
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.3234
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	< 0.011
Phenols	mg/L	0.005
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	3.2
TOCs	mg/L	3.1
TOCs	mg/L	2.8
TOCs	mg/L	3.0
TOXs	mg/L	0.02
TOXs	mg/L	0.011

[a] Well point elevation = 227.03 m (MSL); ground surface elevation = 230.85 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.45

Groundwater Monitoring Results, Sanitary Landfill
Well 800351, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	225.97
Temperature	ºC	10.4
pH	pH	7.64
Redox	mV	-27
Conductivity	µmhos/cm	914
Chloride[b]	mg/L	8
Sulfate[b]	mg/L	27
TDS[b]	mg/L	567
Cyanide (total)	mg/L	0.34
Ammonia nitrogen[b]	mg/L	0.4
Arsenic[b]	mg/L	0.0036
Barium[b]	mg/L	0.133
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.0745
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.052
Phenols	mg/L	0.006
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	3.1
TOCs	mg/L	2.7
TOCs	mg/L	2.7
TOCs	mg/L	3.3
TOXs	mg/L	< 0.01
TOXs	mg/L	< 0.01

[a] Well point elevation = 222.13 m (MSL); ground surface elevation = 233.64 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.46

Groundwater Monitoring Results, Sanitary Landfill
Well 800361, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	222.99
Temperature	ºC	11.8
pH	pH	7.58
Redox	mV	-24
Conductivity	µmhos/cm	916
Chloride[b]	mg/L	12
Sulfate[b]	mg/L	111
TDS[b]	mg/L	606
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	< 0.1
Arsenic[b]	mg/L	< 0.0025
Barium[b]	mg/L	0.0578
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	0.023
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.1311
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	< 0.011
Phenols	mg/L	0.013
Hydrogen-3	pCi/L	262
TOCs	mg/L	2.1
TOCs	mg/L	2.2
TOCs	mg/L	2.2
TOCs	mg/L	2.1
TOXs	mg/L	0.015
TOXs	mg/L	< 0.01

[a] Well point elevation = 221.21 m (MSL); ground surface elevation = 228.40 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.47

Groundwater Monitoring Results, Sanitary Landfill
Well 800371, 1999

Parameter	Unit	Date of Sampling 10/05/99
Water elevation[a]	m	218.11
Temperature	ºC	10.9
pH	pH	7.65
Redox	mV	-20
Conductivity	µmhos/cm	825
Chloride[b]	mg/L	16
Sulfate[b]	mg/L	20
TDS[b]	mg/L	508
Cyanide (total)	mg/L	< 0.01
Ammonia nitrogen[b]	mg/L	1.5
Arsenic[b]	mg/L	0.0044
Barium[b]	mg/L	0.2226
Beryllium[b]	mg/L	< 0.0002
Cadmium[b]	mg/L	< 0.0002
Chromium[b]	mg/L	< 0.044
Cobalt[b]	mg/L	< 0.026
Copper[b]	mg/L	< 0.017
Iron[b]	mg/L	< 0.037
Lead[b]	mg/L	< 0.002
Manganese[b]	mg/L	0.0728
Mercury[b]	mg/L	< 0.0001
Nickel[b]	mg/L	< 0.04
Silver[b]	mg/L	< 0.0005
Thallium[b]	mg/L	< 0.0015
Vanadium[b]	mg/L	< 0.024
Zinc[b]	mg/L	0.0488
Phenols	mg/L	< 0.005
Hydrogen-3	pCi/L	< 100
TOCs	mg/L	7.1
TOCs	mg/L	7.1
TOCs	mg/L	3.4
TOCs	mg/L	3.4
TOXs	mg/L	0.016
TOXs	mg/L	0.018
Acetone	µg/L	10

[a] Well point elevation = 218.46 m (MSL); ground surface elevation = 228.37 m (MSL); casing material = stainless steel.

[b] Filtered sample.

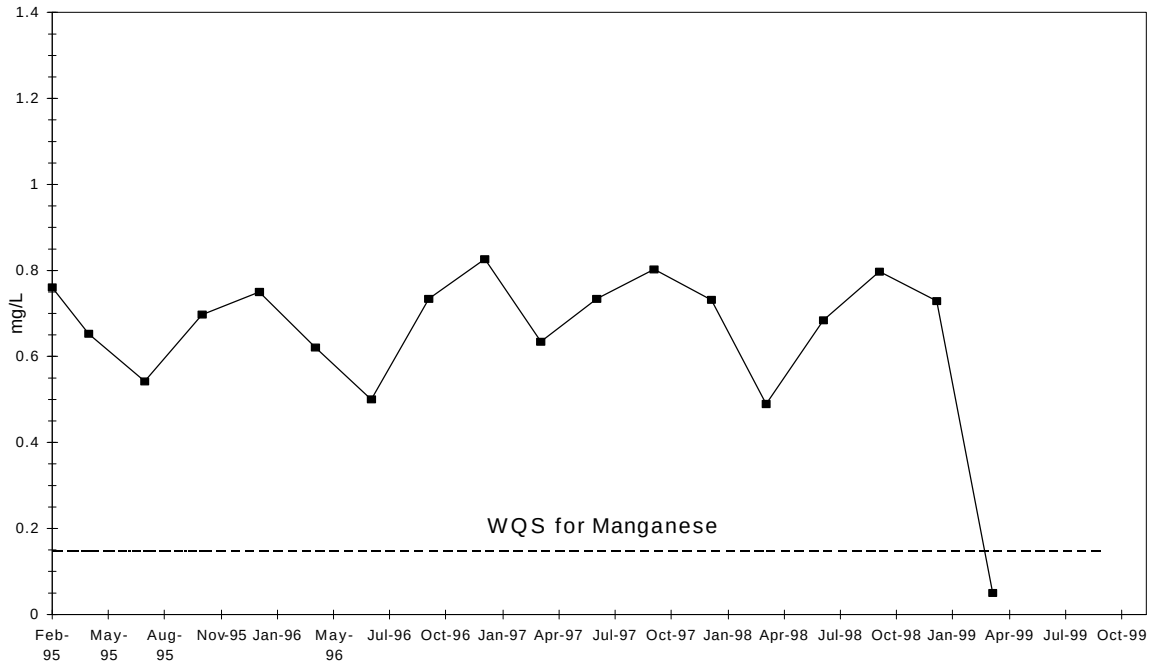


Figure 6.8 Well 800161 Manganese Results

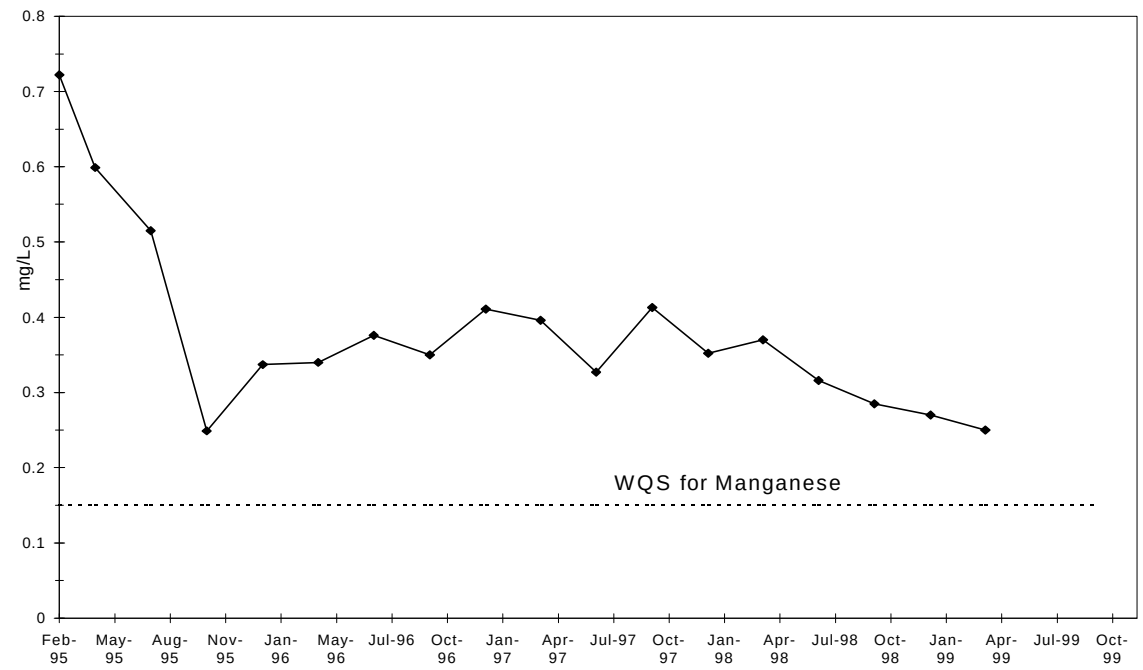


Figure 6.9 Well 800162 Manganese Results

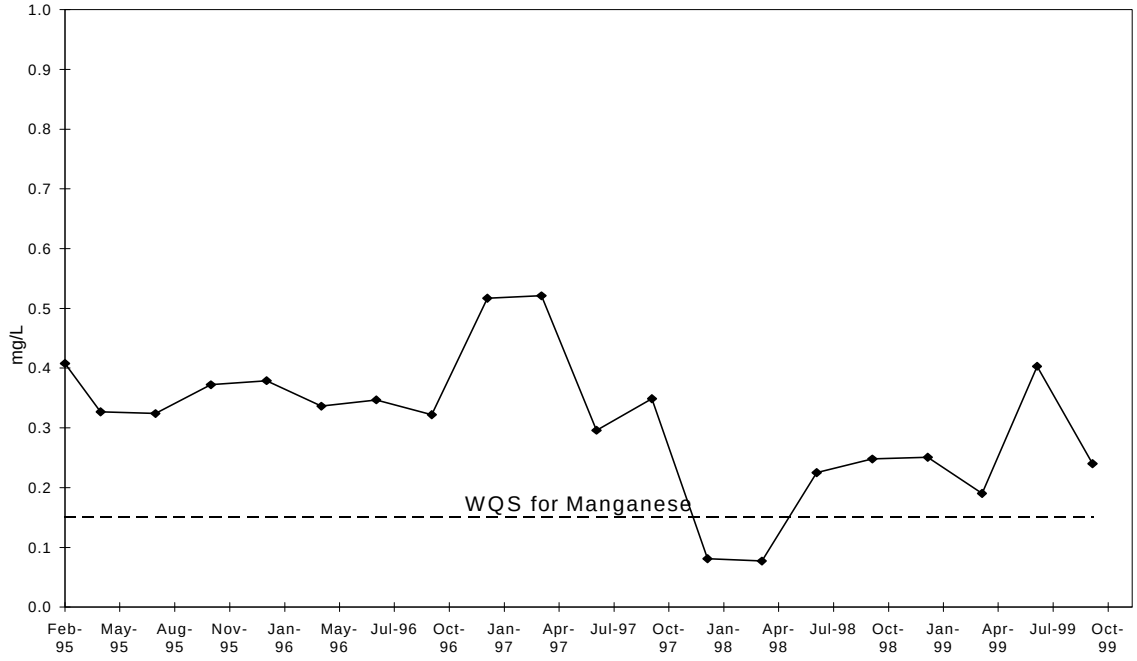


Figure 6.10 Well 800171 Manganese Results

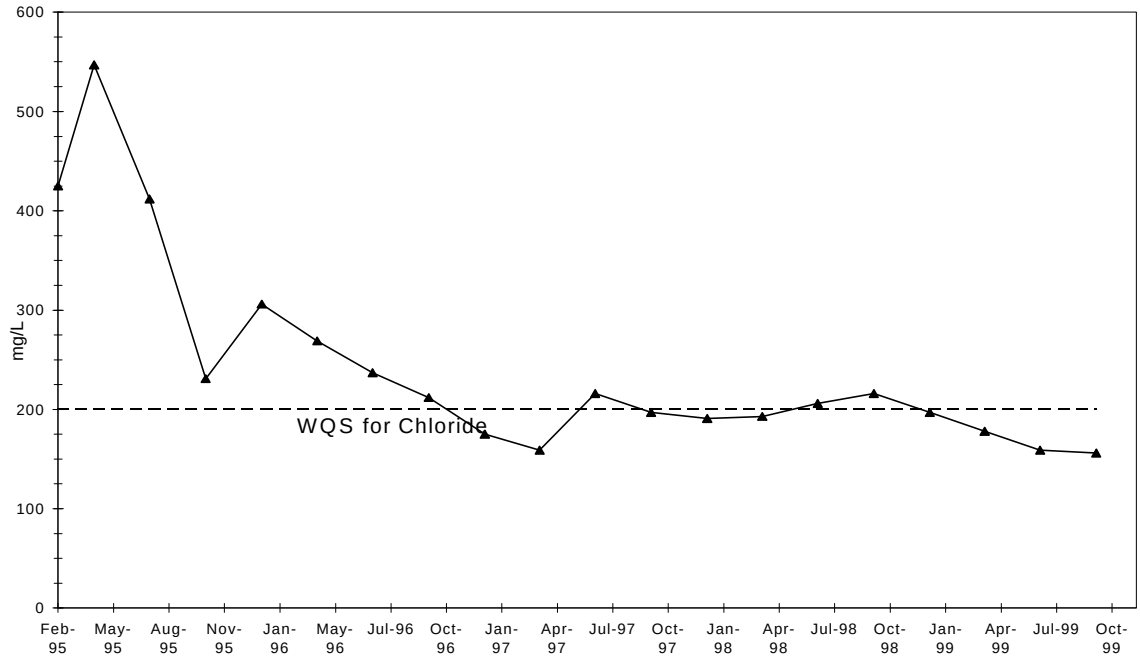


Figure 6.11 Well 800173D Chloride Results

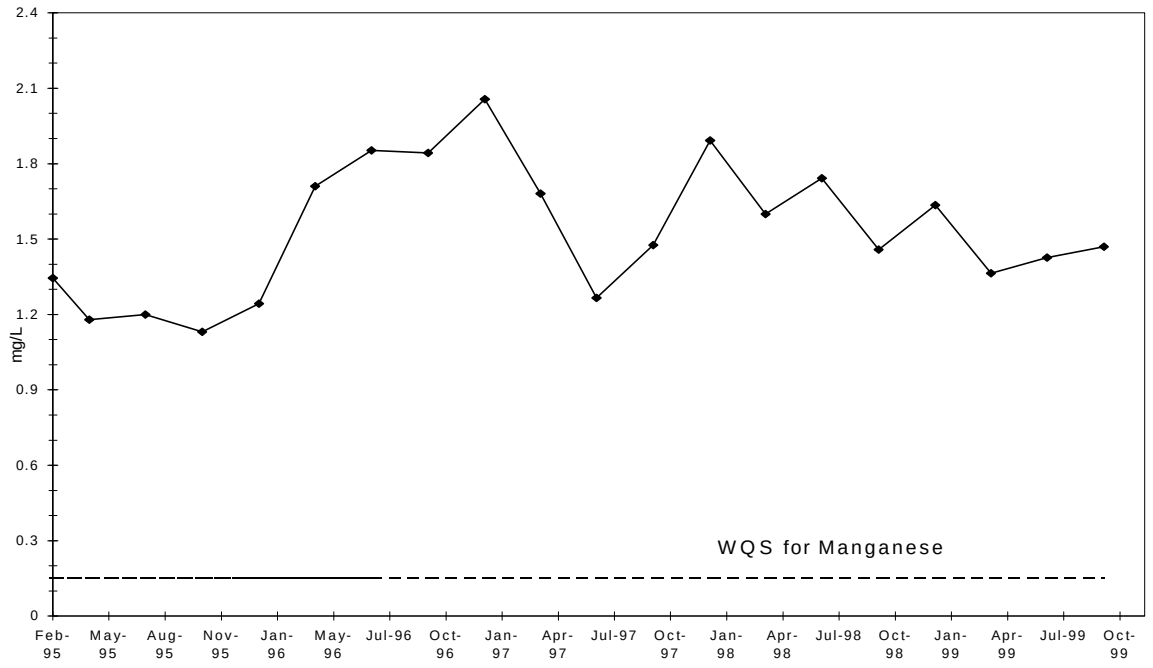


Figure 6.12 Well 800191 Manganese Results

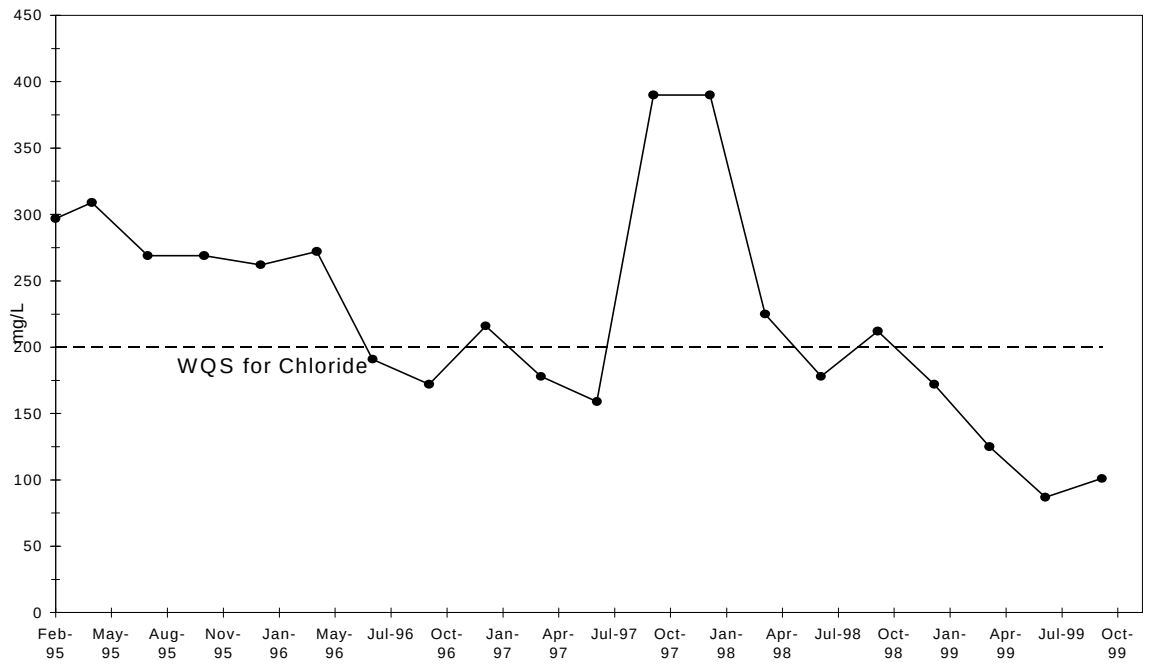


Figure 6.13 Well 800191 Chloride Results

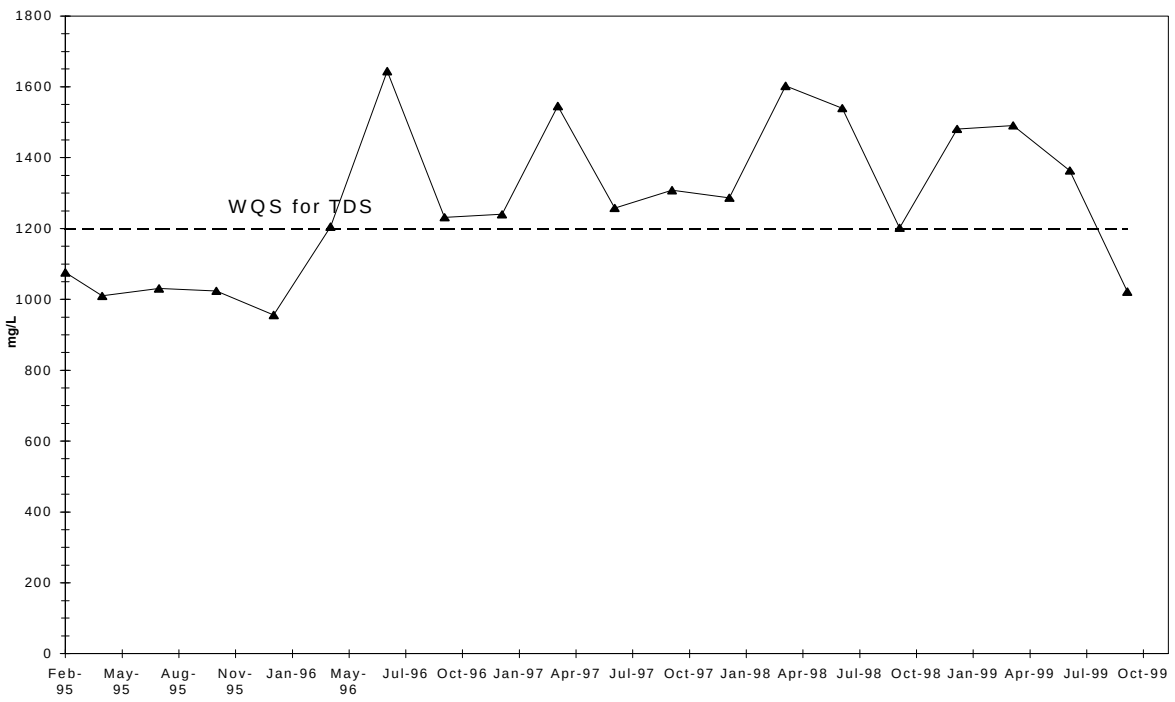


Figure 6.14 Well 800191 TDS Results

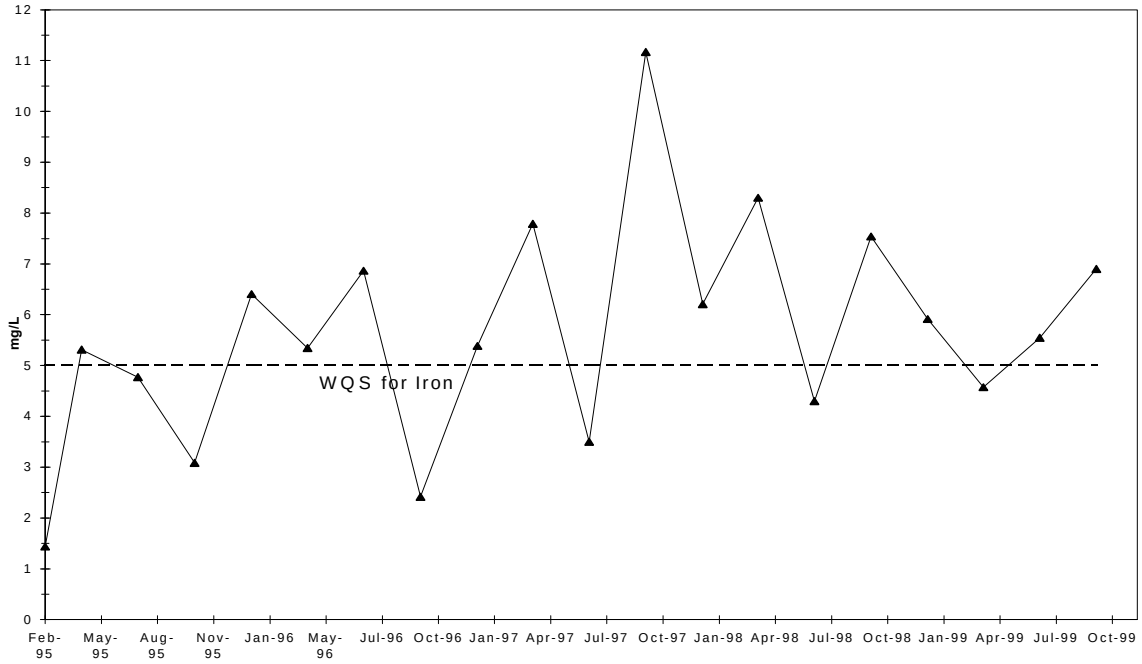


Figure 6.15 Well 800192 Iron Results

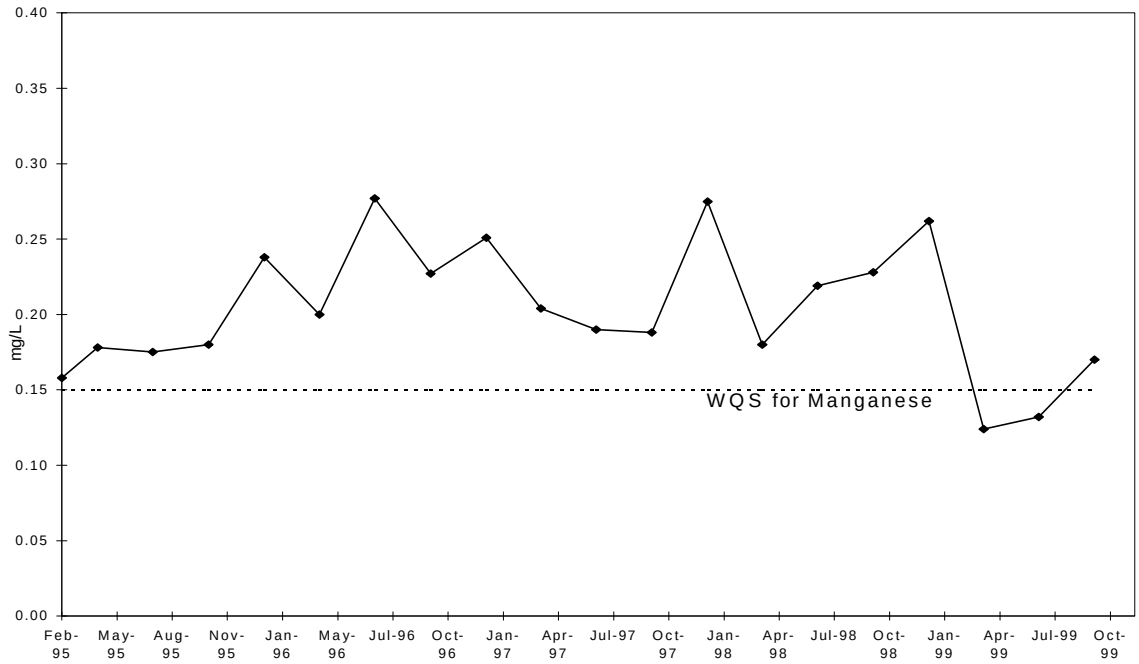


Figure 6.16 Well 800192 Manganese Results

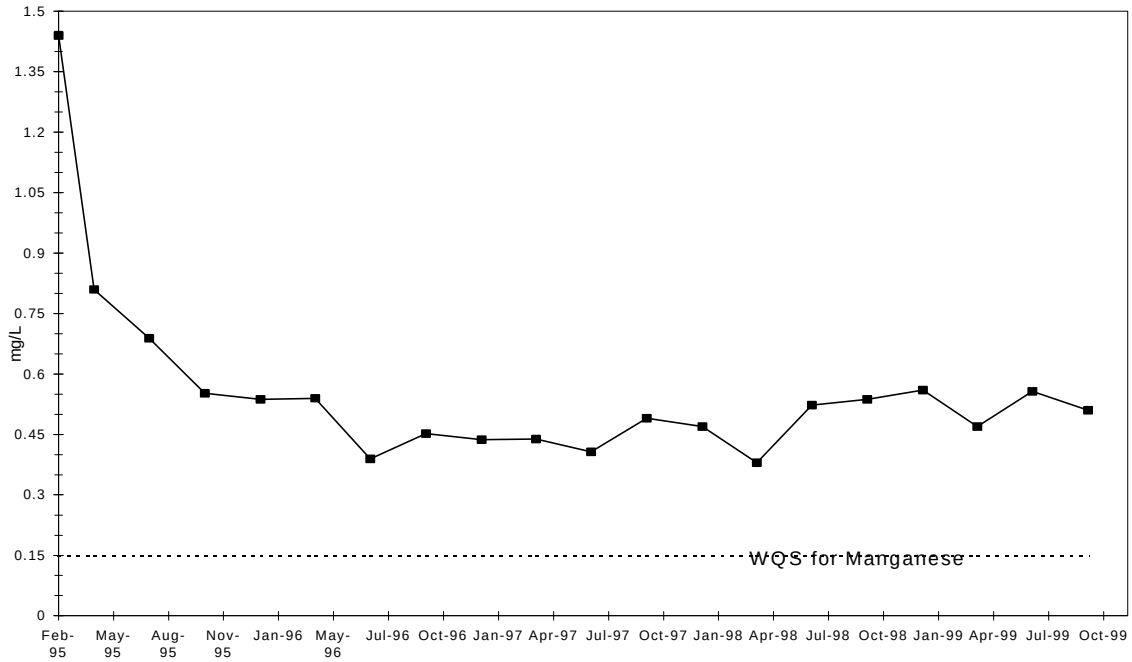


Figure 6.17 Well 800201 Manganese Results

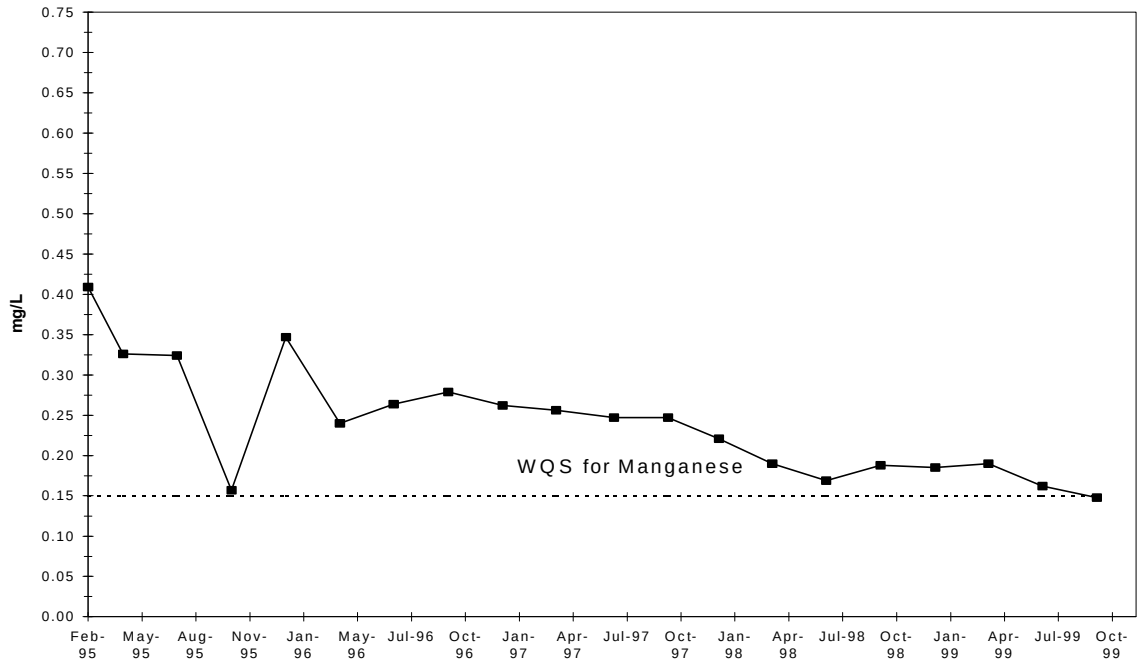


Figure 6.18 Well 800202 Manganese Results

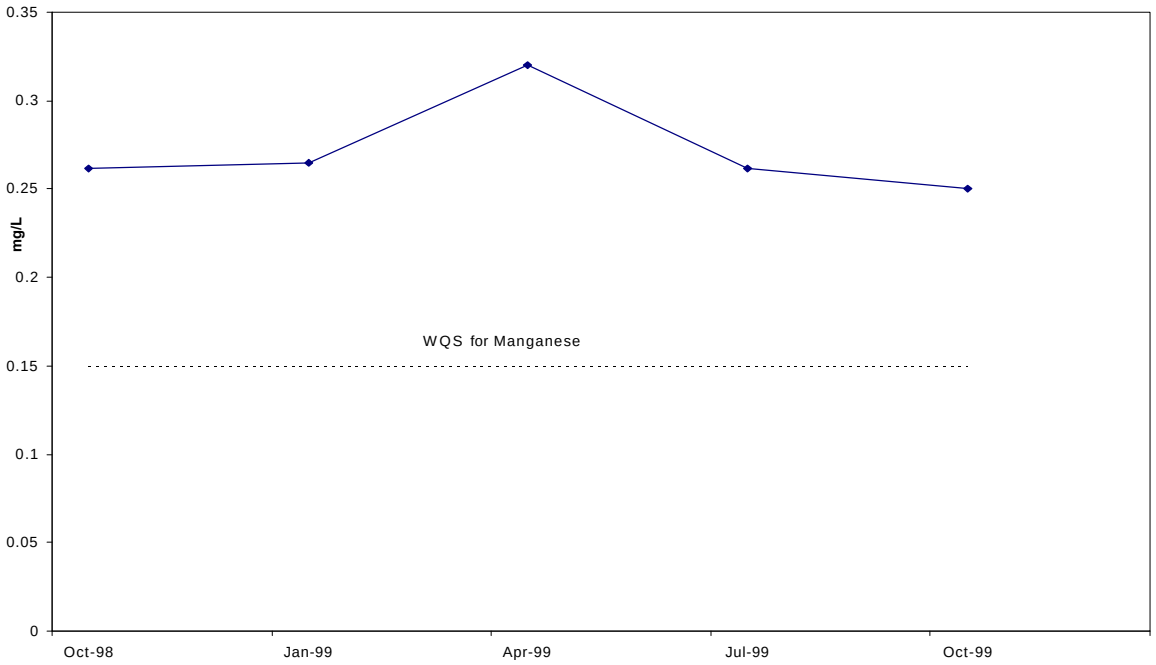


Figure 6.19 Well 800241 Manganese Results

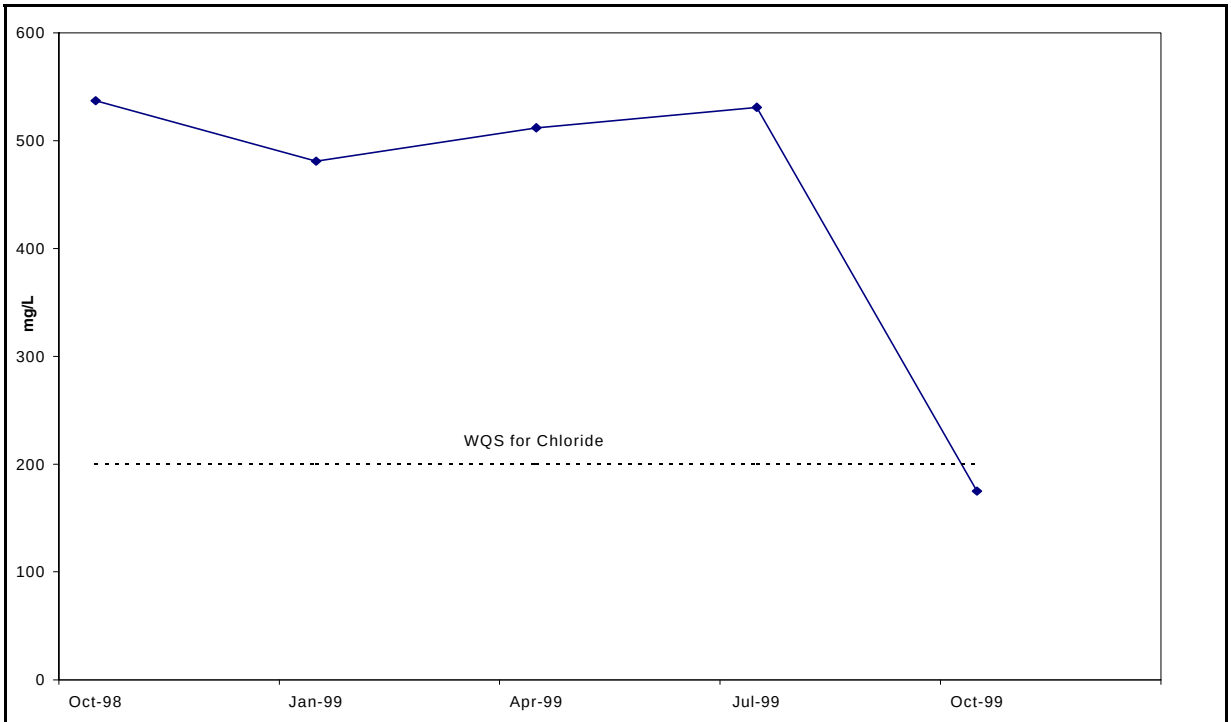


Figure 6.20 Well 800241 Chloride Results

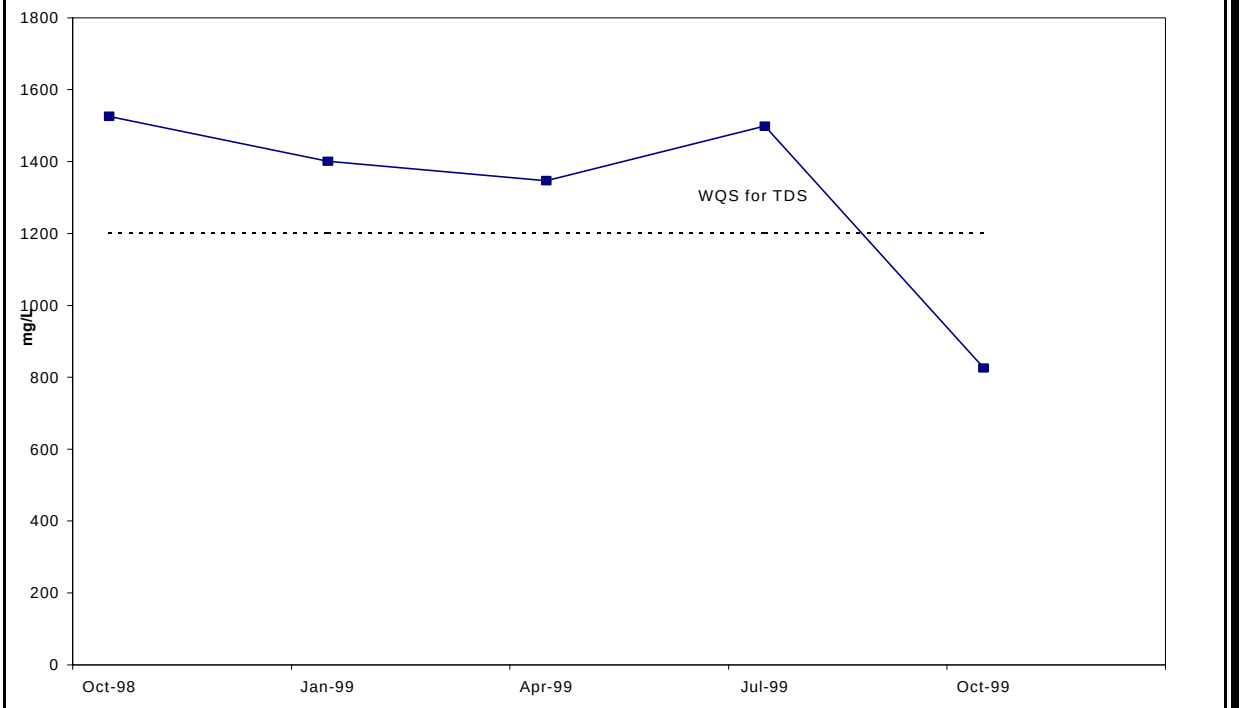


Figure 6.21 Well 800241 TDS Results

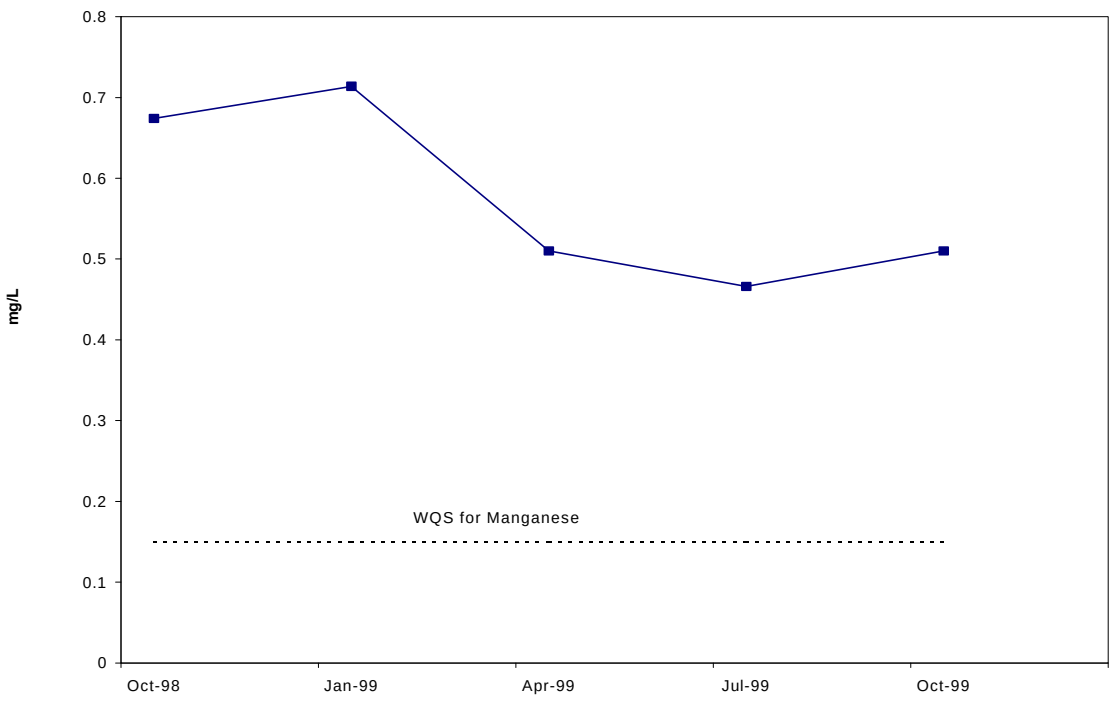


Figure 6.22 Well 800243D Manganese Results

similar concentrations have been measured in monitoring wells several miles from the 800 Area Landfill.

In addition to Well 800241, Wells 800191 and 800381 contained concentrations of TDS above the WQS (1,200 mg/L) during one quarter. TDS levels in these wells ranged from 1,364 to 1,959 mg/L.

Unfiltered Routine Indicator Parameters. These specific parameters include cyanide, phenols (total recoverable), TOC, and TOX and are measured each quarter. All measured unfiltered routine indicator parameters were less than the appropriate WQS values, where applicable, except for cyanide in Well 800351.

Unfiltered Inorganic Parameters. These parameters are measured only during the second quarter and include arsenic, barium, boron, cadmium, chloride, chromium, cobalt, copper, cyanide, fluoride, iron, lead, manganese, mercury, nickel, nitrate as nitrogen, selenium, silver, sulfate, and zinc.

Chloride concentrations exceeded the WQS (200 mg/L) in Well 800241 only, possibly due to road salt intrusion.

Iron concentrations exceeded the WQS (5 mg/L) in Wells 800161, 800163D, 800171, 800181, 800191, 800192, 800201, and 800202. Iron levels in these wells ranged from 5.1 to 38 mg/L. The iron exceedances are probably due to the requirement that these samples be unfiltered.

Lead concentrations exceeded the WQS (0.0075 mg/L) in Wells 800161, 800191, 800201, and 800241. Lead levels in these wells ranged from 0.0079 to 0.0890 mg/L.

Manganese concentrations exceeded the WQS (0.15 mg/L) in Wells 800161, 800162, 800171, 800181, 800191, 800201, 800202, 800241, and 800243D. Manganese levels in these wells ranged from 0.17 to 2.3 mg/L. Elevated manganese levels appear to be normal for this area.

Chromium and nickel concentrations exceeded the WQS (0.1 mg/L) only in 800241.

Organic Parameters. The unfiltered organic parameters were all below their respective detection limits except for trichloroethene in Well 800171 at 1.0 µg/L. The PQL is 5 µg/L. The PQL is the lowest concentration that can be reliably achieved within specific limits of precision and accuracy during routine operating conditions.

Radioactive Constituents. Samples collected from the 800 Area sanitary landfill monitoring wells were also analyzed for hydrogen-3. The results are shown in Tables 6.20 to 6.47. Although the disposal of radioactive materials was prohibited in the sanitary landfill, very low concentrations of hydrogen-3 were detected in Wells 800161, 800171, 800191, 800192, 800281, 800331, and 800361, probably because of inadvertent disposal of radioactivity in ANL-E trash. These results are consistent with 1997 and 1998 results. The presence of hydrogen-3 as tritiated water allows information to be obtained on the subsurface water flow pathway in the sanitary landfill area. The data indicate that the principal direction of subsurface water flow is to the south-southeast, with a small component to the northwest. This is consistent with the estimated subsurface water flow based on water level measurements and general flow patterns in the area. For those wells that had measurable levels of hydrogen-3, the samples were also analyzed for gamma-ray–emitting radionuclides. All concentrations were below their respective detection limits.

6.4. CP-5 Reactor Area

The CP-5 reactor is 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 are in the process of being 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 new 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 new deep well was installed during June 1997 to determine whether there had been any vertical migration of hydrogen-3 in the groundwater from the CP-5 reactor. The results are shown in Tables 6.48 to 6.51. Table 6.52 characterizes all wells in this area (see Figure 6.18 for locations).

Well 330011 is installed in a relatively porous, saturated region of soil and as a result, recharges quickly. Purging the well by removing several well volumes of water does not lower the water level appreciably. The water has a higher conductivity and temperature than similar wells at other locations. As in past years, the manganese WQS (0.15 mg/L) was exceeded three quarters, and levels ranged from 0.11 to 1.25 mg/L. Low levels of barium were noted each quarter; all levels were well below the WQS of 2 mg/L. As in past years, barium was detected each quarter in Well 330021; all levels were considerably below the appropriate WQS.

Manganese and nickel exceeded the WQS (0.15 and 0.10 mg/L, respectively) each quarter in Well 330031. Manganese levels ranged from 0.19 to 0.34 mg/L, and nickel levels ranged from 0.44 to 1.06 mg/L. The source of nickel is unknown. Similar manganese concentrations have been measured at distances from the CP-5 reactor (see Section 6.3.2.3). Chloride concentrations exceeded the WQS (200 mg/L) each quarter, and chloride levels ranged from 252 to 291 mg/L. Barium and iron were detected at levels well below the WQS each quarter, except for iron one quarter (5.4 mg/L) at the WQS (5 mg/L).

Barium, iron, and manganese were detected each quarter in Well 330012D; all levels were considerably below the appropriate WQS. Nickel was detected two quarters at levels well below the WQS (10 mg/L).

Each sample collected from Well 330011 in 1999 contained low concentrations of dichlorofluoromethane; concentrations ranged from 1 to 8 µg/L. These results are elevated compared with those noted in 1998. Well 330012D contained very low concentrations of dichlorofluoromethane each quarter; concentrations ranged from 1 to 9 µg/L. Low levels of trichlorofluoromethane were noted two quarters.

Radionuclide levels were greater than those noted in 1998 (see Figures 6.24 and 6.25). As in previous years, hydrogen-3 was detected in Wells 330011, 330021 (two quarters), and 330031. The levels of hydrogen-3 ranged from less than 100 to 1,281 pCi/L. Hydrogen-3 was also detected each quarter in samples from 330012D at levels of 186 to 2,651 pCi/L. The increase in the hydrogen-3 concentration during the last two quarters is being investigated. Strontium-90 was detected in Wells 330011 and 330012D, and the levels ranged from 0.45 to 1.46 pCi/L (Figure 6.25). Cesium-137 was detected occasionally, and the levels ranged from less than 1.0 to 1.75 pCi/L.

TABLE 6.48

Groundwater Monitoring Results, 300 Area Well 330011, 1999

Parameter	Unit	Date of Sampling			
		03/19/99	06/11/99	09/03/99	11/16/99
Water elevation[a]	m	220.47	220.30	219.01	219.07
Temperature	°C	14.9	16.3	19.5	18.1
pH	pH	7.12	7.23	7.18	6.88
Redox	mV	-2	-12	6	15
Conductivity	µmhos/cm	944	874	1,122	1,458
Chloride[b]	mg/L	16	13	61	139
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0445	0.0437	0.0870	0.0933
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.1835	0.1139	1.2500	0.6401
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	pCi/L	669	598	1,186	1,281
Strontium-90	pCi/L	0.45	0.45	0.70	0.90
Dichlorofluoromethane	µg/L	1	2	7	8

[a] Well point elevation = 221.00 m (MSL); ground surface elevation = 227.10 m (MSL); casing material = steel.

[b] Filtered sample.

TABLE 6.49

Groundwater Monitoring Results, 300 Area Well 330021, 1999

Parameter	Unit	Date of Sampling			
		03/19/99	06/09/99	09/03/99	11/16/99
Water elevation[a]	m	227.02	226.10	224.94	224.27
Temperature	ºC	8.2	10.8	14.1	12.5
pH	pH	7.46	7.24	7.52	7.30
Redox	mV	-18	-13	-16	-9
Conductivity	µmhos/cm	759	762	613	791
Chloride[b]	mg/L	5	6	5	7
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0222	0.0241	0.0268	0.0326
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	< 0.037	< 0.037	< 0.037	< 0.037
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	< 0.017	< 0.017	< 0.017	0.0618
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	< 0.04	< 0.04	< 0.04	< 0.04
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	1.5	< 1.0	1.8	< 1.0
Hydrogen-3	pCi/L	< 100	< 100	174	175
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Methylene chloride	µg/L	< 1	2	< 1	< 1

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

[b] Filtered sample.

TABLE 6.50

Groundwater Monitoring Results, 300 Area Well 330031, 1999

Parameter	Unit	Date of Sampling			
		03/19/99	06/09/99	09/03/99	11/16/99
Water elevation[a]	m	226.12	225.49	224.17	223.47
Temperature	ºC	9.6	11.4	13.6	13.1
pH	pH	7.09	7.11	7.16	6.99
Redox	mV	-2	-7	8	7
Conductivity	µmhos/cm	1,903	1,807	1,431	1,757
Chloride[b]	mg/L	291	252	267	252
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0461	0.0546	0.0539	0.0471
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.026
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	0.1619	5.411	2.375	1.512
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.185	0.3363	0.3432	0.3257
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	0.4446	1.063	0.603	0.7283
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	0.0115	0.0349	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	pCi/L	183	129	262	304
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Carbon disulfide	µg/L	< 1	< 1	< 1	1

[a] Well point elevation = 221.95 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.51

Groundwater Monitoring Results, 300 Area Well 330012D, 1999

Parameter	Unit	Date of Sampling			
		03/19/99	06/11/99	09/03/99	11/16/99
Water elevation[a]	m	190.59	190.78	190.51	190.02
Temperature	ºC	13.4	14.0	14.5	13.3
pH	pH	7.10	7.38	7.45	7.33
Redox	mV	-4	-26	-11	-11
Conductivity	µmhos/cm	1,164	1,123	1,098	1,262
Chloride[b]	mg/L	44	43	90	86
Arsenic[b]	mg/L	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Barium[b]	mg/L	0.0595	0.0620	0.0727	0.0557
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	< 0.044	< 0.044	< 0.044	< 0.044
Cobalt[b]	mg/L	< 0.026	< 0.026	< 0.026	< 0.0260
Copper[b]	mg/L	< 0.017	< 0.017	< 0.017	< 0.017
Iron[b]	mg/L	0.1320	0.2746	0.1469	0.0745
Lead[b]	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Manganese[b]	mg/L	0.0711	0.0597	0.0680	0.0766
Mercury[b]	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel[b]	mg/L	0.0408	< 0.0400	< 0.0400	0.0495
Silver[b]	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Thallium[b]	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium[b]	mg/L	< 0.024	< 0.024	< 0.024	< 0.024
Zinc[b]	mg/L	< 0.011	< 0.011	< 0.011	< 0.011
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	1.1
Hydrogen-3	pCi/L	414	186	2,651	1,974
Strontium-90	pCi/L	0.59	0.47	1.03	1.46
Dichlorofluoromethane	µg/L	1	1	4	9
Trichlorofluoromethane	µg/L	< 1	< 1	3	8

[a] Well point elevation = 185.65 m (MSL); ground surface elevation = 227.13 m (MSL); casing material = stainless steel.

[b] Filtered sample.

TABLE 6.52

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	227.10	224.2 – 221.1	0.05/PVC	8/89
330021	5.8	227.75	226.3 – 221.7	0.05/SS	9/93
330031	5.2	227.13	225.6 – 221.0	0.05/SS	9/93
330012D	41.5	227.13	191.7 – 185.6	0.05/SS	6/97

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

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 that 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. All the hydrogen-3 monitoring results for the CP-5 wells are plotted in Figure 6.24. The source of the strontium-90 and cesium-137 is not known.

6.5. Monitoring of the Seeps South of the 300 Area

In spring 1996, during the RCRA Facility Investigation 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. The locations are shown in Figure 6.26. The seeps are in ravines that are located in a pristine, heavily wooded section of the forest preserve; they carry storm water discharges from the 317 and 319 Areas. Water emanating from the seeps 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 (South of the 317/319/ENE Area).

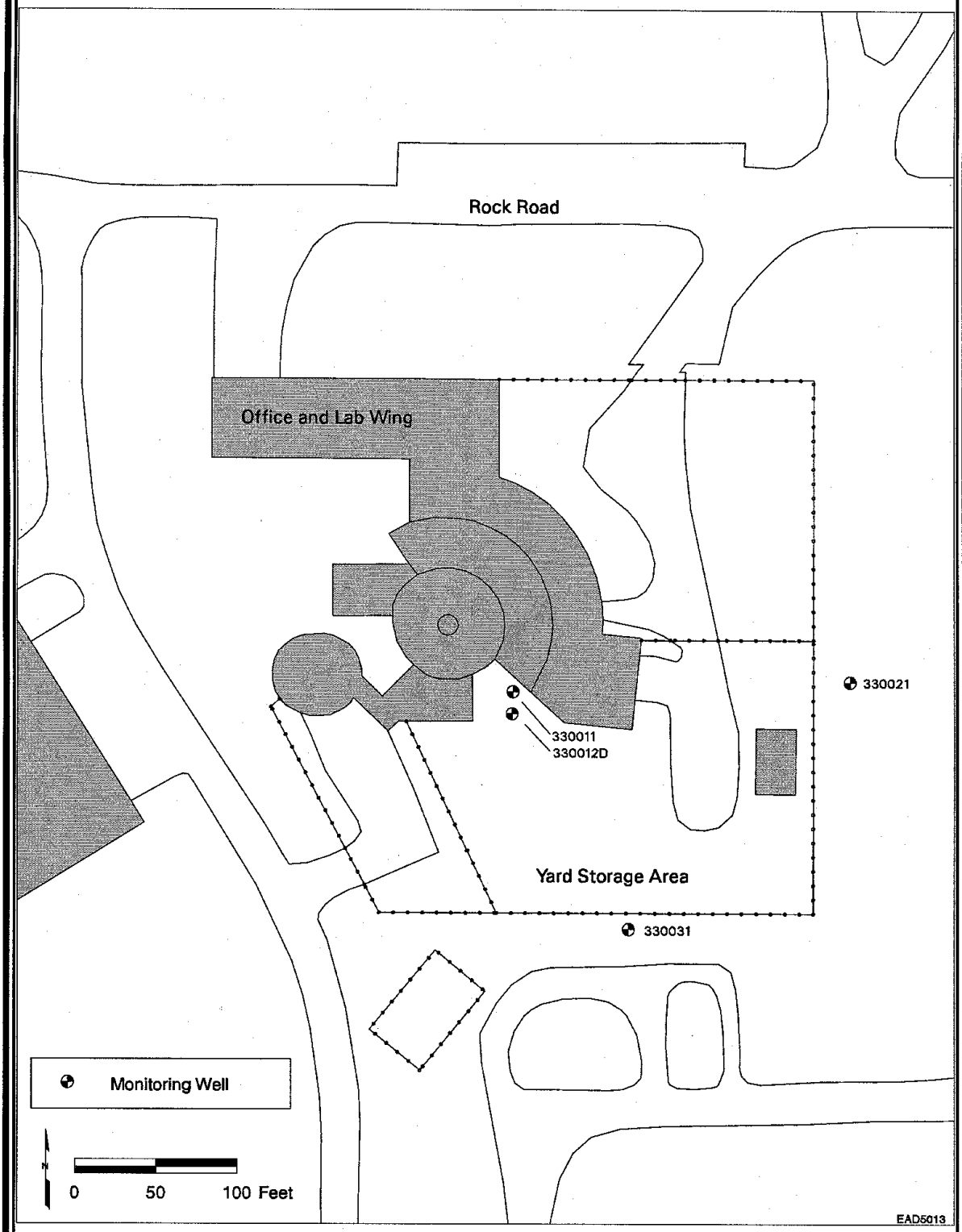


Figure 6.23 Active Monitoring Wells in the CP-5 Reactor Area

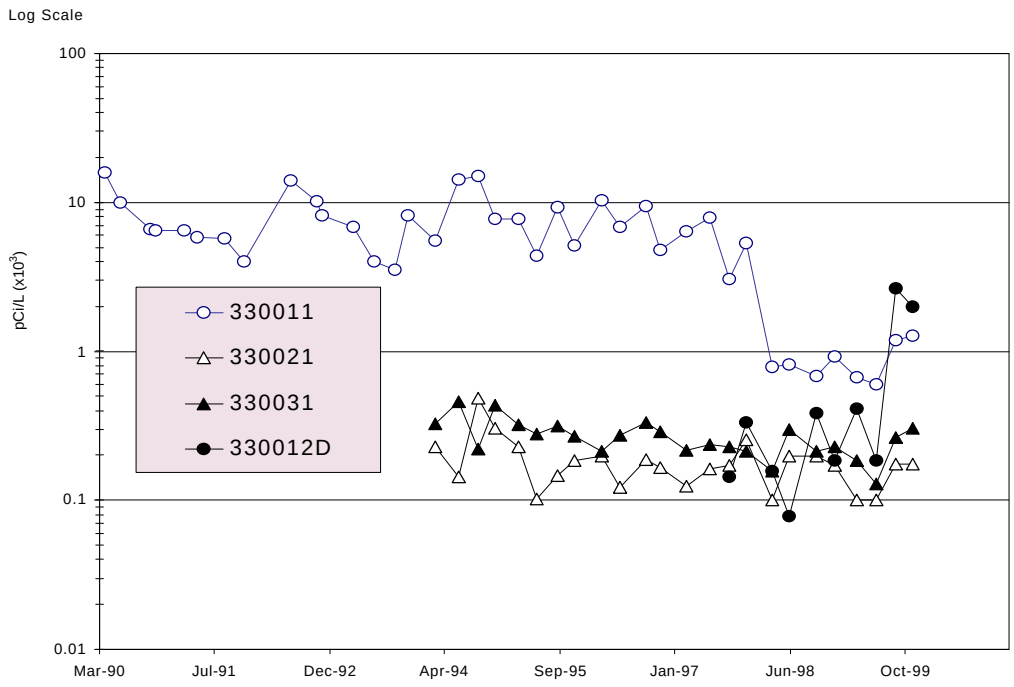


Figure 6.24 Hydrogen-3 Results in the CP-5 Monitoring Wells

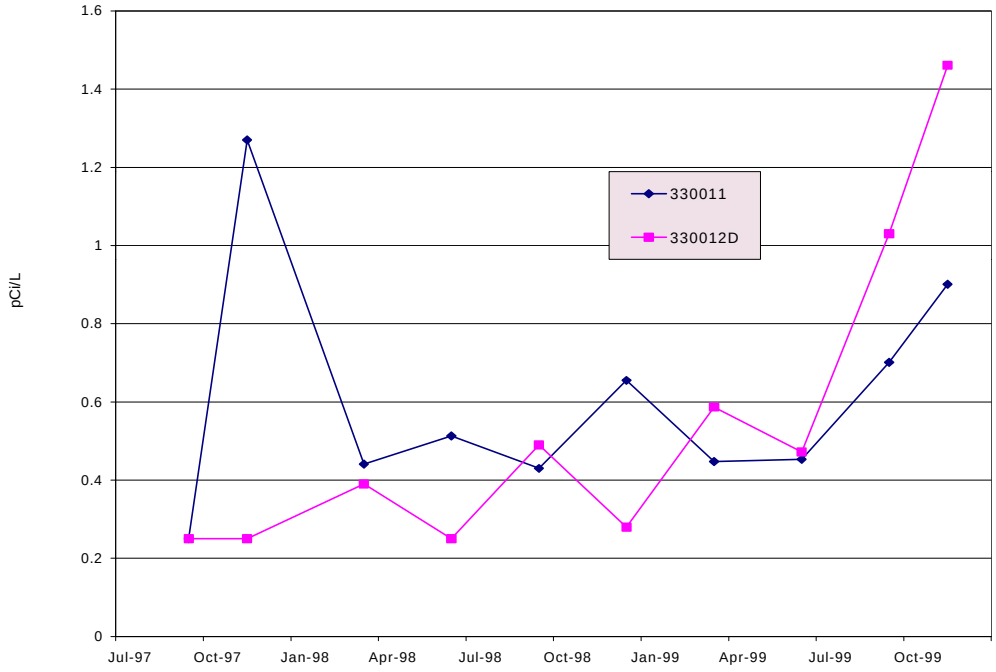


Figure 6.25 Strontium-90 Results in the CP-5 Monitoring Wells

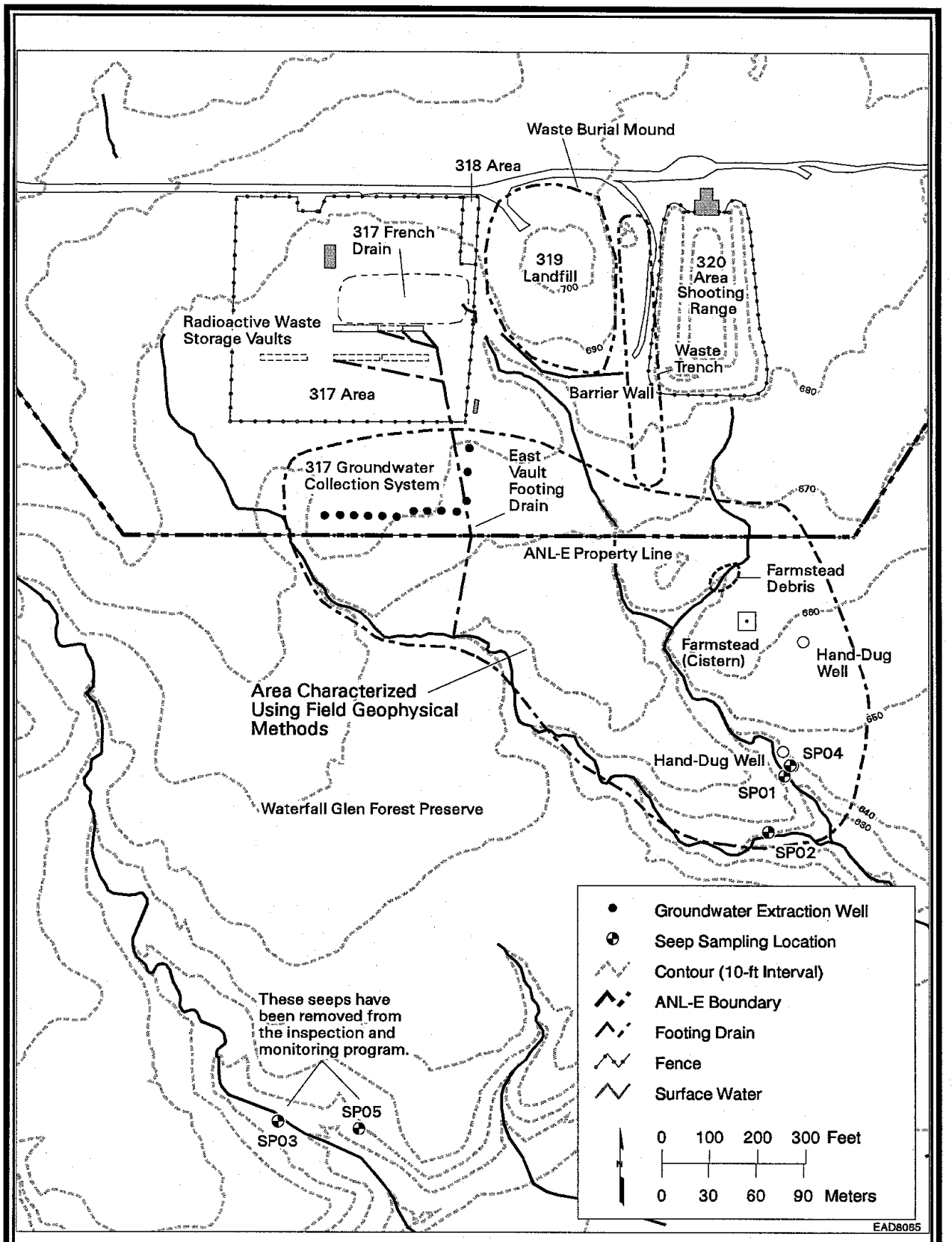


Figure 6.26 Seep Locations South of the 317/319 Area

Samples were collected 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 in measurable concentrations. Since the initial samples were collected, monthly samples were obtained through the end of 1997, and quarterly samples collected to the end of 1998. These results are summarized in the previous SER.[16]

During 1999, attempts were made to sample the three seeps quarterly. Unfortunately, all the seeps were dry during the middle quarters. The available data are given in Table 6.53. The hydrogen-3 and VOC results are consistent with past data, which indicates a gradual decline in concentrations since measurements began in 1996.

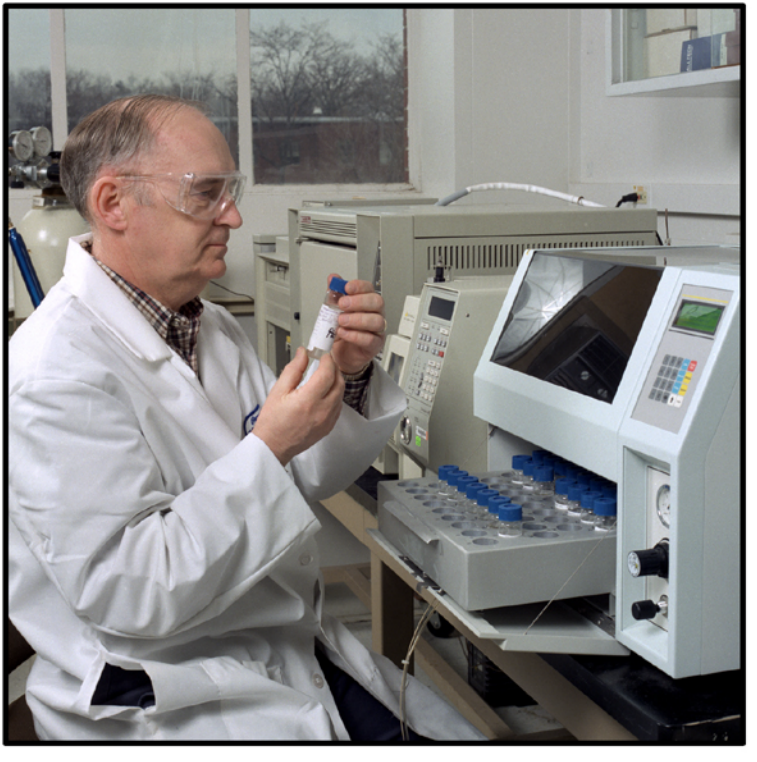
The presence of hydrogen-3 in the seep water supports the hypothesis that the 319 Area is the source of the contamination, because groundwater beneath the landfill contains hydrogen-3 at much higher concentrations. Hydrogen-3 was also detected in the 317 Area groundwater but at much lower concentrations. In addition, the mix of VOCs in groundwater under the 319 Landfill is different than the mix under the 317 Area but consistent with the mix found at the seeps. Geophysical characterization of the area indicates that there is a groundwater divide between the 317 and 319 Areas. The depth of contamination in the study areas is less well understood because the sampling techniques limited the sample collection depth to the upper regions of the glacial till. Because of the presence of the highly impermeable Lemont Drift underlying the more permeable Wadsworth till, the affected groundwater is almost certain to be limited to the upper permeable zones in the Wadsworth till. The seep monitoring and the area characterization study appear to have adequately described the source and pathway of the hydrogen-3 and VOC contaminants.

TABLE 6.53

Contaminant Concentrations in Seep Water, 1999

Site	Date Collected	Hydrogen-3 (pCi/L)	Carbon Tetrachloride (µg/L)	Chloroform (µg/L)	Tetrachloroethene (µg/L)
SP01	March 10	457 ± 49	9	2	< 1
	November 30	619 ± 56	10	3	< 1
SP02	March 10	541 ± 50	2	< 1	< 1
	November 30	1,559 ± 69	1	< 1	< 1
SP04	March 10	182 ± 44	201	24	5
	November 30	103 ± 46	311	32	8

7. QUALITY ASSURANCE



QA plans exist for both radiological and nonradiological analyses; these QA documents were prepared in accordance with DOE Order 5700.6C[29] 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 using the protocols listed in the *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*.[28] 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 till 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 samples are transferred to the analytical laboratory via a computer floppy 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

All nuclear instrumentation is calibrated with standard sources obtained from or traceable to the National Institute of Standards and Technology (NIST). The equipment is usually checked daily 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 1999 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%.

Average values are usually 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	1
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	-	0.1
Radium-228	-	0.1
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 hyphen indicates that a value is not required.

ANL-E continues to participate in the 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 results for 1999. 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-E laboratory. Information that will assist in judging the quality of the results includes

TABLE 7.2

Summary of DOE-EML-QAP Samples, 1999

Matrix	Constituent	Date	Unit	EML	ANL-E	Ratio	Comments
Air filter	Manganese-54	Sept.	Bq/filter	7.91	8.10	1.02	Acceptable
	Cobalt-57	March		3.01	3.25	1.08	Acceptable
		Sept.		7.73	8.03	1.04	Acceptable
	Cobalt-60	March		4.96	5.50	1.11	Warning
		Sept.		6.35	7.23	1.14	Warning
	Strontium-90	March		0.644	0.630	0.98	Acceptable
		Sept.		0.336	0.330	0.98	Acceptable
	Ruthenium-106	Sept.		5.50	8.25	1.50	Not Acceptable
	Antimony-125	March		3.59	4.28	1.19	Warning
	Cesium-137	March		6.05	6.59	1.09	Acceptable
		Sept.		6.43	6.45	1.00	Acceptable
	Uranium-234	March		0.060	0.066	1.10	Acceptable
		Sept.		0.066	0.070	1.06	Acceptable
	Uranium-238	March		0.061	0.063	1.03	Acceptable
		Sept.		0.065	0.070	1.08	Acceptable
	Plutonium-238	March		0.272	0.310	1.14	Acceptable
		Sept.		0.097	0.100	1.03	Acceptable
	Plutonium-239	March		0.124	0.140	1.13	Acceptable
		Sept.		0.136	0.140	1.03	Acceptable
	Americium-241	March		0.134	0.140	1.05	Acceptable
		Sept.		0.127	0.130	1.02	Acceptable
Soil	Potassium-40	March	Bq/kg	362.8	387.0	1.07	Acceptable
		Sept.		821.0	780.0	1.05	Acceptable
	Strontium-90	March		32.4	32.9	1.02	Acceptable
		Sept.		13.00	14.60	1.12	Acceptable
	Cesium-137	March		659.5	746.0	1.13	Acceptable
		Sept.		204.0	261.0	1.28	Warning
	Uranium-234	March		140.7	123.0	0.87	Acceptable
		Sept.		190.0	168.0	0.88	Acceptable
	Uranium-238	March		145.0	132.0	0.91	Acceptable
		Sept.		202.0	173.0	0.86	Acceptable
	Plutonium-239	March		8.11	8.48	1.04	Acceptable
		Sept.		3.20	2.94	0.92	Acceptable
	Americium-241	March		4.89	5.03	1.03	Acceptable
		Sept.		1.44	1.85	1.28	Acceptable

TABLE 7.2 (Cont.)

Matrix	Constituent	Date	Unit	EML	ANL-E	Ratio	Comments
Water	Hydrogen-3	March	Bq/L	121.1	129.0	1.06	Acceptable
		Sept.		80.7	82.4	1.02	Acceptable
	Cobalt-60	March		51.1	54.8	1.07	Acceptable
		Sept.		52.4	54.0	1.03	Acceptable
	Strontium-90	March		4.10	3.66	0.89	Acceptable
		Sept.		1.72	1.64	0.95	Acceptable
	Cesium-137	March		39.4	39.5	1.00	Acceptable
		Sept.		76.0	76.4	1.01	Acceptable
	Uranium-234	March		0.268	0.260	0.97	Acceptable
		Sept.		0.370	0.390	1.05	Acceptable
	Uranium-238	March		0.262	0.280	1.07	Acceptable
		Sept.		0.360	0.380	1.06	Acceptable
	Plutonium-238	March		0.772	0.790	1.02	Acceptable
		Sept.		0.790	0.800	1.01	Acceptable
	Plutonium-239	March		1.009	0.990	0.98	Acceptable
		Sept.		0.870	0.890	1.02	Acceptable
	Americium-241	March		1.146	1.230	1.07	Acceptable
		Sept.		0.850	0.940	1.11	Acceptable

the fact that typical uncertainties for ANL-E'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.

Overall, the ANL-E performance in the EML intercomparison studies on the three matrices resulted in over 91% (48 out of 53) of the analysis being in the DOE-EML-QAP acceptable range. Four samples analyzed by gamma-ray spectrometry fell within the warning category, while one air filter sample analyzed for ruthenium-106 produced unacceptable results. The ANL-E performance on these samples indicated that the reported results are accurate.

7.3. Chemical Analysis

The documentation for nonradiological analyses is contained in the ESH-ASCL Procedure Manual. All samples for NPDES and groundwater are collected and analyzed in accordance with EPA regulations found in 40 CFR Part 136,[23] EPA-600/4-84-017,[30] and SW-846.[8]

Standard reference materials traceable to the NIST exist for most inorganic analyses (see Table 7.3) and are replaced annually. Detection limits are determined with techniques listed in 40 CFR Part 136[23] and are given in Table 7.4. 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 7.5 and 7.6 show the 1999 results for VOCs and SVOCs, respectively. The recoveries listed are those required by the respective methods.

7.4. NPDES Analytical Quality Assurance

ANL-E 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.[23] To demonstrate the capabilities of the ANL-E laboratory for these analyses, the EPA requires that ANL-E participate in the DMR Quality Assurance program. The EPA sends a series of intercomparison samples to ANL-E annually, and the ensuing analytical results are submitted to the EPA for review. The proficiency of the laboratory is determined by comparing the analytical results for the submitted samples with the EPA values. The ANL-E laboratory has consistently performed very well on these tests. In 1999, the EPA decided to privatize the preparation of the intercomparison samples. Because of delays in accrediting providers, the EPA decided to cancel the DMR Quality Assurance Program for 1999. The EPA plans to resume this program in 2000.

TABLE 7.3

Standard Reference Materials Used for Inorganic Analysis

Constituent	Reference Material[a]
Antimony	HPS-10002-2
Arsenic	HPS-10003-1
Barium	HPS-10004-1
Beryllium	HPS-10005-1
Boron	HPS-10007-4
Cadmium	HPS-10008-1
Chromium	HPS-100012-1
Cobalt	HPS-100013-1
Copper	HPS-100014-1
Iron	HPS-100026-1
Lead	HPS-100028-1
Manganese	HPS-100032-1
Mercury	HPS-100033-1
Nickel	HPS-100036-1
Selenium	HPS-100049-1
Silver	HPS-100051-1
Thallium	HPS-100058-1
Vanadium	HPS-100065-1
Zinc	HPS-100068-1
Sulfate	NIST-SRM 3181
Chloride	NIST-SRM 3182
Fluoride	NIST-SRM 3183

[a] HPS = High Purity Standards, Inc.; NIST-SRM = National Institute of Standards and Technology - Standard Reference Materials.

TABLE 7.4

Detection Limit for Metals Analysis, 1999

	Detection Limit (mg/L)	
Constituent	AA[a]	ICP[b]
Antimony	0.0030	NA[c]
Arsenic	0.0025	0.124
Barium	NA	0.023
Beryllium	0.0002	0.019
Boron	NA	0.023
Cadmium	0.0002	0.012
Chromium	0.015	0.020
Cobalt	0.025	0.018
Copper	0.005	0.016
Hexavalent chromium[d]	0.006	NA
Iron	0.025	0.019
Lead	0.0020	0.072
Manganese	0.015	0.018
Mercury	0.0001	NA
Nickel	0.020	0.031
Selenium	0.0030	0.118
Silver	0.0005	NA
Thallium	0.0015	0.068
Vanadium	NA	0.035
Zinc	0.005	0.011

[a] AA = Atomic Absorption Spectroscopy.

[b] ICP = Inductively Coupled Plasma-Atomic Emission Spectroscopy.

[c] NA = not analyzed.

[d] Calorimetric measurement.

TABLE 7.5

Quality Check Sample Results: Volatile Analyses, 1999

Constituent	Recovery[a] (%)	Quality Limit (%)
Benzene	108	73 – 126
Bromobenzene	105	76 – 133
Bromodichloromethane	97	101 – 138
Bromoform	60	57 – 156
Butylbenzene	110	71 – 125
sec-Butylbenzene	84	71 – 145
t-Butylbenzene	96	69 – 134
Carbon Tetrachloride	103	86 – 118
Chlorobenzene	101	80 – 137
Chloroform	116	68 – 120
o-Chlorotoluene	116	81 – 146
p-Chlorotoluene	101	73 – 144
1,2-Dibromo-3-chloropropane	64	36 – 154
Dibromochloromethane	81	68 – 130
1,2-Dibromoethane	112	75 – 149
Dibromomethane	95	65 – 143
1,2-Dichlorobenzene	115	59 – 174
1,3-Dichlorobenzene	105	84 – 143
1,4-Dichlorobenzene	106	58 – 172
1,1-Dichloroethane	116	71 – 142
1,2-Dichloroethane	111	70 – 134
1,1-Dichloroethene	95	18 – 209
cis-1,2-Dichloroethene	113	85 – 124
trans-1,2-Dichloroethene	105	67 – 141
1,2-Dichloropropane	100	19 – 179
1,3-Dichloropropane	112	73 – 145
1,1-Dichloropropene	94	71 – 133
Ethyl Benzene	95	84 – 130
Isopropylbenzene	98	70 – 144
4-Isopropyltoluene	103	72 – 140
Methylene Chloride	113	D – 197[b]
n-Propylbenzene	94	78 – 139
1,1,1,2-Tetrachloroethane	96	88 – 133
Tetrachloroethene	112	84 – 132
Toluene	112	81 – 130
1,1,1-Trichloroethane	110	68 – 149
1,1,2-Trichloroethane	101	70 – 133
Trichloroethene	113	91 – 135
1,2,3-Trichloropropane	101	50 – 158
1,2,4-Trimethylbenzene	89	80 – 144
1,3,5-Trimethylbenzene	92	76 – 142
o-Xylene	112	79 – 141
p-Xylene	90	74 – 138

[a] Average of two determinations.

[b] D denotes that the compound was detected.

TABLE 7.6

Quality Check Sample Results:
Semivolatile Analyses, 1999

Constituent	Recovery[a] (%)	Quality Limit (%)
2-Fluorophenol[b]	56.1	21 – 100
Phenol-d5[b]	44.2	10 – 94
Phenol	44.7	17 – 100
2-Chlorophenol	85.7	36 – 120
1,4-Dichlorobenzene	56.2	37 – 106
n-Nitroso-n-Propylamine	50.2	24 – 198
Nitrobenzene-d5[b]	79.8	35 – 114
1,2,4-Trichlorobenzene	65.8	57 – 129
4-Chloro-3-Methylphenol	92.0	41 – 128
2-Fluorobiphenyl[b]	87.1	43 – 116
Acenaphthene	91.2	47 – 145
2,4-Dinitrotoluene	88.9	48 – 127
2,4,6-Tribromophenol[b]	79.2	10 – 123
Pentachlorophenol	109.0	38 – 152
Pyrene	88.4	70 – 100
Terphenyl-d14[b]	92.2	33 – 141

[a] Average of three determinations.

[b] Required surrogates.

8. APPENDIX

8.1. References

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