

**ARGONNE NATIONAL LABORATORY-EAST
SITE ENVIRONMENTAL REPORT FOR
CALENDAR YEAR 1996**

by

N. W. Golchert and R. G. Kolzow



ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

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Environmental Management Operations**

September 1997



**ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439**

Preceding Report in This Series: ANL-96/3

PREFACE

This Site Environmental Report (SER) was prepared by Environmental Management Operations (EMO) 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 previous years are available on the Internet at <http://www.emo.anl.gov/annrep>.

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ACM	Asbestos-Containing Material
ADS	Activity Data Sheet
AEA	Atomic Energy Act of 1954
ALARA	As Low As Reasonably Achievable
ANL-E	Argonne National Laboratory-East
AMSL	Above Mean Sea Level
AOC	Area of Concern
APS	Advanced Photon Source
ASTM	American Society for Testing and Materials
ATLAS	Argonne Tandem Linac Accelerating System
BAT	Best Available Technology
BGS	Below Ground Surface
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CAAPP	Clean Air Act Permit Program
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CIL	Compliance Inquiry Letter
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
COE	U.S. Army Corps of Engineers
CP-5	Chicago Pile-Five
CRM	Cultural Resource Management
CWA	Clean Water Act
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	Environmental Assessment
EBWR	Experimental Boiling Water Reactor
EIS	Environmental Impact Statement
EM	Environmental Management Program
EML	Environmental Measurements Laboratory
EMO	Environmental Management Operations
EMS	Environmental Protection Data Management System
ENE	East-Northeast
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ERAP	ANL-E Remedial Actions Project
ESA	Endangered Species Act

ACRONYMS

ESH	Environment, Safety and Health
ESH-ASCH	Environment, Safety and Health/Analytical Services, Chemistry Laboratory
ESH-ASCL	Environment, Safety and Health/Analytical Services, Control Laboratory
ESH-ASRC	Environment, Safety and Health/Analytical Services, Radiochemistry Laboratory
ESH-IH	Environment Safety and Health/Industrial Hygiene
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GOCO	Government-Owned Contractor-Operated
HEPA	High-Efficiency Particulate Air
HSWA	Hazardous and Solid Waste Amendments
IAC	Illinois Administrative Code
ICRP	International Commission on Radiological Protection
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
IHPA	Illinois Historic Preservation Agency
IPNS	Intense Pulsed Neutron Source
ISO	International Standards Organization
LEPC	Local Emergency Planning Committee
LLW	Low-Level Radioactive Waste
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
NBL	New Brunswick Laboratory
NCRP	National Council on Radiation Protection and Measurements
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
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRHP	National Register of Historical Places
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyl
PFS	Plant Facilities and Services
PSTP	Proposed Site Treatment Plan
QA	Quality Assurance
QAP	Quality Assurance Program
RCRA	Resource Conservation and Recovery Act

RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RMW	Radioactive Mixed Waste
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Investigation
SIP	State Implementation Plan
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasure
SRM	Standard Reference Material
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
TRC	Total Residual Chlorine
TRI	Toxic Release Inventory
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WM	Waste Management
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 1996. 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 to applicable guidelines and standards. A variety of radionuclides were measured in air, surface water, on-site groundwater, soil, grass, 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. The results of the surveillance program are interpreted in terms of the origin of the radioactive and chemical substances (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 CAP-88 version of the EPA-AIRDOSE/RADRISK computer code, is used in 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. This report also discusses progress being made on environmental corrective actions and restoration projects.

This report summarizes the ongoing environmental protection program conducted by Argonne National Laboratory-East (ANL-E) in 1996. It includes descriptions of the site, the 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 disposal of asbestos, and conventional air pollutants from ANL-E facilities are regulated under the Clean Air Act. 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, [40 CFR 61] Subpart H). All such air emission sources were evaluated to ensure that these requirements are being properly addressed. The ANL-E individual off-site dose required to be reported by U.S. Environmental Protection Agency (EPA) regulations (40 CFR 61, Subpart H) was 0.021 mrem/yr in 1996. This is 0.21% of the 10 mrem/yr standard. This dose excluded the contributions from radon-220 and radon-222 emissions as required by the regulations.

At ANL-E, asbestos-containing material is frequently encountered during maintenance or renovation of existing facilities and equipment. Asbestos is removed and disposed of in strict accordance with NESHAP, Toxic Substance Control Act (TSCA), and Occupational Safety and Health Administration worker protection standards. Other applicable authorities include (1) the accreditation program of the EPA Model Accreditation Plan implementing the Asbestos School Hazard Abatement Reauthorization Act of 1990, which amends the TSCA asbestos provisions,

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and (2) the registration and licensing requirements of the Illinois Commercial and Public Building Asbestos Abatement Act, effective July 14, 1995. All asbestos waste material was disposed of at off-site landfills in Illinois. Approximately 230 m³ (8,100 ft³) of asbestos-containing materials was removed and disposed of off site during 1996.

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) are also significant sources, when operational. The operating air pollution control 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. Only low-sulfur coal was burned six months during 1996, whereas natural gas was used exclusively as a fuel for the other six months of the year. During the period coal was burned, which occurred during colder weather to supplement the gas-fired boilers, no exceedances were observed.

The principal regulatory mechanism designed to achieve the goals of the Clean Water Act is the National Pollutant Discharge Elimination System (NPDES). The authority to implement the NPDES program has been delegated to the State of Illinois. The permit renewal, which became effective October 30, 1994, increased the number of monitored discharge points from 9 to 28. The permit was modified on August 24, 1995, to temporarily increase some limits and to include a three-year compliance schedule to achieve final limits. During 1996, only two exceedances of the NPDES permit limits were reported out of approximately 1,600 measurements.

ANL-E was granted interim status under the Resource Conservation and Recovery Act (RCRA) by submitting a Part A permit application in 1980. In 1990, a Part B permit application was submitted to the Illinois Environmental Protection Agency (IEPA). Twenty-two hazardous waste treatment and storage facilities have been identified. The IEPA issued a draft RCRA Part B permit in September 1996.

ANL-E has prepared and implemented a sitewide underground storage tank (UST) compliance plan. Thirty-three tanks have been removed over the past several years, and 25 tanks

were replaced or upgraded. Of the locations from which tanks were removed or replaced, 17 were found to have some degree of exterior contamination from leaks, spills, or overfills.

In 1986, 10 potential Comprehensive Environmental Response, Compensation and Liability Act sites were identified. Under the Superfund Amendments and Reauthorization Act of 1986, a total of 15 Preliminary Assessment reports were submitted. In late 1990, Site Screening Investigation reports were completed on two individual sites and one composite submittal of three locations (317/319/East-Northeast). At present, characterization studies are conducted on a voluntary basis at various stages for a number of the identified sites. Eventually, the characterization/remediation studies will be regulated through the RCRA Corrective Action process, once ANL-E's RCRA Part B permit has been issued.

The only TSCA compounds in significant quantities at ANL-E are polychlorinated biphenyls (PCBs) contained in electrical capacitors, transformer oil, and PCB-contaminated soil and sludge. 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. PCB-contaminated sludge from the building retention tanks and the laboratory Wastewater Treatment Plant holding tanks was removed in 1996.

DOE implementation of National Environmental Policy Act (NEPA) requirements has been undergoing significant changes since 1992. Most NEPA project reviews sent to DOE for review and approval were determined to be categorical exclusions, although Environmental Assessments will be required for two projects. Currently, there are no active projects at ANL-E requiring an Environmental Impact Statement.

The Environmental Management Plan requests funds for on-site rehabilitation projects, environmental restoration projects, and waste management activities. The rehabilitation projects concentrate on upgrading or replacing existing treatment facilities. Environmental restoration activities consist of projects that assess and clean up inactive waste sites. These include two

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inactive landfills, three French drains (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. A number of decontamination and decommissioning (D&D) projects for on-site nuclear facilities have been identified, including cleanup at the Experimental Boiling Water Reactor and Chicago Pile-Five research reactors. The majority of the Waste Management projects involve improvements to existing treatment or storage facilities.

The major compliance issue at ANL-E in 1996 was the result of new NPDES limits for total dissolved solids (TDS), copper, ammonia nitrogen, and total residual chlorine. Another significant issue involved the resolution of the inadvertent shipment, through an independent contractor, of waste oil contaminated with PCBs to an off-site recycling facility in 1994. Other compliance issues included exceedance of the action levels for copper in drinking water, elevated levels of some routine indicator parameters in the groundwater at the sanitary landfill, UST corrective action, wetlands at APS, 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. The effective dose equivalents were estimated at the site perimeter and to the maximally exposed member of the public with the CAP-88 version of the EPA/AIRDOSE-RADRISK code. The estimated maximum perimeter dose was 0.23 mrem/yr in the south-southeast direction, while the estimated maximum dose to a member of the public was 0.053 mrem/yr. This is 0.053% of the DOE radiation protection standard of 100 mrem/yr for all pathways. Approximately 60% of this estimated dose is due to the release of 388 Ci of radon-220 in 1996. If the radon-220 impact is excluded from reporting, as required in 40 CFR 61, Subpart H, the estimated dose to the maximally exposed individual would be 0.021 mrem/yr. The estimated population dose from all releases to the approximately eight million people living within 80 km (50 mi) of the site was 2.64 man-rem.

Air monitoring was also conducted at ANL-E for total alpha activity, total beta activity, strontium-90, isotopic thorium, isotopic uranium, and plutonium-239. Except for elevated levels of strontium-90 and plutonium-239 in the 317 Area during the demolition of the South Vaults in April, no statistically significant difference was identified between samples collected at the ANL-E perimeter and samples collected off the site. Monitoring for hazardous chemical constituents in ambient air was not conducted.

The only source of 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, neptunium-237, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 0.76 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 0.0343 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 is also monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards. Iron, copper, and zinc were occasionally detected above the standard.

Surface soil and grass samples were collected at 10 perimeter and 10 off-site locations during 1996. The purpose of the sampling was to detect the possible buildup of radionuclides from the deposition of airborne emissions. The results indicate no statistically significant difference between the perimeter and off-site concentrations of potassium-40, cesium-137, radium-226, thorium-228, thorium-232, plutonium-238, plutonium-239, and americium-241.

Sediment samples were collected from Sawmill Creek, above, at, and below the point of wastewater discharge. For comparative purposes, samples were also collected from the beds of 10 off-site streams and ponds. The analysis of the off-site samples for selected radionuclides established their current ambient levels. Elevated levels of plutonium-238 (up to 0.002 pCi/g),

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plutonium-239 (up to 0.020 pCi/g), and americium-241 (up to 0.008 pCi/g) were found in the sediment below the outfall and are attributed to past ANL-E releases.

Dose rates from penetrating radiation (gamma-rays) were measured at 14 perimeter and on-site locations and at five off-site locations in 1996 using thermoluminescent dosimeters. The off-site results averaged 90 ± 4 mrem/yr, 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 129 ± 15 mrem/yr for 1996. 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 1996 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The inhalation pathway dominates. The highest estimated dose was about 0.10 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. Doses from other pathways were calculated and were small at this location. The magnitude of the doses from ANL-E operations are well within all applicable standards and are insignificant when compared to 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 1996. The ANL-E domestic water supply is monitored by collecting quarterly samples from the four supply wells and a treated water tap. All results were less than the limits established by the Safe Drinking Water Act except for elevated levels of TDS. The action level for copper in drinking water was exceeded during 1996.

Ten monitoring wells screened in the glacial till and two in the dolomite were sampled quarterly at the 317/319 Area and analyzed for radiological, volatile organic, semivolatile, PCB, and pesticide/herbicide constituents. The major organic contaminants detected were trichloroethene, 1,1,1-trichloroethane, 1,1-dichloroethane, carbon tetrachloride,

1,2-dichloroethane, cis-1,2-dichloroethene, vinyl chloride, tetrachloroethene, and chloroform. Measurable levels of hydrogen-3, strontium-90, and cesium-137 were present in several of the wells. Remediation continued in this area. A slurry wall was installed south of the 319 Landfill to contain the off-site movement of any pollutants.

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, volatile organic compounds, semivolatiles, PCBs, pesticides and herbicides, and hydrogen-3. Levels above Water Quality Standards for chloride, iron, manganese, and TDS were found in some wells. Above background levels of hydrogen-3, acetone, and methylene chloride were found 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 the supporting standard operating procedures. Newly collected data were compared both with recent results and historical data to ensure that deviations from previous conditions were identified and promptly evaluated. 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. The Laboratory is committed to implementing that system in accordance with ANL-E environmental policy. It is also evaluating the use of International Standards Organization Standard 14001, which is intended to give organizations the elements of an effective environmental management system that can be integrated with other management requirements so that organizations can achieve their environmental and economic goals.

1. INTRODUCTION



1.1. General

This annual report for 1996 on the Argonne National Laboratory-East (ANL-E) environmental protection program provides the U.S. Department of Energy (DOE), environmental agencies, and the public with information on the levels of radioactive and chemical pollutants in the vicinity of ANL-E and on 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 follows the guidelines given in DOE Order 5400.1,¹ DOE Order 231.1,² and supplemental DOE guidance.

ANL-E conducts a continuing program of environmental surveillance on and near the site to determine the identity, magnitude, and origin of radioactive and chemical substances in the environment. The detection of any such materials released to the environment by ANL-E operations is of special interest. One important function of the program is to verify the adequacy of ANL-E's pollution control systems.

ANL-E is a DOE energy research and development laboratory with several principal objectives. It conducts a broad program of research in the basic energy and related sciences (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 1996 included safety studies for light-water and breeder reactors; superconductivity advances and applications; improvements in the use of coal for power production (particularly high-sulfur coal); synchrotron radiation accelerator design; development of electrochemical energy sources, including fuel cells and batteries for vehicles and for energy storage; and evaluation of heat exchangers for the recovery of waste heat from engines.

Other areas of research are the use of superconducting magnets for improved nuclear particle accelerators, fundamental coal chemistry studies, the immobilization of radioactive waste products for safe disposal, medical radioisotope technology, carcinogenesis, and the biological effects of small amounts of radiation. Environmental research studies include biological activity

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of energy-related mutagens and carcinogens; characterization and monitoring of energy-related pollutants; and the effects of acid rain on vegetation, soil, and surface water quality. A significant number of these laboratory studies require the controlled use of radioactive and chemically toxic substances.

The principal nuclear facilities at ANL-E are the Advance 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 1996 that may have measurable impacts on the environment include the use of a coal-fired boiler (No. 5), studies of the closed-loop heat exchanger for waste heat recovery, and the use of large quantities of chlorine for water treatment. The closed-loop heat exchanger studies involved the use of moderately large quantities of toxic or flammable organic compounds such as toluene, Freon, biphenyl oxides, methyl pyridine, and trifluoroethanol. The major potential for environmental impact from these materials would be associated with any accidental releases caused by equipment malfunction. However, no such releases have occurred.

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. The 907-ha (2,240-acre) Waterfall Glen

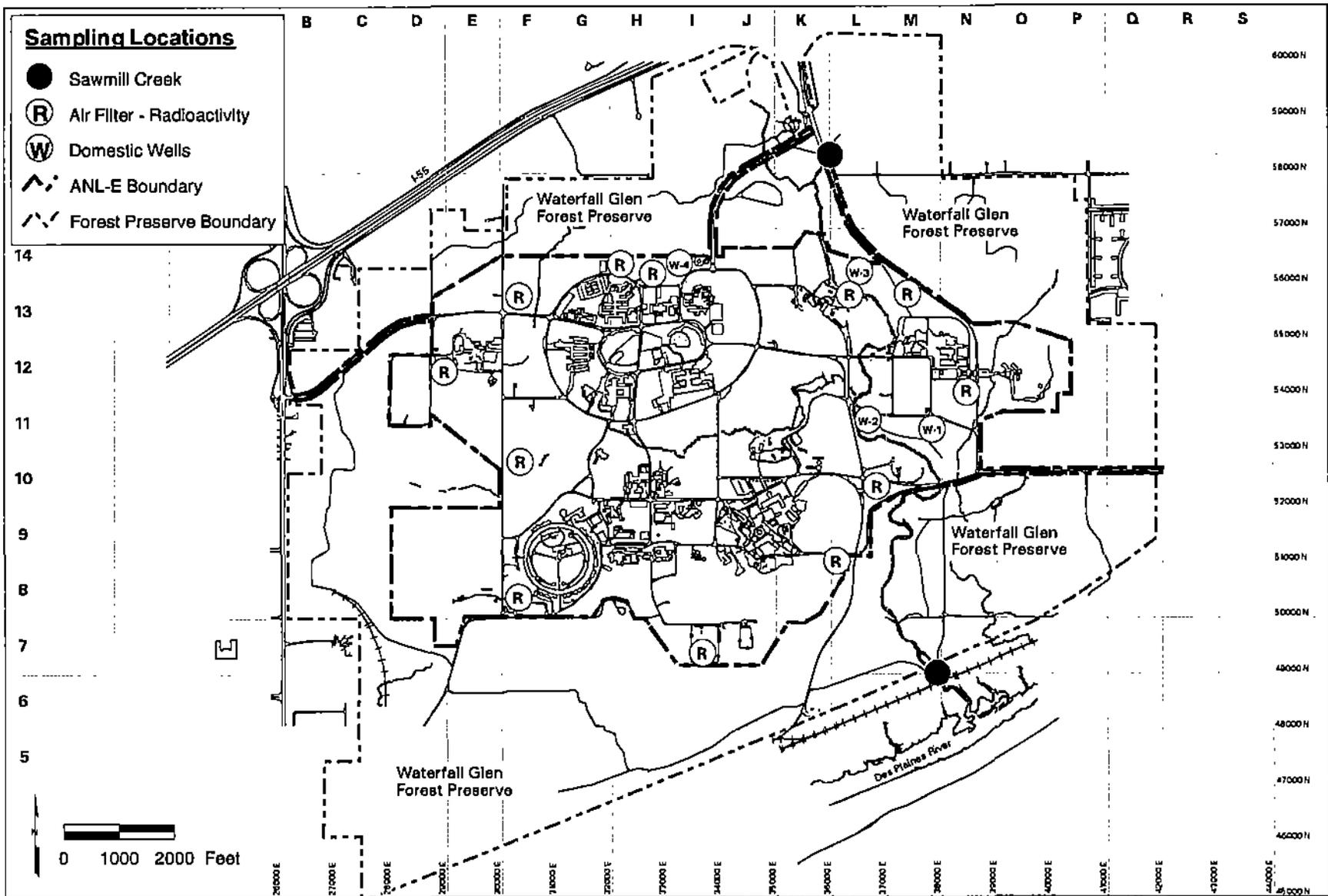


Figure 1.1 Sampling Locations at Argonne National Laboratory-East

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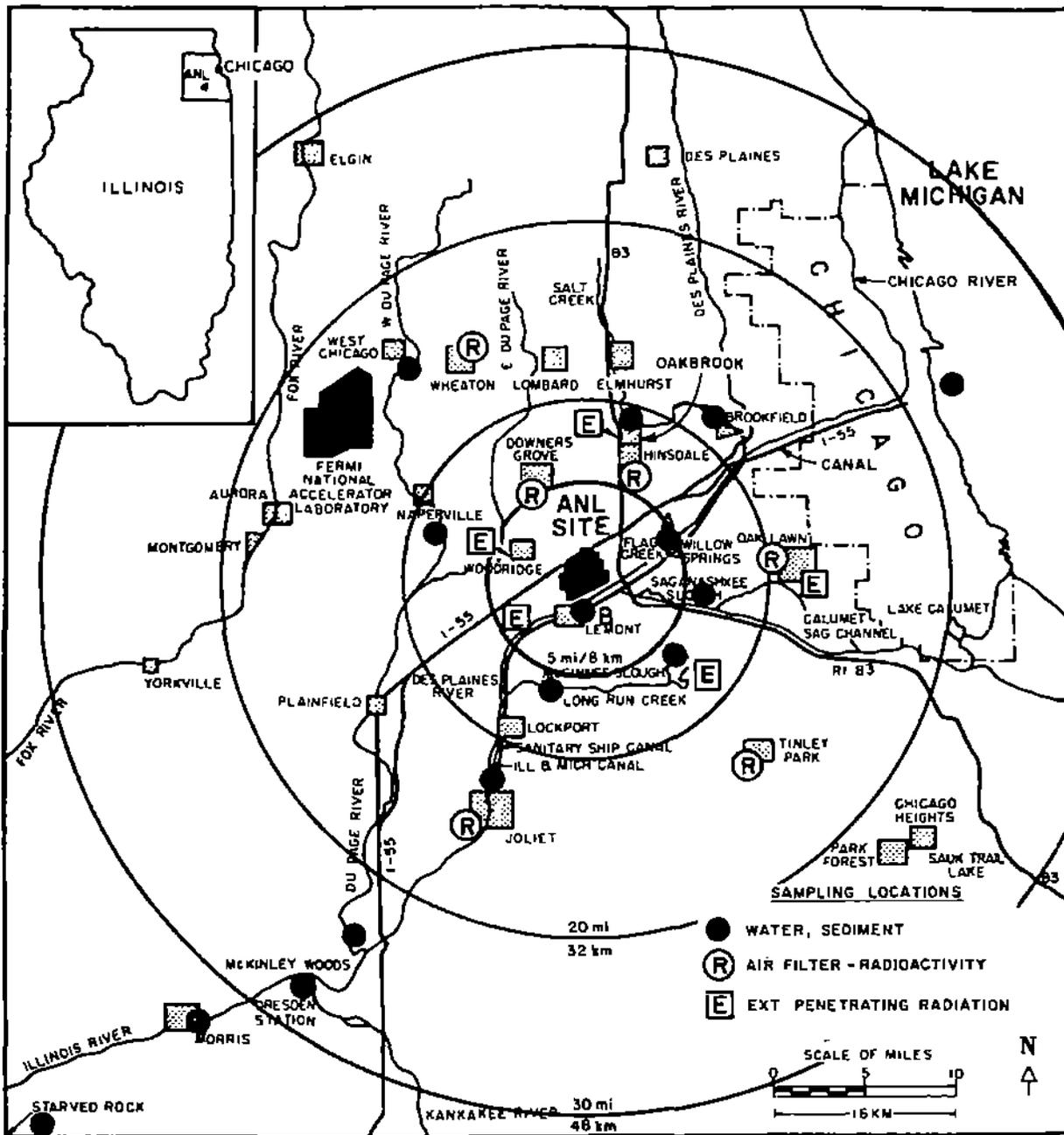


Figure 1.2 Sampling Locations near Argonne National Laboratory-East

Forest Preserve surrounding the site is mostly former ANL-E property that was deeded to the DuPage County Forest Preserve District in 1973 for use as a public recreational area, nature preserve, and demonstration forest. Figure 1.1 contains numbers on the abscissa and letters on the ordinate. In this report, facilities are identified by the alpha-numeric 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. Their presence extends the uninhabited area created by the ANL-E site and surrounding forest preserve about 1.6 km (1 mi) south of the site. The elevation of the channel surface 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°, reaching an average elevation of 200 m (650 ft) above sea level at the top. The land then slopes gradually upward reaching 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.

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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 presents the directional and annular 80-km (50-mi) population distribution for the area, which is used for the population dose calculations 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 1995 based on 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 1949 to 1964 are available^{3,4} 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 1996 data were obtained from the on-site ANL-E meteorological station. The 1996 average monthly and annual wind rose 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° intervals; each radius represents the average wind speed for the direction covering 11.25° on either side of the radius.

TABLE 1.1

Population Distribution in the Vicinity of ANL-E, 1995

Direction	Population (individuals) at 0-5 Miles ^a					Population (thousands) at 5-50 Miles ^a				
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	0	722	4,584	6,116	9,589	48.8	187.8	338.8	203.3	245.3
NNE	0	24	4,022	6,469	5,773	41.3	305.8	488.8	92.6	0
NE	0	805	2,504	2,654	1,808	41.3	678.6	871.7	0	0
ENE	0	1,219	2,724	1,574	1,496	33.7	602.4	180.0	0	0
E	0	18	11	1	42	41.1	469.9	201.4	13.2	28.1
ESE	0	0	56	333	308	22.5	187.3	284.9	248.6	86.7
SE	0	2	220	428	199	20.1	104.6	119.1	29.6	12.4
SSE	0	75	404	222	1,945	13.6	25.3	8.9	11.8	17.8
S	0	108	2,313	927	957	4.3	27.1	2.3	37.6	37.1
SSW	0	34	3,526	1,237	805	17.0	103.9	12.4	19.7	7.6
SW	0	87	20	94	91	13.4	42.5	10.5	17.6	9.6
WSW	0	235	95	717	1,904	5.6	8.8	4.3	8.5	7.4
W	0	851	1,417	9,646	10,477	30.2	76.4	21.8	16.1	7.1
WNW	0	277	253	6,642	4,945	48.5	117.2	23.5	7.2	56.6
NW	0	603	2,841	7,620	7,401	45.4	75.7	108.0	20.7	19.2
NNW	0	537	3,029	4,936	10,252	36.5	118.5	232.4	152.6	117.1
Total	0	5,597	28,019	49,616	57,992	463.2	3,131.7	2,908.7	879.1	652.1
Cumulative total ^b	0	5,597	33,616	83,232	141,224	604.5	3,736.2	6,644.9	7,524.0	8,176.2

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

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

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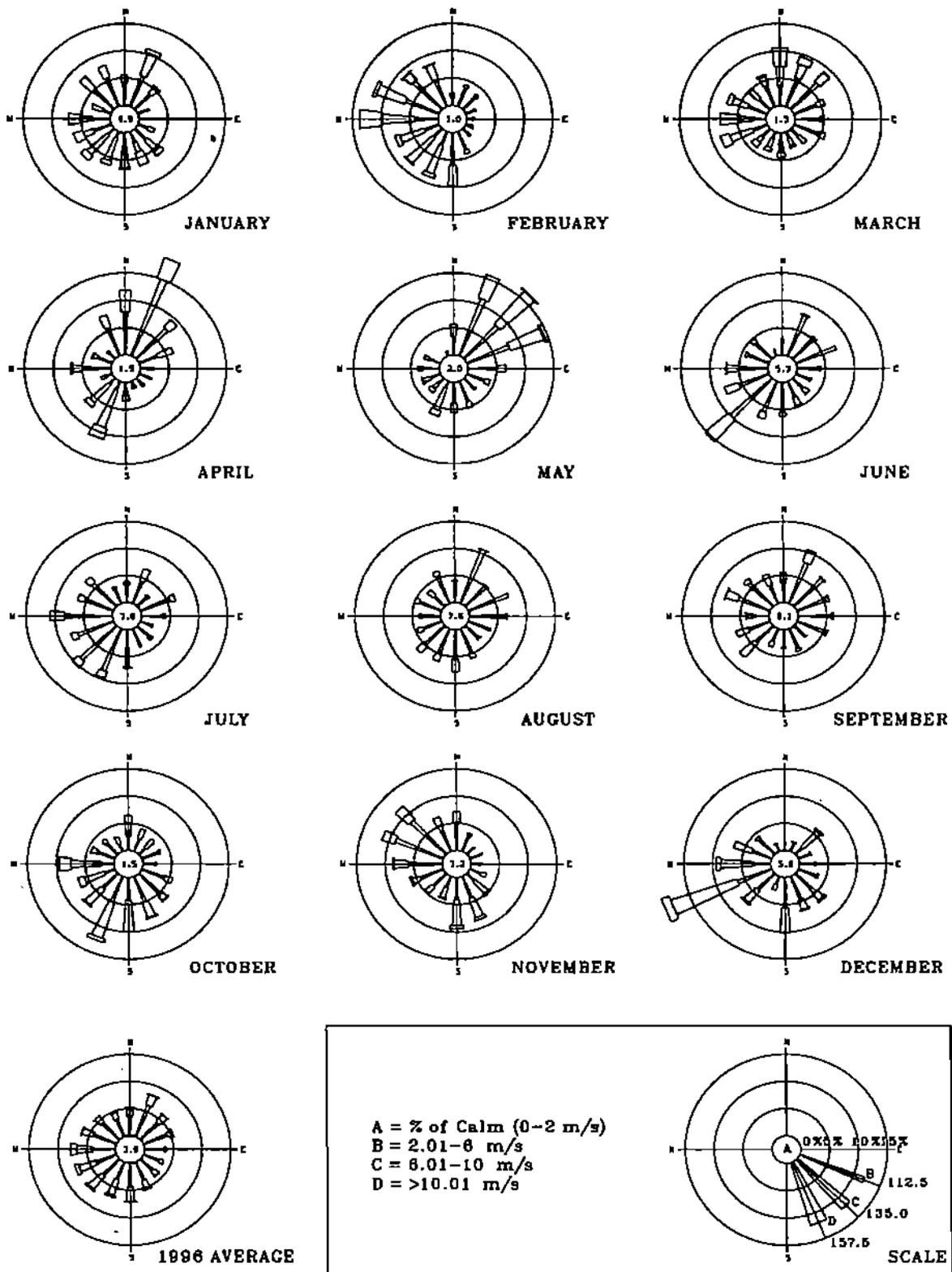


Figure 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory-East, 1996

The annual average wind rose for 1996 is consistent with the long-term average wind direction, which usually varies from the west to south, but with a significant northeast component. Precipitation and temperature data for 1996 are shown in Table 1.2. The monthly precipitation data for 1996 showed some differences from the average. For example, May, July, and November are above the average, while February, March, and August are below the average. A single rainfall event on July 17, 1996, measured 29.4 cm (11.57 in.) with 7.4 cm (2.89 in.) falling in one hour. The annual total is 25% higher than the long-term average. The temperatures are similar to the long-term averages.

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. Niagaran and Alexandrian dolomite is about 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, 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; 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

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TABLE 1.2

ANL-E Weather Summary, 1996

Month	Precipitation (cm)			Temperature (°C)		
	ANL-E 1996	ANL-E Historical Average ^a	Historical Average ^b	ANL-E 1996 Monthly Average	ANL-E Historical Average ^a	Historical Average ^b
January	3.81	3.61	4.06	-5.0	-5.9	-5.9
February	1.52	3.38	3.33	-2.9	-3.7	-3.3
March	2.03	5.56	6.58	-0.2	0.6	2.2
April	6.86	9.14	9.30	7.6	8.3	9.3
May	12.98	7.82	8.00	13.2	14.5	15.1
June	11.05	9.47	10.36	20.5	19.7	20.3
July	34.32	10.97	9.22	20.7	21.7	22.8
August	1.19	8.71	8.97	22.2	20.9	22.2
September	8.38	7.14	8.51	18.0	16.8	18.2
October	5.05	6.58	5.79	11.5	11.4	11.9
November	7.67	4.37	5.23	0.5	2.9	4.3
December	<u>4.60</u>	<u>3.20</u>	<u>5.33</u>	-2.6	-4.2	-2.4
Total	99.46	80.01	79.95			

^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.

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 has been positively associated with particular tectonic features. Most of the recent local seismic activity

is believed to be caused by isostatic adjustments of the earth's crust in response to glacial loading and unloading, rather than by motion along crustal plate boundaries.

Several areas of considerable seismic activity are located at moderate distances (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 (approximate threshold of major damage) once in about 600 years, with an error range of -250 to +450 years.

1.7. Hydrology

Most groundwater supplies in the ANL-E area are derived from the Niagaran, and to some extent, the Alexandrian dolomite bedrock. Dolomite well yields are variable, but many are near 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.

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 about 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

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aquifer from the underlying sandstone aquifer. This shale retards the hydraulic connection between the two aquifers.

The four domestic water supplies in use in 1996 on the ANL-E site (see Figure 1.1) are drilled about 90 m (300 ft) deep and terminate in the Niagaran dolomite. This water supply was used until January 1997 when Lake Michigan was acquired. A well drilled in the Galesville sandstone 490 m (1,600 ft) deep has been taken out of service. The water level in the Niagaran dolomite has decreased under ANL-E pumping and dropped about 11 m (35 ft) between 1948 and 1996. The aquifer appears to be adequate for future ANL-E use, but this groundwater source is used throughout the area. Several small capacity water wells used for laboratory experiments, fire protection, and sanitary facilities also exist on the site, primarily in the 800 Area and the meteorology complex.

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 originate on site and 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. There is also a network of ditches and culverts that transport 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 south branch at Lower Freund Pond. The upper Freund Brook branch discharges into the Middle Freund Pond. As a result of the deluge on July 17, 1996, which deposited 28 cm (11 in.) of rainfall in less than 24 hours, the dam

impounding the Middle Freund Pond was bypassed. The excess rainfall cut a trench around the dam that resulted in the draining of Middle Freund Pond. The pond remained drained for the remainder of 1996.

Sawmill Creek carried effluent water continuously from a sewage treatment plant (Marion Brook Treatment Plant) located a few kilometers north of the site until October 27, 1986, when the plant was closed. Residential and commercial development in the area has 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. This effluent averaged 2.5 million L (0.67 million gal) per day. The effluent flow is similar to that in 1994 and 1995, but a reduction from the 3.9 million L (1 million gal) discharged in 1993, and is attributed to the completion of a sewer replacement project that eliminated infiltration. The combined ANL-E effluent consisted of 53% laboratory wastewater and 47% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 25 million L (6.7 million gal) per day during 1996. The 30% higher flow in Sawmill Creek is directly related to the greater precipitation in 1996.

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 about 1.1 million L (290,589 gal) per 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, on the Illinois River about

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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 equestrian sports. 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.

From early photographs of the site, it appears 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, often not forming 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.

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 inhabit the ANL-E site. The white-tailed and fallow deer populations are each maintained at a target density of 20 deer per square mile 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, reflecting the creek's high silt load, steep gradient, and historic release of sewage effluent from the Marion Brook

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sewage-treatment plant north of the site. The fauna consists primarily of blackflies, midges, isopods, flatworms, segmented worms, and creek chubs. A few other species of minnows, sunfishes, and catfish are also present. Clean water invertebrates, such as mayflies and stoneflies, are rare or absent. The fish species that have been recorded in ANL-E aquatic habitats include black bullhead, bluegill, creek shub, golden shiner, goldfish, green sunfish, largemouth bass, stoneroller, and orange-spotted sunfish.

The Des Plaines River system, including ANL-E streams, has been rated as “poor” in terms of the fish species present, as determined by the U.S. Fish and Wildlife Service (FWS), the result of domestic and industrial pollution and stream modification.

1.11. Archaeology

ANL-E, 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 by either professional cultural resource investigation or by interviews of ANL-E staff with local collectors. A variety of site types, including mounds, quarries, lithic workshops, and habitation sites have been reported by amateurs within a 25-km (16-mi) radius.

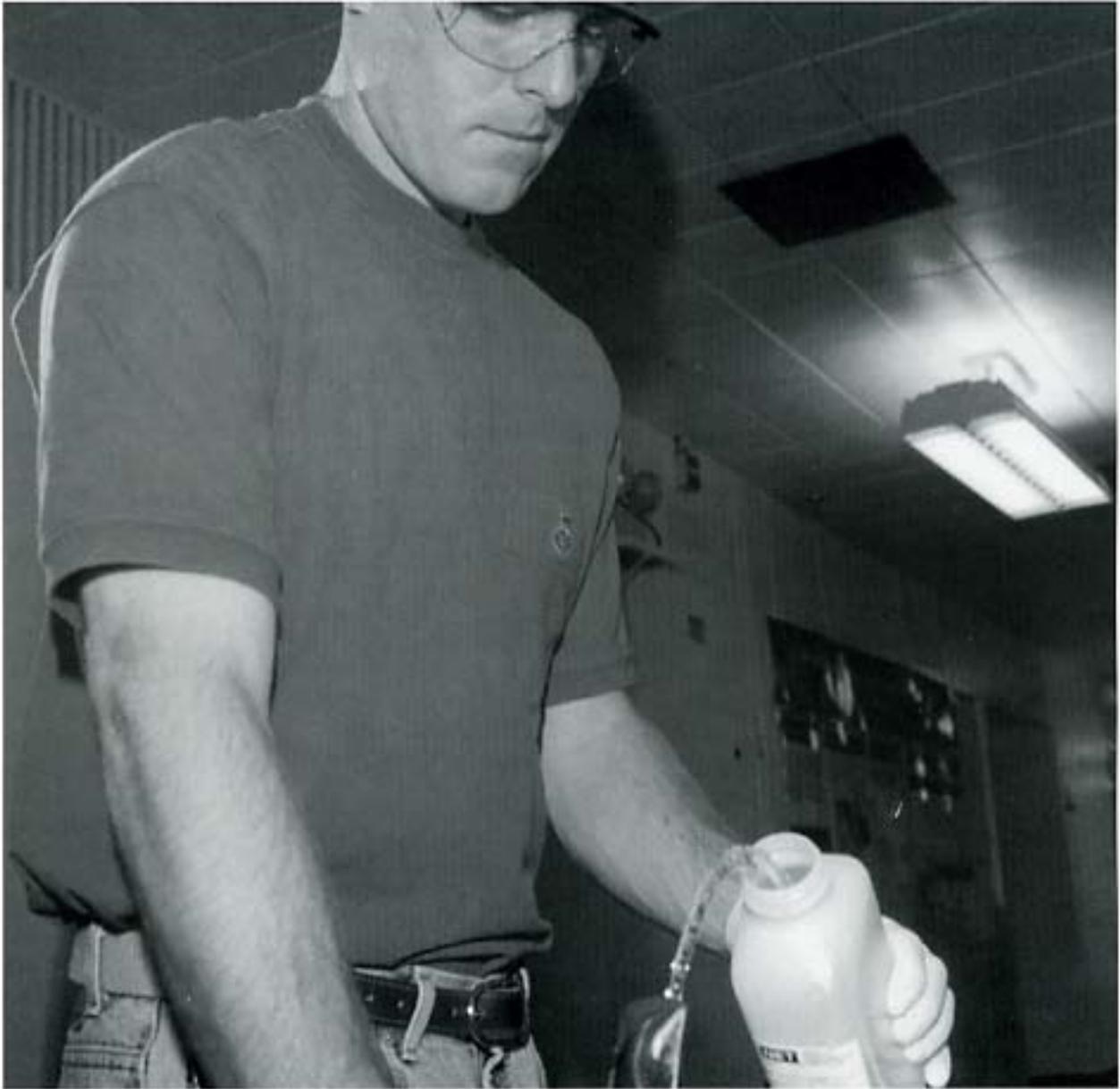
The 26 recorded sites include prehistoric chert quarries, special purpose camps, base camps, and historical farmsteads. The range of human occupation spans several time periods (Early Archaic through Mississippian Prehistoric to Historical). To date, 20 sites may be eligible for the National Register of Historic Places (NRHP); the remainder have not been formally evaluated for NRHP eligibility.

1.12. Endangered Species

No federal-listed threatened or endangered species are known to reside on the ANL-E site. However, the federal-listed endangered Indiana bat (*Myotis sodalis*) and the federal-listed endangered Hine's emerald dragonfly (*Somatochlora hineana*) are known to exist in the area.

Three state-listed endangered bird species — great egret (*Casmerodius alba*), black-crowned night heron (*Nycticorax nycticorax*), and pied-billed grebe (*Podilymbus podiceps*) — have been observed on the ANL-E site, but are not known to breed there. Hairy marsh yellow cress (*Rorippa islandica* var *hispida*), state-listed as endangered, and the Kirtland's snake (*Clonophis kirtlandi*), state-listed as threatened, have been observed on the ANL-E site. Five state-listed endangered species — river otter (*Lutra canadensis*), white lady's slipper (*Cypripedium candidum*), red-shouldered hawk (*Buteo lineatus*), slender sandwort (*Arenaria patula*), and inland shadblow (*Amelanchier interior*) — and two state-listed threatened species, early fen sedge (*Carex crawei*) and marsh speedwell (*Veronica scutellata*), are not known to inhabit the site but can be found in the area.

2. COMPLIANCE SUMMARY



2. COMPLIANCE SUMMARY

ANL-E is a government-owned, contractor-operated (GOCO) 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), and the State Fire Marshal, as well as 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 1996 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 a number of hazardous air pollutants. The program 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 to the IEPA a Clean Air Act Permit Program (CAAPP) application for a sitewide, federally-enforceable operating permit to cover emissions of all regulated air pollutants at the facility. This would supersede the state air pollution control permits that are currently in effect. All facilities that are designated as major emission sources for regulated air pollutants are

2. COMPLIANCE SUMMARY

subject to this requirement. ANL-E meets the definition of a major source because of potential emissions of oxides of nitrogen (NO_x) in excess of 25 tons per year and sulfur dioxide (SO₂) in excess of 100 tons per year at the Building 108 Central Heating Plant.

Facilities subject to Title V must characterize emissions of all regulated air pollutants, not only those that make them qualify as major sources. For ANL-E, in addition to NO_x and SO₂, emissions of carbon monoxide, particulates, volatile organic compounds (VOCs), hazardous air pollutants (a list of 188 chemicals, including radionuclides), and ozone-depleting substances must also be evaluated. The air pollution control permit program requires that facilities pay annual fees based upon the total amount of regulated air pollutants (except carbon monoxide) they will be allowed to emit.

Upon acknowledgment of the application by the IEPA as timely and complete, ANL-E would receive an application shield and remain in compliance with the CAA. The ANL-E CAAPP application was submitted to the IEPA on September 19, 1995, and the Notice of Completeness was issued by the IEPA 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. An exception to this is the ANL-E Fire Department's open burning permit (used for fire training), which must be renewed on an annual basis.

The ANL-E CAAPP application was still awaiting technical review by the IEPA in 1996. A major revision updating the original application submitted in 1995 was sent to the IEPA on September 9, 1996. A second revision was nearing completion at the end of 1996 for submittal in early 1997. The IEPA assigned a permit writer to the ANL-E application in late fall of 1996 and indicated that review of the application would begin sometime in 1997.

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 1996, a total of 42 air pollution control permits were in place covering all known emission points. Section 2.15 contains a list

2. COMPLIANCE SUMMARY

(Table 2.12) of the air pollution control permits in effect at ANL-E. The IEPA conducted an air emissions inspection on June 6, 1996; no significant issues were identified.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAPs) constitute a body of federal regulations that set forth emission limits and other requirements, such as monitoring, record keeping, and operational requirements, for activities generating emissions of certain hazardous air pollutants. The only standards affecting ANL-E operations are those for asbestos, radionuclides, and halogenated solvent cleaning. A total of 23 air pollution control permits for NESHAP sources have been issued by the IEPA to ANL-E. Three new air pollution control permits for NESHAP sources were issued by the IEPA; four NESHAP air pollution control permits were renewed; and two NESHAP air pollution control permits were withdrawn in 1996.

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 panels. This material is removed as necessary during renovations or maintenance of equipment and facilities. The removal and disposal of this material is governed by the asbestos NESHAP.

The standards for asbestos specify detailed requirements for removal and disposal of certain types of ACM. Until the November 1990 revisions, only friable (easily crushed) ACM was regulated. Now, however, many other types of ACM are regulated, including nonfriable materials that have been, or could be reduced to a crumbly, pulverized or powder state through the process of removal or disposal. This change greatly increases the amount of material regulated by the NESHAP.

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The standards describe accepted procedures for removing ACM, including notification of the IEPA prior to removal of greater than certain amounts, work practices and procedures to be used, and emission control procedures to be used. The use of specially trained individuals for removal of ACM is mandated.

ANL-E maintains an asbestos abatement program designed to assure compliance with these and other regulatory requirements. ACM is removed from buildings by either a specially trained Waste Management (WM) crew (for small-scale short-duration projects) or by outside contractors specializing in ACM removal work (for large-scale insulation removal projects lasting a day or longer). All removal work is performed in strict compliance with both NESHAP and Occupational Safety and Health Administration (OSHA) requirements governing worker safety at ACM removal sites. When ACM is encountered during a renovation or demolition project, it is carefully wetted or otherwise encapsulated and completely removed. The work area is sealed off by using disposable glove bags or temporary plastic sheeting barriers, and high-efficiency particulate air (HEPA) filtration equipment is used to control emissions. Air is monitored in the vicinity of such work by ANL-E Environment, Safety and Health Industrial Hygiene (ESH-IH) personnel or contractors approved by ESH-IH both during the removal work and after the work is completed, in order to verify that adequate precautions have been taken to minimize the release of airborne asbestos fibers. Personal exposure air samples are also collected. Asbestos fiber counts are analyzed using Phase Contrast Microscopy, and selected samples are analyzed by Transmission Electron Microscopy.

Approximately 230 m³ (8,100 ft³) of ACM were removed from ANL-E buildings during 1996. These materials included various structural or facility components such as surfacing materials, thermal system insulation, floor tile and mastic, and transite wallboard. Also included were items that were part of the removal activity and became contaminated with asbestos, such as Tyvek coveralls, gloves, and polyethylene sheets. Asbestos-containing laboratory equipment such as laboratory furnaces, firebrick, and asbestos gloves also were removed and included in the annual estimate. The primary types of asbestos identified in these materials were chrysotile and amosite.

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Most of ANL-E asbestos removal activities are small nonscheduled renovation operations. The duration of these projects is usually not more than eight hours, and glovebag removal techniques normally are used. A total of 98 small removal projects were completed, which generated 67 m³ (2,360 ft³) of ACM waste. Projects performed by outside contractors accounted for 24 m³ (835 ft³) of the ACM waste from small projects.

The asbestos NESHAP standards require that the IEPA be notified before beginning large asbestos removal projects involving more than 80 m (260 ft) of pipe insulation, or 15 m² (160 ft²) of other materials, or 1 m³ (35 ft³) of ACM where the length or area cannot be measured. The Notification of Demolition and Renovation Form must be forwarded to the IEPA within a prescribed time limit. Four Notification of Demolition and Renovation forms were provided to the IEPA during 1996. Project information is provided in Table 2.1.

NESHAP requires estimation of the total amount of ACM to be removed during renovation or demolition activities during each upcoming calendar year. If this amount exceeds the regulatory levels given above, the IEPA must be notified. ANL-E made such a notification during December 1996 for activities planned for 1997. It is estimated that no more than 128 m³ (4,500 ft³) of ACM waste will be generated during 1997.

A separate portion of the standards contains requirements for waste disposal sites used for disposing of ACM. The acceptable disposal practice involves placing wetted waste materials into labeled, leakproof plastic bags for disposal in landfills. Off-site shipments are to be accompanied by completed shipping manifests. The principal requirements applicable to landfill disposal of ACM relate to covering the ACM daily with at least six inches of non-asbestos-containing materials and maintenance of disposal records. 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.

TABLE 2.1

Asbestos Abatement Projects: IEPA Notification, 1996

Completion Date	Asbestos Abatement Contractor	Notification Quantity			Material	Building	Disposal Quantity	
		(ft)	(ft ²)	(ft ³)			(ft ³)	Landfill
03/12/96	Insulco Asbestos Management, Inc.	150	340	- ^a	Pipe and heating, ventilating, and air-conditioning (HVAC) unit insulation	202	355	County ^b
06/17/96	Action Wrecking	570	29,675	-	Pipe insulation, transite wall panels, floor tile	810 813 814 815	3,375	County
08/16/96	Insulco Asbestos Management, Inc.	-	105	71	Boiler insulation	108	350	County
11/27/96	Action Wrecking	1,080	10,500	-	Pipe and tank insulation, transite wall panels	24 24A	1,620	County
						Total	5,700	

^a A hyphen indicates not measured in the above unit.

^b County Environmental Livingston Landfill, Pontiac, Ill.

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TABLE 2.2

Disposal of Asbestos-Containing Materials, 1996

Project Size	Landfill	Quantity (ft ³)	Total Quantity (ft ³)
Small-scale	County Environmental ^a	2,255	
	Chambers Liberty ^b	52	
	On-site, pending disposal at County	55	2,362
Large	County Environmental	5,700	5,700
			Total 8,062

^a County Environmental Livingston Landfill, Pontiac, Ill.

^b Chambers Liberty Landfill, Monticello, Ind.

2.1.1.2. Radionuclide Emissions

The NESHAP standard for radionuclide emissions from DOE facilities (Title 40, Part 61, Subpart H, of the Code of Federal Regulations [CFR]) 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 200, 205, and 212), ventilation systems for inactive reactors (Building 330, inactive reactor CP-5), 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 small ventilation systems and fume hoods are occasionally used 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

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1996 was 0.021 mrem, which, excluding radon-220, is 0.21% of the 10 mrem per year EPA standard. Section 4.6.1. contains a more detailed discussion of these emission points and compliance with the standard.

2.1.2. Conventional Air Pollutants

The ANL-E site contains a number of sources of conventional air pollutants, including a steam plant; oil-fired boilers; gasoline, methanol/gasoline blend, and ethanol/gasoline blend fuel-dispensing facilities; two alkali metal reaction booths; bulk chemical tanks; a dust collection system; a medical equipment sterilization unit; and fire training activities. The Central Shops degreaser was replaced in April 1996 with a unit that did not use chlorinated solvents. The emission sources that have been granted operating air pollution control permits by the IEPA are provided in Section 2.14. During 1996, five new air pollution control permits were issued by the IEPA (see Section 2.15) and one air pollution control permit (oil-fired boilers) was voluntarily withdrawn by ANL-E.

The operating air pollution control permit for the steam plant requires continuous opacity and sulfur dioxide 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 six minutes and 1.8 lb SO₂ per million Btu averaged over a one-hour period]. Table 2.3 gives the hours that Boiler No. 5 operated on low-sulfur coal during 1996. No exceedances occurred at Boiler No. 5 during 1996. The IEPA conducted an air emission compliance inspection of the steam plant on June 6, 1996.

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. Stage II vapor recovery systems were installed at both facilities by November 1, 1994. Pursuant to Illinois Administrative Code, Title 35, Part 254 (35 IAC 254), ANL-E submits an emissions summary

2. COMPLIANCE SUMMARY

to the IEPA each May 1 for the previous calendar year. The summary from 1996 is presented in Table 2.4.

2.2. Clean Water Act

The Clean Water Act (CWA) was established in 1977 as a major amendment to the Federal Water Pollution Control Act of 1972 and was modified substantially by the Water Quality Act of 1987. Section 101 of the CWA provides for the restoration and maintenance of water quality in all waters throughout the country, with the ultimate goal of "fishable and swimmable" water quality. The act established the National Pollutant Discharge Elimination System (NPDES) permitting system, which is the regulatory mechanism designed to achieve this

goal. The authority to implement the NPDES program has been delegated to those states, including Illinois, that have developed a program substantially the same and at least as stringent as the federal NPDES program.

The 1987 amendments to the CWA significantly changed the thrust of enforcement activities. Greater emphasis now 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. The ANL-E sanitary wastewater treatment facility was upgraded in 1996 to replace aging components. The ANL-E laboratory wastewater treatment facility is currently being upgraded to improve treatment capabilities.

TABLE 2.3

Boiler No. 5: Hours of
Operation, 1996

Month	Low-Sulfur Coal
January	638.0
February	696.0
March	744.0
April	612.0
May	0
June	0
July	0
August	0
September	0
October	0
November	24.0
December	506.0
Total Hours	3,220.0

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TABLE 2.4

1996 Annual Emissions Report: Emissions Summary^a

Source	CO	NO _x	Particulate	SO ₂	VOM	NVOM
Boiler 1 - Building 108	1,773	78,989	818	491	382	^b
Boiler 2 - Building 108	7	21,306	204	163	95	-
Boiler 3 - Building 108	61	60,947	615	861	287	-
Boiler 4 - Building 108	86	18,242	184	49	86	-
Boiler 5 - Building 108	58,310	315,121	883	244,274	412	-
APS Generator - Caterpillar (1 unit)	364	1,897	7	157	51	-
APS Generator - Kohler (2 units)	1,233	1,664	65	342	59	-
Boiler - Building 825	30	120	-	239	-	-
206 Alkali Reaction Booth	-	-	< 1	-	-	-
308 Alkali Reaction Booth	-	-	5	-	-	-
Central Shops Degreaser ^c	-	-	-	-	-	77
Central Shops Dust Collector	-	-	< 1	-	-	-
Building 201 - EtO Sterilizer	-	-	-	-	19	-
Building 212 - Exhausts	-	-	< 1	-	-	-
Waste Mgmt. HEPA System - Sitewide	-	-	< 1	-	-	-
Building 809 - Woodshop Dust Collector	-	-	9	-	-	-
Building 306 - Bulking Sheds	-	-	-	-	296	-
Building 306 - Building Vents	-	-	1	-	-	-
Building 46 - Methanol/Gasoline	-	-	-	-	5	-
Building 46 - Ethanol/Gasoline	-	-	-	-	15	-
Building 46 - 10,000 Gal Gasoline	-	-	-	-	473	-
Building 108 - Sulfuric Acid Tank	-	-	44	-	-	-
Building 300 - 10,000 Gal Gasoline	-	-	-	-	240	-
Building 300 - 8,000 Gal Gasoline	-	-	-	-	216	-
Building 300 - 6,000 Gal Gasoline	-	-	-	-	960	-
APS Facility - Accelerator	-	62	-	-	-	-
Torch Cut Lead-Based Paint - Sitewide	-	-	2	-	-	-
PCB Tank Cleanout - Sitewide	-	-	-	-	1,528	-
Building 200/317 - Lead Brick Cleaning	-	-	< 1	-	-	-
Building 376 - Transportation Research Facility	11	50	4	3	4	-
Total (lb/yr)	61,875	498,398	2,841	246,579	5,128	77
Total (ton/yr)	30.94	249.20	1.46	123.29	2.56	0.04

^a CO = carbon monoxide; VOM = volatile organic material; NVOM = nonvolatile organic material.

^b A hyphen indicates no emissions for this parameter.

^c Perchloroethylene is no longer classified as a volatile organic material and was designated by IEPA as a nonvolatile organic compound as well as a hazardous air pollutant.

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 contains numeric limits 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. Wastewater discharge activities at ANL-E are covered by NPDES Permit No. IL 0034592. This permit was renewed during 1994, effective October 30, 1994. For reasons discussed below, the permit was modified during 1995, effective August 24, 1995. The modification incorporates interim limits and a compliance schedule for achieving final effluent limits at Outfall 001.

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, steam boiler blowdown, and drinking water filter backwash), laboratory wastewater (from laboratory sinks and floor drains in most buildings), and storm water. Water softener regenerant is discharged to the DuPage County sewer system. Cooling water and cooling tower blowdown are currently 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 characterizes these outfalls; Figure 2.1 shows their locations. Outfall 010 is used for emergency overflow discharge from the coal pile.

2.2.1.1. Effluent Monitoring Results and Compliance Issues

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 1996, there were

2. COMPLIANCE SUMMARY

TABLE 2.5

Characterization of NPDES Outfalls at ANL-E, 1996

Outfall	Description	Flow ^a
001A	Sanitary Treatment Plant	0.3
001B	Laboratory Treatment Plant	0.4
001	Combined Outfall	0.7
003A	Swimming Pool	0.0
003B	300 Area (Condensate)	0.019
003C	Building 205 Footing Tile Drainage	0.014
003D&E	Steam Trench Drainage (Condensate)	0.018
003F	Building 201 Fire Pond Overflow Storm Water	0.092
003G	North Building 201 Storm Sewer (Condensate)	0.027
003H	Building 212 Cooling Tower Blowdown	0.016
003I	Buildings 200 and 211 Cooling Tower Blowdown	0.006
003J	Building 213 and Building 213 Parking Lot Storm Water	0.008
004	Building 203 Cooling Tower and Building 221 Footing Drainage and Storm Water	0.024
005A	Westgate Road Storm Water	Storm Water Only
005B	800 Area East Storm Water	Storm Water Only
005C	Building 200 West	0.004
005D	Storm Water	Storm Water Only
005E	Building 203 West Footing Drainage and Condensate	0.026
006	Cooling Tower Blowdown and Storm Water	0.029
007	Domestic Cooling Water for Compressor and Storm Water	0.005
008	Transportation and Grounds Storm Water	0.005
010	Coal Pile Runoff Emergency Overflow	Storm Water Only
101	North Fenceline 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
106 A&B	Southern East Area Storm Water Discharge	Storm Water Only
108	Eastern 300 Area Storm Water and Cooling Water	0.020
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

2. COMPLIANCE SUMMARY

TABLE 2.5 (Cont.)

Outfall	Description	Flow
113	Southern and Eastern 800 Area Landfill Storm Water Runoff	0.044
114	Northern and Western 800 Area Landfill Storm Water Runoff	<0.0001
115	314, 315, and 316 Cooling Water, Eastern and Southern APS Construction Area	0.005
116	Water Treatment Plant and Storm Water	0.003

^a Flow is measured in million gallons per day except for storm water only.

two exceedances of NPDES permit limits out of approximately 1,600 measurements. This represents greater than a 99% compliance rate. The iron limit was exceeded at Outfall 001A in May. This was due to excessive precipitation resulting in increased flow through the sanitary wastewater treatment plant (WTP) (5.6 million L [1.5 million gal/day]). The flow contained coal pile runoff and the resulting iron was not able to settle out due to the high flow. The limit for zinc was exceeded at Outfall 001 in October. Zinc was added to domestic water in an effort to coat pipes to prevent copper leaching into the drinking water (note the following discussion). It appears that excessive addition of zinc resulted in elevated zinc levels in the wastewater.

The decrease in exceedances from the 1995 compliance rate (49 exceedances) can be explained by the permit modification issued by the IEPA effective August 24, 1995. The permit modification provided ANL-E with a provisional variance from the existing limits for ammonia-nitrogen, copper, and total dissolved solids (TDS) and included a compliance schedule that would address bringing these discharges under their respective limits. The compliance schedule required ANL-E to meet the permit limits for these discharges by July 1, 1998. The ANL-E sanitary wastewater treatment facility was upgraded during 1996 to improve treatment capabilities to meet applicable limits by July 1, 1998. The laboratory wastewater treatment facility is currently being upgraded and will be completed during 1997.

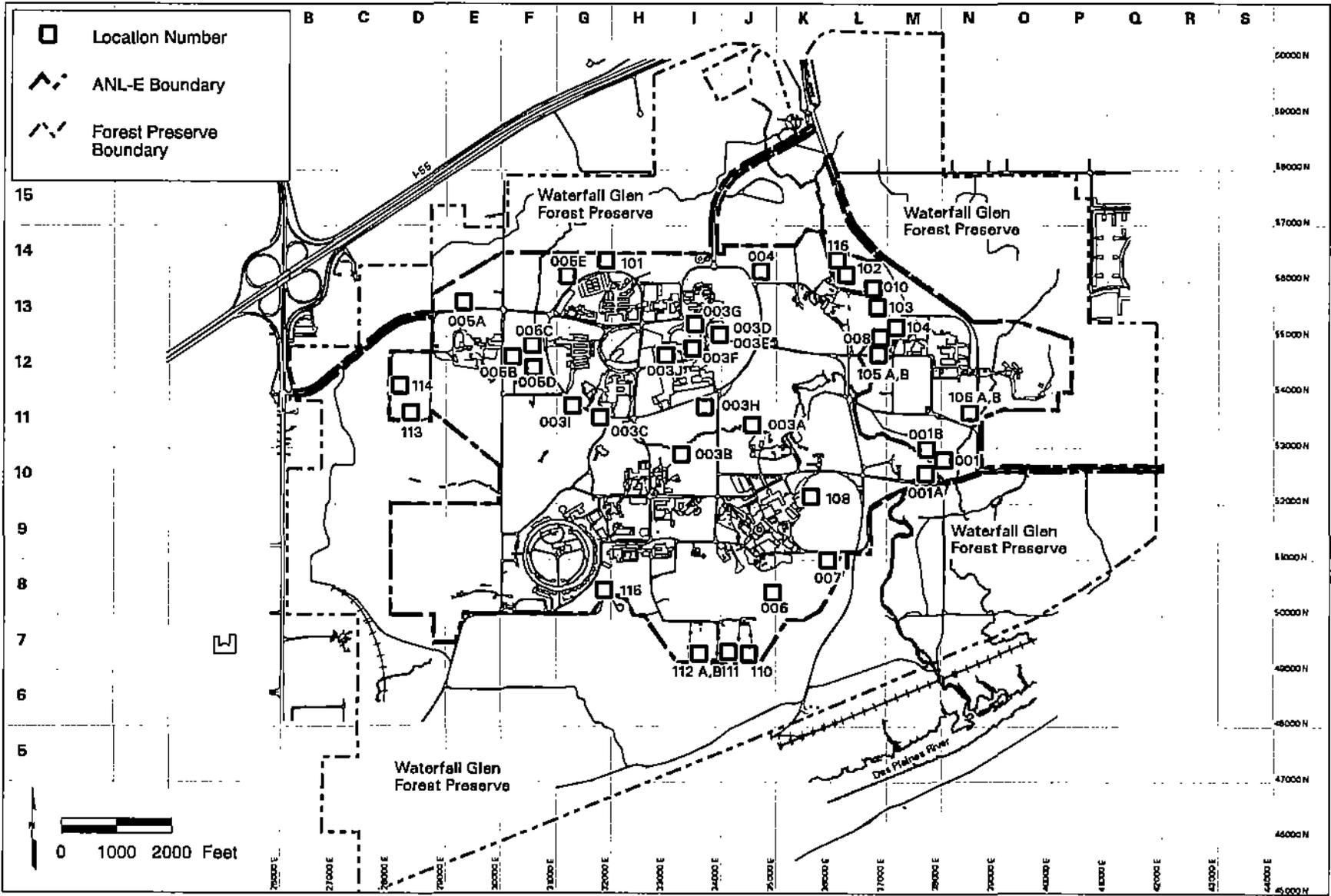


Figure 2.1 NPDES Permit Locations, 1996

2. COMPLIANCE SUMMARY

At the beginning of 1995, the NPDES permit limit for TDS was 1,000 mg/L. Supply-water TDS concentrations in the range of 750 mg/L (well head) to 950 mg/L (treated ANL-E well water) allow limited capacity for the addition of dissolved solids to the site wastewater. Additions of TDS to the wastewater come from many sources. Discharge of effluents from boiler operations can be a major active source. The modified NPDES permit, effective August 24, 1995, incorporates an interim TDS limit (1,500 mg/L) and a compliance schedule for achieving final TDS effluent limits by July 1, 1998, at Outfall 001. Lake Michigan water, which has a much lower TDS concentration than ANL-E's well water, was incorporated as the ANL-E source water during January 1997.

The ANL-E well water obtained by ANL-E from the Niagaran dolomite has very low copper concentrations. However, after treatment and distribution through copper pipe, which is used for the domestic water distribution within ANL-E buildings, a copper concentration range of 0.5 mg/L to 1.0 mg/L is typical at drinking fountains. This range has been determined by the copper/lead monitoring program required by the EPA (Section 6.1.1.). The acceptable copper level for human consumption is significantly above the NPDES permit limit (0.051 mg/L) at Outfall 001. The WTP does not include a process to remove copper. Past samples collected from the WTP effluent have been below the state effluent limit of 0.5 mg/L. Concentrations in Sawmill Creek, below the point where the treated wastewater has been discharged, however, have consistently exceeded the state stream standard for copper (0.02 mg/L) for the past 10 years. This trend may be indicative of the current ambient levels of copper in surface water because of the increased use of copper pipe. The corrective action currently being taken by ANL-E to control copper levels in the domestic water supply includes injecting polyphosphate and zinc to coat the copper piping. One exceedance of the zinc limit at Outfall 001 probably was due to excessive addition of zinc in an effort to reduce the corrosion of the domestic water supply piping. Lake Michigan water is less aggressive on the copper pipes than the ANL-E well water used in 1996. It is expected that copper levels will decrease with the incorporation of Lake Michigan source water in 1997. On August 24, 1995, the IEPA modified the ANL-E NPDES permit to incorporate interim copper limits and a compliance schedule for achieving final copper effluent limits at Outfall 001. The final limits are effective July 1, 1998.

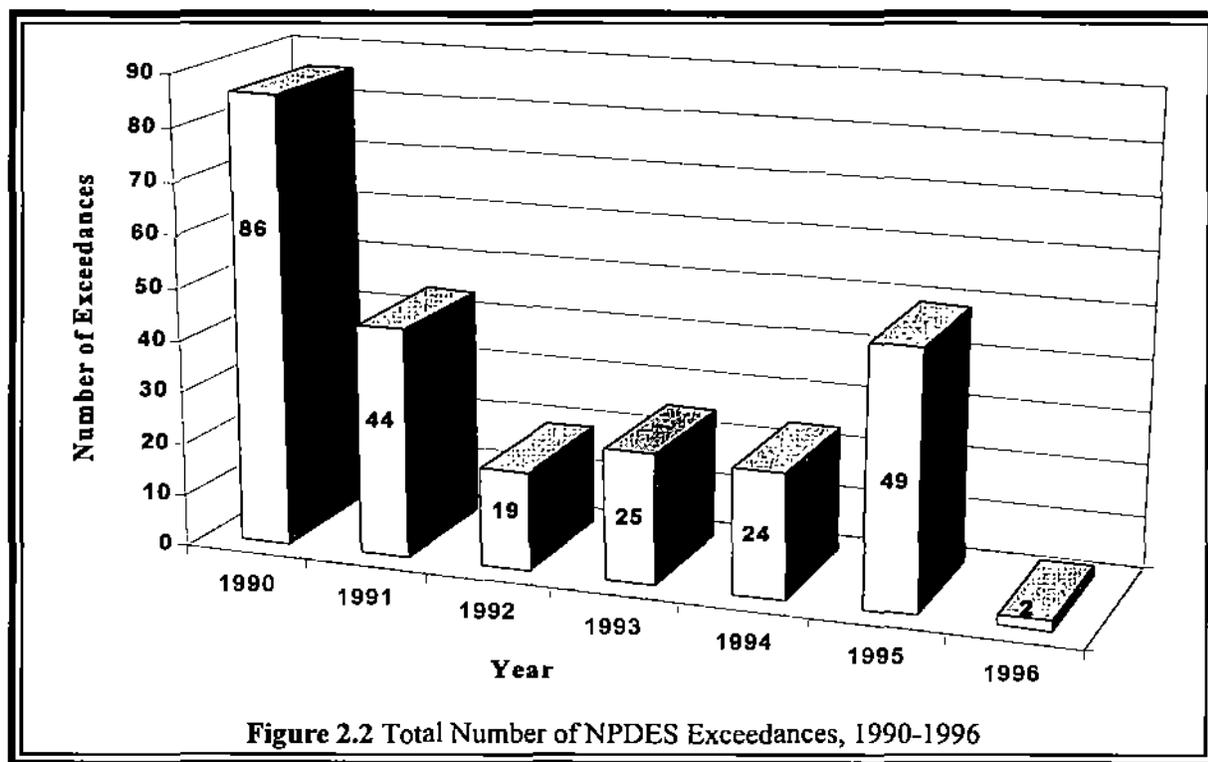
2. COMPLIANCE SUMMARY

The ANL-E WTPs provide minimal treatment for ammonia-nitrogen. The modified NPDES permit, effective August 24, 1995, incorporates an interim ammonia-nitrogen limit and a compliance schedule for achieving a final ammonia-nitrogen limit at outfall 001 by July 1, 1998.

The discharge of total residual chlorine (TRC) at Outfalls 003A, 007, and 116 is regulated by Special Condition No. 8 of the NPDES Permit. Special Condition No. 8 states that the discharge from Outfalls 003A, 007, and 116 must not exceed 0.05 mg/L TRC as a daily maximum concentration limit. Compliance with this limit is required as soon as possible, but no later than two years after the effective date of the permit (i.e., by October 30, 1996). Compliance may be achieved by construction of dechlorination equipment or by alternative means. The source of the residual chlorine is presumed to be primarily from improper domestic water connections. A residual chlorine level of 0.5 mg/L is maintained throughout the system and, as a result, the discharge of domestic water may result in an exceedance. ANL-E located and identified sources of chlorine in these systems in 1996 and eliminated or moved each source to a more appropriate drain system by the required date.

In the spring of 1996, a sanitary sewer near Building 201 collapsed, which resulted in a surcharge of untreated sewage through a manhole and into the north branch of the Freund Brook. The incident was reported to the IEPA within 24 hours and corrective action was completed within 48 hours of the incident.

Data regarding the total number of each type of exceedance over the past seven years are presented in Figure 2.2. In general, since 1990, the total number of exceedances per year has been reduced. Although the number of exceedances is greater (49) in 1995, the renewal of the NPDES Permit, effective October 30, 1994, placed more restrictive limits on ANL-E discharges and increased by about 600 the number of analyses required each year. For reasons stated above, copper, TDS, and ammonia-nitrogen limits resulted in a substantial increase of exceedances during 1995 prior to the issuance of the modified permit. Since the effective date of the modified permit, August 24, 1995, no NPDES exceedances have occurred for these parameters.



To improve the level of compliance with permit limits, ANL-E is in the sixth year of an intensive effort to upgrade existing facilities and to build additional wastewater treatment facilities. The sanitary WTP upgrade was completed during 1996. The laboratory WTP upgrade is scheduled for completion in 1997. These and other corrective action projects are described in the Environmental Management Plan for ANL-E and are identified in Chapter 3.

2.2.1.2. Additional NPDES Monitoring

The current permit requires semiannual testing of Outfall 001B, the laboratory WTP outfall, for all the priority pollutants (a list of 124 metals and organic compounds identified by the IEPA as being of particular concern). During 1996, this sampling was conducted in June and December. Chloroform (6 $\mu\text{g/L}$ and 2 $\mu\text{g/L}$), dibromochloromethane (6 $\mu\text{g/L}$ and 1 $\mu\text{g/L}$), and bromodichloromethane (3 $\mu\text{g/L}$ and 2 $\mu\text{g/L}$) were detected in both the June and December samples at low concentrations resulting from normal ANL-E operations. The source of most of these materials is suspected to be from the contact of chlorinated water with organic chemicals in the laboratory, as well as the discharge of small amounts of chemicals from various research and

2. COMPLIANCE SUMMARY

support operations. Methylene chloride (13 $\mu\text{g/L}$) and carbon tetrachloride (1 $\mu\text{g/L}$) were noted in the June sample. All semivolatile concentrations were below the detection limits. Low concentrations of zinc (0.580 mg/L), copper (0.114 mg/L), cadmium (0.0003 mg/L), lead (0.008 mg/L), mercury (0.0002 mg/L), silver (0.004 mg/L), and phenols (0.020 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 was conducted on June 19 and June 20, 1996. The data indicate a negligible amount of toxicity to the fathead minnow, and no toxic effect to the water flea. Data from the past three years seem to indicate that cessation of chlorination of ANL-E's effluent correlates to a beneficial effect on aquatic life in the receiving streams.

Acute toxicity testing at Outfalls 003H, 003I, 003J, 004, 006, and 115 twice a year during the months of July and August is required, as well as the annual acute toxicity testing during June at Outfall 001. Samples were collected July 22 through 26, 1996, and August 12 through 16, 1996. The samples were tested on the fathead minnow and the water flea. The effluents from outfalls 006 and 115 showed toxicity to the water flea. These results are similar to those obtained in 1995. No toxicity was detected at the remaining outfalls for either the fathead minnow or the water flea.

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 the regulation, 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 during 1992.

The NPDES permit issued October 1994, which includes both NPDES outfalls and the 15 storm water outfalls, requires the storm water outfalls to be characterized for submission of

2. COMPLIANCE SUMMARY

a permit application. Three additional storm water outfall locations requiring characterization have since been identified. Storm water characterization was completed at the 18 outfalls. 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 NPDES permit contains two special conditions requiring Storm Water Pollution Prevention Plans (SWPPP) for both the APS construction site (Special Condition 12) and the rest of the ANL-E site (Special Condition No. 11). Both of these plans were completed according to the requirements by the mandated date, May 1, 1995, which was 180 days after the effective date of the permit. The 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 on the effectiveness of the SWPPP annually. The inspection covering the two plans was completed on December 6, 1996. The permit requires the report arising from the annual inspection to be submitted to the IEPA within 60 days after the one-year period following the previous year's inspection; this was accomplished December 18, 1996. All requirements of Special Condition Nos. 11 and 12 covering the SWPPP have been fulfilled.

The requirements in both special conditions are effective for the life of the permit, which expires October 30, 1999. Changes to the plans will be required throughout this time and are presently being made to address the completion of the APS site by incorporating the continuing elements of the APS SWPPP into the sitewide plan. This will be accomplished by the summer of 1997.

2.2.3. NPDES Inspections and Audits

On October 28 and 29, 1996, the IEPA conducted a Compliance Sampling Inspection of NPDES outfalls and related facilities, as well as associated sampling, analysis, and record keeping requirements. During the inspection, the IEPA provided a copy of the inspection report from the

2. COMPLIANCE SUMMARY

1995 inspection. The issue of concern during that inspection, erosion control at the APS site, was partially addressed during 1996.

During the inspection, the inspector noted some erosion control issues at the sanitary and laboratory WTPs. The inspector also noted that sampling points for outfalls 001A and 001B needed modifications to improve sample collection. Finally, the inspector questioned whether ANL-E had any plans to reroute drains to eliminate discharges from Outfalls 003C, 003H, 003J, and 005C. Rerouting of drains was a pollution prevention activity identified in the ANL-E SWPPP. A formal report for the 1996 inspection had not been issued by the IEPA as of the end of 1996.

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, Subtitle C, Chapter I, 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, Subtitle C, Chapter I, 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. 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 136. To demonstrate the capabilities of the ANL-E laboratory for these analyses, the EPA requires ANL-E to participate in the DMR Quality Assurance program. The EPA sends a series of control 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 to the actual values. The ANL-E laboratory has consistently performed very well on these tests. However, in 1996, ANL-E analytical results for ammonia-nitrogen, cadmium, and

2. COMPLIANCE SUMMARY

pH, were evaluated as "not acceptable." Also *Ceriodaphnia* acute toxicity results, performed by an outside contractor laboratory were also evaluated as "not acceptable." Corrective actions were implemented and documented to DOE in March 1997.

2.2.6. Spill Prevention Control and Countermeasures Plan

ANL-E maintains a Spill Prevention Control and Countermeasures (SPCC) plan as required by the CWA and EPA regulations in 40 CFR 112. This plan describes the actions to be taken in case of oil or oil product releases to waterways in the environment. 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 was updated in 1995. No reportable spills occurred during 1996.

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 at a RCRA-permitted facility be cleaned up, regardless of when the waste was placed in the unit or whether the unit was originally 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.

2.3.1. Hazardous Waste Treatment and Disposal

Because of the nature of the research activities conducted at ANL-E, small quantities of a large number of waste chemicals are generated. Many of these materials are classified as hazardous waste under RCRA. A small amount of these wastes also exhibit radioactivity, thereby

2. COMPLIANCE SUMMARY

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 (AEA) of 1954. Hazardous waste is collected by the ANL-E WM Department from individual on-site generators and shipped off site for treatment and disposal at an approved hazardous waste treatment and disposal facility. During 1996, a small quantity of reactive hazardous waste, that is, alkali metals, were treated on site (see Table 2.7). 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. Treatment options for mixed waste are extremely limited (see Section 2.3.5)

ANL-E has 22 Hazardous Waste Management Units consisting of 14 container storage units, four miscellaneous treatment units, one tank storage unit, and three tank chemical treatment units. Table 2.6 provides descriptions of all of the units. There were no RCRA closures conducted in 1996.

Three treatability studies were conducted at ANL-E during 1996. The Mixed Waste Immobilization/Encapsulation Treatability Study used soil contaminated with RCRA metals and radioactive waste water. Approximately nine kilograms of soil were treated during 1996. The treatment residues as well as the untreated soil will be disposed of off site. This study will be continued in 1997.

The Lead Contaminated Soil Treatability Study Using Soil Washing used an innovative dual-phased liquid extraction process designed to remove small lead particles from fine-grained contaminated soil. Approximately 10 kg (22 lb) of clay soils were treated. The treatment residues were collected and will be under investigation. This study will continue through 1997.

The Electrodialysis of Acrylonitrile Process Waste Stream Treatability Study involved processing a waste stream from an off-site generator through a desalting electrodialysis system. Of the 17 kg (37 lb) of wastewater used for the study, approximately 2 L (0.5 gal) (16 archived samples) are being stored for future evaluation. All other treatment residues were returned to the wastewater generator.

TABLE 2.6

Hazardous Waste Treatment and Storage Facilities, 1996

Description	Location	Purpose
Current Interim Status Facilities		
Waste and Storage	Building 306 - Storage Room A-142	Storage of ignitable radioactive mixed waste (RMW)
	Building 306 - Storage Room A-150	Storage of solid and liquid RMW
	Building 306 - Storage Room C-131	Drum storage and lab packing of solid and liquid hazardous waste
	Building 306 - Storage Room C-157	Drum storage and lab packing of hazardous waste
	Building 306 - Storage Room D-001	Storage of solid RMW containing toxic metal constituents
Tank Storage	Building 306	Storage of corrosive and toxic mixed waste and radiological liquid wastes (4,000 gal)
Portable Storage Units	Building 306	Storage of hazardous, radiological, or RMW (3 units)
		Bulking operations to consolidate and reduce the volume of lab-packed waste in containers (1 unit)
Container Storage Area	Building 325C, East	Storage of liquid and solid bulk or lab-packed flammable and reactive hazardous waste and solid and liquid bulk polychlorinated biphenyls (PCBs) and miscellaneous PCB units
	Building 325C, West	Storage of bulk and lab-packed liquid flammable hazardous waste
	Building 303 Mixed Waste Storage Facility	Storage of containers of ignitable, corrosive, oxidizing, reactive, and solid RMW
	Building 307 Hazardous Waste Storage Facility	(To be constructed)

TABLE 2.6 (Cont.)

Description	Location	Purpose
Container Storage Area (Cont.)	Building 331 Radioactive Waste Storage Facility	Storage of containers of flammable, toxic, corrosive, and oxidizing waste
Dry Mixed Waste Storage Area	Building 374A	Storage of solid RMW 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
Concrete Storage Pad	317 Area	Storage of solid radioactive waste and solid RMW in the form of steel-encased lead shielding containers and containerized solid RMW
Alkali Metal Passivation Booth	Building 308	Destruction of water reactive alkali metals
Alkali Metal Passivation Booth	Building 206	Destruction of water reactive alkali metals possibly contaminated with radionuclides
Low-Level Waste (LLW) Neutralization/Precipitation System	Building 306	Treatment of aqueous, corrosive LLW, some of which is contaminated with heavy metals
	Building 306 Chemical/Photo-Oxidation Unit	Treatment of ignitable liquid RMW containing organic contaminants
	Building 306 TRU Neutralization/Precipitation Treatment Unit	Treatment of corrosive aqueous RMW containing transuranic radionuclides and RCRA metals
	Building 306 Mixed Waste Immobilization/Macroencapsulation Unit	Treatment of solid, semisolid, and organic liquid RMW containing RCRA metals
	317 Area Dry Ice Pellet Decontamination Unit	Treatment of solid RMW having radionuclide and/or RCRA metal surface contamination

2. COMPLIANCE SUMMARY

Figure 2.3 shows the locations of the major hazardous and nonhazardous waste treatment, storage, and disposal areas at ANL-E.

2.3.2. Permit Status

ANL-E was granted interim status under RCRA on April 30, 1982, after submitting a notification of Waste Handling Activities and a Part A application on November 3, 1980. On December 20, 1990, a new Part B permit application (one had been submitted to the EPA on December 19, 1985, but not acted upon) was submitted to the IEPA, which had been granted authority to administer most of the RCRA program. Revisions to the permit application were submitted on June 17, 1991, and September 24, 1991, in response to IEPA and EPA comments.

The RCRA Part B Permit application was revised and updated in 1993. Revision I was submitted to the IEPA on November 11, 1993, and included information on four new portable hazardous waste storage units and a mixed waste storage tank. ANL-E responded to the EPA's notice of deficiency comments regarding the alkali metal passivation booths in Buildings 308 and 206 and incorporated the response into the revised application. Revision II of the Part B application was submitted on May 26, 1995, and included a new hazardous waste storage facility, a new mixed waste storage facility, and a new radioactive waste storage facility. In response to a technical review of the Part B permit application by the IEPA, a final application was prepared and submitted to the IEPA on August 26, 1996. The IEPA issued a draft RCRA Part B Permit on September 26, 1996. ANL-E is preparing comments on the draft permit during the public comment period, which is scheduled to close January 13, 1997. A final permit is expected during the fall of 1997. The RCRA Part B Permit will contain corrective action requirements (see Section 2.3.9).

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

ANL-E typically generates a wide variety of hazardous waste and mixed waste each year. Hazardous and mixed wastes generated, treated, and stored during 1996 are described in

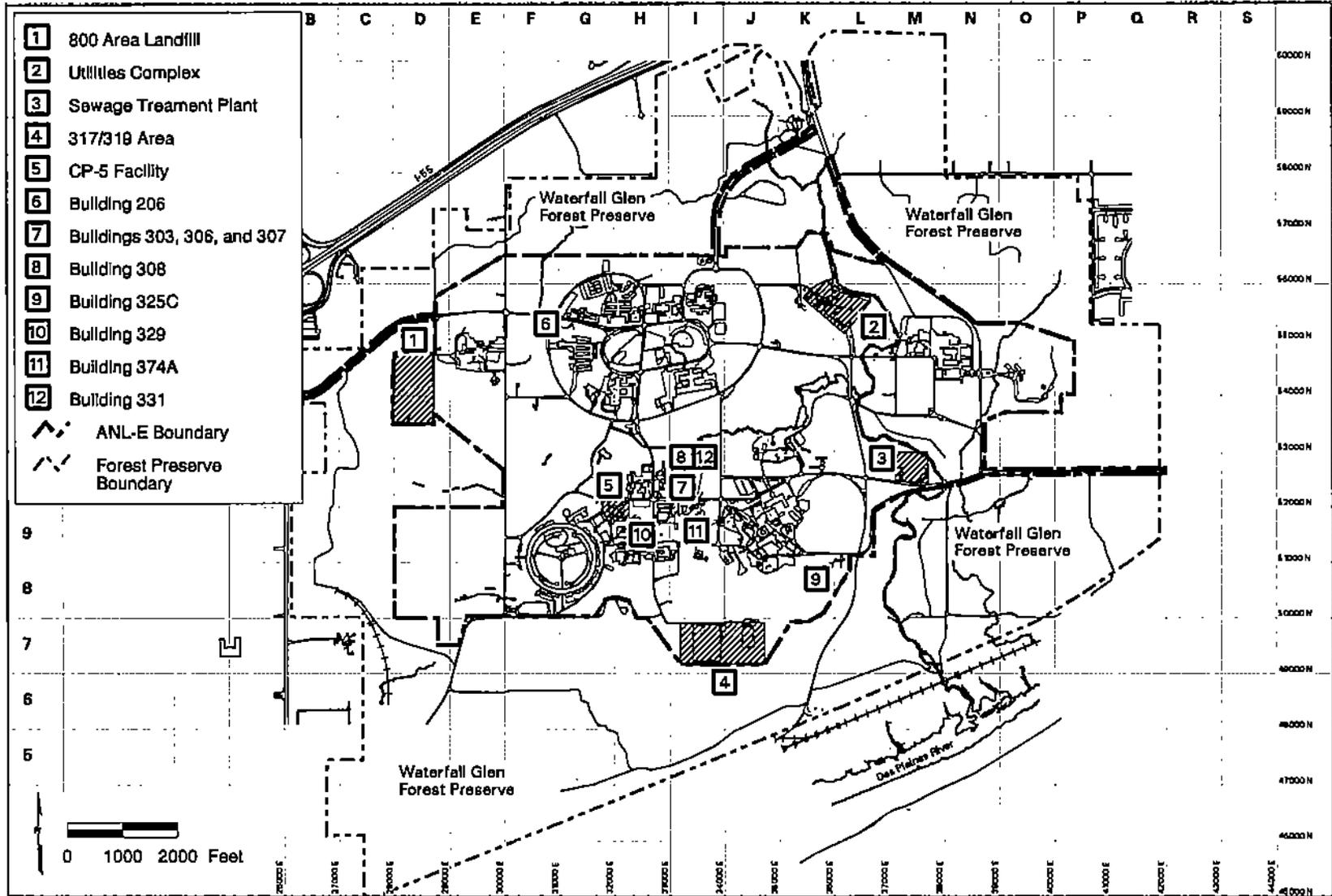


Figure 2.3 Major Treatment, Storage, and/or Disposal Areas at ANL-E

2. COMPLIANCE SUMMARY

Tables 2.7 and 2.8, respectively. One shipment of lead mixed waste was sent to an off-site commercial disposal facility, Envirocare of Utah, Inc. All hazardous waste shipped off site went to an IEPA-permitted hazardous waste disposal facility. The reactive hazardous waste (sodium potassium alloy) was treated on site in the Building 206 alkali metal reaction booth. This unit renders the waste nonhazardous.

2.3.4. Facility Modifications

During 1996, rooms in Building 306 were modified to accommodate new mixed waste treatment systems. Room C-139 houses the Aqueous Transuranic Waste Treatment System and Advanced Photo-Oxidation Treatment System. The room was modified so as to have sufficient HEPA-filtered ventilation and utilities such as potable water and electricity. Room D-033 houses the Immobilization/Macroencapsulation Treatment System. The room was modified to install a 210 L (55-gal) in-line drum mixer. Concrete slabs that served as a ceiling were replaced with a more permanent structure that allows for the addition of stabilization media to the drum in the mixer. The RCRA Part B Permit Application for these processes was submitted to the IEPA in 1996.

The Experimental Boiling Water Reactor (EBWR) is being converted into a Radioactive Waste Storage Facility (Building 331). The total storage capacity of the facility is about 208 m³ (7,345 ft³). Solid, remote-handled, and solid and liquid contact-handled radioactive and mixed waste will be stored in the facility. The conversion utilizes the existing structural, mechanical, and electrical systems of the EBWR to the maximum extent possible. The scope of the conversion includes architectural, structural, mechanical, and electrical upgrades. Safety upgrades include exit improvements in the event of an emergency and a new once through ventilation system with HEPA filtration.

2.3.5. 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.

2. COMPLIANCE SUMMARY

TABLE 2.7

Hazardous Waste Treatment, Storage, and Disposal, 1996

Waste	Gallons	Pounds
Hazardous Waste - Generated and Disposed		
Aerosol cans	135	371
Brake cleaner fluid	10	86
Debris contaminated with lead	110	330
Debris contaminated with methylene chloride	30	120
Dilute ethanol solution with silver	220	1,830
Filter contaminated with chromium	30	70
Hazardous debris, with flammables	420	2,520
Hazardous paint wastes	60	420
Hazardous waste oils	1,155	8,240
Labpacks of liquid chemicals	2,277	18,216
Labpacks of solid chemicals	1,560	6,229
Lead acid batteries	35	425
Mercury vapor light bulbs	175	175
Mercury switches	110	550
Metallic sulfides	120	685
Metal scrap containing cadmium	180	1,440
Petroleum distillates	185	1,300
Petroleum naptha with tetrachloroethylene (parts washers)	72	482
Soil contaminated with mercury	55	600
Waste acidic solutions	680	5,520
Waste caustic solutions	385	3,500
Waste diesel fuel/water	770	6,160
Waste perchloroethylene	165	2,145
Water with lead solution	165	1,379
Hazardous Waste - Treated		
Alkali metals	74	594

2. COMPLIANCE SUMMARY

TABLE 2.8

Mixed Waste Treatment, Storage, and Disposal, 1996

Waste	Gallons	Pounds
Mixed Waste - Generated		
Acidic solutions	155	1,400
Acidic solutions with heavy metals	99	890
Aqueous solutions with heavy metals	93	770
Elemental mercury	0.1	5
Flammable liquids	5	37
Metal scrap with cadmium	925	27,750
Metal scrap with heavy metals	60	1,800
Mixed waste (MW) debris with chromium	75	1,875
RMW debris with heavy metals	188	750
RMW lead articles	4,850	436,500
RMW PCB sludge and debris	4,770	119,250
RMW sludges with heavy metals	1,291	12,900
RMW soil with heavy metals	170	1,560
Transuranic (TRU) acids	7.3	66
TRU cadmium	75	1,880
TRU lead	33	3,270
Mixed Waste - Treated		
RMW acidic solutions (neutralized)	334	3,006
Mixed Waste - Shipped		
Lead articles	289	25,965
Mixed Waste - In Storage		
Acidic solutions	224	2,016
Acidic solutions with heavy metals	716	5,943
Alkali metals	23	230
Aqueous solutions with heavy metals	101	909
Aqueous solutions with organics	19	130
Cyanide solution	10	84

2. COMPLIANCE SUMMARY

TABLE 2.8 (Cont.)

Waste	Gallons	Pounds
Elemental mercury	5	230
Flammable liquids	216	1,509
Metal scrap with cadmium	1,931	38,620
Metal scrap with heavy metals	135	4,050
RMW debris with chromium	350	8,750
RMW debris with heavy metals	262	1,048
RMW debris with volatile organics	55	220
RMW lead articles	6,837	615,330
RMW PCB articles	1	10
RMW PCB sludge and debris	18,326	458,150
RMW sludges with heavy metals	1,401	14,010
RMW soil with heavy metals	341	3,137
TRU acids	268	2,412
TRU cadmium	130	3,258
TRU lead	165	16,335
Uranyl nitrate	120	2,400

Accordingly, facilities generating, treating, storing, or disposing of mixed waste must comply with both DOE requirements and RCRA permitting and facility standards. ANL-E generates and stores several types of mixed waste, including acids, solvents, sludges, metals, and debris contaminated with radionuclides (see Table 2.8). Lead mixed waste was disposed of at an off-site commercial facility.

A new Mixed Waste Storage Facility became operational in 1996. The facility is subdivided into storage areas for different types of mixed waste. Each storage area, except the reactive waste storage area which has a nonfluid fine suppression system, is designed with a separate concrete holding basin for retaining fire suppression fluids in the event of a fire. Each basin is isolated to prevent cross-contamination of waste types.

2.3.6. 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 required the DOE to 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 in March 1995. The plan provides for on-site treatment of nearly all of the low-level mixed waste generated at ANL-E. A small amount of low-level mixed waste would be shipped to a DOE incinerator in Oak Ridge, Tennessee. Another type of mixed waste (i.e., transuranic [TRU] mixed waste) would be shipped to DOE's Waste Isolation Pilot Plant in New Mexico for disposal. Mixed waste at ANL-E has been managed in accordance with the PSTP as of October 1995, while awaiting IEPA approval of the PSTP.

FFCA activities that were performed in 1996 included (1) continuation of treatment of corrosive, low-level waste (LLW) in the aqueous neutralization/precipitation system under a treatability study; (2) initiation of treatment of alkali metals contaminated with radioactive materials in the Building 206 alkali metal passivation facility; (3) initiation of system testing of a mixed waste stabilization system, a TRU neutralization/precipitation system, and a carbon dioxide decontamination unit; (4) cancellation of the LLW vitrification system due to budget constraints; (5) initiation of a treatability study for mercury contaminated with radioactive material (the mercury will be treated by amalgamation, which will make it suitable for disposal at the Hanford Site); and (6) disposal of 12,273 kg (27,000 lb) of lead mixed waste at an off-site commercial facility.

2.3.7. RCRA Inspections: Hazardous Waste

A RCRA Compliance Inspection was conducted by the EPA on March 20 and 21, 1996. During the inspection, the EPA noted an apparent violation of 35 IAC 722.134(a)(2), because of the failure to mark and make visible for inspection on each container, the date upon which waste

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accumulation began. The apparent violation was corrected at the time of the inspection. No other issues were identified.

2.3.8. Underground Storage Tanks

In response to UST regulations, ANL-E prepared a Sitewide Underground Tank Compliance Plan. The ANL-E site currently contains 25 existing, upgraded, replaced, or new USTs; 33 tanks have been removed over the last several years. The majority of these tanks are being used, or were used in the past, for storage of fuel oil for emergency generators or space heaters. The on-site vehicle maintenance facilities use underground gasoline and methanol/gasoline blend tanks. The ethanol/gasoline blend is stored in an aboveground tank. The compliance plan establishes a program for replacing or upgrading tanks that must remain in use. Currently, all tanks remaining in use are being monitored under a new record keeping program initiated by ANL-E.

Two USTs located near Building 816 were used to store fuel oil for a steam boiler that provided steam heat to nearby buildings. The USTs were removed in 1985. However, contaminated soil was left in place. The contaminated soil in the vicinity of these two USTs was removed during July and August 1996.

2.3.9. Corrective Action for Solid Waste Management Units

As mentioned previously, the HSWA to RCRA require that any Part B permit issued must include provisions for corrective action for all releases of hazardous constituents from any Solid Waste Management Unit (SWMU) at the site, regardless of when waste was placed in the unit. When issued, the Part B permit will contain a compliance schedule that will govern the corrective action of such units. The Part B permit application submitted to the IEPA identified and provided information on 56 SWMUs, both active and inactive. A RCRA Facility Assessment (RFA) was completed by the IEPA during the summer of 1991. The RFA report from the IEPA was received in December 1993 and identified 740 units (735 SWMUs and five Areas of Concern [AOCs]). The report identified 432 units (427 SWMUs and five AOCs) for further investigation or other work. ANL-E prepared a report entitled "Proposed Revisions to the RCRA Facility Assessment

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Report for Argonne National Laboratory-East.” This report included recommendations to reduce the number of units that the IEPA identified in the RFA report for further investigation or other work from 432 units to 71 units (69 SWMUs and two AOCs). ANL-E is working proactively and on a voluntary basis to characterize, investigate, and remediate these SWMUs, with emphasis on the 800 and 317 Areas. The IEPA has agreed to reduce the number of units to 56 (54 SWMUs and two AOCs), on the basis of its review of the units. The majority of these sites are believed to contain little or no residual contamination; however, a number may be required to undergo some type of corrective action. The process of conducting detailed characterization studies to determine if hazardous materials have been released from a number of these units was begun in 1989. A summary of the preliminary results of these investigations can be found in Chapter 6. More extensive characterization is currently underway at a number of the SWMUs in accordance with the IEPA-approved corrective action work plans for the 800 Area and the 317/319 Areas.

2.4. Solid Waste Disposal

During September 1992, ANL-E ceased operation of its sanitary landfill. This facility began operation in 1966. The original operating permit was issued by the IEPA in 1981 in accordance with 35 IAC 807. A supplemental permit addressing final elevations, a groundwater monitoring program, and closure/postclosure costs was issued by the IEPA on April 24, 1992, and revised on September 15, 1992, and October 22, 1992. The IEPA conducted a closure inspection of this landfill on March 26, 1996. During the inspection, the IEPA expressed concern about the accumulation of drums containing investigation-derived debris on the landfill. It was also concerned about the length of time the drums had been on the landfill and questioned whether a waste determination had been made on the drum contents. Data from characterization studies at the landfill were provided to the IEPA to demonstrate that the drums did not contain hazardous waste. The drums were removed from the landfill shortly after the inspection and located in a designated storage area. The inspector also requested a landfill map that clearly identifies the locations of groundwater and gas monitoring wells.

ANL-E generates a large volume and variety of nonhazardous special wastes. Table 2.9 describes the nonhazardous special wastes generated and disposed of during 1996. All

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TABLE 2.9

Generation and Disposal of Special Waste, 1996

Waste	Unit	Pounds
Antifreeze	200 gal	1,860
Contaminated sand (Wastewater Treatment Plant)	3,840 yd ³	9,919,000
Contaminated water (800 Area leaking underground storage tanks)	3,720 gal	31,000
Contaminated soil (800 Area leaking underground storage tanks)	7,470 yd ³	16,708,000
Ethylene glycol solution	17,000 gal	150,100
Fly ash (boiler house)	2,490 yd ³	2,490,000
Investigation-derived waste	7,315 gal	73,200
Medical waste	178 ft ³	721
Mineral spirits	825 gal	5,625
Nonhazardous liquid chemicals	2,395 gal	18,077
Nonhazardous solid chemicals	2,833 gal	13,643
Petroleum naphtha	136 gal	911
Sanitary sewage sludge	75 yd ³	150,000
Spent sorbent (boiler house)	60 yd ³	60,000
Used oil	3,525 gal	25,400
Asbestos	420 yd ³	420,000
PCBs	1,915 gal	8,239

nonhazardous special waste generated at ANL-E was disposed of at a permitted off-site special waste landfill. 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 polychlorinated biphenyl (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 impacts be considered in an Environmental Assessment (EA) or Environmental Impact Statement (EIS). DOE has promulgated regulations in 10 CFR 1021 that

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list classes of actions that are categorically excluded from further NEPA review. No EISs were prepared during 1996. Two EAs were prepared in 1996. These addressed the Decontamination and Disassembly of the Biological Irradiation Facility (Janus) and Environmental Remediation at ANL-E.

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 (MCLs) and Maximum Contaminant Level Goals (MCLGs), as well as through the imposition of wellhead protection requirements, monitoring requirements, treatment standards, and regulation of underground injection activities. The regulations implementing the SDWA, in 40 CFR 141-143, establish Primary and Secondary National Drinking Water Regulations, which set forth requirements to protect human health (primary standards) and provide aesthetically acceptable water (secondary standards).

2.6.1. Applicability to ANL-E

Through 1996, the drinking water supply at ANL-E consisted of four on-site wells that supplied raw water to the water treatment plant. The treatment plant removed iron, softened the water by ion-exchange, and added chlorine before pumping it to the sitewide distribution system. Because of the nature of the ANL-E drinking water system and the persons served by it, the system was classified as a nontransient, noncommunity water supply, and as such was subject to the regulations applicable to such systems. The Laboratory was subject to regulations under the State of Illinois program administered by the IDPH. The IDPH adopted the Illinois Pollution Control Board regulations of 35 IAC 605, 607, and 611. These regulations are incorporated by reference into the IDPH regulations at 77 IAC 900. These regulatory requirements include a monitoring program; design, operation, and maintenance requirements; and secondary water quality standards. In January 1997, ANL-E's drinking water supply was converted to Lake Michigan water purchased from the DuPage County Water Commission. Since ANL-E is now

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a customer rather than a supplier of water, the public water supply regulations are no longer applicable to ANL-E. However, certain monitoring activities, applicable to users of water, will continue to be conducted by ANL-E.

2.6.2. Monitoring Requirements

The primary drinking water standards establish certain monitoring and analytical requirements. During 1996, both federal and state regulations applied to the ANL-E drinking water monitoring program. ANL-E routinely samples each of the four wells and the treated water quarterly for compliance with applicable regulations. Treated water is also sampled annually for radiological analyses. Chapter 6 of this report presents a detailed discussion of the results of the drinking water program. During 1996, samples continued to be collected, and all state and federally required analyses were conducted. EPA-approved procedures were employed by a certified laboratory. The 1996 results were sent to the IDPH during January 1997. In 1996, ANL-E was required to report on nitrate, inorganics (metals), cyanide, dioxin, semivolatile organics, volatile organics, and synthetic organic chemicals.

The action level for copper was exceeded during 1996. Corrosion control measures have been implemented by ANL-E to reduce the leaching of lead and copper into the water supply. Polyphosphate has been added to the drinking water supply since 1993. To maintain a more consistent level of polyphosphate throughout the water supply system, bubblers were installed at selected locations to maintain flow. The controlled addition of zinc to the drinking water was begun in March 1995 to reduce copper dissolution. Also, ANL-E has identified and replaced several drinking water fountains that were known to contain lead-based components and high levels of copper. Copper and lead will continue to be monitored during 1997 to determine the effect of Lake Michigan water on the distribution piping.

2.7. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) establishes a program to register pesticides, regulate their transportation and disposal, and determine standards for their

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use. During 1996, all pesticides were applied by licensed contractors who provide any pesticides used and remove any unused portions. Herbicides are rarely used, but when they are needed, a licensed contractor is brought in to apply them. In these situations, ANL-E ensures that the herbicide is EPA-approved, that it is used properly, and that any residue is disposed of in accordance with applicable regulations. This is carried out by oversight inspections and maintenance of records.

Between May and September 1996, an outside contractor applied 6,825 L (1,820 gal) of commercial-grade herbicide throughout the ANL-E site. No pesticides were applied during 1996.

2.8. Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) addresses cleanup of hazardous waste disposal sites and response to hazardous substance spills. Under CERCLA, the EPA collects data regarding sites subject to CERCLA action through generation of a Preliminary Assessment (PA) report, followed up by a Site Investigation (SI). Sites are then ranked, on the basis of the data collected, according to their potential to cause human health impacts or environmental damage. The sites with the highest rankings are placed on the National Priority List (NPL) and are subject to mandatory cleanup actions. ANL-E is not included in the NPL.

2.8.1. CERCLA Program at ANL-E

In early 1990, the EPA requested that DOE submit Site Screening Investigation (SSI) reports for six of 13 ANL-E sites for which PA reports had previously 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 those sites for which an SSI was submitted.

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TABLE 2.10

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

Site Name

Waste Sites on Current ANL-E Property

800 Area Landfill and French Drain^a
319 Area Landfill and French Drain^a
Landfill East-Northeast of the 319 Area^a
Compressed Gas Cylinder Disposal Area,
318 Area^a
French Drain, 317 Area^a
Mixed Waste Storage Vaults, 317 Area^a
Shock Treatment Facility, 317 Area^a
Wastewater Holding Basin, Sewage
Treatment Plant
Liquid Waste Treatment Facility, Building 34
Decommissioned Reactor CP-5, Building 330^a
Gasoline Spill, Gasoline Station
810 Area Paint Shop

Waste Sites on Old ANL-E Property
Currently Waterfall Glen Forest Preserve

Reactive Waste Disposal, Underwriters Pond

^a SSI report submitted to the EPA in 1991.

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 impact 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

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ANL-E site and are included as SWMUs in the RCRA Part B permit application. All of the SWMUs on the ANL-E property may be subject to RCRA corrective action. However, several of these SWMUs also contain radiological contamination that is not regulated under RCRA. Therefore, the SWMUs that are both radiologically and chemically contaminated could be cleaned up under other authorities and RCRA, as appropriate.

2.8.3. Emergency Planning and Community Right to Know Act and Superfund Amendments and Reauthorization Act, Title III

2.8.3.1. Sections 302, 304, 311, and 312

Title III of the 1986 Superfund Amendments and Reauthorization (SARA) amendments to CERCLA created the Emergency Planning and Community Right to Know Act (EPCRA) as a free-standing provision for response to emergency situations involving hazardous materials and for making known to federal, state, and local emergency planning authorities information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases. Under EPCRA, ANL-E may be required to submit the following reports each year in compliance with DOE guidance for EPCRA:

Statute		Yes	No	Not Required
EPCRA 302:	Planning Notification	X		
EPCRA 304:	Extremely Hazardous Substances Release Notification	X		
EPCRA 311-312:	Material Data Safety Sheet/Chemical Inventory	X		
EPCRA 313:	TRI Reporting	X		

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Section 302 of SARA Title III designates under Section 102(a) of CERCLA those substances in the statutes referred to in Section 101(14) of CERCLA, identifies reportable quantities for these substances, and sets forth the notification requirements for releases of these substances. This regulation also sets forth reportable quantities for hazardous substances designated under Section 311 of the CWA.

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 1996 that required notification of the LEPC and Illinois Emergency Management Agency.

Under EPCRA Sections 311 and 312, ANL-E is required to provide to applicable emergency response agencies an inventory of hazardous substances stored on site, Material Safety Data Sheets (MSDSs), and completed SARA data sheets (Tier I or II forms) for each hazardous substance stored in quantities above a certain threshold planning quantity (typically 4,536 kg [10,000 lb]; but as low as one pound for certain compounds). However, chemicals used in research laboratories under the direct supervision of a technically qualified individual are exempt from reporting. In November 1987, an inventory and MSDS forms for nine chemicals were submitted to the LEPC; in March 1988, Tier I reports providing additional information on these chemicals were submitted. Updated Tier II forms were submitted to the LEPC by the required March 1 deadline for 1989 through 1996. The Tier II forms updated the previous listings and provided more information regarding the amount of material stored and the location of the material. Table 2.11 lists the hazardous compounds reported under SARA Title III for 1996.

2.8.3.2. Section 313

Section 313 of the EPCRA was enacted as a free-standing provision of SARA in 1986. It 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 the

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TABLE 2.11

Compounds Reported under SARA Title III, 1996

Compound	Hazard Class				
	Fire	Sudden Release of Pressure	Reactive	Acute Health Hazard	Chronic Health Hazard
Diesel Fuel/Heating Oil	X				
Gasoline	X				
Methanol/Gasoline	X				
Chlorine		X		X	
Chlorofluorocarbon 11		X			
Sulfuric Acid				X	
Calcium Oxide				X	
Oils Containing PCBs					X
Lubricating Oils	X				
NALCO 356 Amine Corrosion Inhibitor	X			X	
Pyrofoam					X

information because DOE, which is subject to Executive Order 12856 and participates in the EPA 33/50 program, directs ANL-E to do so. In 1996, threshold chemical usage quantities were 4,536 kg (10,000 lb) for listed chemicals either manufactured or processed. Argonne reviewed SARA 313 reporting requirements with EPA Region V. The 1994 reports were withdrawn and no reports were made for 1995. Reporting for constituents in fuel will not be required in the future. ANL-E will file reports for Freon 22 and ethylene glycol for 1996. The Freon was used to charge new coolers at the APS site. Ethylene glycol coolant was removed from service in Building 200 and replaced with water. The ethylene glycol was recycled. ANL-E data reflect operations and maintenance activities; they do not reflect exempt research and development.

2.9. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) (15 U.S.C. § 2601 et seq.) was enacted to require chemical manufacturers and processors to develop adequate data on the health and

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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 for designated chemicals. Of these specially regulated substances, only asbestos and PCBs are found at the ANL-E site. Compliance with the requirements for asbestos handling is ensured through the safety training program.

2.9.1. PCBs in Use at ANL-E

Regulations for the use and disposal of PCBs can be found in 40 CFR 761. Most of the PCBs in use at ANL-E are contained in capacitors, power supplies, and small transformers.

During 1995, a physical inventory to identify suspect PCB items was completed. Approximately 1,750 suspect items have been identified and are contained in the PCB Item Inventory. Most of the suspect PCB items are contained in electrical equipment such as capacitors, power supplies, or transformers, which are used for high voltage generation or control. Confirmation of suspect PCB items was initiated in 1996 and will be completed in 1997. Confirmation of suspect PCB items is determined by field testing using a kit that detects the presence of chlorinated species. All items that yield positive test results using the field tests will be subjected to additional analytical testing to verify and quantify the PCB concentration. Positively identified PCB items are appropriately labeled and identified with a unique number for inventory and tracking purposes. Additional descriptive information on these PCB items is maintained in a database.

2.9.2. Disposal of PCBs

Disposal of PCBs from ANL-E operations includes materials lab-packed and bulked through WM and bulk solids shipped off site through WM. Table 2.9 gives the amounts of PCBs and PCB-contaminated materials shipped by ANL-E during 1996.

2.9.3. Disposal of PCB-Contaminated Material

Contamination from historical PCB spills has resulted in the generation of PCB- and low level radioactive-contaminated sludge from the building retention tanks and holding tanks at the laboratory WTP. The retention tanks are collection vessels that hold the wastewater discharge from individual site buildings prior to its discharge to the six holding tanks at the laboratory WTP. The purpose of the retention tanks is to ensure that wastewater containing unacceptable quantities of radioactive materials is not discharged to the laboratory WTP. To prevent continued contamination of the ANL-E wastewater treatment system, all of the building retention tanks with PCBs are being "cleaned out." For each such tank, this cleaning process was coordinated with EPA Region V and will involve the removal of all settled sludge in the tanks and triple rinsing of the tanks. The six holding tanks at the laboratory WTP also were cleaned out and certified to be PCB free. A total of 18,056 L (4,770 gal) of sludge contaminated with PCBs was generated in 1996 from the clean out of these tanks. Since a disposal option does not presently exist, this sludge is in permitted storage for future disposal.

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 or critical habitat of such species. The FWS has been delegated authority to conduct these consultations and enforce the ESA.

To comply with the ESA, federal agencies are required to assess the proposed project area to determine if any threatened or endangered species or critical habitat of these species exist. 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 will then be carried out to determine the extent of impact and any special actions that must be taken to minimize this impact.

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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 for an adverse impact exists, this impact will be further assessed and evaluated through the preparation of a more detailed NEPA document, such as an EA or EIS.

Neither federal- nor state-listed threatened or endangered species are known to reside on the ANL-E site. The federal-listed endangered Indiana bat, *Myotis sodalis*, and the federal-listed threatened Hine's emerald dragonfly, *Somatochlora hineana*, reside in the area. Two state-listed endangered species — river otter, *Lutra canadensis*, and white lady's slipper, *Cypripedium candidum* — and two state-listed threatened species — kirtland's snake, *Clonophis kirtlandi*, and early fen sedge, *Carex crawei* — reside in the area and may possibly reside on the ANL-E site. Impacts to these species are also assessed during the NEPA process. No project at ANL-E has ever had to be stopped, delayed, or modified as a result of potential impact to endangered species. During 1996, as required under the ESA, ANL-E consulted with the FWS regarding a potential adverse affect off site on the Hine's Emerald Dragonfly, *Somatochlora hineana*, from a proposed groundwater remediation project in the 800 and 317/319 Areas. In February 1997, the FWS concluded that the project is unlikely to adversely affect the hydrology of the dragonfly breeding area.

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 site of the proposed projects. It further requires federal agencies to assess all sites, buildings, and objects on the site to determine if any qualify for inclusion in the NRHP. The act also establishes a procedure for proceeding with archaeological activities and a system of civil and criminal penalties for unlawfully damaging or removing archaeological artifacts from historic or culturally important sites.

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The NHPA is implemented at ANL-E through the NEPA review process, as well as through the internal digging permit process. All proposed actions must consider the potential impact to historic or culturally important artifacts and document this consideration in 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 carefully documented and removed. Prior to disturbing the soil, an ANL-E digging permit must be obtained from the Plant Facilities and Services (PFS) Division. Prior to digging, 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 impacted.

Preparation of a Cultural Resource Management (CRM) plan, which included the final site map, was completed in September 1995. The plan, which was under review in 1996, summarizes the results of the ANL-E site survey and includes additional information from surveys of smaller projects. The plan will be submitted formally to DOE during 1997. Three of the archaeological sites identified have been determined by the Illinois Historic Preservation Agency (IHPA) to be historically significant and eligible for listing on the NRHP. ANL-E has chosen to leave the sites undisturbed.

Approximately 20 of the sites identified have been determined by the IHPA to be potentially eligible for NRHP listing. If the sites are to be disturbed, further testing is required before doing so. Another 20 sites (approximately) have been determined to be NRHP ineligible. All sites are identified on the map and described in detail in the CRM plan.

The survey conducted for the preparation of the CRM plan did not include an evaluation of on-site historic structures. Three structures may have historical significance: the former CP-5 Reactor (CP-5), the EBWR, and the Argonne Thermal Source Reactor. A formal evaluation of those structures was conducted and a report submitted to the IHPA on August 14, 1996. In a letter dated September 26, 1996, the IHPA provided notification that before any eligibility determination could be made regarding these three structures, ANL-E needed to develop a historic context addressing its role in the development of nuclear research, experimentation, and technology in Illinois and in the United States. This issue will be addressed during 1997.

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On November 20, 1996, IHPA representatives visited ANL-E to tour the three historic facilities and to clarify issues that had arisen during the evaluation process. The IHPA also wanted to visit two archaeological sites, which it had previously determined to be eligible for listing on the NRHP. DOE had requested a letter of consultation from the IHPA addressing these two sites as part of the preparation of an EA for ANL-E site remediation activities. The EA is being prepared pursuant to the requirements of NEPA.

Two issues were discussed during the visit. Agency representatives indicated, as the IHPA did in its September 26, 1996, letter that ANL-E needed to develop a historic context for the site, that is, what, if any, historic significance can be attributed to the activities that have been conducted at ANL-E. Once a historic context is developed, ANL-E will then need to develop a plan for reviewing all structures on site and identifying those that have contributed to ANL-E activities that are historically significant. This issue is still outstanding.

A more immediate issue involved the impact of proposed remediation activities for the ENE Landfill area on two archaeological sites in that area. These sites are NRHP eligible. IHPA representatives determined that the sites likely would be impacted by proposed remediation activities and indicated that the sites would need to be mitigated or the remediation activities modified. DOE will avoid the two sites, if possible, and enter into a formal avoidance agreement with IHPA. If it is not possible to avoid the sites, DOE will conduct a Phase III archaeological data recovery excavation in accordance with a plan approved by the IHPA.

2.12. Floodplain Management

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

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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 impacted, 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. There were no significant floodplain management issues during 1996.

2.13. Protection of Wetlands

Federal policy on wetland protection is contained in Executive Order 11990. In addition, 10 CFR 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 current federal policy is for no net decrease in the amount of wetland as a result of federal activities.

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.

In February of 1989, the U.S. Army Corps of Engineers (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/ANL-E. The plan outlined procedures for the construction of a new wetland area,

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Wetland R, and also identified actions to be taken to avoid a fourth wetland, Wetland C, during APS construction activities. In addition, DOE/ANL-E committed to monitoring the progress of Wetlands C and R for a period of five years. The monitoring period began in 1992.

During October 1996, the COE conducted a compliance inspection to assess compliance with the conditions of the permit issued in February 1989 addressing APS wetlands. The inspection resulted in a COE letter contending that the state of the APS wetlands reflects a lack of compliance with the COE permit (see Section 2.14.1).

During 1993, a sitewide wetlands delineation was completed of the ANL-E site. 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*.⁴ The results of the survey were delineated on a site map indicating the aerial extent of all wetlands present at ANL-E down to 500 m² (1/8th acre). The findings are documented in an accompanying report that describes in detail the soil, vegetation, and hydrology of each wetlands area delineated on the map. Thirty-five individual wetland areas were identified totaling approximately 18 ha (45 acres). The wetlands areas were also digitized onto a computer-aided design file in order to provide ANL-E engineers with scale maps for planning and designing projects. The delineation will also be useful for determining project impacts under NEPA review.

Activities in 1996 included delineations performed for several specific projects to be conducted in close proximity to wetlands identified on the sitewide map. The purpose of these delineations was to specifically identify wetland boundaries in order to assess project impacts. In 1996, ANL-E established a Land Management and Habitat Restoration Committee to address sustainable landscaping and other land use issues at the ANL-E site through the development of a long-range management plan. Wetlands management is a component of this long-range plan. In 1997, a plan will be developed that will address the enhancement/management of existing wetlands, wetland restoration activities, and related regulatory issues.

2.14. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 1996.

2.14.1. Major Compliance Issues

A number of significant outstanding compliance issues were addressed by ANL-E during 1996.

2.14.1.1 Clean Water Act - NPDES

The ANL-E revised NPDES permit became effective October 30, 1994. The new permit included a number of changes to sampling parameters for various outfalls and ANL-E was not consistently able to meet the permit limits for TDS and copper. It was also anticipated that ANL-E would have difficulty consistently meeting the new permit limits for ammonia-nitrogen. In March 1995, ANL-E requested a modification to the NPDES permit to temporarily relax the permit limits on the above parameters in the interim, while establishing a compliance schedule to meet the new permit limits. A modified permit was issued in August 1995, which provided interim limits for TDS, copper, and ammonia-nitrogen at Outfall 001. ANL-E must be able to meet the final effluent limits for those parameters at Outfall 001 by July 1, 1998. The permit also provided a schedule for performing certain actions as a means for attaining the final effluent limits by July 1998. ANL-E was able to meet all of the milestones identified for 1996 and has made progress toward meeting final effluent limits. A continuing issue for 1997 will be the ability to meet the milestones identified in the compliance schedule.

ANL-E also had been unable to consistently meet permit limits for TRC at three outfalls. A compliance schedule for meeting those limits is also identified in the modified NPDES permit; ANL-E had to meet the TRC limits by October 30, 1996. The TRC limits were met by the specified date, and the IEPA was notified to that effect by a letter dated November 6, 1996.

2. COMPLIANCE SUMMARY

2.14.1.2 Safe Drinking Water Act - Copper and Lead

During 1996, ANL-E exceeded the action level for copper in drinking water samples. Normally, a number of follow-up actions must be performed, that is, additional sampling and maintenance of corrosion control measures. In January 1997, ANL-E's drinking water supply was converted to Lake Michigan water purchased from the DuPage County Water Commission. Since ANL-E is now a customer rather than a supplier of water, the public water supply regulations are no longer applicable to ANL-E. Certain monitoring activities, applicable to users of water, will continue to be conducted by ANL-E.

2.14.1.3 Toxic Substances Control Act - PCBs

In August of 1994, ANL-E inadvertently shipped waste oil contaminated with PCBs to an off-site recycling facility. The EPA and IEPA were made aware of the incident, and both agencies conducted investigations at ANL-E relating to the incident. On November 14, 1994, the IEPA issued a Compliance Inquiry Letter (CIL) regarding the incident, which stated that ANL-E was in apparent violation of 35 IAC Parts 808 and 809 (Special Waste Regulations). The CIL requested information on the reasons for the apparent violations and a description of the steps that would be taken to address them. DOE responded to the CIL on December 14, 1994. On January 10, 1995, the IEPA responded that ANL-E had returned to compliance for the apparent violations.

The EPA conducted two follow-up investigations on November 10, 1994, and January 13, 1995. In a letter dated March 19, 1996, the EPA transmitted a Complaint and Notice of Opportunity for Hearing to the University of Chicago regarding the above incident. The complaint alleged violations of the TSCA and proposed penalties for the alleged violations. On April 9, 1996, ANL-E responded to the complaint and requested an informal conference. In a letter dated August 6, 1996, the EPA provided ANL-E with information on potential downward adjustments to the penalties proposed in the complaint. An informal settlement conference was held in November 1996. A settlement is expected to be reached in 1997.

2.14.1.4 RCRA - 800 Area Landfill

DOE's failure to modify its property deed to reflect the fact that the landfill had been used for the disposal of ACM, thus making said disposal part of the public record and subject to discovery during a title search of the property, resulted in a formal notice of noncompliance from the IEPA. DOE responded to the IEPA on July 8, 1994, indicating that steps would be taken to modify the deed. DOE has conducted a survey to obtain an accurate legal description of the ANL-E boundary. DOE is undertaking discussions with the adjacent property owner to resolve these issues.

The IEPA-approved sanitary landfill groundwater monitoring program continues to indicate that the Groundwater Quality Standards of some routine indicator parameters are consistently being exceeded. Contamination in this area will be addressed under the RCRA Corrective Action Program (see Section 2.3.9).

2.14.1.5 RCRA - Underground Storage Tanks

During the removal of a number of USTs in October 1995, four of the tanks were found to be leaking. The leaking USTs were reported to the IEPA in two separate incidents and received UST incident numbers 952081 and 952114. A Corrective Action Completion Report addressing both incidents was submitted to the IEPA in December 1995. In a letter dated April 5, 1996, the IEPA rejected the Corrective Action Completion Report, citing several technical points. On May 9, 1996, ANL-E submitted additional information to the IEPA to supplement the original report. The IEPA again rejected the report on September 10, 1996.

The IEPA had determined that the corrective actions taken for Incident No. 952114 were insufficient because adequate sampling was not conducted following removal of the tank involved in that incident, UST 21. Only one sample was collected from the excavation rather than the required five samples. In the May 9, 1996, supplemental information report, it was explained that the proximity of another tank, UST 20, to the excavation for UST 21, prevented the collection of all required samples. The report also indicated that UST 20 had been recently taken out of

2. COMPLIANCE SUMMARY

service and would be removed in the near future, in accordance with UST regulations. ANL-E committed to collecting additional samples from the UST 21 excavation at the time UST 20 was removed.

In the September 10, 1996, letter, the IEPA indicated that UST Incident No. 952114 would be held open until the additional samples were collected and the data submitted to the IEPA for review and approval. In that same letter, the IEPA indicated that the corrective actions taken for Incident No. 952081 were adequate, but that ANL-E needed to submit a Professional Engineer Certification Form for that incident. A form had been submitted previously, but it addressed both incidents. Since Incident No. 952114 will remain open until additional sampling is performed, a separate form addressing only Incident No. 952081 needed to be submitted to the IEPA.

A Professional Engineer Certification Form for Incident No. 952081 was submitted to the IEPA on December 11, 1996. On January 6, 1997, the IEPA transmitted a letter stating that the corrective actions for Incident No. 952081 were considered complete. As stated above, Incident No. 952114 remains open. An issue for 1997 will be to take the actions necessary to close out Incident No. 952114.

2.14.1.6 Wetlands

On October 3, 1996, the COE conducted a compliance inspection to assess compliance with the permit issued in February 1989. In a letter dated October 10, 1996, the COE stated that it had been determined that the APS project was in noncompliance with the permit that had been issued. The letter did not state specifically which provisions of the permit had been violated. The COE letter requested that a management plan be submitted for Wetland R addressing the removal of adventive species, improvement of wetland vegetation, and management practices to be implemented to sustain ecological integrity at the wetland. The letter also requested the submittal of an assessment of the cause of the water deficit at Wetland C and a plan to restore water levels in the wetland. A management plan for Wetland R and an assessment for the cause of the water deficit at Wetland C is scheduled to be submitted to COE during January 1997.

2.14.2. Regulatory Agency Interactions

The regulatory agency interactions with ANL-E during 1996 related primarily to site inspections regarding permit requirements. The preceding sections of this chapter contain detailed discussions of specific issues related to each major piece of environmental regulation.

During 1996, DOE conducted two program reviews, NEPA and Hazardous Materials Management. The reviews are conducted against performance measures identified as part of the prime contract between the University of Chicago and DOE.

The purpose of the NEPA review was to evaluate the effectiveness of ANL-E's NEPA review program. DOE recommended that ANL-E establish a check-point system to capture all projects that may require NEPA review and documentation; establish a consistent ANL-E NEPA review program; and propose more sitewide, blanket categorical exclusions to DOE to streamline further the NEPA review process.

The purpose of the Hazardous Materials Management review was to verify that appropriate controls are in place at ANL-E to manage materials that could pose an environmental liability. The scope of the review included the management of materials in inventory, materials in use, and wastes. A draft review report was issued to ANL-E on August 2, 1996. ANL-E provided DOE with comments on August 28, 1996. DOE did not issue a final report before the end of 1996. Two issues were outlined in the draft report: (1) The Chemical Management System/Chemical Tracking System is not being implemented consistently across the ANL-E site, and ESH guidance on use of the system is not well defined; and (2) the orphan waste project funded by Multiprogram Energy Laboratories-Facilities Support and general funding responsibilities for characterizing wastes are not well defined. ANL-E must also clarify how it is managing potential regulatory, safety, and environmental risks of uncharacterized wastes.

2. COMPLIANCE SUMMARY

2.15. Environmental Permits

Table 2.12 lists all environmental permits in effect at the end of 1996. Other portions of this chapter discuss special requirements of these permits and compliance with those requirements. The results of monitoring required by these permits are discussed in those sections, as well as in Chapters 5 and 6.

TABLE 2.12

ANL-E Environmental Permits in Effect December 31, 1996

Type	Source	Building	Issued	Expiration Date ^a
Air	ALEX Alkali Metal Scrubber	370	12/05/91	12/03/96
NESHAP	Alkali Metal Reaction Booth	206	06/09/93	06/09/97
Air	Alkali Metal Reaction Booth	308	02/15/89	11/18/98
Air	Argonne Service Station	300	01/09/91	10/04/00
Air	Central Shops Dust Collector	363	03/12/91	01/08/01
Air	Gasoline Dispensing Facility ^b	46	02/01/93	05/22/00
Air	Ethylene Oxide Sterilizer	201	03/27/91	01/08/01
Air	Methanol/Gasoline Storage Tank	46	09/24/91	09/23/96
Air	Open-Burning Permit - Fire Dept.	333	02/04/94	04/16/97
Air	Grieve Oven	366	08/08/91	08/06/96
Air	Central Heating Plant	108	12/28/93	12/28/98
Air	Sulfuric Acid Storage Tank	108	01/17/91	12/01/99
Air	Wood Shop Dust Collector	809	12/16/93	10/17/96
NESHAP	Advanced Photon Source	400	12/21/93	07/26/98
NESHAP	Alpha Gamma Hot Cell Facility	212	03/25/91	08/09/00
NESHAP	Building Exhausts ^c	212	07/30/91	07/23/96
NESHAP	Building Vents	306	08/06/91	07/25/96
NESHAP	CP-5 D&D Project	330	05/10/91	12/08/96
NESHAP	Continuous Wave Deuterium Demonstration	369	05/09/91	12/28/99
NESHAP	Cyclotron	211	05/10/91	12/01/99

TABLE 2.12 (Cont.)

Type	Source	Building	Issued	Expiration Date
NESHAP	Intense Pulsed Neutron Source	375	03/25/91	08/09/00
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	Rad Hoods	Sitewide	07/09/92	07/09/97
NESHAP	D&D HEPA Filter System	317	05/10/94	05/10/99
Air	APS Emergency Generators (3)	400	05/16/94	03/15/99
Air	Waste Bulking Sheds ^d	306	06/14/94	07/25/96
NESHAP	WMO HEPA Filter Systems (2)	Sitewide	09/28/94	09/28/99
NESHAP	Building Rehab - Phase 1 ^e	306	03/13/95	07/25/96
Air	Hazardous Waste Storage Facility	307	05/24/95	04/26/00
NESHAP	Mixed Waste Storage Facility	303	05/18/95	04/26/00
NESHAP	Rad (TRU) Waste Storage Facility	331	05/18/95	04/26/00
NESHAP	Lead Brick Cleaning (CO ₂)	200/317	06/20/95	06/19/00
Air	Paint Spray Booth ^f	306	07/03/95	06/27/00
Air	Torch Cutting (Welding) Fumes	Sitewide	07/20/95	07/20/00
NESHAP	PCB Tank Cleanout ^g	Sitewide	08/16/95	09/28/99
NESHAP	Lab Wastewater Treatment Plant	575	08/29/95	08/29/00
NESHAP	Melt Attack/Coolability Experiment	315	03/22/96	03/22/01
NESHAP	Radon Remediation Demonstration ^h	200	03/18/96	08/09/00
Air	Boiler No. 5 Low NO _x Gas Burner ⁱ	108	06/21/96	12/28/98
Air	Transportation Research Facility	376	07/25/96	07/25/01
NESHAP	Janus D & D Project	202	06/12/96	06/12/01
	Title V (CAAPP)	Sitewide	Pending	
Hazardous Waste	RCRA Part A Permit	Sitewide	04/30/82	J
Hazardous Waste	RCRA Part A Modification - Storage Units	Sitewide	02/18/93	-

TABLE 2.12 (Cont.)

Type	Source	Building	Issued	Expiration Date
Hazardous Waste	RCRA Part A Modification - Scintillation Vials	Sitewide	09/22/93	-
Hazardous Waste	RCRA Part A Modification - Storage	303/307/331	10/12/95	-
Hazardous Waste	RCRA Part B - Draft	Sitewide	09/26/96	-
Miscellaneous	Nuisance Wildlife Control	Sitewide	03/28/96	01/31/97
Miscellaneous	Deer Population Control Permit	Sitewide	02/28/96	03/31/96
Miscellaneous	Deer Population Control Permit	Sitewide	11/01/96	01/29/97
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 Leachate Test Wells	800 Area	08/31/90	-
Solid Waste	Landfill Groundwater Assessment	800 Area	09/30/91	-
Solid Waste	Landfill Leachate Characterization	800 Area	09/30/91	-
Solid Waste	Landfill Revised Closure Plan	800 Area	04/24/92 ^k	-
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	-
Water	APS Wetland	400 Area	02/02/89	-
Water	Landfill Wetlands	800 Area	05/20/81	-
Water	Lime Sludge Application - Land Application	Sitewide	01/12/94	12/31/98

TABLE 2.12 (Cont.)

Type	Source	Building	Issued	Expiration Date
Water	NPDES Permitted Outfalls	Sitewide	10/31/94	07/01/99
Water	NPDES Storm Water Outfalls	Sitewide	10/31/94	07/01/99

- ^a Expiration dates on 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 Includes ethanol/gasoline tank.
- ^c Plasma spray booth added to permit 05/27/94.
- ^d Construction permit issued; operated under Building 306 permit.
- ^e Construction permit issued; operated under Building 306 permit.
- ^f Permit originally issued for Building 815.
- ^g Construction permit issued; operated under WM HEPA permit.
- ^h Construction permit issued; operated under Building 200 permit.
- ⁱ Construction permit issued; operated under Central Heating Plant permit.
- ^j A hyphen indicates no expiration date.
- ^k Revised September 15, 1992, and October 22, 1992.

3. ENVIRONMENTAL PROGRAM INFORMATION



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.

3.1.1 Environmental Management Programs

In 1989, DOE established the goal of achieving compliance with all applicable environmental authorities, assessing and cleaning up releases of hazardous materials from inactive waste sites, and returning all such sites to unrestricted use. To increase the likelihood of achieving this goal, DOE established the Environmental Restoration and Waste Management Program, now called the Environmental Management Program (EM). This program identifies specific needs and establishes a system for allocating funds to support ongoing activities and resolve various deficiencies. Each DOE facility has prepared a set of planning documents (Activity Data Sheets [ADSs]) describing those activities necessary to bring that specific site into compliance and to identify and clean up inactive waste sites. These planning documents are contained in a report, the Environmental Management Plan, which is updated and published annually. The 1996 plan contained information on 14 separate projects (see Table 3.1). The plan is a public document that is available from DOE upon request.

ANL-E management has designated Environmental Management Operations (EMO) as the lead environmental organization. EMO's mission is to proactively support ANL-E operations by conducting those activities that ensure compliance with applicable environmental statutes, regulations, DOE Orders, and ANL-E policies and procedures. These activities include restoration of the ANL-E site; proper collection, treatment, and disposal of radioactive, hazardous, and other regulated waste materials; and the conduct of the ANL-E environmental protection program. These activities are carried out to minimize potential adverse effects on

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TABLE 3.1

Environmental Management Projects

ADS Number	Title
CH 1300	Facility Operations and Maintenance - Defense Programs
CH 1301B	Facility Operations and Maintenance - Nondefense Programs
CH 1303	Rehabilitation of Waste Management Building
CH 1304	Hazardous, Radioactive, and Mixed Waste Storage Facility
CH 1306	Sanitary Wastewater Treatment Plant Improvements
CH 1309	Laboratory Wastewater Treatment Plant Improvements
CH 1432	Remedial Support Activities
CH 1433	Solid Waste Storage/Disposal Sites
CH 1434	Mixed Waste Storage/Disposal Sites
CH 1435	Treatment Sites
CH 1436	Facilities Conversion D&D Projects
CH 1437	Reactor Facilities D&D Projects
CH 1438	Support Facilities D&D Projects
CH 1439	Program Management

the health and safety of personnel at the ANL-E site and the general public, to property, and to the environment.

EMO is divided into four major operational units: ANL-E Remedial Actions Project; Waste Management; Environmental Protection; and Administration, Finance, and Information Management. The principal function of EMO is to serve as the ANL-E focal point for implementation of the DOE Office of Environmental Management program.

3.1.1.1 ANL-E Remedial Actions Project (ERAP)

The role of ERAP is to manage environmental restoration tasks in accordance with applicable DOE Orders and environmental requirements. ERAP provides project management and engineering support for environmental remediation efforts. Project management functions include the development of work scopes, project budgets, and schedules. The remedial actions

3. ENVIRONMENTAL PROGRAM INFORMATION

implemented by ERAP are designed to minimize any current or future impact to the environment or human health.

3.1.1.2. Waste Management Department

The Waste Management Department supports the scientific mission of ANL-E by delivering customer-defined quality products and services for the safe collection, treatment, storage, and disposal of all regulated waste generated at the Illinois site at minimal cost and burden to its customers. These products and services are delivered by Waste Management professionals who operate in a customer-centered culture and who are committed to waste prevention, protection of the surrounding community and the environment, and continuous quality improvement.

3.1.1.3. Environmental Protection Department

The Environmental Protection Department supports ANL-E operations, organizations, and DOE environmental missions by providing technical experts and services to address environmental issues. The department is composed of the Environmental Compliance Section and the Monitoring and Surveillance Section. Environmental protection activities are those sets of 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 with DOE Orders.

3.1.2. Remedial Progress in 1996

Remedial actions work at ANL-E was reorganized into a single, consolidated project: ERAP. The single project approach for environmental cleanup work has recently received strong endorsement from DOE Headquarters. The goal of the ERAP is to complete all remedial actions by FY 2001.

With respect to 1996 accomplishments, in the 317/319/ENE Area, the field sampling activities for the RCRA Facility Investigation (RFI) were completed, and work on the

3. ENVIRONMENTAL PROGRAM INFORMATION

investigation report was begun. Two in-ground concrete storage vaults located in the 317 Area, which had been used in prior years to store sealed containers of radioactive waste, were decontaminated and demolished. An interim action to contain a leachate seep and contaminated groundwater emanating from the inactive 319 Area Landfill, which was begun in 1995, was completed and put into service; it has successfully eliminated the discharge of leachate from the area to the forest preserve. A program to seal 27 abandoned or unused groundwater wells and upgrade 7 additional wells throughout the ANL-E site and areas adjacent to the site was completed. ANL-E worked closely with the IEPA to review the SWMUs listed in the RCRA Facility Assessment. As a result of this review, the number of SWMUs was reduced from 71 to 56. The removal and recycling of lime sludge from the lime sludge pond continued. A total of 8,410 m³ (11,000 yd³) of sludge was removed from the pond and applied to farmland as a soil conditioner. A second phase of the RFI for the 800 Area was begun. A site of two former underground fuel storage tanks, which was found to be contaminated with petroleum hydrocarbons, was remediated. A draft EA for remedial activities anticipated at the ANL-E site was prepared.

Five significant waste management facility improvement projects were completed: (1) construction of a new mixed waste storage facility; (2) conversion of the former EBWR into a radioactive waste storage facility; (3) Phase I rehabilitation of Building 306, ANL-E's primary waste handling facility; (4) rehabilitation of the sanitary WTP; and (5) upgrading of the cooling water supply treatment plant. Taken together, all projects represent approximately \$15 million of facility completions in 1996, thereby providing ANL-E with significantly improved waste storage, waste handling, and pollution control facilities.

ANL-E shipped a substantial quantity of radioactive waste accumulated in the past off site for disposal or storage, thereby significantly reducing the ANL-E inventory. Waste Management personnel moved into their newly rehabilitated area in Building 306. The new area provides for the inspection, compaction, assay, and shipment of low-level radioactive waste in one area, thus streamlining these operations. Five new mixed waste treatment systems were installed to treat mixed wastes in accordance with the FFCA-proposed site treatment plan for ANL-E.

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In October, ANL-E management announced a plan to complete site remediation efforts (both remedial actions and decontamination and decommissioning) by 2001 at a cost of \$57 million (1997 dollars). This plan saves nearly \$100 million and 10 years from the previous baseline estimates based on the DOE budget development guidance at that time. If funded by DOE at requested levels, ANL-E would be the first multiprogram laboratory to complete its environmental restoration.

3.2. Environmental Support Programs

3.2.1. Self-Assessment

Early in the year, the responsibility of internal self-assessment was delegated from the central ESH/Quality Assurance (QA) organization to line management. As a result, the process changed from a checklist format to a focus on the activities of individual organizations. At the beginning of the year, each organization developed an agenda of activities that would be reviewed that year. A schedule was prepared and assignments were made to manage the organization's self-assessment program. The plan was approved by the organization director and provided to the Director for ESH/QA Oversight.

The independent assessments were conducted by technically qualified and knowledgeable persons independent of the line organization. The assessments focused on providing meaningful information regarding achievements of the organizational mission, meeting performance requirements and expectations, and advising the appropriate levels of management regarding actions that may promote quality improvement. A summary report was prepared that documents the self-assessment process, determines lessons learned, and develops any action plans based on any discovered weaknesses. The summary reports were provided to the organization directors.

3.2.2. 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

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protection training for ANL-E personnel is primarily provided by the ESH Training Section, although ancillary training may be delivered by subject matter experts from other organizations. Personnel training requirements are mandated by DOE Orders, the U.S. Department of Transportation (DOT), the EPA, and OSHA regulations and are identified by a Job Hazards Checklist form that is completed by every employee and reviewed by the 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.

3.2.3. Waste Minimization and Pollution Prevention

Waste minimization is a policy specifically identified by the Congress in the 1984 Hazardous and Solid Waste Amendments to RCRA. RCRA requires hazardous waste generators to establish a program to reduce the volume or toxicity of waste to the degree determined by the generator to be "economically practicable." Hazardous waste generators, such as ANL-E, must certify in their waste manifest that this requirement has been fulfilled. Generators must also identify in their annual reports to the IEPA efforts undertaken during the year to reduce the volume and toxicity of waste generated and the changes in volume and toxicity actually achieved. Executive Orders state that federal entities should implement waste minimization and pollution prevention initiatives even if they are less than cost effective, for example, affirmative procurements.

Pollution is to be prevented at the source wherever and whenever possible. Those potential waste materials that cannot be eliminated or minimized by source reduction are to be recycled, that is, used, reused, or reclaimed to the maximum practical extent. All unavoidable waste is to be treated to reduce volume, toxicity, or mobility before storage or disposal. It is ANL-E policy

3. ENVIRONMENTAL PROGRAM INFORMATION

that reducing or eliminating the generation of waste be given prime consideration in all research, process design, and operations.

DOE Orders 5400.1¹ and 5820.2A⁵ and their successors mandate that the management of radioactive waste and other pollutants be accomplished in a manner that minimizes the quantities of such wastes that require ultimate disposal.

ANL-E has a long-standing history of waste minimization and pollution prevention dating back to the founding of ANL-E 50 years ago. The first activities included recycling of metals, rare earths, and radionuclides. Historic recycling programs, including recycling of paper and print cartridges, are expanding. ANL-E conducted "dumpster dives" of nonhazardous waste streams and used the results to recommend the expansion of the paper recycling program. The program has increased paper recycling efforts by 75% since 1993. In 1996, the program was expanded to include all mixed office paper. This has tripled the volume of recycled paper.

Construction and maintenance efforts typically generate large quantities of debris and waste. This was significantly reduced by diversion, recycling, or reuse. Examples are as follows:

- Dirt from several construction and remediation projects was used as fill for other projects, thus avoiding disposal of spoils and purchase of fill.
- Lime sludge from a discontinued water treatment process was recycled by application to farm fields for neutralization of acidic soil.
- Three miles of removed chain-link fence was recycled.
- Fifty large cement blocks were used as fill, thus avoiding the costs to dispose of the blocks and purchase fill material.
- An on-site road was resurfaced and the old asphalt recycled for other road construction projects.

These activities have resulted in considerable reuse of materials and avoidance of natural resource consumption.

3. ENVIRONMENTAL PROGRAM INFORMATION

ANL-E participates in an energy conservation program with its electricity supplier. ANL-E has agreed to reduce consumption of electricity use during peak load times, thus enabling the supplier to meet demand without the addition of new generation capacity.

During 1996, ANL-E hosted the DOE XII Pollution Prevention Conference. As part of the conference, ANL-E was recognized for outstanding achievement in six areas by DOE-Chicago. ANL-E's continuous efforts in pollution prevention were recognized by the IEPA when ANL-E received the IEPA Partners in Pollution Prevention STAR Performer Award in December of 1996.

3.2.4. Site Environmental Performance Measures Program

In May 1995, the ANL-E operating contract with the University of Chicago was renegotiated. The new contract includes a performance fee based on performance of research and operations, including ES&H performance. Performance objectives and supporting metrics have been developed to administer the contract and determine the performance fee. Each performance measure is weighted and at the end of the performance period, a rating (outstanding, excellent, good, marginal, or unsatisfactory) is assigned. The performance fee is based on these ratings.

For the period of the performance-based contract, August 1995 to September 1996, the environmental measures involved performance related to EM-funded activities and the "E" portion of ES&H activities. Performance measures and associated ratings for EM-funded activities were utilization of funding (outstanding), scope and cost control (good), and project performance (excellent). The overall rating for EM-funded activities was outstanding. The measures and grades for the "E" measures were chlorine outfalls elimination (good), meeting environmental permit limits (excellent), solid waste reduction (outstanding), and hazardous waste reduction (outstanding). The overall rating for environmental performance during this contract period was excellent.

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3.2.5. 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 incorporation of national environmental protection goals in the formulation and implementation of ANL-E programs. It has an equal commitment to advance 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.

ANL-E is committed to managing all of its programs and facilities in an environmentally sound manner, to correct existing environmental problems, and to minimize risks to the environment or public health. To manage these commitments, ANL-E has structured its activities to focus on these goals. Line organizations have primary responsibility for environmental management, with professional staff support from the core ES&H organizations. The ESH/QA organization provides oversight. The organizational responsibilities have been documented. ANL-E is evaluating the use of International Standards Organization (ISO) 14001, which is intended to provide organizations with the elements of an effective environmental management system that can be integrated with other management requirements, to assist organizations in achieving environmental and economic goals.

3.3. Environmental Monitoring Program Description

As required by DOE Order 5400.1,¹ ANL-E conducts a routine environmental monitoring program. This program is designed to determine the effect the operation of ANL-E is having on the environment surrounding the site. This section describes this monitoring program. A total of 2,068 samples were collected and 22,438 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.

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3.3.1. Air Sampling

Continuously operating air samplers are used at ANL-E to collect samples for the measurement of concentrations of airborne particulate matter contaminated by radionuclides. Currently, nonradiological air contaminants in ambient air are not monitored. Particulate 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 particulate 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 m³/h (2,472 ft³/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. The sampling units are serviced every six months, and the flow meters are recalibrated annually.

Additional samples of particulate matter in air, used for radiochemical analysis of plutonium and other radionuclides, are collected at two perimeter locations and one off-site location. These samples are collected on special filter media that are changed every 10 days by ANL-E staff. The flow rate calibration and servicing schedule is the same as discussed above.

At the time of sample collection, the date and time when sample collection began, 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

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5-cm (2-in.) low-lip stainless-steel planchet, and counted to determine alpha and beta activity. The balance of the filter is saved.

The air filter samples collected for radiochemical analysis are composited by location for each month. After addition of the 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 CAP-88 version⁶ of the EPA-AIRDOSE atmospheric dispersion computer code and dose conversion method.

3.3.2. 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 Sawmill Creek below the point at which ANL-E discharges its treated wastewater. The results of radiological analysis of water collecting at this location are compared to upstream and off-site results to determine the ANL-E contribution. The results of the chemical analyses are compared to the applicable IEPA stream quality standards to determine if 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 if radionuclides in the creek are detectable in the river. Water samples are collected from remote locations in the spring and fall to serve as additional control samples.

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In addition to surface water, subsurface water samples are also collected at 34 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 of the domestic water, which comes from four on-site wells, are also 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 330 (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 four ANL-E wells that provide 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 tritium analysis, 20 mL of concentrated nitric acid (HNO_3) is added per gallon of water as a preservative, and the sample is filtered through Whatman No. 2 filter paper to remove 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-846⁷ or the Contract Laboratory Program (CLP) are met or deviations are documented. All samples are assigned a unique number

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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.

3.3.3. 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 several locations below the point at which ANL-E discharges its treated wastewater. Periodically, sediment samples are collected from several on-site ponds and lagoons. Ten off-site bottom sediment samples are collected each year, five in the spring and five in the fall, from remote locations to serve as controls. 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 portion is taken for gamma-ray spectrometric measurement, and other appropriate aliquots are used for specific radiochemical analyses.

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3.3.4. Soil

Soil integrates small amounts of particulate matter and serves as a collector of the deposition of airborne releases of radioactive materials. Although it should not be used as the primary measurement system for air monitoring, in many cases, it may be the only available avenue if insufficient air sampling occurred at the time of an incident. The ANL-E program is designed to provide samples for analysis to determine if any changes in concentrations have occurred over the year. No analysis for chemical constituents is carried out on these samples.

Each year soil is collected from 10 locations at the site perimeter (five spring and five fall) and from 10 remote locations (five spring and five fall). Sampling sites are selected in reasonably level areas that represent undisturbed soil. Two 1-m (3-ft) squares are marked off, and soil samples are collected from the corners and center of each square. Samples are collected with a 10.4-cm (4-in.) diameter coring tool to a depth of 5 cm (2 in.). All 10 cores are composited as a single sample. This procedure follows the American Society for Testing and Materials (ASTM) Standard Method for Sampling Surface Soil for Radionuclides, C-998.

At the time of sample collection, the date, time, and sample collector identification number are recorded on a preprinted sample label 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.

The entire sample is dried at 110°C (230°F) for several days, ball milled, and sieved through a No. 70 mesh screen. The material that does not pass the No. 70 mesh screen is discarded. A 100-g portion is taken for gamma-ray spectrometric measurement, and appropriate aliquots are taken for radiochemical analysis. Because a known area of surface soil was collected, results are calculated in terms of concentration and deposition per unit area.

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3.3.5. Vegetation

Grass samples are collected to determine the uptake of radionuclides from the soil by vegetation. This sampling is performed to monitor the vegetation part of the food chain pathway.

Grass samples are collected each year from 10 perimeter and 10 off-site locations at the same places as the soil samples. All vegetation within one of the 1-m plots used for soil sampling is cut just above the soil surface and collected.

At the time of sample collection, the date, time, and sample collector identification number are recorded on a preprinted sample label 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.

Grass samples are washed in water to remove surface dirt, dried at 110°C (230°F) for several days, and ground. A 100-g aliquot is measured by gamma-ray spectrometry, and appropriate aliquots are taken for radiochemical analysis.

3.3.6. 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 14 locations at the site perimeter and on the site and at five locations off the site. 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 laboratory by the vendor, it is entered into the EMS system.

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3.3.7. Data Management

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

The ANL-E-developed EMS program is the basic data management tool; it generates sampling schedules, all other tracking and calculation routines, and the final analytical result tabulations. The EMS program 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 (water, soil, plant, etc.), 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 program 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 are doing the sampling in the field. Field data are entered into the EMS system. At the time when the samples are submitted to the analytical laboratory, chain-of-custody documents are generated. The EMS system distributes sample data electronically (via diskette) to the ESH data management system and accepts back the analytical data (via diskette or E-mail).

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As the laboratory results are compiled, the data are entered into the EMS program. 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 program. When all results have been completed and entered into the EMS, a final result card is generated listing all data related to each sample. The electronic files are backed up by the EMO computer network server. The printed final result card is filed after review, then ultimately put in DOE's archives in Chicago. EMO staff annually print and bind the complete results for reference, by sample type, for the past calendar year. Final results are thus available both on-line via the network and in hard copy.

3.4. Compliance with DOE Order 5820.2A

DOE Order 5820.2A, "Radioactive Waste Management," Section III-3 (k)⁵ requires that an environmental monitoring and surveillance program be conducted to determine any releases or migration from low-level waste 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 the monitoring of the liquid effluent streams and the 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. This includes 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 tritium and gamma-ray emitters; perimeter soil and plant samples analyzed for gamma-ray emitters, plutonium, and americium; and subsurface water samples at all the monitoring wells with analyses for tritium, strontium-90, and gamma-ray emitters, plus selected monitoring for VOCs. The results are presented in Chapters 4 and 6 of this report.

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4.1. Description of Monitoring Program

The radioactivity of the environment around ANL-E was determined by measuring the concentrations of radioactive nuclides in naturally occurring materials and by measuring the external penetrating radiation dose. Sample collections and measurements were made at the site perimeter and off the 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 concentrated on these media. In addition, samples of soil, plants, and materials from the beds of lakes and streams also were analyzed. The program followed the guidance provided in the DOE Environmental Regulatory Guide.⁸ The results of radioactivity measurements are expressed in terms of pCi/L for water; fCi/m³ and aCi/m³ for air; and pCi/g, fCi/g, and/or nCi/m² for soil, bottom sediment, and vegetation. Penetrating radiation measurements are reported in units of mrem/yr and population dose in man-rem.

DOE has provided guidance⁹ for effective dose equivalent calculations for members of the public based on International Commission on Radiological Protection (ICRP) Publications 26 and 30.^{10,11} Those procedures have been used in preparing this report. The methodology requires three components to be calculated: (1) the committed effective dose equivalent (CEDE) from all sources of ingestion, (2) the CEDE from inhalation, and (3) direct effective dose equivalent from external radiation. These three components are 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 assure 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, which exclude actual or potential accidental or unplanned releases.

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The measured or calculated environmental radionuclide concentrations are converted to a 50-year committed effective dose equivalent with the use of the CEDE factors¹² and are compared to the annual dose limits for uncontrolled areas. The CEDEs are calculated from the DOE Derived Concentration Guides (DCGs)⁹ 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. 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. Such values are enclosed in parentheses. Occasionally, other standards are used, and their sources are identified in the text.

4.2. Air

The radioactive content of particulate matter 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 PM₁₀ units (particulate matter less than 10 micrometers) and at five off-site locations.

Samples were collected at the site perimeter to determine if 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.

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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 0.05-MeV beta and a 5.5-MeV alpha on filter paper. 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 in its normal range. The perimeter beta activity averaged 27 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 few years and are of natural origin. The beryllium-7 concentration increases in the spring, indicating 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 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 decreased regularly since 1987, reached a minimum in 1991, and are now increasing. The increase in the beryllium-7 air concentrations has been observed worldwide by the DOE Environmental Laboratory's Surface Air Sampling Program and is attributed to an increase in solar activity.¹³

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 about $20,000 \text{ m}^3$

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TABLE 4.1

Total Alpha and Beta Activities in Air Filter Samples, 1996^a
(Concentrations in fCi/m³)

Month	Location	No. of Samples	Alpha Activity			Beta Activity		
			Avg.	Min.	Max.	Avg.	Min.	Max.
January	Perimeter	39	1.7	0.6	2.5	34.3	19.1	47.8
	Off Site	23	2.2	1.2	3.6	38.5	23.9	84.9
February	Perimeter	48	1.5	0.5	2.5	28.5	14.3	46.5
	Off Site	17	1.8	0.6	3.2	31.1	19.1	51.3
March	Perimeter	48	1.8	0.8	2.7	27.9	9.9	37.6
	Off Site	19	2.0	0.7	3.2	28.7	8.8	56.8
April	Perimeter	45	1.4	0.3	2.5	19.8	4.2	30.1
	Off Site	15	1.6	0.7	2.3	21.3	10.3	36.2
May	Perimeter	54	1.0	0.2	1.7	14.6	2.3	23.4
	Off Site	20	1.4	0.4	2.9	17.3	5.1	35.5
June	Perimeter	41	1.6	0.4	4.3	19.2	7.0	31.1
	Off Site	13	1.6	0.3	3.4	19.0	11.4	27.7
July	Perimeter	53	1.4	0.4	2.1	24.5	16.8	30.7
	Off Site	19	1.3	0.5	2.4	22.9	8.8	34.2
August	Perimeter	44	1.8	1.1	2.6	30.7	23.5	36.4
	Off Site	15	1.9	0.9	2.7	31.4	19.2	45.4
September	Perimeter	43	1.9	0.6	3.6	35.8	11.7	58.4
	Off Site	18	2.1	0.4	4.4	37.2	18.3	82.8
October	Perimeter	57	1.4	0.5	2.1	29.6	13.7	41.9
	Off Site	20	1.4	0.9	2.3	26.7	17.5	41.2
November	Perimeter	43	1.2	0.6	1.8	26.7	12.5	37.1
	Off Site	16	1.6	0.9	2.6	26.1	13.3	43.3
December	Perimeter	31	1.4	0.8	2.1	34.2	17.6	42.6
	Off Site	19	1.6	0.4	3.0	31.1	11.0	54.5
Annual	Perimeter	546	1.5 ± 0.2	0.2	4.3	27.2 ± 4.2	2.3	58.4
Summary	Off Site	214	1.7 ± 0.3	0.3	4.4	27.6 ± 4.3	5.1	84.9

^a These 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 the air and disappears within four days by radioactive decay.

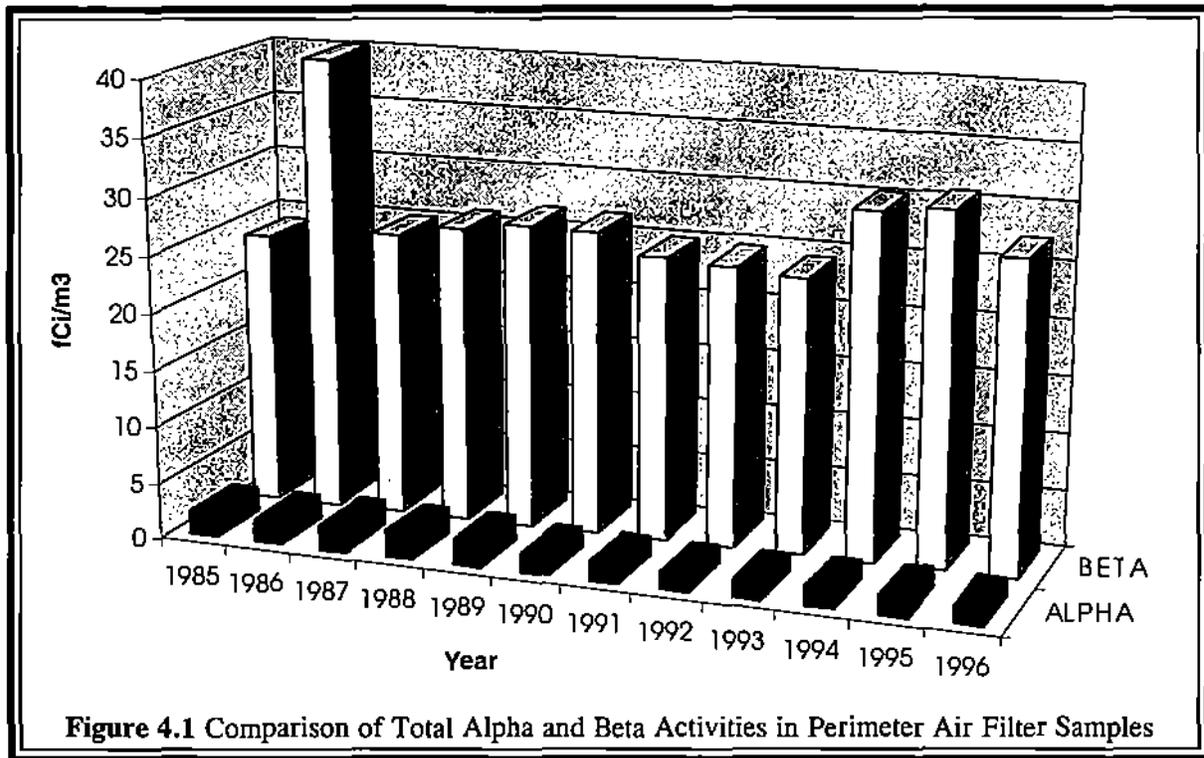
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TABLE 4.2

Gamma-Ray Activity in Air Filter Samples, 1996
(Concentrations in fCi/m³)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	111	26
	Off Site	111	26
February	Perimeter	111	22
	Off Site	98	20
March	Perimeter	155	18
	Off Site	166	16
April	Perimeter	126	12
	Off Site	125	13
May	Perimeter	118	9
	Off Site	88	10
June	Perimeter	122	13
	Off Site	91	14
July	Perimeter	171	17
	Off Site	127	16
August	Perimeter	136	23
	Off Site	100	23
September	Perimeter	143	28
	Off Site	133	31
October	Perimeter	123	24
	Off Site	90	22
November	Perimeter	100	23
	Off Site	92	24
December	Perimeter	50	30
	Off Site	54	25
Annual Summary	Perimeter	122 ± 19	20 ± 4
	Off Site	106 ± 18	20 ± 4
Dose (mrem)	Perimeter	(0.00031)	(2.31)
	Off Site	(0.00027)	(2.27)

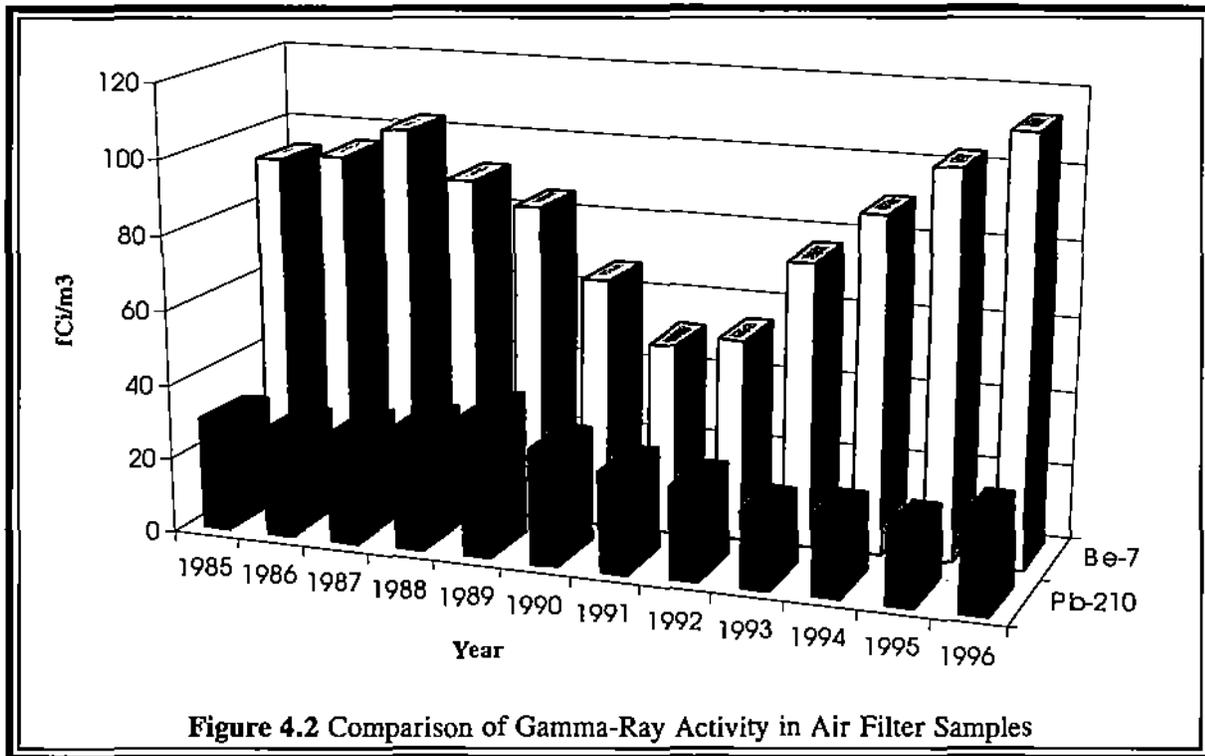
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(700,000 ft³). Samples were ignited at 600°C (1,112°F) to remove organic matter and were prepared for analysis by vigorous treatment with hot hydrochloric, hydrofluoric, and nitric acids.

Plutonium and thorium were separated on an anion exchange column, and the uranium was extracted from the column effluent. Following the extraction, the aqueous phase was analyzed for radiostrontium by a standard radiochemical procedure. The separated plutonium, thorium, and uranium fractions were electrodeposited and measured by alpha spectrometry. The chemical recoveries were monitored by adding known amounts of plutonium-242, thorium-229, and uranium-236 tracers prior to ignition. Because spectrometry cannot distinguish between plutonium-239 and plutonium-240, it should be understood that 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.

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A considerable amount of remedial activity was conducted in the 317 Area during early spring. This culminated with the demolition in late April of two vaults previously used to store radioactive waste. The elevated strontium-90 and plutonium-239 in the 317 Area sample is the result of this work. As discussed in Section 4.5, the direct radiation dose, as measured by TLDs, was also elevated. For all other samples, the strontium-90 concentrations have decreased over the past several years so that during 1996, most of the results were less than the detection limit of 10 aCi/m³. Strontium-89 was not observed above the detection limit of 100 aCi/m³. The other plutonium-239 concentrations were similar to last year at all locations.

The thorium and uranium concentrations are 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 bulk of these elements in the air was due to resuspension of soil.

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TABLE 4.3

Strontium, Thorium, Uranium, and Plutonium Concentrations
in Air Filter Samples, 1996
(Concentrations in $\mu\text{Ci}/\text{m}^3$)

Month	Location ^a	Strontium-90	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-238	Plutonium-239
January	7I	< 10	12 ± 3	14 ± 2	10 ± 2	14 ± 3	19 ± 3	0.5 ± 0.3
	12N	< 10	24 ± 3	29 ± 3	20 ± 2	25 ± 2	29 ± 3	1.1 ± 0.4
	Off Site	< 10	5 ± 1	7 ± 1	4 ± 1	6 ± 1	8 ± 1	0.2 ± 0.1
February	7I	< 10	4 ± 1	5 ± 1	3 ± 1	5 ± 1	6 ± 1	0.3 ± 0.1
	12N	< 10	^b	-	-	11 ± 1	12 ± 1	0.5 ± 0.2
	Off Site	< 10	3 ± 1	4 ± 1	2 ± 1	4 ± 1	4 ± 1	0.1 ± 0.1
March	7I	12 ± 2	5 ± 1	6 ± 1	3 ± 1	7 ± 1	7 ± 1	0.5 ± 0.2
	12N	< 10	14 ± 2	17 ± 2	11 ± 2	17 ± 1	19 ± 1	0.6 ± 0.2
	Off Site	< 10	6 ± 1	7 ± 1	5 ± 1	8 ± 1	8 ± 1	0.2 ± 0.1
April	7I	46 ± 2	7 ± 2	15 ± 2	5 ± 1	9 ± 1	10 ± 1	24.7 ± 1.9
	12N	< 10	21 ± 2	27 ± 2	16 ± 2	25 ± 2	26 ± 2	0.7 ± 0.3
	Off Site	< 10	5 ± 1	6 ± 1	4 ± 1	6 ± 1	5 ± 1	< 0.1
May	7I	< 10	6 ± 1	7 ± 1	5 ± 1	6 ± 2	7 ± 1	0.9 ± 0.4
	12N	< 10	9 ± 2	13 ± 2	8 ± 1	12 ± 2	11 ± 2	0.7 ± 0.3
	Off Site	< 10	3 ± 1	4 ± 1	3 ± 1	5 ± 1	4 ± 1	0.4 ± 0.2
June	7I	< 10	4 ± 2	7 ± 1	3 ± 1	5 ± 1	7 ± 1	1.2 ± 0.5
	12N	< 10	8 ± 1	9 ± 1	6 ± 1	9 ± 2	10 ± 1	0.6 ± 0.3
	Off Site	< 10	4 ± 1	4 ± 1	2 ± 1	4 ± 2	4 ± 1	0.3 ± 0.3
July	7I	< 10	5 ± 3	9 ± 2	6 ± 2	7 ± 2	7 ± 2	1.4 ± 0.8
	12N	< 10	8 ± 1	10 ± 1	6 ± 1	9 ± 1	9 ± 1	1.5 ± 0.4
	Off Site	< 10	13 ± 1	17 ± 1	10 ± 1	15 ± 1	15 ± 1	0.5 ± 0.2
August	7I	< 10	7 ± 2	6 ± 1	4 ± 1	6 ± 2	7 ± 1	1.7 ± 0.5
	12N	< 10	8 ± 3	11 ± 2	9 ± 2	11 ± 2	11 ± 2	0.1 ± 0.4
	Off Site	< 10	4 ± 1	5 ± 1	3 ± 1	6 ± 1	6 ± 1	0.2 ± 0.1
September	7I	< 10	2 ± 1	5 ± 1	3 ± 1	6 ± 1	6 ± 1	0.6 ± 0.3
	12N	-	-	-	-	-	-	-
	Off Site	-	-	-	-	-	-	-
October	7I	< 10	3 ± 1	5 ± 1	3 ± 1	6 ± 1	7 ± 1	0.8 ± 0.2
	12N	< 10	8 ± 3	10 ± 2	7 ± 1	11 ± 3	10 ± 2	< 0.1
	Off Site	< 10	2 ± 1	4 ± 1	2 ± 1	5 ± 1	4 ± 1	0.3 ± 0.3
November	7I	< 10	5 ± 1	6 ± 1	5 ± 1	7 ± 1	8 ± 1	1.0 ± 0.3
	12N	< 10	11 ± 2	14 ± 1	9 ± 1	14 ± 1	15 ± 1	0.3 ± 0.2
	Off Site	< 10	2 ± 1	2 ± 1	1 ± 1	3 ± 1	3 ± 1	0.1 ± 0.1
December	7I	< 10	8 ± 1	10 ± 1	6 ± 1	11 ± 1	11 ± 1	1.1 ± 0.4
	12N	< 10	15 ± 2	17 ± 2	12 ± 2	19 ± 2	19 ± 2	0.7 ± 0.3
	Off Site	13 ± 1	2 ± 1	4 ± 1	2 ± 1	4 ± 1	4 ± 1	1.2 ± 0.3
Annual Summary	7I	< 10	6 ± 6	8 ± 8	5 ± 5	7 ± 6	8 ± 8	2.9 ± 15.1
	12N	< 10	12 ± 13	16 ± 16	10 ± 10	15 ± 13	15 ± 16	0.6 ± 1.2
	Off Site	< 10	4 ± 7	6 ± 9	3 ± 5	6 ± 7	6 ± 8	0.3 ± 0.7
Dose(mrem)	7I	< (0.00011)	(0.0139)	(0.0156)	(0.046)	(0.00037)	(0.00042)	(0.0073)
	12N	< (0.00011)	(0.0312)	(0.0314)	(0.102)	(0.00074)	(0.00077)	(0.0014)
	Off Site	< (0.00011)	(0.0108)	(0.0113)	(0.033)	(0.00030)	(0.00029)	(0.0008)

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

^b A hyphen indicates that data are unavailable.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

The major airborne effluents released at ANL-E during 1996 are listed by location in Table 4.4, and the annual releases of the major sources since 1985 are illustrated in Figure 4.3. The radon-220 releases from Building 200, due to radioactive contamination from the "proof-of-breeding" program, have been eliminated. The remaining emissions are from nuclear medicine studies. Even though the CP-5 reactor ceased operations in 1979, hydrogen-3 continues to be emitted from Building 330. During 1996, the primary cooling loop that contained most of the residual hydrogen-3 was removed. Thus, emissions are expected to decrease in 1997. The hydrogen-3 emitted from Building 212 is from tritium recovery studies, while short-lived activation products are emitted from the IPNS and APS. In addition to the nuclides listed in Table 4.4, several other fission products also were released in millicurie or smaller amounts. The quantities listed in Table 4.4 were measured by on-line stack monitors in the exhaust systems of the buildings, except for Building 350.

4.3. Surface Water

All surface water samples collected in the monitoring program were acidified to 0.1N with HNO_3 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, and 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 of a distilled sample in a nonhazardous cocktail. Analyses for transuranium nuclides were performed on 10-L 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.

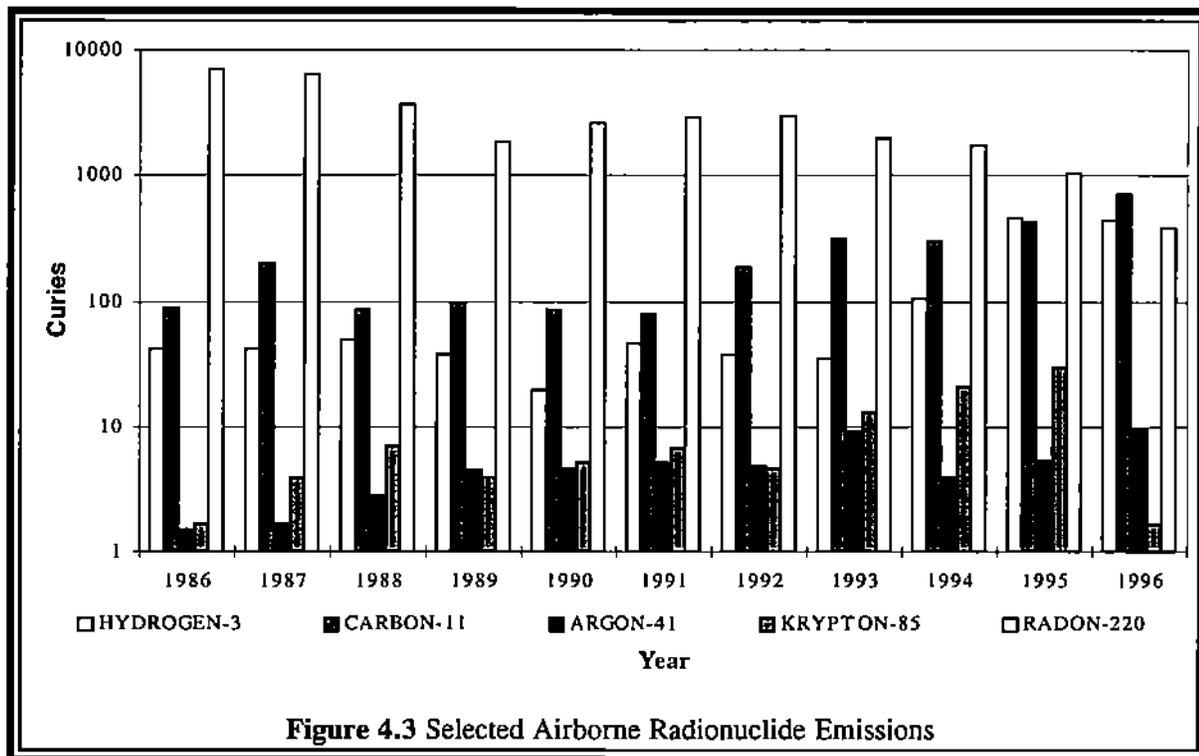
4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.4

Summary of Monitored Airborne Radioactive Emissions from ANL-E Facilities, 1996

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	388.5	1.4×10^{13}
205	Hydrogen-3 (tritiated water [HTO])	12.3 yr	0.16	5.9×10^9
212	Hydrogen-3 (HTO)	12.3 yr	77.8	2.9×10^{12}
	Hydrogen-3 (tritiated hydrogen gas [HT])	12.3 yr	363.5	1.3×10^{13}
	Krypton-85	10.7 yr	1.68	6.2×10^{11}
	Antimony-125	2.71 yr	0.000010	3.7×10^5
	Radon-220	56 s	0.18	6.7×10^9
330 (CP-5)	Hydrogen-3 (HTO)	12.3 yr	1.09	4.0×10^{10}
350 (NBL)	Uranium-234	2.4×10^5 yr	5.9×10^{-7}	2.2×10^4
	Uranium-238	4.5×10^9 yr	5.9×10^{-7}	2.2×10^4
	Plutonium-238	87.7 yr	6.1×10^{-10}	2.3×10^1
	Plutonium-239	2.4×10^4 yr	2.1×10^{-9}	7.8×10^1
	Plutonium-240	6.6×10^4 yr	1.1×10^{-9}	4.1×10^1
	Plutonium-241	14.4 yr	5.8×10^{-8}	2.0×10^3
	Plutonium-242	3.76×10^5 yr	3.3×10^{-12}	1.2×10^{-1}
375 (IPNS)	Carbon-11	20 m	708.5	2.6×10^{13}
	Argon-41	1.8 h	9.5	3.5×10^{11}
411/415 (APS)	Carbon-11	20 m	0.5	1.8×10^{10}
	Nitrogen-13	10 m	21.3	7.9×10^{11}
	Oxygen-15	122 s	2.2	8.1×10^{10}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION



ANL-E wastewater is discharged into Sawmill Creek, which 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 if 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. Upstream of the site, samples were collected once a month and were analyzed for the same radionuclides measured in the below-outfall samples.

Table 4.5 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 nuclides found in the creek water that can be attributed to ANL-E operations are hydrogen-3, strontium-90, neptunium-237, plutonium-239, americium-241, and occasionally cesium-137, plutonium-238, curium-242 and/or californium-252, and curium-244 and/or californium-249. The percentage of individual samples containing activity attributable to

TABLE 4.5
Radionuclides in Sawmill Creek Water, 1996

Activity	Location ^a	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (Nonvolatile)	16K	12	1.7 ± 1.5	0.8	2.9	^b	-	-
	7M	51	1.7 ± 1.6	0.4	4.2	-	-	-
Beta (Nonvolatile)	16K	12	10 ± 7	7	16	-	-	-
	7M	51	16 ± 9	8	32	-	-	-
Hydrogen-3	16K	12	<100	<100	106	<0.0046	<0.0046	0.0049
	7M	51	<100	<100	1265	<0.0046	<0.0046	0.0581
Strontium-90	16K	12	0.28 ± 0.16	<0.25	0.42	0.026	<0.024	0.040
	7M	51	0.53 ± 1.27	<0.25	4.70	0.050	<0.024	0.446
Cesium-137	16K	12	<1.0	<1.0	<1.0	<0.04	<0.04	<0.04
	7M	51	<1.0	<1.0	1.5	<0.04	<0.04	0.06
Uranium-234	16K	12	0.917 ± 0.813	0.219	1.571	0.174	0.042	0.298
	7M	51	0.676 ± 0.553	0.263	1.355	0.128	0.050	0.257
Uranium-238	16K	12	0.840 ± 0.700	0.218	1.307	0.141	0.037	0.220
	7M	51	0.604 ± 0.513	0.176	1.109	0.101	0.030	0.186
Neptunium-237	16K	12	<0.0010	<0.0010	<0.0010	<0.0028	<0.0028	<0.0028
	7M	51	0.0018 ± 0.0066	<0.0010	0.0175	0.0052	<0.0028	0.0485
Plutonium-238	16K	12	<0.0010	<0.0010	0.0010	<0.0028	<0.0028	0.0028
	7M	51	0.0011 ± 0.0054	<0.0010	0.0175	0.0030	<0.0028	0.0499
Plutonium-239	16K	12	<0.0010	<0.0010	0.0026	<0.0031	<0.0031	0.0080
	7M	51	0.0112 ± 0.0561	<0.0010	0.1858	0.0350	<0.0031	0.5832
Americium-241	16K	12	<0.0010	<0.0010	0.0024	<0.0033	<0.0033	0.0079
	7M	51	0.0098 ± 0.0462	<0.0010	0.1443	0.0321	<0.0033	0.4740
Curium-242 and/or Californium-252	16K	12	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
	7M	51	<0.0010	<0.0010	<0.0010	<0.0007	<0.0007	<0.0007
Curium-244 and/or Californium-249	16K	12	<0.0010	<0.0010	<0.0010	<0.0034	<0.0034	<0.0034
	7M	51	0.0013 ± 0.0062	<0.0010	0.0196	0.0044	<0.0034	0.0657

^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.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

ANL-E was 22% for hydrogen-3, 90% for strontium-90, 37% for neptunium-237, 76% for plutonium-239, and 73% for americium-241. The concentrations of all these nuclides are low and a small fraction of the allowed DOE limits. If the concentrations of the radionuclides listed in Table 4.5 were increased by a factor of five, which approximates the effect of the dilution by Sawmill Creek on the ANL-E effluent water, the concentrations would still be below the DOE limits. This demonstrates compliance with DOE Order 5400.5⁹ for use of Best Available Technology (BAT) for release of liquid effluents.

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 disposed of as solid low-level radioactive waste. If the radioactivity is below the release limits, the wastewater is conveyed to the laboratory WTP in dedicated pipes to waste storage tanks. These tanks are again sampled and analyzed for radioactivity and if below the release limits, discharged to the environment. The release limits are based on the DCGs of 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. This effluent monitoring program documents that no liquid releases above the DCGs have occurred and reinforces the demonstration of compliance with the use of BAT as required by DOE Order 5400.5.⁹

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.

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 in Figure 1.1. Samples were scheduled to be collected quarterly and analyzed for

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.6

Total Radioactivity Released to
Sawmill Creek, 1996

Radionuclide	Released (Ci)	Percent
Hydrogen-3	0.76	99.6
Strontium-90	0.0026	0.4
Neptunium-237	0.000007	<0.1
Plutonium-239	0.00010	<0.1
Americium-241	0.00009	<0.1
Total	0.76	

hydrogen-3 and strontium-90 and by gamma-ray spectrometry. The results are presented in Table 4.7.

The source of the radionuclides at Location 7J appears to be leachate from the 319 Area Landfill. A subsurface barrier wall and leachate collection system were constructed south of the 319 Landfill in November 1995 and became operational in 1996. 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, which in turn flows into the Illinois River, data on the radioactivity in the two rivers are 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 if the radioactivity in the creek had any effect on the radioactivity in the river.

Table 4.8 presents 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. The average nonvolatile alpha and beta activities, 0.9 pCi/L and 12.6 pCi/L, respectively, of 24 off-site surface water samples collected

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.7

Radionuclides in Storm Water Outfalls, 1996
(Concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
January 17, 1996	< 100	0.8	< 1	367
April 12, 1996	1,661	3.8	< 1	637
July 17, 1996	< 100	0.6	< 1	523
October 16, 1996	2,092	2.4	< 1	Dry

in 1996, are similar to the levels found in previous years. The hydrogen-3 concentration in these surface water samples averaged 28 pCi/L.

The radioactivity levels in samples of Illinois River water, shown in Table 4.9, were similar to those found previously at these same locations. No radioactivity originating at ANL-E could be detected in the Des Plaines or Illinois Rivers. The elevated hydrogen-3 levels appear to be due to discharges from the Dresden nuclear power station complex.

4.4. Soil, Grass, and Bottom Sediment

The radioactive content of soil, grass, and bottom sediment was measured at the site perimeter and off the site. The purpose of the off-site sampling was to measure deposition for comparison with perimeter samples and with results obtained by other organizations for samples collected at large distances from nuclear installations. Such comparisons are useful in determining if the radioactivity of soil near ANL-E is normal. For this purpose, site-selection criteria and sample collection and sample preparation techniques recommended by the ASTM were used.^{14,15} Sites were selected in several directions and at various distances from ANL-E. Each site was selected on the basis that the soil appeared, or was known to have been, undisturbed for a number of years. Attempts were made to select open, level, grassy areas that were mowed at reasonable intervals. Public parks were selected when available.

TABLE 4.8
Radionuclides in Des Plaines River Water, 1996

Activity	Location ^a	No. of Samples	Concentrations in pCi/L			Dose (mrem)		
			Avg.	Min.	Max.	Avg.	Min.	Max.
Alpha (Nonvolatile)	A	12	1.3 ± 1.4	0.5	2.7	^b	-	-
	B	24	1.0 ± 0.9	0.2	1.8	-	-	-
Beta (Nonvolatile)	A	12	16 ± 13	7	27	-	-	-
	B	24	16 ± 10	5	24	-	-	-
Hydrogen-3	A	12	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	B	24	< 100	< 100	103	< 0.0046	< 0.0046	0.0047
Strontium-90	A	12	0.35 ± 0.25	< 0.25	0.60	0.034	< 0.024	0.057
	B	24	0.36 ± 0.23	< 0.25	0.60	0.034	< 0.024	0.057
Uranium-234	A	12	0.590 ± 0.292	0.436	0.808	0.112	0.083	0.154
	B	24	0.502 ± 0.290	0.277	0.745	0.095	0.053	0.142
Uranium-238	A	12	0.505 ± 0.347	0.304	0.732	0.085	0.051	0.123
	B	24	0.419 ± 0.267	0.216	0.607	0.070	0.036	0.102
Neptunium-237	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
Plutonium-238	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	B	12	< 0.0010	< 0.0010	0.0012	< 0.0028	< 0.0028	0.0033
Plutonium-239	A	12	< 0.0010	< 0.0010	0.0016	< 0.0031	< 0.0031	0.0049
	B	12	< 0.0010	< 0.0010	0.0032	< 0.0031	< 0.0031	0.0101
Americium-241	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	B	12	< 0.0010	< 0.0010	0.0072	< 0.0033	< 0.0033	0.0237
Curium-242 and/or Californium-252	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium-249	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034

^a Location A near Willow Springs is upstream, and 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 4.9

Radionuclides in Illinois River Water, 1996
(Concentrations in pCi/L)

Date Collected	Location	Alpha ^a	Beta ^a	Hydrogen-3	Uranium-234	Uranium-238	Plutonium-239
April 24	McKinley Woods Park, Ill.	1.4 ± 0.4	11.1 ± 0.4	< 100	0.39 ± 0.08	0.34 ± 0.07	<0.001
April 24	Dresden Lock & Dam, Ill.	0.6 ± 0.2	5.5 ± 0.2	814 ± 59	0.52 ± 0.09	0.43 ± 0.08	<0.001
April 24	Morris, Ill.	0.7 ± 0.3	8.2 ± 0.3	329 ± 52	0.49 ± 0.09	0.43 ± 0.08	- ^b
April 24	Starved Rock State Park, Ill.	0.8 ± 0.3	8.3 ± 0.3	<100	0.50 ± 0.06	0.52 ± 0.06	-
September 26	McKinley Woods Park, Ill.	0.3 ± 0.3	11.7 ± 0.3	<100	0.21 ± 0.06	0.13 ± 0.04	<0.001
September 26	Dresden Lock & Dam, Ill.	0.3 ± 0.2	9.6 ± 0.3	721 ± 53	0.23 ± 0.07	0.23 ± 0.06	<0.001
September 26	Morris, Ill.	0.8 ± 0.3	7.0 ± 0.3	829 ± 55	0.31 ± 0.07	0.25 ± 0.06	-
September 26	Morris, Ill.	0.4 ± 0.3	7.9 ± 0.3	897 ± 56	0.28 ± 0.07	0.23 ± 0.06	-
September 26	Starved Rock State Park, Ill.	0.5 ± 0.2	6.7 ± 0.3	314 ± 47	0.24 ± 0.06	0.22 ± 0.05	-

^a Nonvolatile activity.

^b A hyphen indicates that no analysis was performed.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

As part of the QA program, replicate samples were taken from 10% of the locations. The EMS data management system has been programmed to schedule the replicate samples on a rotating basis. The following tables will show paired results from the same location. Comparison of the analytical data in these tables of pairs of samples collected at the same location will provide a measure of the heterogeneity of the media, that is, soil, grass, or bottom sediment.

Each soil sample consisted of 10 cores, totaling 864 cm² (134 in.²) in area by 5 cm (2 in.) deep. Through 1976, samples were collected down to 30 cm (12 in.) to measure total deposition. The results of five years of sample collection at this depth have established the total deposition in the ANL-E environment. Reducing the sampling depth to 5 cm (2 in.) will make the analysis more sensitive to changes in current deposition. The grass samples were obtained by collecting the grass from a 1-m² (10-ft²) area in the immediate vicinity of a soil sample. A grab sample technique was used to obtain bottom sediments from water bodies. After drying, grinding, and mixing 100-g portions of each soil, bottom sediment and grass 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 aliquot of soil. Results are given in terms of the oven-dried (110°C [230°F]) weight.

The results for the gamma-ray emitting nuclides in soil are presented in Table 4.10. Intermediate half-life fission products reported in 1986 have decayed to below their detection limits, and no evidence of Chernobyl fallout is apparent. The cesium-137 levels are similar to those found over the past several years and represent an accumulation from nuclear tests over a period of many years. The annual average concentrations for the perimeter and off-site samples were similar. The plutonium and americium concentrations are given in Table 4.11. The range and average concentrations of plutonium and americium in soil were similar at both perimeter and off-site sampling points. For fallout americium-241 in soil, about 10% is due to direct deposition, while about 90% is due to the decay of the previously deposited plutonium-241. The americium-241/plutonium-239 ratio is consistent with the current estimated value of 0.35 for this ratio in fallout-derived material.¹⁶

TABLE 4.10

Gamma-Ray-Emitting Radionuclides in Soil, 1996
(Concentrations in pCi/g)

Date Collected	Location	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232
	Perimeter ^a					
April 18	12C	19.26 ± 0.69	0.72 ± 0.04	1.05 ± 0.06	1.02 ± 0.04	0.82 ± 0.09
April 18	12D	17.01 ± 0.57	0.20 ± 0.02	1.14 ± 0.06	1.09 ± 0.04	0.75 ± 0.08
April 19	14L	18.14 ± 0.59	0.46 ± 0.03	1.08 ± 0.06	1.15 ± 0.04	0.75 ± 0.08
April 19	5D	15.57 ± 0.55	0.46 ± 0.03	0.96 ± 0.05	1.00 ± 0.04	0.66 ± 0.08
April 19	8N	19.44 ± 0.60	0.22 ± 0.02	1.09 ± 0.06	0.95 ± 0.04	0.76 ± 0.08
April 19	5D	16.47 ± 0.56	0.55 ± 0.03	0.81 ± 0.05	1.03 ± 0.04	0.81 ± 0.08
September 27	10N	20.16 ± 0.72	0.53 ± 0.03	1.07 ± 0.06	1.15 ± 0.04	0.92 ± 0.10
September 27	9N	22.08 ± 0.74	0.31 ± 0.03	1.30 ± 0.07	1.20 ± 0.04	0.93 ± 0.10
September 30	10E	20.14 ± 0.71	0.61 ± 0.03	1.21 ± 0.06	1.01 ± 0.04	0.73 ± 0.09
September 30	14I	18.74 ± 0.69	0.59 ± 0.03	1.09 ± 0.06	1.14 ± 0.04	0.87 ± 0.09
September 30	6J	21.50 ± 0.73	0.56 ± 0.03	1.07 ± 0.06	1.11 ± 0.04	0.80 ± 0.09
September 30	14I	16.06 ± 0.64	0.50 ± 0.03	0.83 ± 0.06	0.92 ± 0.04	0.76 ± 0.09
	Average	18.71 ± 4.66	0.47 ± 0.35	1.06 ± 0.31	1.07 ± 0.19	0.80 ± 0.17
	Off Site					
April 17	Orland Park, Ill.	22.77 ± 0.75	0.57 ± 0.03	1.24 ± 0.06	1.12 ± 0.04	0.89 ± 0.10
April 17	Palos Hills, Ill.	23.04 ± 0.75	0.59 ± 0.03	1.06 ± 0.06	1.18 ± 0.04	0.86 ± 0.09
April 17	Palos Hills, Ill.	19.94 ± 0.70	0.53 ± 0.03	1.22 ± 0.06	0.97 ± 0.04	0.77 ± 0.09
April 24	Dresden Lock & Dam, Ill.	14.27 ± 0.53	0.36 ± 0.03	0.88 ± 0.05	0.94 ± 0.04	0.66 ± 0.07
April 24	McKinley Woods Park, Ill.	12.74 ± 0.50	0.47 ± 0.03	0.68 ± 0.05	1.00 ± 0.04	0.83 ± 0.08
April 24	Morris, Ill.	14.54 ± 0.60	0.19 ± 0.02	0.69 ± 0.05	0.71 ± 0.04	0.50 ± 0.08
April 24	McKinley Woods Park, Ill.	14.22 ± 0.53	0.47 ± 0.03	0.87 ± 0.05	1.14 ± 0.04	0.88 ± 0.08
September 24	Pioneer Park, Naperville, Ill.	17.24 ± 0.67	0.58 ± 0.03	1.26 ± 0.07	1.56 ± 0.05	1.25 ± 0.11
September 24	Pioneer Park, Naperville, Ill.	13.64 ± 0.60	0.53 ± 0.03	0.74 ± 0.05	1.05 ± 0.04	0.86 ± 0.09
September 25	Romeoville, Ill.	16.72 ± 0.66	0.17 ± 0.02	1.30 ± 0.07	1.32 ± 0.05	1.04 ± 0.10
September 25	Lemont, Ill.	18.98 ± 0.69	0.58 ± 0.03	1.15 ± 0.06	1.06 ± 0.04	0.83 ± 0.09
September 26	Channahon, Ill.	19.99 ± 0.71	0.29 ± 0.03	1.65 ± 0.07	1.56 ± 0.05	1.14 ± 0.10
September 26	Starved Rock State Park, Ill.	13.01 ± 0.59	0.16 ± 0.02	0.87 ± 0.06	0.68 ± 0.04	0.53 ± 0.08
September 26	Channahon, Ill.	18.91 ± 0.69	0.22 ± 0.03	1.36 ± 0.07	1.46 ± 0.05	1.13 ± 0.10
	Average	17.14 ± 7.61	0.41 ± 0.37	1.07 ± 0.63	1.12 ± 0.60	0.87 ± 0.47

^a The perimeter locations are given in terms of the grid coordinates in Figure I.1.

TABLE 4.11

Transuranics in Soil, 1996

Date Collected	Location	Plutonium-238 (fCi/g)	Plutonium-238 (nCi/m ²)	Plutonium-239 (fCi/g)	Plutonium-239 (nCi/m ²)	Pu-238/Pu-239	Americium-241 (fCi/g)	Americium-241 (nCi/m ²)	Am-241/Pu-239
Perimeter ^a									
April 18	12C	0.8 ± 0.3	0.023 ± 0.011	18.3 ± 1.9	0.557 ± 0.057	0.042	6.4 ± 1.2	0.194 ± 0.035	0.348
April 18	12D	0.3 ± 0.2	0.014 ± 0.010	6.3 ± 1.0	0.254 ± 0.041	0.054	2.4 ± 0.7	0.097 ± 0.028	0.384
April 19	14L	0.5 ± 0.3	0.020 ± 0.014	11.8 ± 1.8	0.514 ± 0.078	0.039	5.2 ± 1.3	0.226 ± 0.057	0.441
April 19	5D	0.4 ± 0.3	0.015 ± 0.012	12.3 ± 1.8	0.503 ± 0.075	0.029	5.8 ± 1.3	0.238 ± 0.055	0.473
April 19	8N	0.4 ± 0.3	0.019 ± 0.013	5.9 ± 1.1	0.257 ± 0.047	0.075	1.8 ± 0.6	0.079 ± 0.028	0.309
April 19	5D	0.4 ± 0.4	0.016 ± 0.013	15.7 ± 2.4	0.596 ± 0.089	0.028	7.1 ± 1.2	0.271 ± 0.045	0.454
September 27	10N	0.3 ± 0.3	0.014 ± 0.012	13.3 ± 1.7	0.608 ± 0.080	0.023	4.4 ± 0.9	0.203 ± 0.042	0.334
September 27	9N	0.8 ± 0.5	0.038 ± 0.022	7.2 ± 1.4	0.341 ± 0.067	0.112	2.5 ± 1.0	0.119 ± 0.045	0.349
September 30	10E	0.9 ± 0.4	0.044 ± 0.019	15.0 ± 1.6	0.769 ± 0.080	0.058	5.2 ± 1.2	0.268 ± 0.064	0.349
September 30	14I	0.6 ± 0.4	0.038 ± 0.021	15.9 ± 2.0	0.947 ± 0.116	0.040	5.9 ± 1.1	0.354 ± 0.063	0.373
September 30	6J	0.9 ± 0.5	0.039 ± 0.021	15.2 ± 2.1	0.697 ± 0.095	0.056	5.9 ± 0.9	0.270 ± 0.042	0.388
September 30	14I	0.9 ± 0.4	0.042 ± 0.022	15.5 ± 2.1	0.762 ± 0.101	0.055	4.3 ± 0.9	0.213 ± 0.045	0.280
Average		0.6 ± 0.1	0.027 ± 0.008	12.7 ± 2.6	0.567 ± 0.135	0.051	4.8 ± 1.1	0.211 ± 0.051	0.373
Off Site									
April 17	Orland Park, Ill.	0.6 ± 0.3	0.021 ± 0.012	14.8 ± 1.7	0.553 ± 0.065	0.038	4.7 ± 1.0	0.175 ± 0.038	0.317
April 17	Palos Hills, Ill.	0.7 ± 0.4	0.028 ± 0.015	14.8 ± 1.8	0.582 ± 0.069	0.048	4.7 ± 1.0	0.184 ± 0.038	0.317
April 17	Palos Hills, Ill.	0.6 ± 0.4	0.026 ± 0.014	14.4 ± 1.6	0.570 ± 0.065	0.045	5.2 ± 1.0	0.206 ± 0.040	0.362
April 24	Dresden Lock & Dam, Ill.	0.4 ± 0.3	0.013 ± 0.010	9.3 ± 1.5	0.328 ± 0.054	0.041	4.2 ± 1.2	0.148 ± 0.043	0.452
April 24	McKinley Woods Park, Ill.	0.8 ± 0.4	0.038 ± 0.020	17.1 ± 2.2	0.790 ± 0.100	0.048	7.2 ± 1.2	0.332 ± 0.056	0.420
April 24	Morris, Ill.	0.3 ± 0.3	0.015 ± 0.012	4.2 ± 0.8	0.207 ± 0.041	0.070	2.0 ± 0.6	0.097 ± 0.031	0.468
April 24	McKinley Woods Park, Ill.	0.5 ± 0.3	0.017 ± 0.011	13.9 ± 1.8	0.510 ± 0.066	0.033	6.1 ± 1.4	0.223 ± 0.050	0.437
September 24	Pioneer Park, Naperville, Ill.	0.5 ± 0.3	0.029 ± 0.017	14.3 ± 1.7	0.810 ± 0.098	0.035	5.5 ± 0.8	0.313 ± 0.043	0.387
September 24	Pioneer Park, Naperville, Ill.	0.6 ± 0.4	0.027 ± 0.017	13.0 ± 1.9	0.596 ± 0.087	0.045	6.0 ± 0.7	0.276 ± 0.034	0.464
September 25	Romeoville, Ill.	0.2 ± 0.2	0.013 ± 0.014	4.8 ± 1.0	0.279 ± 0.060	0.047	1.9 ± 0.6	0.112 ± 0.035	0.402
September 25	Lemont, Ill.	0.6 ± 0.4	0.030 ± 0.019	22.9 ± 2.5	1.191 ± 0.130	0.025	6.9 ± 1.2	0.358 ± 0.063	0.300
September 26	Channahon, Ill.	0.3 ± 0.3	0.013 ± 0.015	7.9 ± 1.4	0.382 ± 0.066	0.035	2.0 ± 0.9	0.095 ± 0.044	0.248
September 26	Starved Rock State Park, Ill.	< 0.1	0.007 ± 0.013	3.3 ± 0.9	0.236 ± 0.066	0.029	1.3 ± 0.6	0.091 ± 0.045	0.384
September 26	Channahon, Ill.	0.3 ± 0.3	0.011 ± 0.010	5.0 ± 1.0	0.178 ± 0.036	0.061	2.6 ± 0.6	0.092 ± 0.022	0.514
Average		0.5 ± 0.1	0.021 ± 0.005	11.4 ± 3.3	0.515 ± 0.163	0.043	4.3 ± 1.2	0.193 ± 0.055	0.391

^a The perimeter locations are given in terms of the grid coordinates in Figure 1.1.

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The radionuclide concentrations measured in grass are listed in Table 4.12. The annual averages and concentration ranges were similar at the perimeter and off-site locations and were similar to those of previous years, indicating no contribution from ANL-E operations. In terms of deposition, the plutonium-239 concentration was a factor of about 10^4 less in the grass than in the soil from the same location.

Table 4.13 gives the results of analyses of bottom sediment samples for gamma-ray emitters and transuranics. The annual off-site averages were in the same range found in off-site samples collected in previous years. Plutonium results varied widely among locations and were strongly dependent on the retentiveness of the bottom material. A set of sediment samples was collected on July 11, 1996, 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 4.13, show that the concentrations in the sample above the 7M outfall are similar to those of the off-site samples. The plutonium, americium, and cesium-137 concentrations are elevated below the outfall, indicating that their origin is in ANL-E wastewater. 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 14 locations at the site boundary and on the site. Readings were also taken at five off-site locations for comparative purposes. These locations are shown in Figure 1.2.

The results are summarized in Tables 4.14 and 4.15, 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

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TABLE 4.12

Radionuclides in Grass, 1996

Date Collected	Location	Potassium-40 (pCi/g)	Cesium-137 (fCi/g)	Plutonium-239 (fCi/g)	Deposited Plutonium-239 (pCi/m ²)
	Perimeter ^a				
April 18	12D	5.18 ± 0.31	< 10	0.1 ± 0.1	0.01 ± 0.01
April 19	14L	6.21 ± 0.33	< 10	1.0 ± 0.2	0.13 ± 0.03
April 19	5D	3.88 ± 0.30	< 10	0.3 ± 0.1	0.04 ± 0.01
April 19	8N	4.77 ± 0.32	14 ± 13	0.2 ± 0.1	0.03 ± 0.01
April 19	5D	7.56 ± 0.36	< 10	0.8 ± 0.2	0.10 ± 0.02
September 27	10N	12.23 ± 0.44	< 10	0.2 ± 0.1	0.02 ± 0.01
September 27	9N	11.73 ± 0.42	< 10	0.1 ± 0.1	0.02 ± 0.01
September 30	10E	16.30 ± 0.50	< 10	< 0.1	< 0.01
September 30	14I	13.72 ± 0.43	< 10	< 0.1	< 0.01
September 30	6J	15.61 ± 0.51	< 10	< 0.1	< 0.01
September 30	14I	15.96 ± 0.46	< 10	< 0.1	< 0.01
	Average	10.29 ± 1.03	< 10	0.3 ± 0.1	0.03 ± 0.01
	Off Site				
April 17	Orland Park, Ill.	5.45 ± 0.32	< 10	0.6 ± 0.1	0.08 ± 0.02
April 17	Palos Hills, Ill.	6.03 ± 0.34	52 ± 15	1.6 ± 0.3	0.19 ± 0.04
April 17	Palos Hills, Ill.	5.13 ± 0.33	33 ± 14	1.1 ± 0.1	0.14 ± 0.02
April 24	Dresden Lock & Dam, Ill.	5.54 ± 0.33	< 10	0.2 ± 0.1	0.03 ± 0.01
April 24	McKinley Woods Park, Ill.	5.36 ± 0.33	< 10	0.2 ± 0.1	0.02 ± 0.01
April 24	Morris, Ill.	25.61 ± 0.62	18 ± 15	0.4 ± 0.1	0.05 ± 0.01
April 29	McKinley Woods Park, Ill.	6.98 ± 0.35	< 10	0.7 ± 0.1	0.07 ± 0.02
September 24	Pioneer Park, Naperville, Ill.	16.02 ± 0.51	< 10	0.5 ± 0.1	0.05 ± 0.01
September 24	Pioneer Park, Naperville, Ill.	16.65 ± 0.53	< 10	0.3 ± 0.1	0.03 ± 0.01
September 25	Romeoville, Ill.	20.61 ± 0.53	< 10	< 0.1	< 0.01
September 25	Lemont, Ill.	22.74 ± 0.63	< 10	< 0.1	< 0.01
September 26	Channahon, Ill.	18.16 ± 0.52	< 10	0.2 ± 0.1	0.02 ± 0.01
September 26	Starved Rock State Park, Ill.	11.91 ± 0.46	< 10	0.3 ± 0.1	0.03 ± 0.01
September 26	Channahon, Ill.	27.51 ± 0.65	< 10	< 0.1	< 0.01
	Average	13.83 ± 1.32	< 10	0.5 ± 0.1	0.05 ± 0.01

^a The perimeter locations are given in terms of the grid coordinates in Figure 1.1.

TABLE 4.13

Radionuclides in Bottom Sediment, 1996

Date Collected	Location	Concentrations in pCi/g					Concentrations in fCi/g		
		Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Plutonium-238	Plutonium-239	Americium-241
July 11	Perimeter ^a								
July 11	Sawmill Creek 25 m Above Outfall	9.10 ± 0.50	0.01 ± 0.02	0.52 ± 0.05	0.37 ± 0.03	0.36 ± 0.07	0.2 ± 0.3	1.1 ± 0.5	0.5 ± 0.3
July 11	Sawmill Creek At Outfall	7.21 ± 0.45	0.20 ± 0.03	0.47 ± 0.05	0.34 ± 0.03	0.32 ± 0.07	1.7 ± 0.5	20.0 ± 2.1	8.5 ± 1.2
July 11	Sawmill Creek 50 m Below Outfall	7.34 ± 0.45	0.12 ± 0.02	0.42 ± 0.05	0.36 ± 0.03	0.32 ± 0.07	< 0.1	3.9 ± 1.1	1.6 ± 0.7
July 11	Sawmill Creek 100 m Below Outfall	9.91 ± 0.51	0.06 ± 0.02	0.47 ± 0.05	0.42 ± 0.03	0.27 ± 0.07	0.1 ± 0.2	2.6 ± 0.7	1.1 ± 0.5
July 11	Sawmill Creek At Des Plaines River Off Site	13.02 ± 0.58	0.46 ± 0.03	0.62 ± 0.05	0.53 ± 0.04	0.43 ± 0.08	0.6 ± 0.3	12.3 ± 1.6	2.8 ± 0.7
April 17	McGinnis Slough Orland Park, Ill.	24.71 ± 0.78	0.02 ± 0.02	1.37 ± 0.07	0.97 ± 0.05	0.78 ± 0.10	< 0.1	0.5 ± 0.4	0.6 ± 0.4
April 17	Saganashkee Slough Palos Hills, Ill.	17.79 ± 0.67	0.02 ± 0.02	1.58 ± 0.07	0.98 ± 0.04	0.72 ± 0.09	0.1 ± 0.1	1.0 ± 0.5	0.8 ± 0.4
April 24	Illinois River Dresden Lock & Dam, Ill.	14.50 ± 0.54	0.26 ± 0.03	0.77 ± 0.06	0.87 ± 0.04	0.61 ± 0.08	0.2 ± 0.2	5.6 ± 1.2	2.4 ± 0.7
April 24	Illinois River McKinley Woods Park, Ill.	5.90 ± 0.38	< 0.01	0.26 ± 0.04	0.25 ± 0.03	0.19 ± 0.06	0.1 ± 0.2	0.3 ± 0.3	0.7 ± 0.4
April 24	Illinois River Morris, Ill.	8.69 ± 0.44	< 0.01	0.26 ± 0.04	0.45 ± 0.03	0.32 ± 0.07	0.1 ± 0.2	0.7 ± 0.6	0.4 ± 0.3
April 24	Illinois River McKinley Woods Park, Ill.	7.16 ± 0.40	< 0.01	0.40 ± 0.05	0.37 ± 0.03	0.23 ± 0.06	< 0.1	0.3 ± 0.3	0.2 ± 0.2
September 24	DuPage River Pioneer Park, Naperville, Ill.	12.04 ± 0.57	0.03 ± 0.02	0.73 ± 0.06	0.82 ± 0.04	0.67 ± 0.09	0.3 ± 0.2	1.0 ± 0.4	0.3 ± 0.3
September 25	Des Plaines River Romeoville, Ill.	4.41 ± 0.39	0.07 ± 0.02	0.86 ± 0.06	0.56 ± 0.04	0.41 ± 0.08	0.1 ± 0.1	14.1 ± 2.0	4.3 ± 0.7
September 25	Long Run Creek Lemont, Ill.	20.21 ± 0.72	0.06 ± 0.02	1.19 ± 0.07	1.10 ± 0.05	0.78 ± 0.10	< 0.1	1.8 ± 0.5	0.9 ± 0.5
September 25	Long Run Creek Lemont, Ill.	17.79 ± 0.68	0.03 ± 0.02	1.11 ± 0.07	0.97 ± 0.05	0.77 ± 0.10	0.1 ± 0.1	1.2 ± 0.4	0.6 ± 0.4
September 26	DuPage River Channahon, Ill.	13.92 ± 0.61	< 0.01	0.95 ± 0.06	0.95 ± 0.04	0.74 ± 0.09	< 0.1	1.0 ± 0.3	0.4 ± 0.3
September 26	Illinois River Starved Rock State Park, Ill.	4.45 ± 0.39	0.03 ± 0.02	0.39 ± 0.05	0.25 ± 0.03	0.17 ± 0.07	0.1 ± 0.2	0.7 ± 0.4	0.3 ± 0.2
September 26	Illinois River Starved Rock State Park, Ill.	4.71 ± 0.40	0.02 ± 0.02	0.39 ± 0.05	0.27 ± 0.03	0.18 ± 0.07	< 0.1	0.5 ± 0.3	0.5 ± 0.2
	Average	12.02 ± 14.69	0.04 ± 0.16	0.79 ± 0.96	0.68 ± 0.71	0.51 ± 0.57	0.1 ± 0.2	2.2 ± 8.3	1.0 ± 2.5

^a The perimeter locations are given in terms of the grid coordinates in Figure 1.1.

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TABLE 4.14

Environmental Penetrating Radiation at Off-Site Locations, 1996

Location	Dose Rate (mrem/yr)				Average
	Period of Measurement				
	1/4-4/9	4/9-7/2	7/2-10/8	10/8-1/3	
Lemont	87	89	91	88	89 ± 2
Oak Brook	88	101	108	98	99 ± 8
Orland Park	82	86	98	72	85 ± 11
Woodridge	87	96	105	91	95 ± 8
Willow Springs	77	92	95	77	85 ± 9
Average	84 ± 4	93 ± 5	99 ± 6	85 ± 9	90 ± 4

TABLE 4.15

Environmental Penetrating Radiation at ANL-E, 1996

Location ^a	Dose Rate (mrem/yr)				Average
	Period of Measurement				
	1/4-4/9	4/9-7/2	7/2-10/8	10/8-1/3	
14G Boundary	92	82	115	99	97 ± 14
14I Boundary	86	109	108	86	97 ± 13
14L Boundary	76	98	93	80	87 ± 10
6I 200 m N of Quarry Road	88	-	105	106	100 ± 11
7I Center, Waste Storage Area Facility 317	7,345	7,629	610	509	4,023 ± 3,921
7I Boundary	125	135	136	110	127 ± 12
8H Boundary	87	94	107	88	94 ± 9
8H 65 m S of Building 316	100	93	107	83	96 ± 10
8H 200 m NW of Waste Storage Area (Heliport)	99	91	114	90	99 ± 11
8H Boundary, Center, St. Patrick Cemetery	87	103	104	99	98 ± 8
9H 50 m SE of CP-5	184	216	145	81	157 ± 57
9I 65 m NE of Building 350, 230 m NE of Building 316	86	90	92	80	87 ± 5
9/10 EF - Boundary	114	103	112	109	110 ± 5
10/11 K - Lodging Facilities	90	92	88	82	88 ± 4

^a See Figure 4.4.

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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 90 ± 4 mrem/yr and were similar to last year's off-site average of 92 ± 4 mrem/yr.¹⁷ To compare boundary results for individual sampling periods, the standard deviation of the 20 individual off-site results is useful. This value is 9 mrem/yr, so individual results in the range of 90 ± 18 mrem/yr may be considered to be the average natural background with a 95% probability.

In the past, two site boundary locations, 7I (south) and 14I (north), had dose rates consistently above the average background. At 7I, this was due to radiation from ANL-E's 317 Area in the northern half of grid 7I. Waste is packaged and temporarily kept in this area before removal for permanent disposal off site. The dose at this perimeter fence location was about 127 ± 12 mrem/yr. In previous years, this value has ranged up to 941 mrem/yr, which was in 1985. About 300 m (960 ft) south of the fence in grid 6I, the measured dose dropped to 100 ± 11 mrem/yr, within the normal background range.

During much of the early spring, a significant remediation project was conducted in the 317 Area. The South-Middle and Southeast Vaults were used in the past for the temporary storage of radioactive waste materials. Each vault is approximately 3 m (10 ft) deep, 4 m (13 ft) wide, and 30 m (100 ft) long and is equipped with a series of removable 0.3-m (1-ft) thick concrete shield blocks. Radiological surveys indicated high levels of contamination at localized areas on the walls, floor, and troughs of the vaults and in soil beneath large cracks found in the concrete floor. The highly contaminated concrete and soil were removed. The shield blocks were placed into the vaults, the upper sections of the vaults demolished, and the vaults then backfilled with 1 m (3 ft) of clean soil. This was completed by the end of April 1996.

The elevated dose in the 317 Area was caused by these activities. The removed contamination was temporarily stored in the area along with other waste. This was shipped off site by the end of June, resulting in a significantly lower dose during the second half of the year.

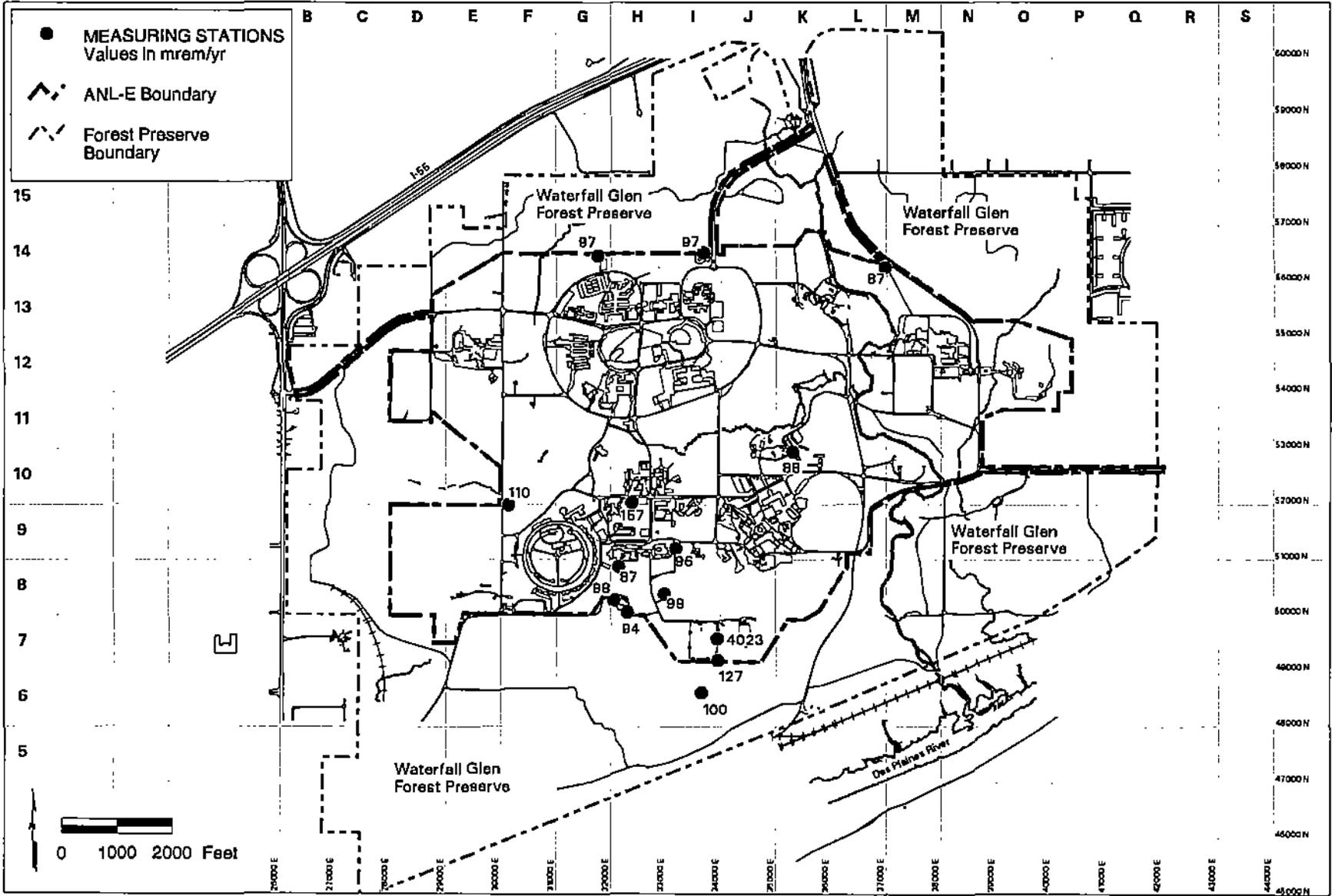


Figure 4.4 Penetrating Radiation Measurements at the ANL-E Site, 1996

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As mentioned in Section 4.2, the scabbling of the vaults resulted in measurable air concentrations of strontium-90 and plutonium-239.

In the past, an elevated dose had been measured in the perimeter area at Location 14I, at the north boundary. This dose was attributed to the use of cobalt-60 irradiation sources in Building 202. However, the irradiation program using the cobalt-60 source was terminated at the end of FY 1990 and has not been used since then. The perimeter dose at Location 14I, 97 ± 13 mrem/yr, was within the normal background range. The dose of Location 9/10 EF is slightly elevated and may be due to the operation of the APS facility.

In the past, an elevated on-site dose had been measured at Location 9H, next to the Chicago Pile-Five (CP-5) reactor, where irradiated hardware from the CP-5 was stored. During the past few years, considerable cleanup of the CP-5 yard occurred as part of the CP-5 decontamination and decommissioning (D&D) project. The dose at Location 9H decreased from about 1,200 mrem/yr in 1989 to 157 mrem/yr in 1996. The cleanup was completed in 1994; the residual dose is from sources in the building, which is currently undergoing D&D.

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 DOE⁹ stipulates that DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,¹⁸ which requires the use of the CAP-88 version⁶ of the EPA-AIRDOSE/RADRISK code to calculate the dose for radionuclides released to the air and to demonstrate compliance with the regulation. The dose limit applicable for 1996 for the air pathway is 10 mrem/yr effective dose equivalent. The EPA-AIRDOSE/RADRISK

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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 1996, 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 release rates are those listed in Table 4.4; separate calculations were performed for each of the seven 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 4.16 and 4.17), Building 205 (Tables 4.18 and 4.19), Building 212 (Tables 4.20 and 4.21), Building 330 (Tables 4.22 and 4.23), Building 350 (Tables 4.24 and 4.25), Building 375 (Tables 4.26 and 4.27), and Building 411 (Tables 4.28 and 4.29). The doses given in these tables are the committed whole body effective dose equivalents.

During 1995, a significant D&D program was completed for the M-Wing hot cells in Building 200, which were 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; to 388 Ci in 1996. The present radon-220 emissions will continue because of the ongoing nuclear medical program that separates radium-224 from the thorium-228 parent.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.16

Radiological Airborne Releases from Building 200, 1996

Source Term: Radon-220 = 388.5 Ci (plus daughters)

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	500	9.5×10^{-2}	1,000	2.6×10^{-2}
NNE	600	6.8×10^{-2}	1,100	2.2×10^{-2}
NE	750	4.2×10^{-2}	2,600	4.3×10^{-3}
ENE	1,700	8.8×10^{-3}	3,100	3.0×10^{-3}
E	2,400	4.8×10^{-3}	3,500	2.5×10^{-3}
ESE	2,200	5.0×10^{-3}	3,600	2.2×10^{-3}
SE	2,100	4.7×10^{-3}	4,000	1.6×10^{-3}
SSE	2,000	6.7×10^{-3}	4,000	2.1×10^{-3}
S	1,500	6.4×10^{-3}	4,000	1.2×10^{-3}
SSW	1,000	2.9×10^{-2}	2,500	5.7×10^{-3}
SW	800	4.9×10^{-2}	2,200	1.1×10^{-2}
WSW	1,100	1.9×10^{-2}	1,500	1.1×10^{-2}
W	750	3.6×10^{-2}	1,500	1.1×10^{-2}
WNW	800	2.7×10^{-2}	1,300	1.1×10^{-2}
NW	600	4.7×10^{-2}	1,100	1.5×10^{-2}
NNW	600	5.3×10^{-2}	800	3.2×10^{-2}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.17

Maximum Perimeter and Individual Doses from
Building 200 Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	1.4×10^{-13}	5.6×10^{-14}
Inhalation	9.4×10^{-2}	3.1×10^{-2}
Air Immersion	6.5×10^{-4}	1.9×10^{-4}
Ground Surface	4.6×10^{-5}	1.9×10^{-5}
Total	9.5×10^{-2}	3.2×10^{-2}
Radionuclide		
Thallium-208	5.6×10^{-4}	1.6×10^{-4}
Bismuth-212	1.1×10^{-2}	4.3×10^{-3}
Lead-212	5.7×10^{-2}	2.2×10^{-2}
Radon-220	2.6×10^{-2}	4.7×10^{-3}
Total	9.5×10^{-2}	3.2×10^{-2}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.18

Radiological Airborne Releases from Building 205, 1996

Source Term: Hydrogen-3 = 0.16 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	850	7.0×10^{-6}	1,300	3.5×10^{-6}
NNE	1,000	5.3×10^{-6}	2,100	1.6×10^{-6}
NE	1,200	3.6×10^{-6}	2,700	9.6×10^{-7}
ENE	2,400	1.1×10^{-6}	3,000	7.8×10^{-7}
E	2,200	1.3×10^{-6}	2,400	6.4×10^{-7}
ESE	2,000	1.4×10^{-6}	3,500	5.6×10^{-7}
SE	1,800	1.4×10^{-6}	3,900	4.1×10^{-7}
SSE	1,500	2.6×10^{-6}	4,000	5.3×10^{-7}
S	1,300	1.8×10^{-6}	3,900	3.2×10^{-7}
SSW	1,100	5.3×10^{-6}	2,400	1.5×10^{-6}
SW	900	8.6×10^{-6}	2,100	3.1×10^{-6}
WSW	1,100	4.1×10^{-6}	1,800	1.9×10^{-6}
W	1,300	2.6×10^{-6}	1,800	2.0×10^{-6}
WNW	1,100	3.3×10^{-6}	1,700	1.7×10^{-6}
NW	1,100	3.2×10^{-6}	1,500	2.0×10^{-6}
NNW	900	5.2×10^{-6}	1,500	2.3×10^{-6}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.19

Maximum Perimeter and Individual Doses from
Building 205 Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (900 m SW)	Individual (1,300 m N)
Ingestion	2.0×10^{-6}	8.3×10^{-7}
Inhalation	6.6×10^{-6}	2.7×10^{-6}
Air Immersion	- ^a	-
Ground Surface	-	-
Total	8.6×10^{-6}	3.5×10^{-6}
Radionuclide		
Hydrogen-3	8.6×10^{-6}	3.5×10^{-6}

^a A hyphen indicates no exposure by this pathway.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.20

Radiological Airborne Releases from Building 212, 1996

Source Term:	Hydrogen-3 (HT)	= 77.8 Ci
	Hydrogen-3 (HTO)	= 363.5 Ci
	Krypton-85	= 1.68 Ci
	Antimony-125	= 1.0×10^{-5} Ci
	Radon-220	= 0.18 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	800	2.1×10^{-2}	2,000	4.8×10^{-3}
NNE	1,000	1.5×10^{-2}	2,500	3.4×10^{-3}
NE	1,300	8.8×10^{-3}	2,000	4.4×10^{-3}
ENE	1,500	6.8×10^{-3}	2,500	2.9×10^{-3}
E	1,600	6.1×10^{-3}	2,800	2.4×10^{-3}
ESE	1,200	8.9×10^{-3}	2,500	2.6×10^{-3}
SE	1,400	6.0×10^{-3}	3,500	1.3×10^{-3}
SSE	1,400	8.0×10^{-3}	4,500	1.2×10^{-3}
S	1,500	4.0×10^{-3}	5,000	6.1×10^{-4}
SSW	1,600	8.0×10^{-3}	5,000	1.3×10^{-3}
SW	1,400	1.4×10^{-2}	2,400	7.2×10^{-3}
WSW	1,300	8.8×10^{-3}	2,300	3.5×10^{-3}
W	1,700	5.9×10^{-3}	2,200	3.9×10^{-3}
WNW	1,500	5.7×10^{-3}	2,000	3.6×10^{-3}
NW	1,300	6.8×10^{-3}	2,000	3.4×10^{-3}
NNW	1,000	1.2×10^{-2}	2,000	4.1×10^{-3}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.21

Maximum Perimeter and
Individual Doses from
Building 212 Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (800 m N)	Individual (2,400 m SW)
Ingestion	5.0×10^{-3}	1.7×10^{-3}
Inhalation	1.6×10^{-2}	5.5×10^{-3}
Air Immersion	7.9×10^{-7}	2.4×10^{-7}
Ground Surface	2.1×10^{-6}	7.2×10^{-7}
Total	2.1×10^{-2}	7.2×10^{-3}
Radionuclide		
Hydrogen-3	2.1×10^{-2}	7.2×10^{-3}
Krypton-85	1.0×10^{-6}	3.4×10^{-7}
Antimony- 125	2.1×10^{-6}	7.3×10^{-7}
Radon-220	2.9×10^{-6}	1.5×10^{-8}
Total	2.1×10^{-2}	7.2×10^{-3}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.22

Radiological Airborne Releases from Building 330 (CP-5), 1996

Source Term: Hydrogen-3 (HTO) = 1.09 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	1,500	1.9×10^{-5}	2,000	1.2×10^{-5}
NNE	1,800	1.4×10^{-5}	3,300	5.5×10^{-6}
NE	2,100	9.9×10^{-6}	2,800	6.2×10^{-6}
ENE	2,200	8.9×10^{-6}	3,300	4.6×10^{-6}
E	1,500	1.7×10^{-5}	3,100	5.0×10^{-6}
ESE	1,300	1.9×10^{-5}	3,500	3.8×10^{-6}
SE	1,200	1.9×10^{-5}	3,500	3.3×10^{-6}
SSE	1,000	3.4×10^{-5}	3,500	4.4×10^{-6}
S	500	5.7×10^{-5}	3,000	3.2×10^{-6}
SSW	700	7.7×10^{-5}	3,500	5.6×10^{-6}
SW	900	5.9×10^{-5}	2,400	1.8×10^{-5}
WSW	1,400	1.9×10^{-5}	2,000	1.1×10^{-5}
W	700	5.5×10^{-5}	2,000	1.1×10^{-5}
WNW	700	4.5×10^{-5}	1,900	9.7×10^{-6}
NW	1,500	1.3×10^{-5}	2,000	8.4×10^{-6}
NNW	1,600	1.4×10^{-5}	1,900	1.1×10^{-5}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.23

Maximum Perimeter and Individual Doses from
Building 330 (CP-5) Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (700 m SSW)	Individual (2,400 m SW)
Ingestion	1.8×10^{-5}	4.2×10^{-6}
Inhalation	5.9×10^{-5}	1.4×10^{-5}
Air Immersion	^a	-
Ground Surface	-	-
Total	7.7×10^{-5}	1.8×10^{-5}
Radionuclide		
Hydrogen-3	7.7×10^{-5}	1.8×10^{-5}

^a A hyphen indicates no exposure by this pathway.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.24

Radiological Airborne Releases from Building 350, 1996

Source Term:	Uranium-234	=	5.9×10^{-7} Ci
	Uranium-238	=	5.9×10^{-7} Ci
	Plutonium-238	=	6.1×10^{-10} Ci
	Plutonium-239	=	2.1×10^{-9} Ci
	Plutonium-240	=	1.1×10^{-9} Ci
	Plutonium-241	=	5.8×10^{-8} Ci
	Plutonium-242	=	3.3×10^{-12} Ci

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	1,700	9.5×10^{-6}	2,200	6.8×10^{-6}
NNE	1,800	8.5×10^{-6}	3,200	4.0×10^{-6}
NE	2,200	6.4×10^{-6}	3,100	3.9×10^{-6}
ENE	2,000	7.3×10^{-6}	3,100	3.9×10^{-6}
E	1,700	9.5×10^{-6}	2,500	5.5×10^{-6}
ESE	900	1.9×10^{-5}	3,000	3.8×10^{-6}
SE	900	1.8×10^{-5}	3,000	3.3×10^{-6}
SSE	700	2.7×10^{-5}	2,700	5.0×10^{-6}
S	600	1.4×10^{-5}	2,700	2.7×10^{-6}
SSW	400	4.2×10^{-5}	2,500	6.9×10^{-6}
SW	600	3.8×10^{-5}	2,700	6.3×10^{-6}
WSW	800	1.9×10^{-5}	2,100	6.1×10^{-6}
W	900	1.2×10^{-5}	2,200	4.9×10^{-6}
WNW	1,000	9.8×10^{-6}	2,100	4.5×10^{-6}
NW	1,900	5.6×10^{-6}	2,400	4.2×10^{-6}
NNW	1,900	6.1×10^{-6}	2,200	5.1×10^{-6}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.25

Maximum Perimeter and Individual Doses from
Building 350 Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (2,500 m SSW)
Ingestion	3.1×10^{-7}	5.1×10^{-8}
Inhalation	4.1×10^{-5}	6.8×10^{-6}
Air Immersion	2.3×10^{-14}	3.8×10^{-15}
Ground Surface	4.0×10^{-9}	6.6×10^{-10}
Total	4.2×10^{-5}	6.9×10^{-6}
Radionuclide		
Uranium-234	2.2×10^{-5}	3.6×10^{-6}
Uranium-238	1.9×10^{-5}	3.2×10^{-6}
Plutonium-238	5.7×10^{-8}	9.4×10^{-9}
Plutonium-239	2.2×10^{-7}	3.7×10^{-8}
Plutonium-240	1.2×10^{-7}	1.9×10^{-8}
Plutonium-241	1.1×10^{-7}	1.8×10^{-8}
Plutonium-242	3.3×10^{-10}	5.5×10^{-11}
Total	4.2×10^{-5}	6.9×10^{-6}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.26

Radiological Airborne Releases from Building 375 (IPNS), 1996

Source Term Carbon-11 = 708.5 Ci
 Argon-41 = 9.5 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	1,600	3.7×10^{-2}	3,200	1.0×10^{-2}
NNE	1,700	3.2×10^{-2}	3,100	1.0×10^{-2}
NE	1,700	3.1×10^{-2}	2,700	1.3×10^{-2}
ENE	1,500	3.8×10^{-2}	2,500	1.4×10^{-2}
E	600	2.0×10^{-1}	2,500	1.6×10^{-2}
ESE	600	1.8×10^{-1}	2,500	1.3×10^{-2}
SE	600	1.6×10^{-1}	2,500	1.1×10^{-2}
SSE	600	2.0×10^{-1}	3,000	1.0×10^{-2}
S	800	6.7×10^{-2}	3,000	6.0×10^{-3}
SSW	800	1.5×10^{-1}	3,500	9.0×10^{-3}
SW	800	1.5×10^{-1}	4,000	6.9×10^{-3}
WSW	1,500	3.7×10^{-2}	2,700	1.2×10^{-2}
W	2,200	2.0×10^{-2}	2,700	1.2×10^{-2}
WNW	1,500	3.1×10^{-2}	2,600	1.1×10^{-2}
NW	2,200	1.5×10^{-2}	2,500	1.1×10^{-2}
NNW	1,800	2.3×10^{-2}	2,200	1.6×10^{-2}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.27

Maximum Perimeter and Individual Doses from
Building 375 (IPNS) Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (600 m SSE)	Individual (2,400 m E)
Ingestion	- ^a	-
Inhalation	8.8×10^{-3}	6.9×10^{-4}
Air Immersion	1.9×10^{-1}	1.5×10^{-2}
Ground Surface	7.3×10^{-3}	7.3×10^{-4}
Total	2.0×10^{-1}	1.6×10^{-2}
Radionuclide		
Carbon-11	2.0×10^{-1}	1.6×10^{-2}
Argon-41	3.4×10^{-3}	3.1×10^{-4}
Total	2.0×10^{-1}	1.6×10^{-2}

^a A hyphen indicates no exposure by this pathway.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.28

Radiological Airborne Releases from Building 411/415 (APS), 1996

Source Term: Carbon-11 = 0.5 Ci
 Nitrogen-13 = 21.3 Ci
 Oxygen-15 = 2.2 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/yr)	Distance to Nearest Resident (m)	Dose (mrem/yr)
N	1,500	1.1×10^{-3}	2,000	5.8×10^{-4}
NNE	1,600	8.8×10^{-4}	2,100	5.0×10^{-4}
NE	2,200	4.5×10^{-4}	3,100	2.1×10^{-4}
ENE	2,500	3.3×10^{-4}	3,300	1.8×10^{-4}
E	1,600	8.8×10^{-4}	3,400	1.8×10^{-4}
ESE	1,500	8.8×10^{-4}	3,500	1.4×10^{-4}
SE	400	9.3×10^{-3}	3,000	1.6×10^{-4}
SSE	400	1.2×10^{-2}	3,000	2.1×10^{-4}
S	350	7.4×10^{-3}	2,500	1.9×10^{-4}
SSW	400	1.4×10^{-2}	2,800	2.8×10^{-4}
SW	550	8.0×10^{-3}	3,000	2.3×10^{-4}
WSW	800	3.1×10^{-3}	1,400	1.0×10^{-3}
W	800	2.9×10^{-3}	1,500	8.8×10^{-4}
WNW	500	5.2×10^{-3}	1,400	8.8×10^{-4}
NW	350	9.4×10^{-3}	1,600	6.4×10^{-4}
NNW	1,500	8.0×10^{-4}	2,000	4.3×10^{-4}

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.29

Maximum Perimeter and Individual Doses from
Building 411/415 Air Emissions, 1996
Dose (mrem/yr)

Pathway	Perimeter (400 m SSW)	Individual (1,400 m WSW)
Ingestion	- ^a	-
Inhalation	4.0×10^{-4}	3.1×10^{-5}
Air Immersion	1.3×10^{-2}	9.9×10^{-4}
Ground Surface	2.4×10^{-4}	2.2×10^{-5}
Total	1.4×10^{-2}	1.0×10^{-3}
Radionuclide		
Carbon-11	3.2×10^{-4}	2.9×10^{-5}
Nitrogen-13	1.3×10^{-2}	9.9×10^{-4}
Oxygen-15	8.3×10^{-4}	2.7×10^{-5}
Total	1.4×10^{-2}	1.0×10^{-3}

^a A hyphen indicates no exposure by this pathway.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

In August of 1992, operation of the Janus reactor (Building 202) was terminated because of a lack of programmatic support. In early 1993, the fuel was removed and shipped to the Savannah River Plant for reprocessing. Likewise, the cyclotron in Building 211 ceased operation at the end of 1992 because of the lack of use. The facility was placed in standby status awaiting future D&D. Neither facility will produce radiological airborne emissions in the future.

In the past, the dominant emission source was radon-220 from Building 200. However, with the D&D of the M-Wing hot cells, the residual emissions from Building 200 account for only 60% of the off-site dose while the IPNS facility in Building 375 accounts for 30% of the dose. The rest of the emissions account for the other 10%. The highest perimeter dose was in the south southeast direction with a maximum dose of 0.23 mrem/yr (location 7H in Figure 1.1). The major contributor to this dose was air immersion of carbon-11 (0.20 mrem/yr). The completion of the D&D activities in Building 200 and subsequent reduction in radon-220 emissions result in a shift of the maximum perimeter dose from the north to the south. The major contributors to this perimeter dose are emissions from the IPNS in Building 375.

The full-time resident who would receive the largest annual dose (0.053 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 (0.02 mrem/yr). If radon-220 plus daughters were excluded from the calculation, as required by NESHAP,¹⁸ the maximally exposed resident would receive a dose of 0.021 mrem/yr, primarily carbon-11 from the IPNS facility (Building 375).

The individual doses to the maximally exposed member of the public and the maximum fence line dose are shown in Figure 4.5. The decrease in individual and population doses since 1988 are due in part to the decrease of the radon-220 emissions, which resulted from the cleanup of the Building 200 M-Wing hot cells.

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 4.30, together with the natural external radiation dose. The natural radiation dose listed is the product

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

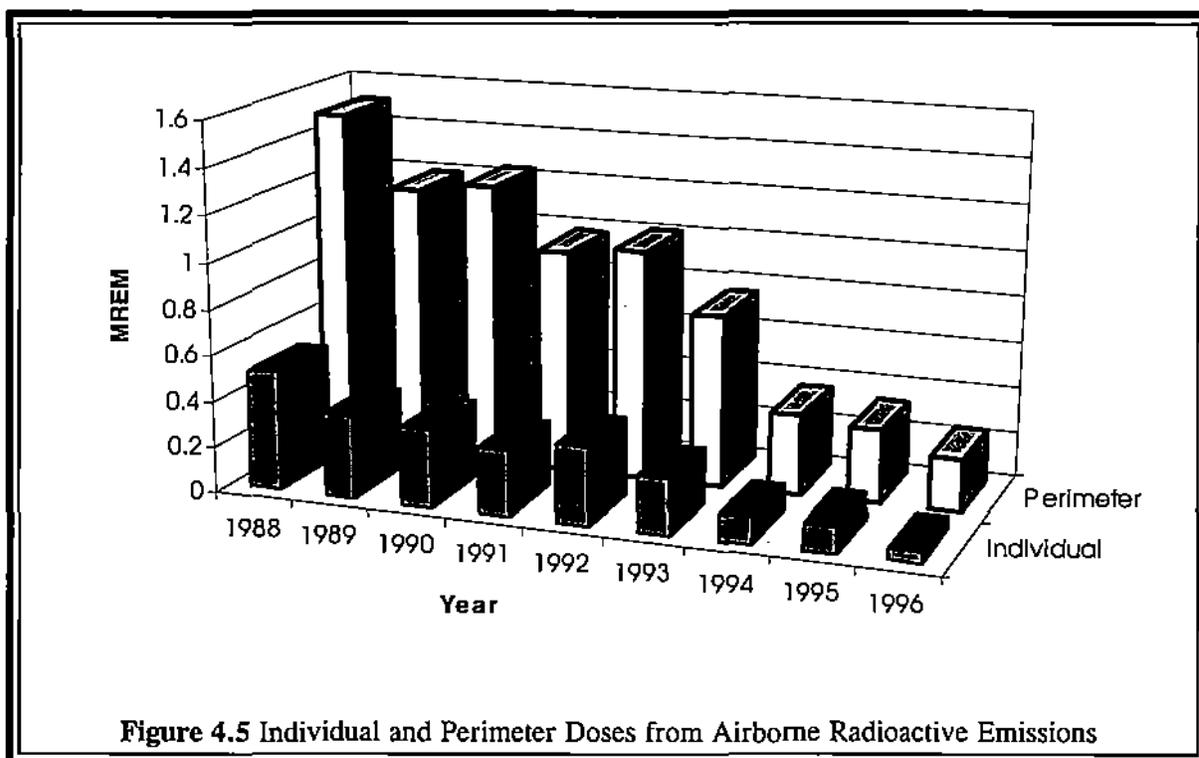


Figure 4.5 Individual and Perimeter Doses from Airborne Radioactive Emissions

of the 80-km (50-mi) population and the natural radiation dose of 300 mrem/yr.¹⁹ It is assumed that this dose is representative of the entire area within an 80-km (50-mi) radius. The population dose since 1987, due to ANL-E operations, is shown in Figure 4.6.

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.⁹ 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 .²⁰ This annual intake is then multiplied by the CEDE for the appropriate lung retention class.⁵ Because the CEDE factors are in units of $\text{rem}/\mu\text{Ci}$, this calculation gives the 50-year CEDE. The applicable CEDE factors are listed in Table 4.31.

The calculated doses in Tables 4.2 and 4.3 were obtained 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

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

TABLE 4.30

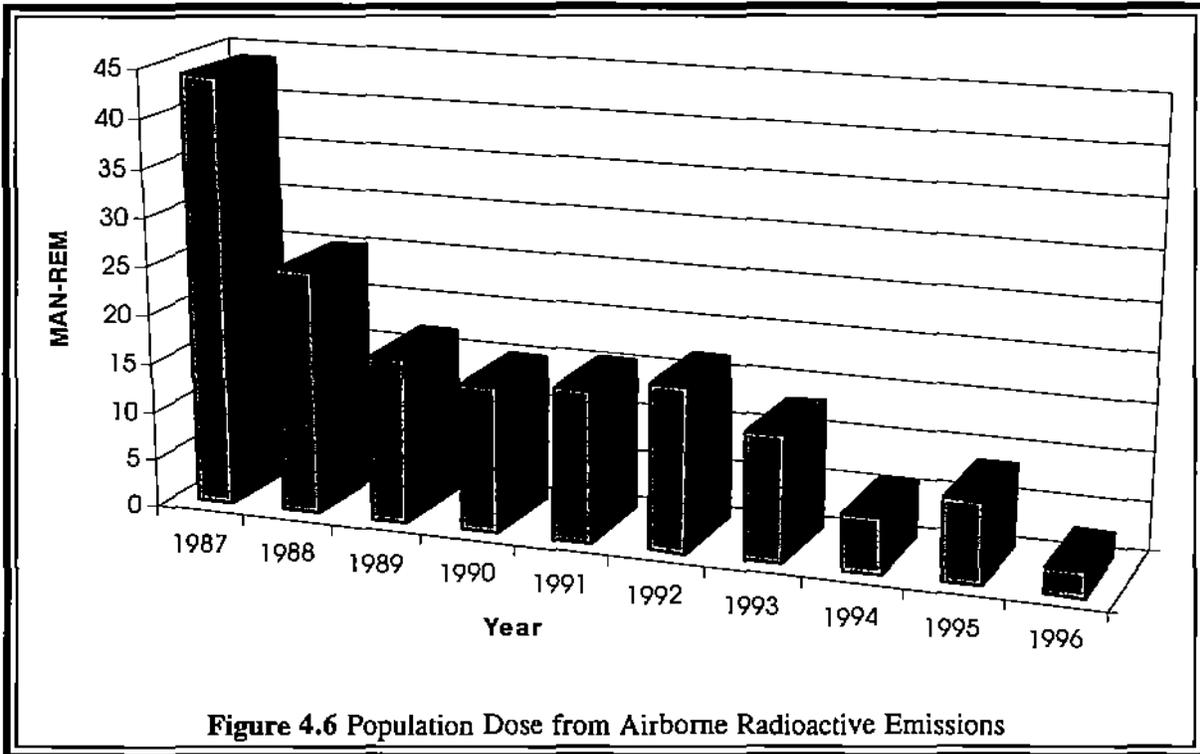
Population Dose within 80 km, 1996	
Radionuclide	Man-rem
Hydrogen-3	0.73
Carbon-11	0.88
Nitrogen-13	0.01
Oxygen-15	<0.01
Argon-41	0.06
Krypton-85	<0.01
Antimony-125	<0.01
Thallium-208	<0.01
Lead-212	0.87
Bismuth-212	0.09
Radon-220	<0.01
Uranium-234	<0.01
Uranium-238	<0.01
Plutonium-238	<0.01
Plutonium-239	<0.01
Plutonium-240	<0.01
Plutonium-241	<0.01
Plutonium-242	<0.01
Total	2.64
Natural	2.5×10^6

the total alpha and total beta measurements since the guidance does not provide CEDE factors for such measurements.

4.6.2. Water Pathway

Following the methodology outlined in DOE Order 5400.5,⁹ the annual intake of radionuclides (in μCi) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter ($\mu\text{Ci}/\text{mL}$) 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 4.31) to obtain the dose received in that year. This procedure

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is carried out for all radionuclides, and the individual results are summed to obtain the total ingestion dose.

The only location where radionuclides attributable to ANL-E operations could be found in off-site water was Sawmill Creek below the wastewater outfall (see Table 4.5). 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 were used as the sole water supply by an individual) are given in Table 4.32. 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.

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TABLE 4.31

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

Nuclide	Ingestion	Inhalation
Hydrogen-3	6.3×10^{-5}	9.6×10^{-5}
Beryllium-7	^a	2.7×10^{-4}
Carbon-11	-	8.0×10^{-6}
Strontium-90	0.13	1.32
Cesium-137	0.05	0.032
Lead-210	-	13.2
Radium-226	1.1	-
Thorium-228	-	310
Thorium-230	-	260
Thorium-232	-	1100
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.

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TABLE 4.32

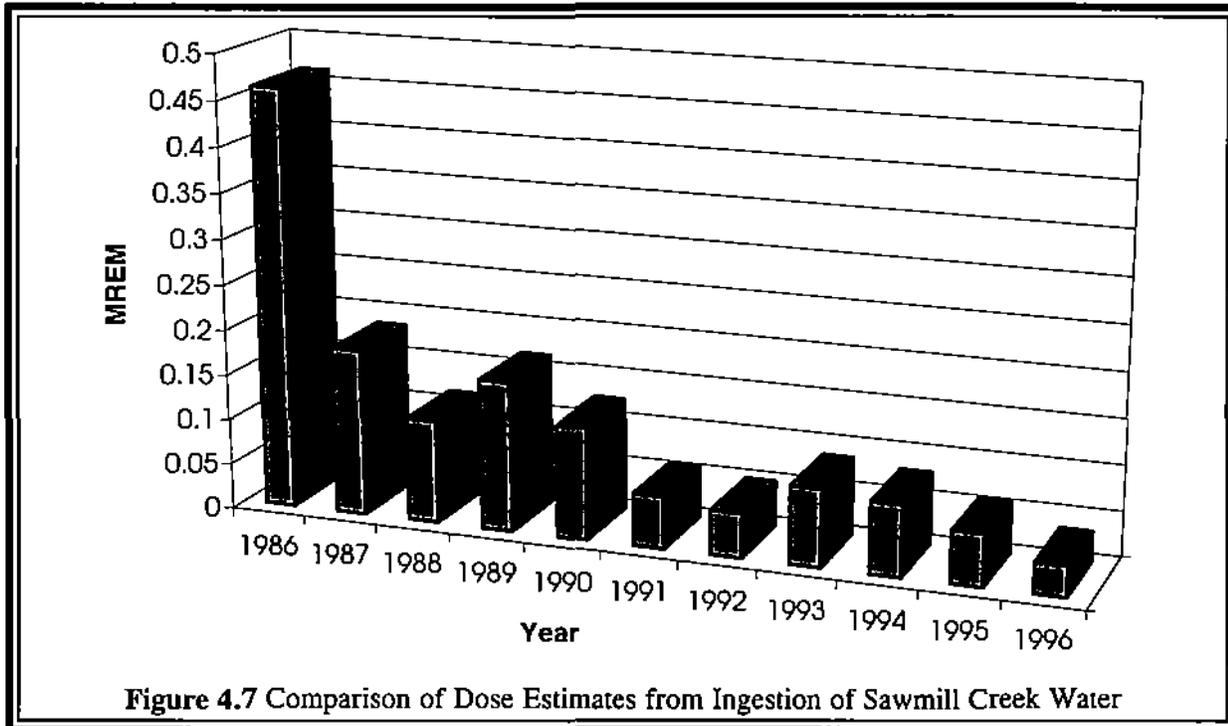
Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 1996

Radionuclide	Total Released (Ci)	Net Avg. Conc. (pCi/L)	Dose (mrem)
Hydrogen-3	0.76	75	0.0034
Strontium-90	0.0026	0.26	0.0247
Neptunium-237	0.000007	0.0007	0.0002
Plutonium-239	0.00010	0.0099	0.0031
Americium-241	0.00009	0.0087	0.0029
Total	0.763		0.0343

As indicated in Table 4.5, occasional Sawmill Creek samples (fewer than 10%) contained traces of cesium-137, plutonium-238, curium-242 and 244, or californium-249 and 252, but the averages were only slightly greater than the detection limit. The annual dose to an individual consuming water at these concentrations can be calculated with the same method used for those radionuclides more commonly found in creek water; this method of averaging, however, probably overestimates the true concentration. Annual doses range from 3×10^{-3} to 6×10^{-5} mrem/yr for these radionuclides.

DOE Order 5400.5⁹ requires that an evaluation be made of the dose to aquatic organisms from liquid effluents. The dose limit is one 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 each). Using the annual average concentrations of the radionuclides listed in Table 4.5, a dose can be estimated. The sum of the exposure from these radionuclides is estimated to be about 5×10^{-6} rad/yr, well within the DOE standard; it therefore demonstrates compliance with that portion of the order.

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The EPA has established drinking water standards based on a maximum dose of 4 mrem/yr for man-made beta particle and photon-emitting radionuclides.²¹ The EPA standard is 2×10^4 pCi/L for hydrogen-3 and 8 pCi/L for strontium-90. The net concentrations in Table 4.32 correspond to 0.38% (hydrogen-3) and 3.2% (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 $0.28 \text{ m}^3/\text{s}$ ($10 \text{ ft}^3/\text{s}$), while the flow rate of the Des Plaines River in the vicinity of ANL-E is about $25 \text{ m}^3/\text{s}$ ($900 \text{ ft}^3/\text{s}$). Applying this ratio to the concentration of radionuclides in Sawmill Creek listed in Table 4.32, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.0006 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^{-4} man-rem.

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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 about 127 ± 12 mrem/yr. Approximately 300 m (960 ft) south of the fence line (grid 6I), the measured dose was 100 ± 11 mrem/yr, the same as the normal range of the off-site average (90 ± 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 0.004 mrem/yr, if the energy of the radiation were that of a 0.66-MeV cesium-137 gamma-ray, and about 0.012 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, since 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 0.03 mrem/yr at the 317 Area fence (location 7I).

4.6.4. Dose Summary

The total effective dose equivalent received by off-site residents during 1996 was a combination of the individual doses received through the separate pathways that contributed to exposure: hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 (plus daughters), and actinides through the airborne pathway. The highest dose was about

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0.053 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 is 2.64 man-rem. The dose pathways are presented in Table 4.33 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 0.10 mrem/yr attributable to ANL-E operations into perspective, comparisons can be made to annual average doses received by the public from natural or accepted sources of radiation. These values are listed in Table 4.34. It is obvious that 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 4.33

Summary of the Estimated Dose to the Public, 1996
(mrem/yr)

Pathway	ANL-E Estimate	Applicable Standard
Air (less radon)	0.021	10 (EPA)
Air Total	0.053	100 (DOE)
Water	0.034	100 (DOE)
Direct Radiation	0.01	100 (DOE)
Maximum Public	0.10	100 (DOE)

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TABLE 4.34

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

Source	Dose (mrem)
Natural Sources	
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. 93.¹⁹

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION



5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

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 SO₂ and opacity. No exceedances for opacity or SO₂ were noted during 1996 over a period of 3,220 hours of 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. 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. Table 5.1 summarizes the two exceedances of permit limits during 1996.

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. Samples of water 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

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 lavatories, the cafeteria, office buildings, and other portions of the site that do not contain radioactive or hazardous materials. This wastewater is treated in a biological wastewater treatment system consisting of primary clarifiers, trickling filters, final clarifiers, and

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TABLE 5.1

NPDES Permit Limit Exceedances, 1996		
Outfall	Parameter	Number of Exceedances
001	Zinc	1
001A	Iron	1

slow sand filters. Wastewater generated by research-related activities, such as laboratories and experimental equipment, flows to a series of retention tanks located in each building. When a retention tank is full, a sample is collected and analyzed for radioactivity. If the wastewater is found to be below the release limits for discharge, it is pumped to the laboratory wastewater collection system, which directs the flow to the laboratory wastewater treatment system. This system consists of a series of concrete holding tanks that collect the wastewater prior to discharge. As with the retention tanks, once a holding tank is full, it is sampled and analyzed for radioactivity. If the level of radioactivity is below ANL-E discharge criteria, which were selected to ensure compliance with DOE Orders, it is pumped to a lined equalization basin, slowly combined with the sanitary waste stream, and discharged to Sawmill Creek. If either a retention tank or holding tank is found to contain unacceptable levels of radioactivity, the wastewater is pumped into portable tanks, treated by evaporation in Building 306, and the residue is disposed of as radioactive waste. Figure 5.1 shows the two wastewater treatment systems that are located adjacent to each other. The volume of wastewater discharged from these facilities averaged 1.19 million L/day (0.31 million gal/day) for the sanitary wastewater and 1.38 million L/day (0.36 million gal/day) for the laboratory process wastewater.

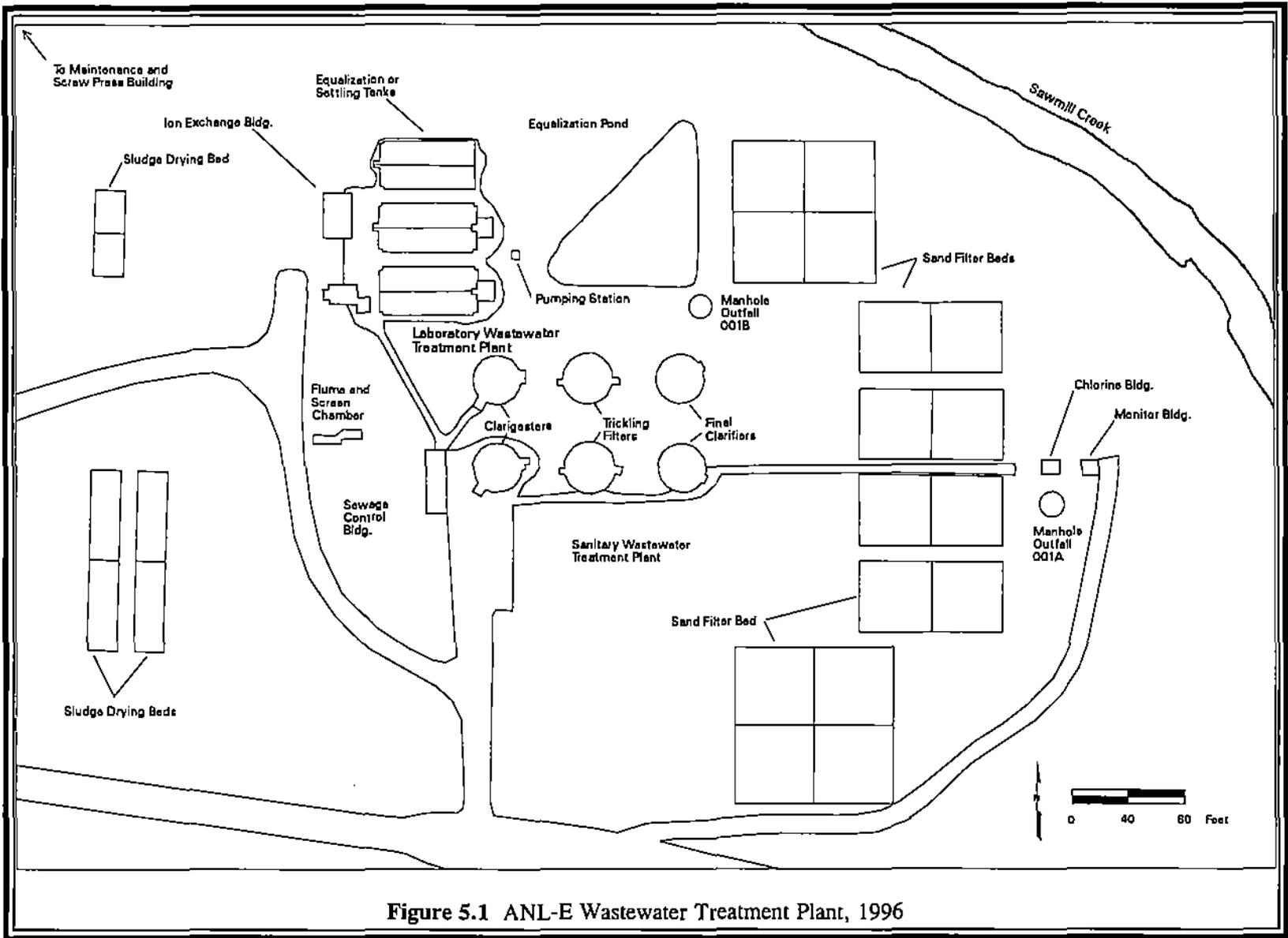


Figure 5.1 ANL-E Wastewater Treatment Plant, 1996

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5.1.1. Wastewater Treatment Plant Renovations

Two projects to renovate the existing sanitary and laboratory wastewater treatment facilities were in various phases of construction during 1996. The sanitary WTP was upgraded during 1996 to replace equipment that had reached its design life and to add equipment where a more efficient or sound environmentally process could be applied. The design and construction of the improvements were conducted in two phases. Phase 1 construction started in July 1995 and was completed in July 1996. Phase 2 work resulted from IEPA-requested enhancements to the Phase 1 design. Phase 2 construction started in January 1996 and was completed in September 1996.

Phase 1 included renovation of two primary and two final clarifiers, a sludge digestion Imhoff tank, and two trickling filters. Eight intermittent sand filters were demolished and completely rebuilt. New facilities and appurtenances included a maintenance building with a new motor control center and instrumentation panels, new sludge pumps and air compressor, new influent flow monitoring equipment and new headworks that include a bar screen and channel grinder, new site utility underground piping, and a new underground electrical duct bank system.

Phase 2 included construction of a new facility to house the mechanical sludge dewatering equipment, which includes a screw press, progressive cavity pump, a polymer feed system, a sludge holding tank, and instrumentation panels. Two new recirculation pump stations were installed, and adjustable timer controls for the final clarifer sludge pumps were installed. Vertical riser vents on all 16 intermittent sand filters were constructed to improve operating efficiency of the sand filter system, and new automatic switching valves on the inlet distribution piping to the intermittent sand filters were installed.

Renovation and expansion of the existing laboratory WTP to provide additional treatment capability began during January 1996. In addition to increasing flow capacity to 3.8 million L/day (1.1 million gal/day), the laboratory WTP upgrade will provide additional treatment capability for heavy metals, suspended solids, and volatile organics. The upgraded laboratory WTP will provide continuous treatment through a system with numerous treatment unit operations, some of which will be selected on an as-needed basis to meet the variable nature of

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the laboratory wastewater. Treatment capabilities of the upgraded laboratory WTP will include screening and grit removal, pH adjustment, gravity separation, aeration, flow equalization, hydroxide precipitation, powdered activated-carbon adsorption, coagulation flocculation, and solids contact clarification. The project is currently under construction and is on schedule to meet the NPDES compliance schedule "construction complete" milestone of July 1, 1997.

5.1.2. Effluent Monitoring

The two treatment plant systems process the vast majority of wastewater generated by ANL-E. However, 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. However, these discharge points are included in the site NPDES permit as separate regulated outfalls.

ANL-E-processed wastewater discharges are regulated by NPDES Permit No. IL 0034592 (effective October 30, 1994, and modified August 24, 1995).²³ Discharge limits for 26 surface water discharge points (outfalls) and two internal monitoring points are included in this permit. The analyses required and the frequency of analysis for each point are specified in the permit. The analytical methods required for NPDES monitoring are listed in Table 1B of 40 CFR 136.²⁴ Sample collection, preservation, and holding times are also mandated by requirements stipulated in Table 2 of 40 CFR 136.²⁴

The NPDES outfall locations are shown in Figure 5.2. Outfalls 001A and 001B, the two internal monitoring points representing the effluent from the sanitary system and laboratory system, respectively, are both located at the WTP. Their flows combine to form Outfall 001, which also is located at the treatment facility. The combined stream flows through an outfall pipe that discharges into Sawmill Creek approximately 1,100 m (3,500 ft) south of the treatment plant.

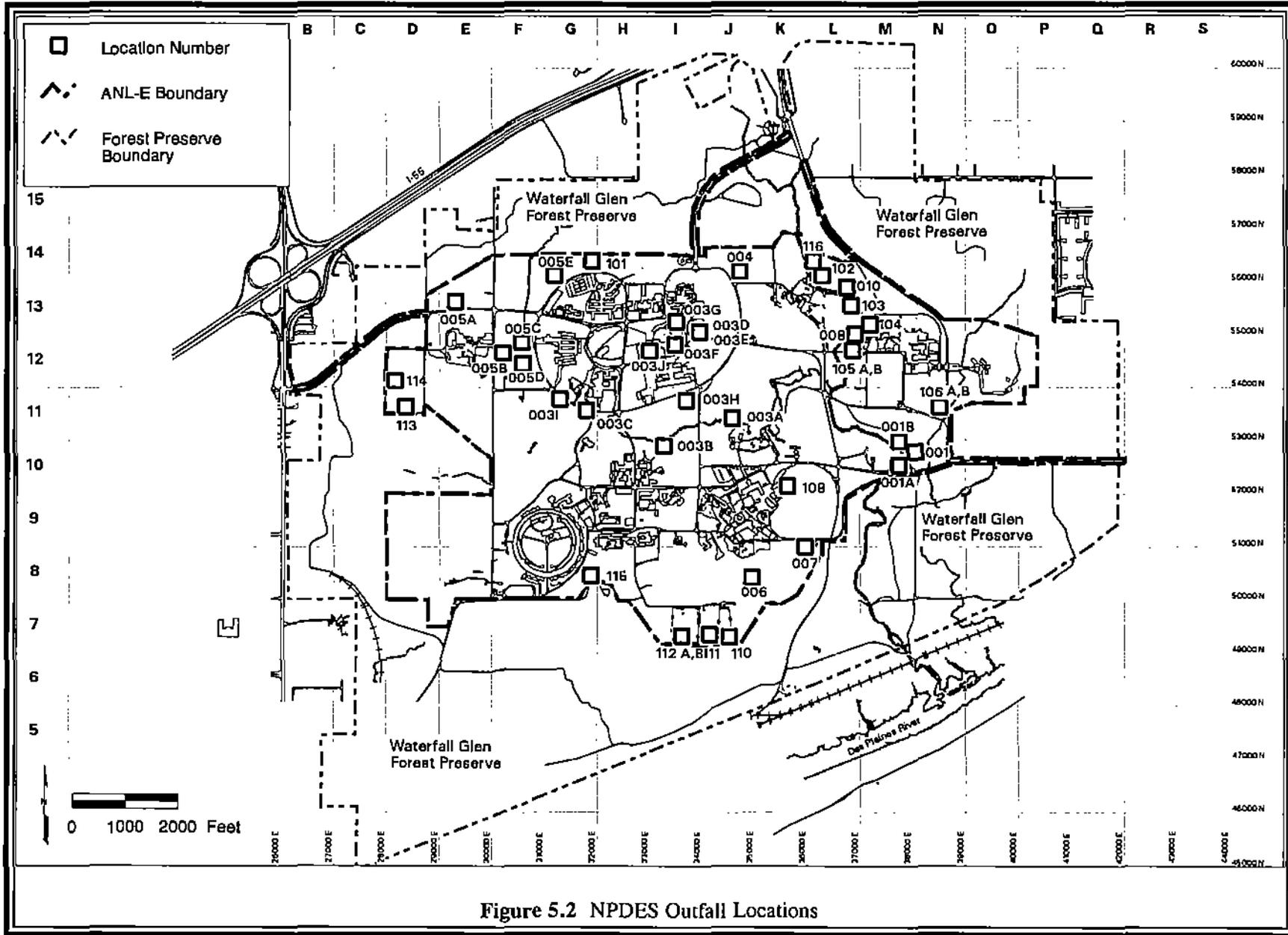


Figure 5.2 NPDES Outfall Locations

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5.1.2.1. Sample Collection

NPDES samples are collected by ANL-E's EMO personnel, with the exception of samples from locations 001, 001A, and 001B, which are collected by PFS personnel. All samples are collected using 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 Analysis - NPDES

NPDES sample analyses were performed by using standard operating procedures (SOPs) and were written, reviewed, and issued as controlled documents by members of the ESH Analytical Services Group's Radiochemistry Laboratory (ESH-ASRC), Chemistry Laboratory (ESH-ASCH), and Control Laboratory (ESH-ASCL). These SOPs cite protocols that can be found in 40 CFR 136, "Test Procedures for the Analysis of Pollutants under the Clean Water Act." Six metal analyses were performed by using flame atomic absorption spectroscopy. Mercury was 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 (BOD₅) was determined by using a dissolved oxygen probe. Total suspended solids (TSS), TDS, and fats, oils, and grease were determined gravimetrically. Sulfate determination was performed by using a turbidimetric technique; chloride was determined by titrimetry. Ammonia was determined by distillation, followed by an ion selective electrode finish. Five VOCs were determined by using a purge and trap sample pretreatment, followed by gas chromatography-mass spectroscopy detection. The PCB Arochlor 1260 was 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 was determined by distillation, followed by a beta liquid scintillation counting technique.

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Semiannually, NPDES Outfall 001B is sampled and analyzed 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. PCB/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 biannually. An off-site contracted laboratory performed both the sample collection and analyses. The testing is performed by using ANL-E effluent with Sawmill Creek receiving water, introducing species of fish and invertebrates, and measuring survival over two to four days. Statistically significant mortality is reported as a function of effluent concentration.

5.1.2.3. Results

During 1996, approximately 99% of all NPDES analyses were in compliance with their applicable permit limits, as compared to 1995, 1994, 1993, 1992, and 1991 rates of 97%, 97.5%, 97.5%, 98%, and 96%, respectively. 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 is composed 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, pH, and TSS. The limits for five-day BOD are a monthly average of 10 mg/L with a maximum value of 20 mg/L. The permit limits for TSS are a maximum concentration of 24 mg/L.

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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 were within the permit limits during 1996.

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. One exceedance of the limit for iron was noted during May 1996. It appears that excessive precipitation resulted in a large volume of coal-pile runoff flowing through the sanitary wastewater treatment system. The high flows resulted in a shortened detention time for iron settling. Elevated levels of iron historically have been associated with increased coal-pile runoff contributions to the sanitary wastewater system.

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, TSS, mercury, pH, and COD.

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 1996
(Concentrations in mg/L)

Constituent	Minimum	Average	Average Limit	Maximum	Maximum Limit
Chromium	^a	<0.02	1.00	<0.02	2.00
Copper	<0.010	0.042	0.50	0.215	1.00
Iron	0.09	0.468	2.00	4.76	4.00
Lead	-	<0.10	0.20	<0.10	0.40
Manganese	<0.015	0.063	1.00	0.266	2.00
Zinc	0.05	0.154	1.00	0.495	2.00
Oil & Grease	<5.0	<5.0	15.0	5.1	30.0

^a A hyphen indicates no minimum values.

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The limits established for BOD are a daily maximum of 20 mg/L with a 30-day average of 10 mg/L. The permit also contains BOD mass loading limits of 114 lb/day as a daily maximum and 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 with a 30-day average of 12 mg/L. The TSS mass loading limits are 136 and 68 lb/day, respectively. There were no exceedances of the BOD or TSS concentration limits in 1996.

The daily maximum concentration limit for mercury is 6 $\mu\text{g/L}$; the 30-day average is 3 $\mu\text{g/L}$. The corresponding loading values are 0.034 lb/day and 0.017 lb/day. No exceedances of the mercury concentration limit were noted.

No concentration limits have been established for COD. The once-per-week grab samples give a rough indication of the organic and inorganic content of this stream. The values obtained in 1996 ranged from less than 10 mg/L to 28 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 18, 1996, and December 3, 1996, 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 found in ANL-E treated drinking water. The samples contained some VOCs at very low levels. The majority of compounds found are halomethanes. The concentrations of volatile organics identified in these samples are contained in Table 5.3. Currently, no permit limits or effluent standards with which to compare these results are available for these compounds.

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The laboratory WTP consists of six 259,000-L (69,000-gal) equalization or settling (holding) tanks (see Figure 5.1) that are pumped to a lined equalization pond before being discharged to Sawmill Creek. During 1989, a study was performed to determine the levels of VOCs in the influent to these tanks and to determine the variability of this concentration. A number of different volatile organics were found to be present from time to time, with the concentration varying greatly throughout the day. Maximum levels were found to occur in the late afternoon. As a follow-up to this study, each month one influent sample is obtained at about 1300 hours and analyzed for VOCs. During August 1993, the discharge of water from Manhole 2E (refer to Section 6.2.2.3.) in the 317 Area began on a regular basis. This water is known to contain volatile organics at consistent levels. A modified NPDES permit was issued by the IEPA to reflect this discharge.

Overall, the 1996 results are quite similar to the 1995 results. Table 5.4 shows the 1996 results for the most common compounds found. Bromoform, bromodichloromethane, chloroform, and dibromochloromethane are halomethanes that are produced due to contact of the chlorinated water supply with organic chemicals. Elevated chloroform levels are probably due to research activity.

TABLE 5.3

Outfall 001B Priority Pollutant Monitoring Results, 1996
(Concentrations in $\mu\text{g/L}$)

Compound	Concentration in June Sample	Concentration in December Sample
Bromodichloromethane	3	2
Bromoform	4	< 1
Chloroform	6	2
Dibromochloromethane	6	1
Methylene Chloride	13	< 1
Carbon Tetrachloride	1	< 1

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TABLE 5.4

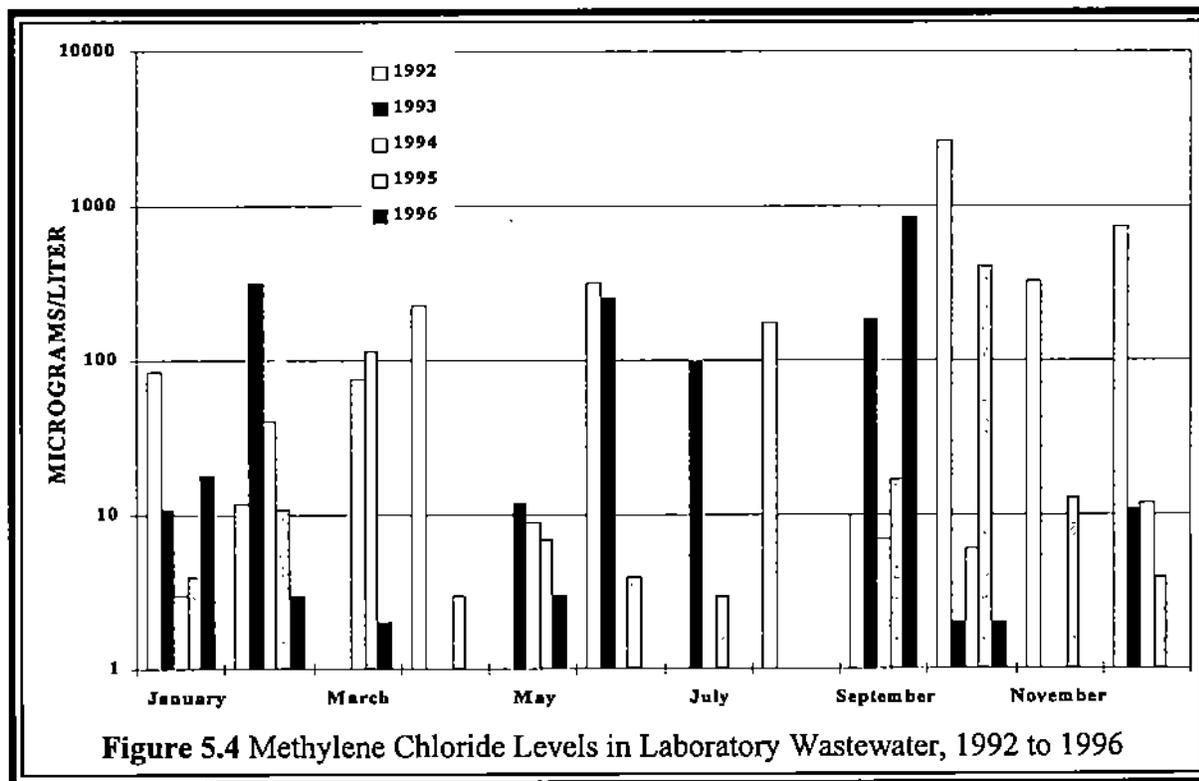
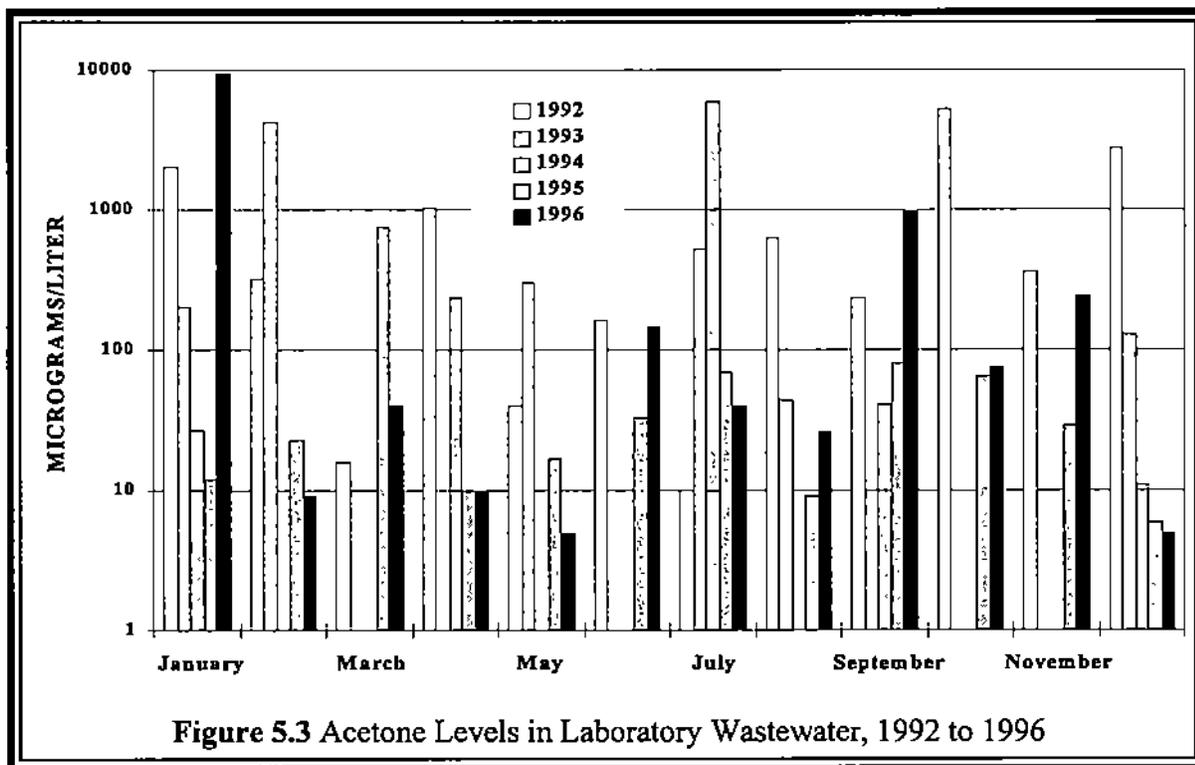
Volatile Organic Compounds in Laboratory Wastewater, 1996
(Concentrations in $\mu\text{g/L}$)

Month	Acetone	Chloroform	Methylene Chloride	Bromodi-chloroethane	Dibromo-chloromethane	Bromoform
January	9,497	6	18	7	5	1
February	9	3	3	3	4	2
March	40	2	2	2	4	2
April	10	8	1	6	4	<1
May	<5	17	3	4	5	2
June	144	2	<1	4	8	5
July	40	12	<1	6	13	14
August	26	3	<1	6	11	10
September	975	470	844	9	11	6
October	77	9	2	8	16	16
November	247	4	<1	5	8	7
December	<5	9	<1	2	2	<1

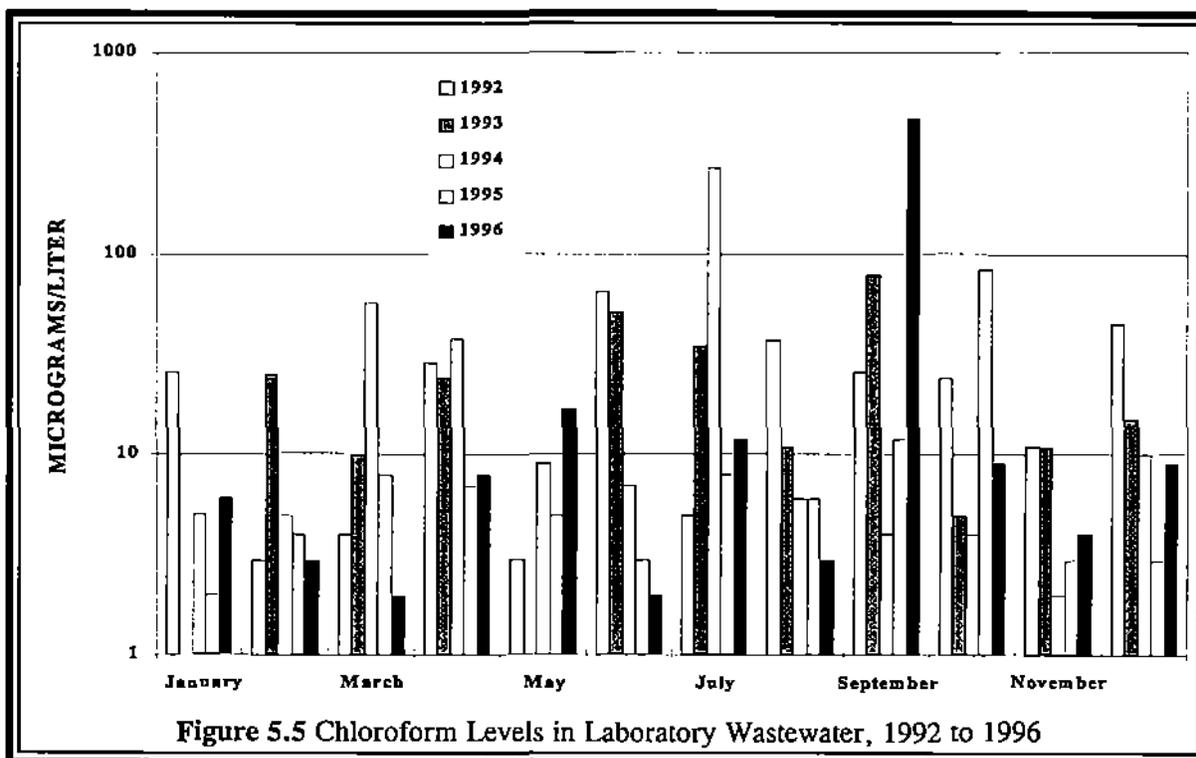
Similar to 1995, the more persistent VOCs were noted at greater frequency but at lower ranges of concentration. Acetone was found in 10 samples, and levels ranged to 9,497 $\mu\text{g/L}$. Methylene chloride was found in seven samples and ranged to 844 $\mu\text{g/L}$. Infrequent trace levels of other chemicals, that is, 2-butanone, ethyl ether, carbon tetrachloride, chlorodifluoromethane, cyclohexane, 4-methyl-2-pentanone, trichloroethene, tetrachloroethene, and 1,1,1-trichloroethane were also noted.

Figures 5.3, 5.4, and 5.5 present comparisons of the 1992 through 1996 laboratory wastewater results for the more persistent VOCs. Data are presented on a logarithmic scale for ease of comparison. The persistent presence of acetone at elevated concentrations is likely due to laboratory activities such as rinsing glassware. ANL-E continues a waste generator education program regarding disposal of chemicals down laboratory drains. ANL-E plans to strengthen the program for the overall reduction of volatile organics in laboratory wastewater.

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Outfall 001. The treated wastewater streams from the two treatment systems are combined and samples for analysis of most of the permit parameters are collected from a manhole downstream of the former chlorine contact chamber. This combined effluent then flows through the outfall sewer to Sawmill Creek. The effluent travels through this sewer for approximately 1,300 m (4,160 ft) before being discharged.

The permit requires analysis of the combined effluent once a week for TDS, chloride, and sulfate. The results, limits, and number of exceedances are presented in Table 5.5. An interim limit of 1,500 mg/L became effective August 24, 1995. The limit is effective up to June 30, 1998.

Elevated TDS levels are believed to be related to discharges from boiler operations, that is, boiler blowdown, which is known to contain high levels of TDS; road salt intrusion; and domestic water treatment. Chemical analysis for chloride shows a close relationship between TDS levels

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

TABLE 5.5

Outfall 001 Monitoring Results and Effluent Limits, 1996
(Concentrations in mg/L)

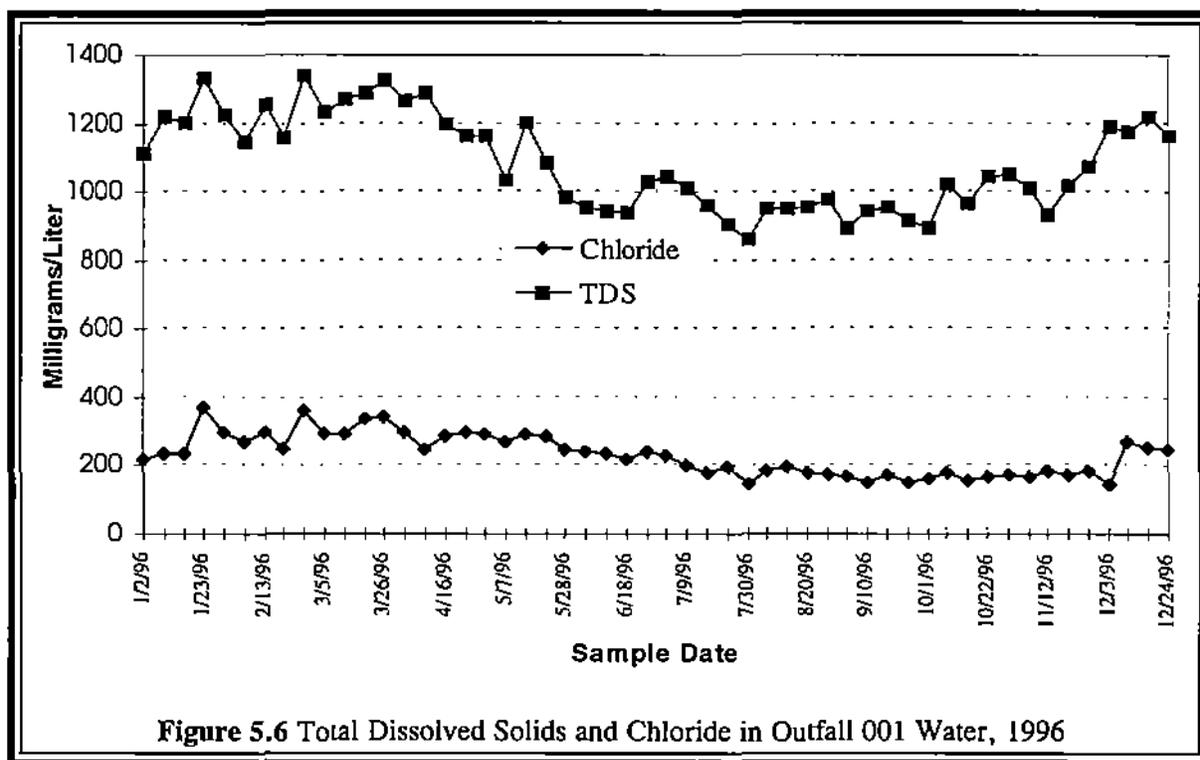
Constituent	Minimum	Average	Maximum	Limit	Exceedances
Copper	0.013	0.048	0.118	1.0 ^a	0
Total Dissolved Solids	862	1,081	1,339	1,500 ^a	0
Ammonia-Nitrogen	0.2	3.4	13.0	Monitor only ^a	0

^a Interim limit effective August 24, 1995.

and chloride levels. Figure 5.6 shows the results of TDS and chloride analyses for 1996. The groundwater at ANL-E is characterized by high TDS levels, that is, approximately 800 ppm. This elevated concentration allows only a narrow margin of added TDS (about 200 ppm) to the wastewater to remain below the NPDES effluent standard of 1,000 ppm (modified August 24, 1995). The modified NPDES permit incorporates an interim TDS limit (1,500 mg/L) and a compliance schedule for achieving final TDS effluent limits at Outfall 001. The final limits will be effective July 1, 1998. Limits for sulfate and chloride were not exceeded during 1996.

The well water obtained by ANL-E from the Niagaran dolomite has very low copper concentrations. However, after treatment and distribution through domestic water distribution copper piping, a copper concentration range of 0.5 mg/L to 1.0 mg/L is typical at drinking fountains. The range has been determined by the previously required lead/copper monitoring program (see Chapter 6). The action level for copper in drinking water has been established at 1.3 mg/L. Essentially all the ANL-E monitoring locations are below this action level. These acceptable levels for human consumption are significantly above the NPDES permit limit at Outfall 001. The WTP has no process for removing copper. Past samples collected from the combined WTP effluent have been below the IEPA effluent limit of 0.5 mg/L, but concentrations measured in Sawmill Creek, below the point where the treated wastewater has been discharged, have consistently exceeded the IEPA stream standard for copper (0.02 mg/L) for several years. This is indicative of the current ambient levels of copper in surface water as a result of the

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increased use of copper pipe for domestic water distribution. The modified NPDES permit (effective August 24, 1995) incorporates an interim upper limit (1.0 mg/L daily maximum) and a compliance schedule for achieving final copper effluent limits at Outfall 001. The final limits will be effective July 1, 1998. There were no copper exceedances during 1996.

The ANL-E WTPs provide minimal treatment for ammonia-nitrogen. The modified NPDES permit (effective August 24, 1995) incorporates interim ammonia-nitrogen limits (monitor only) and a compliance schedule for achieving final ammonia-nitrogen effluent limits at Outfall 001. Final limits will be effective July 1, 1998. There were no ammonia-nitrogen exceedances in 1996.

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 1996 testing was conducted on samples collected June 19 through 23, 1996, using the water flea, *Ceriodaphnia dubia*, and fathead minnow, *Pimephales promelas*.

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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 (that is, 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 5.6 summarizes the results from the various toxicity tests for 1996. Table 5.7 summarizes the test results from 1991 to 1996.

The permit also requires that weekly pH, ammonia-nitrogen, dissolved iron, manganese, and zinc measurements be made. One exceedance of the zinc limit was noted in 1996. In an effort to control copper levels in the domestic water supply, a corrective action of injecting polyphosphate and zinc to coat the copper piping was implemented. This has resulted in a progressive increase of zinc in the wastewater. It appears that excessive addition of zinc in the domestic water supply resulted in elevated levels of zinc in the wastewater. Zinc addition was immediately lowered with a subsequent lowering of zinc levels in the wastewater. Monthly monitoring for lead, hexavalent and trivalent chromium, and beta radioactivity is required.

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 5.8 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. The 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 (36-in.) concrete pipe to a tributary brook flowing north to the Freund Brook. Table 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

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TABLE 5.6

Outfall 001 Aquatic Toxicity Test Results, 1996

Test	Endpoint	96/48-Hour LC ₅₀ (%)
96-Hour Fathead Minnow Acute Toxicity	Survival	> 100.0
48-Hour <i>Ceriodaphnia</i> Acute Toxicity	Survival	> 100.0

TABLE 5.7

Outfall 001 Aquatic Toxicity Test Results, 1991 to 1996

Test	1991 (%)	1992 (%)	1993 (%)	1994 (%)	1995 (%)	1996 (%)
Minnow, Acute, LC ₅₀	61.6	< 6.2	100.0	100.0	> 100	> 100
<i>Ceriodaphnia</i> , Acute, LC ₅₀	17.1	35.4	100.0	100.0	> 100	> 100
Minnow, Chronic, Survival, NOEC ^b	50.0	100.0	50.0	100.0	- ^a	-
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	-	-
<i>Ceriodaphnia</i> , Chronic, Survival, NOEC	50.0	50.0	50.0	100.0	-	-
<i>Ceriodaphnia</i> , Chronic, Survival, LOEC	100.0	100.0	100.0	100.0	-	-
<i>Ceriodaphnia</i> , 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 A hyphen indicates that no analysis was performed due to change in permit.

^b NOEC = No Observable Effect Concentration is the highest concentration of the effluent at which no adverse effect is observed.

^c LOEC = Lowest Observable Effect Concentration is the lowest concentration of the effluent at which an adverse effect is observed.

TABLE 5.8
NPDES Effluent Summary, 1996

Discharge Location	Number of Samples Collected	Permit Constituent	Limit		Number Exceeding Limit
			30-Day Average	Daily Maximum	
003A	0	Flow		None	0
		pH		6-9	0
		TSS	15	30	0
		TRC ^a		0.05	NA ^b
003B	12	Flow		None	0
		pH		6-9	0
		Temperature		<2.8°C Rise	0
003C	12	Flow		None	0
		pH		6-9	0
003D	12	Flow		None	0
		pH		6-9	0
		Temperature		<2.8°C Rise	0
003E	12	Flow		None	0
		pH		6-9	0
		Temperature		<2.8°C Rise	0
003F	11	Flow		None	0
		pH		6-9	0
		Temperature		<2.8°C Rise	0
		TDS		Monitor Only	NA

TABLE 5.8 (Cont.)

Discharge Location	Number of Samples Collected	Permit Constituent	Limit		Number Exceeding Limit
			30-Day Average	Daily Maximum	
003G	12	Flow	None		0
		pH	6-9		0
		Temperature	<2.8°C Rise		0
003H	12	Flow	None		0
		pH	6-9		0
		Temperature	<2.8°C Rise		0
		TDS	Monitor Only		NA
003I	12	Flow	None		0
		pH	6-9		0
		Temperature	<2.8°C Rise		0
		TDS	Monitor Only		NA
		Oil & Grease	Monitor Only		NA
003J	12	Flow	None		0
		pH	6-9		0
		Temperature	<2.8°C Rise		0
		TDS	Monitor Only		NA
004	12	Flow	None		0
		pH	6-9		0
		TSS	15	30	0

TABLE 5.8 (Cont.)

Discharge Location	Number of Samples Collected	Permit Constituent	Limit		Number Exceeding Limit
			30-Day Average	Daily Maximum	
005C	12	Flow	None		0
		pH	6-9		0
		Temperature	<2.8°C Rise		0
		Oil & 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	0
		TDS	Monitor Only		NA
		Temperature	<2.8°C Rise		0
007	41	Flow	None		0
		pH	6-9		0
		Temperature	<2.8°C Rise		0
		TRC	0.05		NA
		Oil & Grease	Monitor Only		NA
008	12	Flow	None		0
		pH	6-9		0
		VOC	Monitor Only		NA

TABLE 5.8 (Cont.)

Discharge Location	Number of Samples Collected	Permit Constituent	Limit		Number Exceeding Limit
			30-Day Average	Daily Maximum	
010	0	Flow		None	NA
		pH		6-9	NA
		TSS	15	30	NA
		Total Iron	2	4	NA
		Dissolved Iron		1.0	NA
		Lead		0.1	NA
		Zinc		1.0	NA
		Manganese		1.0	NA
		Hexavalent Chromium	0.011	0.016	NA
		Trivalent Chromium	0.519	2.0	NA
		Copper	0.031	0.051	NA
		Oil & Grease	15	30	NA
108	12	Flow		None	0
		pH		6-9	0
		Temperature		<2.8°C Rise	0
111	2	Flow		None	NA
		Tritium		Monitor Only	NA
112A	2	Flow		None	NA
		Tritium		Monitor Only	NA

TABLE 5.8 (Cont.)

Discharge Location	Number of Samples Collected	Permit Constituent	Limit		Number Exceeding Limit
			30-Day Average	Daily Maximum	
112B	2	Flow	None		NA
		Tritium	Monitor Only		NA
113	7	Flow	None		0
		Tritium	Monitor Only		NA
		PCB 1260	Monitor Only		NA
		Lead, Copper, Nickel, Zinc	Monitor Only		NA
114	4	Flow	None		0
		Tritium	Monitor Only		NA
		PCB 1260	Monitor Only		NA
		Lead, Copper, Nickel, Zinc	Monitor Only		NA
115	12	Flow	None		0
		pH	6-9		0
		Temperature	< 2.8°C Rise		0
		TDS	Monitor Only		NA
116	18	Flow	None		0
		pH	6-9		0
		TRC	0.05		NA

^a NPDES Special Condition gives ANL-E two years to comply with the TRC limit.

^b NA = not applicable.

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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 5.8. No exceedances occurred during 1996.

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 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

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, and the rate is low enough to generally not discharge without rainwater to attain flow. The discharge is through a cement raceway to the south fork of the north branch of Freund Brook. Table 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

Outfall 003G. Footing tile drainage from the Inner Circle steam trench is pumped to the storm sewer passing around the northeast 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 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

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 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

Special Condition 9 of the NPDES permit requires acute toxicity testing on the effluent from Outfalls 003H, 003I, 003J, 004, 006, and 115. The testing is performed on the fathead minnow

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(*Pimephales promelas*) and daphnids (*Ceriodaphnia dubia*). The testing is performed on a biannual basis during the months of July and August. These outfalls were sampled during the periods of July 22 through 26 and August 12 through 16, 1996. Unlike 1995, in 1996, Outfall 003H was not acutely toxic to the fathead minnow and daphnids. The results are summarized in Tables 5.9 and 5.10.

Outfall 003I. This outfall collects storm water from Buildings 200, 211, and the western portion of Building 205 areas and also gets cooling tower discharge from the cooling tower located behind Building 200. Table 5.8 gives the sampling requirements and effluent limits. No exceedances were noted during 1996. Results of acute toxicity tests for Outfall 003I are presented in Tables 5.9 and 5.10. Outfall 003I was not acutely toxic to daphnids but was slightly toxic to the fathead minnow.

Outfall 003J. This outfall collects storm water from the Building 213 area and parking lot, which 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 5.8. No exceedances were noted during 1996. Results of acute toxicity tests for Outfall 003J are presented in Tables 5.9 and 5.10. Outfall 003J was not acutely toxic to the fathead minnow or daphnids.

Outfall 004. This outfall discharges storm water from the Building 203 and Building 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 5.8 gives the sampling requirements and effluent limits. No exceedances were noted during 1996. Results of acute toxicity tests for Outfall 004 are presented in Tables 5.9 and 5.10. Outfall 004 was not acutely toxic to the fathead minnow or daphnids.

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.

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TABLE 5.9

Acute Toxicity Results: Fathead Minnow, 1996

NPDES Outfall	96-Hour LC ₅₀ <i>P. promelas</i> July 22-26, 1996	96-Hour LC ₅₀ <i>P. promelas</i> August 12-16, 1996	Comments
003H	> 100%	> 100%	Not acutely toxic
003I	> 100%	100%	Slightly toxic
003J	> 100%	> 100%	Not acutely toxic
004	> 100%	> 100%	Not acutely toxic
006	> 100%	> 100%	Not acutely toxic
115	> 100%	> 100%	Not acutely toxic

TABLE 5.10

Acute Toxicity Results: *Ceriodaphnia*, 1996

NPDES Outfall	48-Hour LC ₅₀ <i>C. dubia</i> July 22-26, 1996	48-Hour LC ₅₀ <i>C. dubia</i> August 12-16, 1996	Comments
003H	> 100%	> 100%	Not acutely toxic to daphnids
003I	> 100%	> 100%	Not acutely toxic to daphnids
003J	> 100%	> 100%	Not acutely toxic to daphnids
004	> 100%	> 100%	Not acutely toxic to daphnids
006	47.7%	27.9%	Acutely toxic to daphnids
115	< 20%	< 20%	Acutely toxic to daphnids

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 clear water system discharges to this outfall, which passes through sewers to the west of the loading dock and to the beaver pond west of

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Building 200. The sampling requirements and effluent limits are given in Table 5.8. No exceedances occurred during 1996.

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 (36-in.) corrugated pipe into the pond. This is a storm water only discharge.

Outfall 005E. This outfall discharges footing tile drainage from the west side of Building 203 and Building 208. The outfall 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 5.8. No exceedances occurred during 1996.

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 5.8. No exceedances of NPDES limits occurred in 1996. Results of acute toxicity tests for Outfall 006 are presented in Tables 5.9 and 5.10. As in 1995, Outfall 006 was acutely toxic to *Ceriodaphnia* but not to the fathead minnow. The source of the acute toxicity is unknown.

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 5.8 gives the sampling requirements and effluent limits. From measurements made during the period of January through September, it was noted that occasional exceedances (17 out

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of 30 samples) of the TRC limit of 0.05 mg/L occurred. Special Condition 8 of the NPDES permit allowed ANL-E two years (until October 30, 1996) to achieve compliance with the 0.05 mg/L TRC limit. Therefore, the IEPA does not consider an exceedance of the TRC limit up to this date to be "reportable." Moreover, it was learned that certain oxidized chemical species such as bromine, iodine, ozone, oxidized manganese, oxidized copper, and oxidized chromium, could interfere with both the field or laboratory measurement of TRC and lead to erroneously high results. Laboratory analyses of the chemical species were conducted on samples that had elevated TRC values. It was found that total manganese, if in the oxidized state, could account for the elevated TRC readings. In a subsequent experiment, the oxidized manganese was separated and although it would not account for all the interference, it represented a significant fraction and indicated the presence of a strong oxidizing agent.

To obtain true TRC readings, masking reagents were added to the samples so that the interferences could be determined. After correcting for the interference, all TRC results are less than the limit of 0.05 mg/L. On the basis of these data, it was apparent that previous TRC results were erroneously recorded and that the true TRC values were within the permitted limit.

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, located directly west of Building 24. Industrial activity in this small watershed involves the activities 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. The only NPDES limit that applies at this point is pH. No exceedances were noted during 1996.

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

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water is pumped to the equalization basin located in the western area 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 1996.

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 with 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 WTP, 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 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 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.

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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, as well as Buildings 24 and 25. The area is served by a number of roadways leading to and from these buildings, with contributing storm grate inlets 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 receive runoff from areas around Building 40, elevated water tower tanks for potable water distribution, 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, Building 33, which has electrical transformers located outside of it, and a portion of Argonne Park. As is Outfall 105 above, this watershed is served by two distinct outfalls. The industrial activities within this watershed are 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 end 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). The industrial activities ongoing in this watershed are shipping and receiving, a metals reclaim dumpster (Building 363), loading dock activities, and numerous outdoor equipment storage areas. Table 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

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Outfall 110. The watershed for this outfall includes the 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 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 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 the 317 Area radioactive waste storage and remediation activities, the 319 Landfill Area, and the associated roadways for access. This outfall is sampled semiannually for flow and hydrogen-3 (tritium) and has no permit limits. Tritium results were less than 100 pCi/L during January and July 1996.

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 conjoin into one flow approximately 100 m (328 ft) south of the ANL-E fence line. Industrial activity within this watershed consists of the 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. Tritium results were less than 100 pCi/L during January and July 1996.

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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 seven months in 1996.

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 four months in 1996.

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 are the APS construction; all roadways associated with APS construction; loading docks in the APS buildings; and the Building 314, 315, and 316 complex storage, loading areas, and cooling water discharges. Table 5.8 gives the sampling requirements and effluent limits. No exceedances occurred during 1996.

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Results of acute toxicity tests for Outfall 115 are presented in Tables 5.9 and Table 5.10. Outfall 115 was acutely toxic to *Ceriodaphnia* but not to the fathead minnow. The source of the acute toxicity is unknown.

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 No. 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 5.8 gives the sampling requirements and effluent limits. TRC levels exceeded the NPDES permit limit of 0.05 mg/L in 8 out of 12 samples collected between January and September 1996. Special Condition No. 8 of the NPDES permit allows ANL-E two years (until October 30, 1996) to achieve compliance with the 0.05 mg/L TRC limit. Therefore, the IEPA does not consider an exceedance of the TRC limit up to this date to be "reportable." For reasons explained above for Outfall 007, it appears that these TRC results were erroneously recorded and that the true TRC values were within the permitted limit.

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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 5.11. The results are then compared to IEPA General Effluent Limits found in 35 IAC, Subtitle C, Part 304.²⁵

5.2.1. Sample Collection

Samples for analysis of inorganic constituents are collected daily from Outfall 001 located at the WTP using a refrigerated time proportional sampler. A portion of the sample is transferred to a clean bottle, a security seal is affixed, and chain of custody is maintained. Five daily samples are composited on an equal volume basis to produce a weekly sample that is then analyzed.

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 5.11 gives the results for 1996. Most of the annual average results did not exceed General Effluent Limits. The maximum concentration for zinc exceeded the General Effluent Limit²⁵ one time, probably because of the addition of zinc to the domestic water distribution system.

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

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TABLE 5.11

Chemical Constituents in Effluents from ANL-E Wastewater Treatment Plant, 1996
(Concentrations in mg/L)

Constituent	No. of Samples	Concentrations			Limit
		Avg.	Min.	Max.	
Arsenic	52	0.0022	<0.0020	0.0038	0.25
Barium	52	0.0233	0.0165	0.0333	2.0
Beryllium	52	^a	-	<0.0002	-
Cadmium	52	0.0001	<0.0001	0.0003	0.15
Chromium	52	-	-	<0.0200	1.0
Cobalt	52	0.0227	<0.0150	0.0254	-
Copper	52	0.0417	<0.0200	0.0938	0.5
Fluoride	52	0.4443	0.3100	0.6480	15.0
Iron	52	0.2647	0.1190	0.6400	2.0
Lead	52	0.0018	<0.0005	0.0051	0.2
Manganese	52	0.0368	<0.0150	0.1338	1.0
Mercury	52	0.0005	<0.0001	0.0074	0.5
Nickel	52	0.0215	<0.0200	0.0260	1.0
Silver	52	0.0012	<0.0010	0.0031	0.1
Thallium	52	-	-	<0.0015	-
Vanadium	52	0.0204	<0.0200	0.0428	-
Zinc	52	0.3838	0.1380	1.2300	1.0
pH (Units)	47	-	7.89	8.30	6.0-9.0

^a A hyphen indicates that all results were less than the detection limit.

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 to IEPA General Use Water Quality Standards found in 35 IAC, Subtitle C, Part 302.²⁶

5.3.1. Sample Collection

A proportional sampler is 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

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Creek water is assured. Samples are collected in precleaned, labeled bottles and security seals are used. After pH measurement, the daily samples are acidified and then combined into equal volume weekly composites and analyzed for the same set of inorganic constituents as those given in Table 5.12.

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. Fluoride was determined by a specific ion electrode.

5.3.2. Results

The results obtained are shown in Table 5.12. As in previous years, the annual average concentration for copper was above the Water Quality Standards (WQSs). The maximum concentrations for copper, iron, and zinc exceeded the WQS. Elevated levels of copper and zinc are probably due to leaching of copper from the domestic water distribution system (see Section 6.1.1). The cause of elevated iron levels is unknown but may be inadequate retention time of high flows that are known to contain increased coal-pile runoff discharges.

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TABLE 5.12

Chemical Constituents in Sawmill Creek: Location 7M,^a 1996
(Concentrations in mg/L)

Constituent	No. of Samples	Concentrations			Limit
		Avg.	Min.	Max.	
Arsenic	51	0.0022	<0.0020	0.0041	1.0
Barium	51	0.0484	0.0253	0.0958	5.0
Beryllium	51	- ^b	-	<0.0002	-
Cadmium	51	0.0004	<0.0001	0.0019	0.05
Chromium	51	0.0200	<0.0200	0.0230	1.0
Cobalt	51	-	-	<0.0250	-
Copper	51	0.0377	<0.0100	0.2470	0.02
Fluoride	51	0.3221	0.0200	0.5820	1.4
Iron	51	0.5160	0.1310	3.3200	1.0
Lead	51	0.0052	<0.0008	0.0428	0.1
Manganese	51	0.0825	0.0160	0.3220	1.0
Mercury	51	0.0001	<0.0001	0.0003	0.5
Nickel	51	0.0240	<0.0200	0.0400	1.0
Silver	51	-	-	<0.0010	0.005
Thallium	51	-	-	<0.0015	-
Vanadium	51	-	-	<0.0200	-
Zinc	51	0.2653	0.0530	1.3100	1.0
pH (Units)	49	-	7.08	8.29	6.5-9.0

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

^b A hyphen indicates that all results were less than the detection limit.

6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION

The groundwater below the ANL-E site is monitored through the collection and analysis of samples obtained from the on-site water supply wells and from a series of groundwater monitoring wells located near several sites that have the potential for causing groundwater impact. Federal and state drinking water regulations are used to evaluate the quality of groundwater used for human consumption at ANL-E. Regulations establishing comprehensive water quality standards for the protection of groundwater have been enacted — IEPA Groundwater Quality Standards, 35 IAC, Subtitle F, Part 620.²⁷ In addition, demonstration of compliance with the groundwater protection requirements in DOE Order 5400.1, 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. Potable Water System

The ANL-E domestic water was supplied by four wells that are described in Section 1.7 and Table 6.1 until January 1997 when Lake Michigan water was obtained. Their locations are shown in Figure 1.1. According to the National Primary Drinking Water Regulations,²¹ the ANL-E system is classified as a nontransient, noncommunity public water system, since it regularly serves at least 25 of the same persons over 6 months of the year. This designation determines the parameters to be monitored and the frequency of monitoring. Monitoring of the ANL-E domestic water supply is conducted to demonstrate compliance with applicable regulations and to obtain information on the concentrations of other constituents.

6.1.1. Regulatory Required Monitoring

By virtue of an incorporation by reference by the IDPH (the regulatory body for nontransient, noncommunity water systems), the primary regulations that applied to ANL-E were the drinking water regulations of the Illinois Pollution Control Board rules at 35 IAC 611. These rules identify the inorganic (Section 611.301), organic (Section 611.311), copper, lead, and water quality parameter (Section 611.356 through 611.359) constituents and monitoring requirements.

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TABLE 6.1

ANL-E Water Supply Wells

Well No.	Location	Well Elevation (ft AMSL)	Static Water Level	Bedrock Elevation	Well Depth (ft bgs)	Inner Diameter (in.)	Year Drilled
1	Building 31	671	≈ 613	605	284	12	1948
2	Building 32	664	≈ 612	601	300	12	1948
3	Building 163	689	≈ 609	600	318	12	1955
4	Building 264	716	≈ 608	595	340	14	1959

All chemical analyses were performed by a commercial laboratory that is certified by the State of Illinois to conduct SDWA analyses. Lead was determined by graphite furnace atomic absorption spectroscopy. Copper was determined by inductively-coupled plasma atomic emission spectroscopy. VOCs were determined by using a purge and trap sample pretreatment followed by gas chromatography-mass spectroscopy detection. The samples were analyzed for the VOCs specified in the regulations by an approved method that allows the minimum detectable limit of 0.0005 $\mu\text{g/L}$ to be met for the VOCs. Nitrate and fluoride were analyzed by using ion chromatography.

Samples were collected quarterly from each of the four ANL-E domestic wells (see Figure 1.1) and a treated tap water sample in Building 200. The tap water was analyzed for nitrate, cyanide, metals, VOCs, and synthetic organic chemicals. Antimony and thallium were analyzed by graphite furnace atomic absorption spectroscopy, while beryllium and nickel were determined by inductively coupled plasma atomic emission spectroscopy. Cyanide was determined by distillation followed by a spectrophotometric finish. Analysis of 2,3,7,8 tetrachlorodibenzodioxin was performed by solvent extraction followed by gas chromatography-mass spectroscopy electron capture detection or liquid chromatography and fluorescence detection. The results were provided to the DuPage County Health Department and the IDPH.

On March 17, 1993, the IDPH granted ANL-E a permanent waiver for sampling of asbestos and an extension to November 24, 1995, for the testing of inorganics/metals. On July 22, 1993,

6. GROUNDWATER PROTECTION

ANL-E submitted seven quarters of organic data and petitioned the IDPH for sampling/analysis waivers from the requirements. On August 6, 1993, the IDPH approved a waiver for the 18 Phase II Volatile Organic Compounds to November 24, 1998; a waiver for Synthetic Organic Chemicals/Herbicides-Pesticides to November 24, 1995; and a permanent waiver for all future sampling for unregulated chemicals. Future sampling is only required at a representative tap; however, wellhead sampling will be continued for informational monitoring of radionuclides and VOCs.

On the basis of requirements and direction from IDPH, the following required analyses were conducted in 1996. Nitrate analyses were conducted on the tap water sample collected February 12, 1996; the tap water sample collected on May 20, 1996, was analyzed for inorganic parameters (antimony, beryllium, cyanide, nickel, and thallium). The results are presented in Table 6.2. All concentrations were less than the State of Illinois MCL. The state also required that the one set of synthetic organic chemicals be analyzed. The tap water sample collected August 27, 1996, was analyzed for these compounds, and the results are listed in Table 6.3. All parameters were less than their respective detection limits and the state limits. Quarterly results of three VOCs (dichloromethane, 1,2,4-trichlorobenzene, and 1,1,2-trichloroethane) are part of the 1996 Phase V federally required analysis. These results are presented in Table 6.4. All results were below the detection limits.

Title 35, Section 611.356, of the IAC requires the collection of finished water samples for lead and copper analyses at selected sites to determine if the concentrations of more than 10% of the samples are above the action level of 0.015 mg/L for lead or 1.3 mg/L for copper. The required sampling protocols maximize the potential for the presence of lead and copper. Sampling locations are determined after a water piping materials survey. Priority sampling locations are those that have lead pipes, are served by lead service lines, or have copper pipes with lead solder joints. Samples must be drawn from where the water has stood motionless in the piping for at least six hours. Because of exceedance of the lead and copper action levels in 1994 and 1995, semiannual sampling was required in 1996 at 40 sites.

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TABLE 6.2

State of Illinois Required Inorganic Chemicals (900.50), 1996
(Concentrations in mg/L)

Chemical	Date Collected	State Limit	ANL-E Result
Nitrate	February 12	10	0.67
Antimony	May 20	0.006	<0.006
Beryllium	May 20	0.004	<0.004
Cyanide	May 20	0.2	<0.002
Nickel	May 20	0.1	<0.05
Thallium	May 20	0.002	<0.002

TABLE 6.3

State of Illinois Required Synthetic Organic Chemicals, 1996
(Concentrations in mg/L)

Chemical	State Limit	ANL-E Result
Dalapon	0.2	<0.02
Dinoseb	0.007	<0.0007
Diquat	0.02	<0.002
Endothal	0.1	<0.01
Endrin	0.002	<0.0002
Glyphosate	0.7	<0.07
Oxamyl (Vydate)	0.2	<0.02
Picloram	0.5	<0.05
Simazine	0.004	<0.0004
Benzo(a)pyrene	0.0002	<0.0002
Di(2-ethylhexyl)adipate	0.4	<0.04
Di(2-ethylhexyl) phthalate	0.006	<0.0006
Hexachlorobenzene	0.001	<0.0001
Hexachlorocyclopentadiene	0.05	<0.005
2,3,7,8-TCDD (dioxin)	3×10^{-8}	$<5 \times 10^{-9}$

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TABLE 6.4

Federally Required Phase V Volatile Organic Results, 1996
(Concentrations in mg/L)

Phase V Chemical	Date Collected			
	February 12	May 20	August 27	November 4
Dichloromethane	<0.0005	<0.0005	<0.0005	<0.0005
1,2,4-Trichlorobenzene	<0.0005	<0.0005	<0.0005	<0.0005
1,1,2-Trichloroethane	<0.0005	<0.0005	<0.0005	<0.0005

Samples were collected by following the above protocols on February 28, 1996, and August 15, 1996, and analyzed by a laboratory certified to conduct SDWA analyses; the results were transmitted to the IDPH through DOE on July 31, 1996, and October 1, 1996. The results indicated that more than 10% of the 40 copper results exceeded the action level for each sampling period, while less than 10% of the lead results exceeded the action level. The results are presented in Table 6.5.

6.1.2. Informational Monitoring

Samples were collected quarterly at the wellhead. These samples were analyzed for several types of radioactive constituents and VOCs to determine their presence in ANL-E drinking water. Samples from each well were tested for total alpha, total beta, hydrogen-3, and strontium-90. Annually, samples were also analyzed 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 6.6. For a nontransient, noncommunity water system, the following EPA limits are established for the nuclides measured in Table 6.6:

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

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TABLE 6.5

Copper and Lead Samples Collected February 28 and August 15, 1996
(Concentrations in mg/L)

Sample No.	February 28		August 15	
	Copper	Lead	Copper	Lead
1	<0.02	<0.005	<0.02	<0.005
2	0.04	<0.005	0.03	<0.005
3	0.09	<0.005	0.13	<0.005
4	0.17	<0.005	0.27	<0.005
5	0.25	<0.005	0.29	<0.005
6	0.27	<0.005	0.32	<0.005
7	0.27	<0.005	0.34	<0.005
8	0.30	<0.005	0.35	<0.005
9	0.36	<0.005	0.41	<0.005
10	0.41	<0.005	0.44	<0.005
11	0.45	<0.005	0.46	<0.005
12	0.46	<0.005	0.53	<0.005
13	0.49	<0.005	0.56	<0.005
14	0.49	<0.005	0.58	<0.005
15	0.52	<0.005	0.60	<0.005
16	0.60	<0.005	0.61	<0.005
17	0.60	<0.005	0.61	<0.005
18	0.61	<0.005	0.62	<0.005
19	0.62	<0.005	0.67	<0.005
20	0.63	<0.005	0.67	<0.005
21	0.63	<0.005	0.76	<0.005
22	0.64	<0.005	0.79	<0.005
23	0.65	<0.005	0.83	<0.005
24	0.65	<0.005	0.85	<0.005
25	0.74	<0.005	0.88	<0.005
26	0.77	<0.005	0.90	<0.005
27	0.88	<0.005	0.90	<0.005
28	0.89	<0.005	0.90	<0.005
29	0.89	<0.005	0.94	<0.005
30	0.99	<0.005	1.0	<0.005
31	1.0	<0.005	1.0	<0.005
32	1.1	0.005	1.0	<0.005
33	1.2	0.006	1.2	<0.005
34	1.4	0.008	1.3	<0.005
35	1.4	0.009	1.4	0.005
36	1.4	0.010	1.4	0.005
	(90th Percentile)	(90th Percentile)	(90th Percentile)	(90th Percentile)
37	1.7	0.013	1.5	0.006
38	1.9	0.018	1.7	0.008
39	2.1	0.020	1.9	0.010
40	2.7	0.065	2.4	0.015
Action Level	1.3	0.015	1.3	0.015

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TABLE 6.6

Radioactivity in ANL-E Domestic Wells, 1996
(Concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Avg.	Min.	Max.
Alpha (nonvolatile)	Well No. 1	4	7.0	4.6	11.1
	Well No. 2	4	4.4	2.5	5.1
	Well No. 3	4	3.0	2.1	4.0
	Well No. 4	4	2.5	1.4	3.4
	Tap	4	0.9	0.1	1.5
Beta (nonvolatile)	Well No. 1	4	16.5	14.8	18.2
	Well No. 2	4	11.1	10.1	12.6
	Well No. 3	4	10.3	8.4	12.2
	Well No. 4	4	10.5	9.0	12.0
	Tap	4	5.2	4.2	6.1
Hydrogen-3	Well No. 1	4	145	< 100	206
	Well No. 2	4	< 100	< 100	106
	Well No. 3	4	< 100	< 100	< 100
	Well No. 4	4	< 100	< 100	< 100
	Tap	4	< 100	< 100	< 100
Strontium-90	Well No. 1	4	0.28	< 0.25	0.39
	Well No. 2	4	< 0.25	< 0.25	< 0.25
	Well No. 3	4	< 0.25	< 0.25	< 0.25
	Well No. 4	4	< 0.25	< 0.25	< 0.25
	Tap	4	< 0.25	< 0.25	< 0.25
Radium-226	Well No. 1	1	-	-	0.46
	Well No. 2	1	-	-	0.83
	Well No. 3	1	-	-	1.04
	Well No. 4	1	-	-	1.16
	Tap	1	-	-	0.72
Radium-228	Well No. 1	1	-	-	0.42
	Well No. 2	1	-	-	0.91
	Well No. 3	1	-	-	1.04
	Well No. 4	1	-	-	0.88
	Tap	1	-	-	0.33
Uranium-234	Well No. 1	1	-	-	2.99
	Well No. 2	1	-	-	0.55
	Well No. 3	1	-	-	0.17
	Well No. 4	1	-	-	0.12
	Tap	1	-	-	0.49
Uranium-235	Well No. 1	1	-	-	0.11
	Well No. 2	1	-	-	0.02
	Well No. 3	1	-	-	0.01
	Well No. 4	1	-	-	< 0.01
	Tap	1	-	-	0.01
Uranium-238	Well No. 1	1	-	-	2.05
	Well No. 2	1	-	-	0.41
	Well No. 3	1	-	-	0.10
	Well No. 4	1	-	-	0.07
	Tap	1	-	-	0.36

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Well 1 was removed from service in 1990, and the system was not operated during 1996; however, samples were collected for monitoring. All the radiological results are in the normal range of concentrations for the various constituents except for strontium-90 in Well 1. The concentration of strontium-90 in Well 1 was 3% of the EPA drinking water standard. Since hydrogen-3 had been identified in Well 1 in the past, these radionuclides may be indicators of continued migration from the same source.

Although VOCs were not required to demonstrate compliance with the Drinking Water Regulations for 1996, the results are included in the informational monitoring section to determine if any past disposal practices have resulted in groundwater contamination and to support the environmental restoration program. Samples were collected quarterly, and the results are presented in Tables 6.7 through 6.10. Samples were analyzed for the SDWA volatile compounds and quantified by EPA Method 524.2. The limit of detection reported in the tables is the practical quantification limit, which is defined as 10 times the method detection limit.

The tap water samples indicated the presence of four VOCs (dichlorobromomethane, bromoform, chlorodibromomethane, and chloroform). These compounds are known to be associated with chlorination of drinking water, that is, trihalomethanes. In addition, low concentrations of xylene were found in the May 20, 1996, and August 27, 1996, tap water samples.

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 ranging from ditches filled with construction 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. The sites that are routinely monitored are the

6. GROUNDWATER PROTECTION

TABLE 6.7

Volatile Organic Compounds in Drinking Water Collected February 12, 1996
(Concentrations in mg/L)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Vinyl Chloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Carbon Tetrachloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1-Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
p-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Bromobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorobromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0044
Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0043
Bromomethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Chlorodibromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0095
Chloroethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0016
Chloromethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibromomethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m-Dichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
o-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
cis-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
trans-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,3-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
2,2-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Styrene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1,1,2,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.7 (Cont.)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Tetrachloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,2-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,3-Trichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dibromo-3-Chloropropane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ethylenedibromide (EDB)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Bromochloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
sec-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
tert-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorodifluoromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluorotrichloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexachlorobutadiene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Isopropylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Isopropyltoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Propylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,3-Trichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,4-Trichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,4-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3,5-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.8

Volatile Organic Compounds in Drinking Water Collected May 20, 1996
(Concentrations in mg/L)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Vinyl Chloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Carbon Tetrachloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1-Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
p-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Bromobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorobromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0086
Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0009
Bromomethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Chlorodibromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0061
Chloroethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0081
Chloromethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibromomethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m-Dichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
o-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
cis-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
trans-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,3-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
2,2-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Styrene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1,1,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.8 (Cont.)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Tetrachloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,2-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,3-Trichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0009
o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dibromo-3-Chloropropane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ethylenedibromide (EDB)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Bromochloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
sec-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
tert-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorodifluoromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluorotrichloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexachlorobutadiene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Isopropylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Isopropyltoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Propylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,3-Trichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,4-Trichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,4-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3,5-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.9

Volatile Organic Compounds in Drinking Water Collected August 27, 1996
(Concentrations in mg/L)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Vinyl Chloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Carbon Tetrachloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1-Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
p-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Bromobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorobromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0130
Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0012
Bromomethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Chlorodibromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0096
Chloroethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0130
Chloromethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibromomethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m-Dichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
o-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
cis-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
trans-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,3-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
2,2-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Styrene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1,2,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.9 (Cont.)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Tetrachloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,2-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,3-Trichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0007
o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dibromo-3-Chloropropane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ethylenedibromide (EDB)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Bromochloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
sec-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
tert-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorodifluoromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluorotrichloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexachlorobutadiene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Isopropylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Isopropyltoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Propylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,3-Trichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,4-Trichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,4-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3,5-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.10

Volatile Organic Compounds in Drinking Water Collected November 4, 1996
(Concentrations in mg/L)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Vinyl Chloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Carbon Tetrachloride	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1-Trichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
p-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Bromobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorobromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0140
Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0015
Bromomethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Chlorodibromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0110
Chloroethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0130
Chloromethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Chlorotoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibromomethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m-Dichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
o-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1-Dichloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
cis-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
trans-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,3-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
2,2-Dichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,1-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3-Dichloropropene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Styrene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,1,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

6. GROUNDWATER PROTECTION

TABLE 6.10 (Cont.)

Parameter	Well 1	Well 2	Well 3	Well 4	Tap
1,1,2,2-Tetrachloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Tetrachloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,1,2-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,3-Trichloropropane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.005
o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2-Dibromo-3-Chloropropane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ethylenedibromide (EDB)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Bromochloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
sec-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
tert-Butylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorodifluoromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluorotrichloromethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexachlorobutadiene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Isopropylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
p-Isopropyltoluene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
n-Propylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,3-Trichlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,2,4-Trichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
1,2,4-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1,3,5-Trimethylbenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

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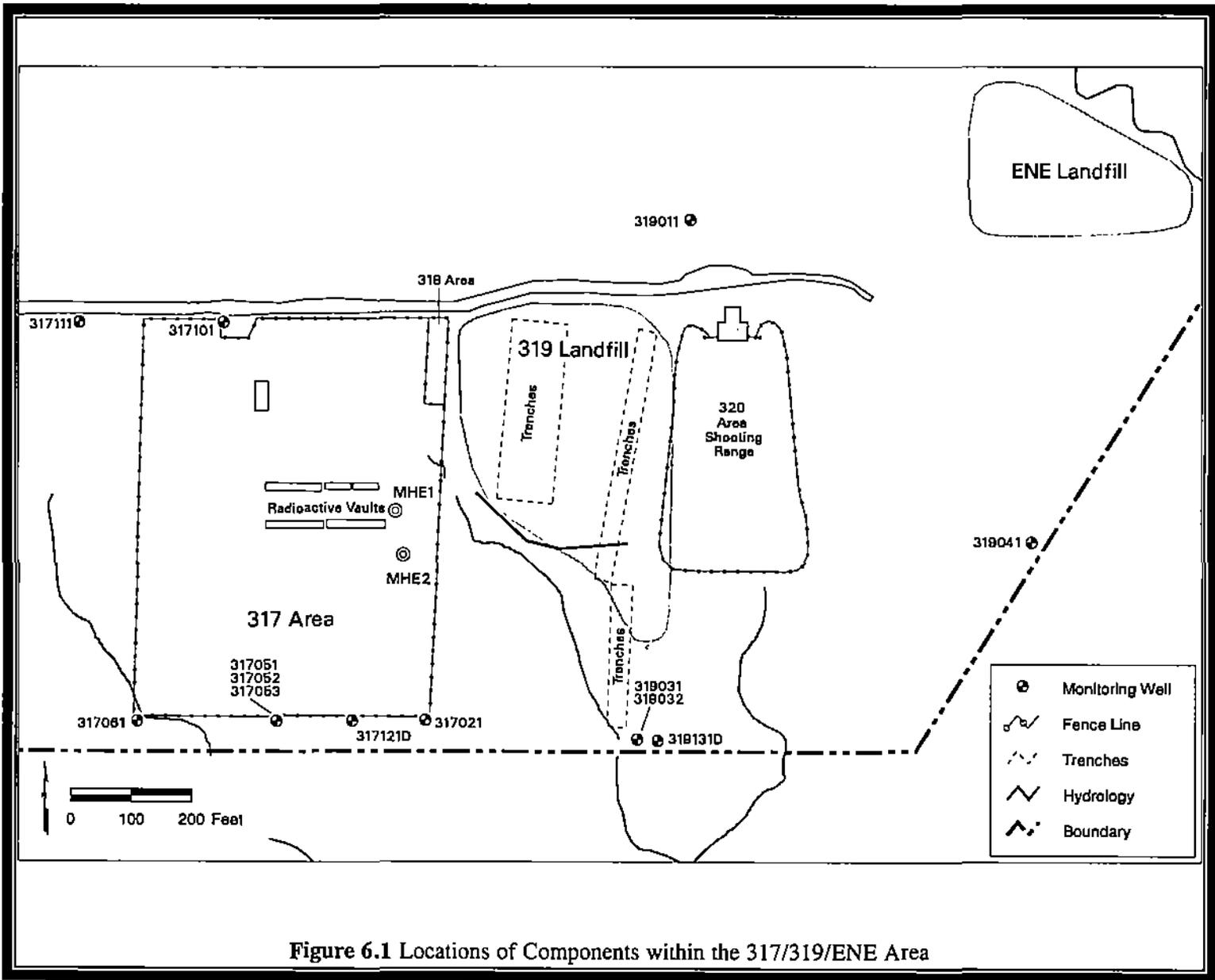
sanitary landfill in the 800 Area and the 317/319 Area, which consists of eight separate waste management units located within a small geographical area. The site of an inactive experimental reactor, CP-5, is also monitored periodically to determine if any releases of radionuclides occurred from this unit.

6.2.1. 317/319 Area

Management of waste has been conducted in eight separate units within the 317 and 319 Areas. The 317 Area is currently used as a temporary storage area for radioactive waste before it is shipped off site for disposal. The area also contained two RCRA-permitted units that were formally closed during 1994 and one permitted area that is still active. The 319 Area is an inactive landfill adjacent to the 317 Area. In addition to these units, a second landfill site, the ENE landfill, is located to the east-northeast of the 319 Area. This unit was used in the late 1940s and early 1950s primarily for the disposal of construction debris from several sites, including the University of Chicago's Manhattan Project. Figure 6.1 is a sketch of the 317/319 Area.

The most significant units in this area in terms of groundwater impact are an inactive French drain (dry well) in the 317 Area and the landfill and French drain in the 319 Area. The 317 Area French Drain operated until the mid 1950s and was used for disposal of unknown amounts of liquid chemical wastes. The landfill at 319 was operated from the mid-1950s until 1968. The French drain, similar to the one in the 317 Area, was operated until 1968. Quantities of a wide variety of liquid wastes, including heavy metals, solvents, and waste oil, some containing PCBs, were poured into this drain.

A series of interim actions was completed in the 317/319 Area to minimize potential releases of hazardous and radioactive materials off site. The 317 Area contained six vaults used for temporary storage of solid radioactive waste. Water from footing drains and/or sumps was collected and discharged into a sewer system. This sewer system, which was designed to drain off site, was closed permanently in 1986 after it was discovered that the water contained very small amounts of several radionuclides. Water collecting in the sewer system periodically was pumped out from manholes into portable tanks, transported to the Waste Management Building,



6. GROUNDWATER PROTECTION

and analyzed for radioactivity before release to the laboratory wastewater collection system. During August 1993, water from these manholes was discharged to the laboratory sewer system. Monthly samples from two manholes associated with this system were analyzed for VOCs. The results are presented in Section 6.2.2.3. The D&D of the 317 Area South Vaults, a former radioactive storage area, was completed. The vaults were decontaminated to low residual radioactivity levels before they were demolished and buried in place.

The 319 Area currently consists of a mound created by waste fill activities. The waste consisted of noncombustible refuse and demolition and construction debris. In addition, suspect waste (material that was not known to be contaminated but that had the potential for hidden radioactive contamination that could not be confirmed by direct measurement, such as the inside of long pipes or ductwork) was also placed in this unit. The landfill consisted of a number of trenches, 3 to 5 m (10 to 15 ft) deep, which were filled with waste material. When the trenches were filled with waste, they were covered with soil. Geophysical surveys have identified at least three of these trenches. One critical action was completed at the 319 Area Landfill. A complex series of underground structures, groundwater barrier and extraction wells, was constructed to prevent the off-site migration of radioactive and chemically contaminated groundwater from the 319 Area.

The French drain in the 319 Area was constructed in the late 1950s in an area of the fill material by placing a corrugated steel pipe vertically into a gravel-filled excavation and backfilling around the pipe. Waste liquids were poured into the pit and flowed into the pipe.

The ENE landfill is believed to consist primarily of construction debris and other noncombustible rubbish such as metal turnings and empty steel drums. The waste was placed in a natural ravine and covered with soil.

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6.2.2. Groundwater Monitoring at the 317/319 Area

Ten active monitoring wells (some of which are clustered or nested) are installed at the locations shown in Figure 6.2. Well data are listed in Table 6.11. The wide range in water level elevations shown in Table 6.11 is not unusual and is due to the fact that some of the wells are screened at different depths in different saturated zones. 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 Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).²⁸

Groundwater monitoring in the 317/319 Area has been conducted since 1986. Wells 319011, 317021, and 319031 were installed in September 1986; 317061 in August 1987; 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. 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. Well 319071, which was dry, was sealed in September 1995 in accordance with state and county well code regulations.

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) was recently discovered and Wells 317052 and 319032 were placed at this depth. 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. The location of the manholes is shown in Figure 6.1.

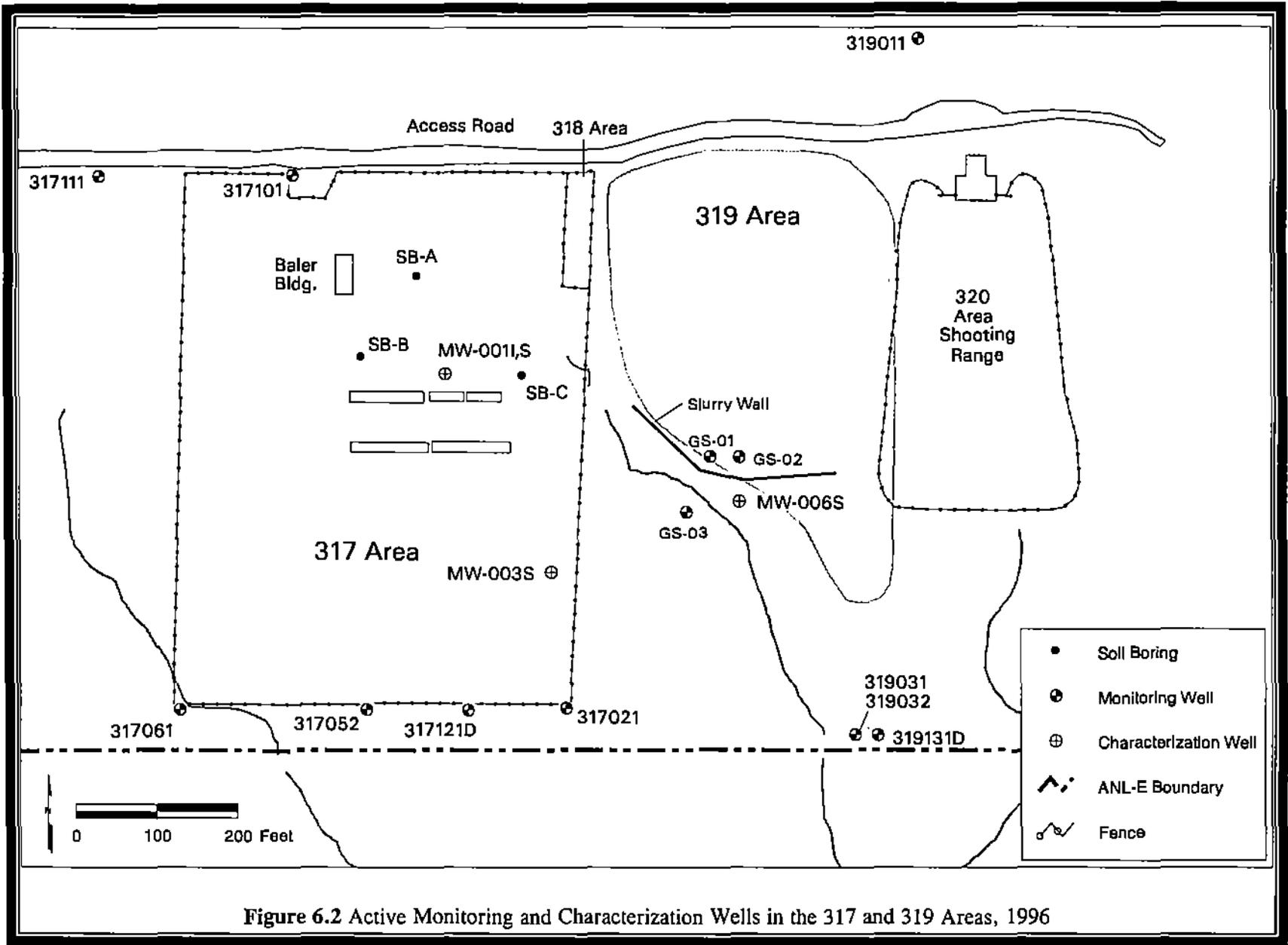


Figure 6.2 Active Monitoring and Characterization Wells in the 317 and 319 Areas, 1996

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TABLE 6.11

Groundwater Monitoring Wells: 317/319 Area

ID Number	Well Depth (ft bgs)	Ground Elevation (ft AMSL)	Monitoring Zone ^a	Well Type ^b	Date Drilled	Water Elevation
319011	40	688.3	35-40/653-648	2/PVC	9/86	655.8
317021	40	686.2	35-40/651-646	2/PVC	9/86	664.2
319031	41	670.2	36-41/634-629	2/PVC	9/86	633.0
319032	25	670.2	20-25/650-645	2/PVC	8/89	650.5
317051	20	683.4	15-20/668-663	2/PVC	7/87	Not Measured
317053	22	683.4	17-22/666-661	2/PVC	8/89	Dry
317052	14	683.4	9-14/674-669	2/PVC	8/89	676.0
317061	40	680.9	35-40/646-641	2/PVC	7/87	659.4
317101	39	692.3	29-39/663-653	2/PVC	8/89	670.2
317111	39	689.8	29-39/670-660	2/PVC	8/89	682.8
317121D	79	681.0	69-79/612-602	6/CS	9/88	612.4
319131D	69	667.8	59-69/609-599	6/CS	9/88	607.1

Note: Wells identified by a "D" are deeper wells monitoring the dolomite bedrock aquifer.

^a Depth/elevation.

^b Inner diameter (in.)/well material (PVC = polyvinyl chloride, CS = carbon steel).

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 that might restrict water movement in the screen 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 to 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

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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, SVOCs, PCB/pesticides, metals, 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 the course of time. In addition, a field blank is also obtained.

6.2.2.2. Sample Analyses - 317/319 Area

The 317/319 groundwater chemical analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of ESH-ASCH. These SOPs reference protocols found in SW-846, 3rd edition, "Test Methods for Evaluating Solid Waste."⁷ Sixteen metals were routinely determined. They were measured 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. 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 spectroscopy detection. PCB/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 317/319 groundwater radiological analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of ESH-ASRC. 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.

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6.2.2.3. Results of Analyses

The description of each well, a list of field parameters measured during sample collection, and the results of chemical and radiological analyses of samples from the wells in the 317/319 Area are contained in Tables 6.12 through 6.21. All radiological and inorganic analytical results are shown in these tables. The analysis 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 $\mu\text{g/L}$.

Field Results. The purging of wells to produce water representative of the groundwater being studied is followed by measuring the field parameters. For the wells reported in this study, temperature, pH, and specific conductance remained fairly constant after two well volumes were removed. The redox potential stabilizes after two well volumes are removed. On the basis of this information, sampling is 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 are measured on one well volume. Well 319031 was dry during the first, second, and fourth quarters.

Inorganic Results. ANL-E chose to use 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 6.22 and 6.23. In 1996, all samples for metals analyses were field-filtered prior to preservation with acid (IEPA requirement for the IEPA-approved groundwater monitoring program at the 800 Area Landfill, Section 6.3.2.3). As noted in previous years, no elevated levels, with respect to the WQS for the inorganics, were noted with the exception of pH at dolomite Well 317121D and chloride at Wells 317101 and 317111. The pH changes drastically between the purging of two to five volumes of water. In each case, the last value obtained was

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TABLE 6.12

Groundwater Monitoring Results, 300 Area Well 317021, 1996^a

Constituent	Units	Date of Sampling				
		03/05/96	05/24/96	09/12/96	11/13/96	11/13/96
Water Elevation	m	198.73	199.89	200.61	199.73	199.73
Temperature	°C	9.6	10.7	11.5	9.9	9.9
pH	pH	7.78	7.40	7.53	7.39	7.39
Redox	mV	-24	-63	-25	-9	-9
Conductivity	µmhos/cm	824	860	827	797	797
Chloride - Filtered	mg/L	17	28	20	20	21
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0319	0.0323	0.0334	0.0614	0.0603
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0362	0.0360	0.0378	0.0974	0.1027
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	1.0	< 1.0
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	0.169	0.168
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
1,1,1-Trichloroethane	µg/L	91	75	57	48	45
1,1-Dichloroethane	µg/L	46	33	39	40	35
1,1-Dichloroethene	µg/L	0.6	0.5	0.5	0.8	3.0
1,2-Dichloroethane	µg/L	0.7	^b	4.0	0.4	0.2
Carbon tetrachloride	µg/L	4	3	2	2	2
Chloroform	µg/L	2	2	2	2	1
Methylene Chloride	µg/L	0.9	-	-	-	-
Tetrachloroethene	µg/L	1	1	0.7	1	1
Trichloroethene	µg/L	4	3	2	4	4
Vinyl Chloride	µg/L	0.8	0.6	-	-	-
cis-1,2-Dichloroethene	µg/L	-	-	-	0.2	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.13

Groundwater Monitoring Results, 300 Area Well 317052, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/24/96	09/13/96	11/13/96
Water Elevation	m	204.72	205.36	204.53	204.36
Temperature	°C	7.5	8.2	12.9	11.3
pH	pH	7.51	7.27	8.65	7.40
Redox	mV	-11	-77	-74	-11
Conductivity	µmho/cm	684	711	811	722
Chloride - Filtered	mg/L	2	2	2	2
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0233	0.0217	0.0659	0.0237
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	< 0.0250	0.1286	< 0.0250
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0334	0.0954	0.0408	0.0100
Cesium-137	pCi/L	1.4	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	2	- ^b	-	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.14

Groundwater Monitoring Results, 300 Area Well 317061, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/24/96	09/13/96	11/13/96
Water Elevation	m	198.49	199.18	198.89	198.83
Temperature	°C	10.4	10.0	10.5	10.0
pH	pH	7.32	6.94	7.40	7.21
Redox	mV	-20	-43	-19	1
Conductivity	µmho/cm	1076	1102	1071	1108
Chloride - Filtered	mg/L	60	52	57	62
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0541	0.0488	0.0688	0.0942
Beryllium- Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	< 0.0250	0.2018	0.0289
Lead - Filtered	mg/L	< 0.0005	< 0.0005	0.0010	< 0.0005
Manganese - Filtered	mg/L	0.0154	0.0174	0.0251	0.0122
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	0.076	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0199	0.0560	0.0335	0.0310
Cesium-137	pCi/L	- ^b	< 1.0	1.2	< 1.0
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.15

Groundwater Monitoring Results, 300 Area Well 317101, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/24/96	09/12/96	11/13/96
Water Elevation	m	201.83	202.13	202.72	202.36
Temperature	°C	11.5	11.5	12.7	11.0
pH	pH	7.07	7.08	7.19	6.87
Redox	mV	13	-28	-5	20
Conductivity	µmhos/cm	1950	2740	2200	2050
Chloride	mg/L	506	600	387	369
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0745	0.0873	0.0714	0.1186
Beryllium - Filtered	mg/L	< 0.0002	0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0349	0.0122	0.0232	0.0460
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0100	0.0667	0.0337	0.0353
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	2	- ^b	-	-
Methylene chloride	µg/L	1	-	-	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.16

Groundwater Monitoring Results, 300 Area Well 317111, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/24/96	09/12/96	11/14/96
Water Elevation	m	202.19	203.04	203.32	202.74
Temperature	°C	11.1	12.7	11.4	10.6
pH	pH	7.34	7.45	7.34	6.95
Redox	mV	-11	-14	-17	16
Conductivity	µmho/cm	1440	1350	1298	1615
Chloride - Filtered	mg/L	182	212	162	275
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0792	0.0726	0.0734	0.0937
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	< 0.0250	< 0.0250	0.1292
Lead - Filtered	mg/L	0.0006	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0555	0.0865	0.0430	0.0649
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0100	0.0291	0.0417	0.0540
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	3	- ^b	-	-
Methylene chloride	µg/L	1	-	-	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.17

Groundwater Monitoring Results, 300 Area Well 317121D, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	03/05/96	09/13/96	11/13/96
Water Elevation	m	186.34	186.34	186.37	186.35
Temperature	°C	10.9	10.9	12.3	10.6
pH	pH	11.18	11.18	12.04	11.40
Redox	mV	-295	-295	-228	- 235
Conductivity	µmhos/cm	841	841	608	673
Chloride - Filtered	mg/L	51	49	40	44
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0428	0.0389	0.0608	0.0488
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	< 0.0250	< 0.0250	0.0864
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0104	0.0101	< 0.0100	0.0107
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	0.134	< 0.1	0.107	< 0.1
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	- ^b	-	2	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.18

Groundwater Monitoring Results, 300 Area Well 319011, 1996^a

Constituent	Units	Date of Sampling				
		03/05/96	05/24/96	09/13/96	09/13/96	11/14/96
Water Elevation	m	198.70	199.39	200.27	200.27	199.23
Temperature	°C	10.3	10.8	10.6	10.6	10.3
pH	pH	7.14	7.16	7.33	7.33	6.99
Redox	mV	-10	-9	-15	-15	13
Conductivity	µmhos/cm	1179	1190	1226	1226	1226
Chloride - Filtered	mg/L	41	49	54	59	62
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0364	0.0352	0.0362	0.0312	0.0378
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	0.0009	0.0007	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Lead - Filtered	mg/L	0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	< 0.0100	< 0.0100	0.0149	0.0101	0.0140
Mercury - Filtered	mg/L	< 0.0001	0.0006	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0148	0.0436	0.0231	0.0387	0.0622
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.19

Groundwater Monitoring Results, 300 Area Well 319031, 1996^a

Constituent	Units	Date of Sampling 09/12/96
Water Elevation	m	193.12
Temperature	°C	11.1
pH	pH	7.24
Redox	mV	-11
Conductivity	μmhos/cm	1028
Chloride - Filtered	mg/L	25
Arsenic - Filtered	mg/L	< 0.002
Barium - Filtered	mg/L	0.0563
Beryllium - Filtered	mg/L	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001
Chromium - Filtered	mg/L	< 0.02
Cobalt - Filtered	mg/L	< 0.015
Copper - Filtered	mg/L	< 0.02
Iron - Filtered	mg/L	< 0.025
Lead - Filtered	mg/L	< 0.0005
Manganese - Filtered	mg/L	< 0.01
Mercury - Filtered	mg/L	< 0.0001
Nickel - Filtered	mg/L	< 0.025
Silver - Filtered	mg/L	< 0.001
Thallium - Filtered	mg/L	< 0.0015
Vanadium - Filtered	mg/L	< 0.02
Zinc - Filtered	mg/L	0.0879
Cesium-137	pCi/L	< 1.0
Hydrogen-3	nCi/L	1.001
Strontium-90	pCi/L	0.35
1,1,1-Trichloroethane	μg/L	2
1,1-Dichloroethane	μg/L	0.4
Trichloroethene	μg/L	3
Trichlorofluoromethane	μg/L	0.5

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

6. GROUNDWATER PROTECTION

TABLE 6.20

Groundwater Monitoring Results, 300 Area Well 319032, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/24/96	09/12/96	11/13/96
Water Elevation	m	196.86	197.19	197.51	197.29
Temperature	°C	10.0	9.8	10.8	10.3
pH	pH	7.09	7.07	7.34	7.07
Redox	mV	11	-37	-19	8
Conductivity	µmhos/cm	1106	1189	1086	1101
Chloride - Filtered	mg/L	24	24	17	19
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0577	0.0599	0.0681	0.0622
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0344	0.0625	0.0532	0.0130
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	0.663	0.564	0.447	0.497
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Dichlorofluoromethane	µg/L	- ^b	-	0.4	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); Casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.21

Groundwater Monitoring Results, 300 Area Well 319131D, 1996^a

Constituent	Units	Date of Sampling		
		03/05/96	09/13/96	11/13/96
Water Elevation	m	184.27	184.43	184.35
Temperature	°C	10.9	11.3	10.2
pH	pH	6.99	7.51	7.22
Redox	mV	-14	-24	0.1
Conductivity	µmhos/cm	1102	1094	1114
Chloride - Filtered	mg/L	49	47	51
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0752	0.0723	0.0699
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	0.0006
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	0.0267	< 0.0250
Lead - Filtered	mg/L	< 0.0005	0.0116	< 0.0005
Manganese - Filtered	mg/L	< 0.01	< 0.01	< 0.01
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0100	0.0228	< 0.0100
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	1.159	1.194	1.295
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25
Carbon Tetrachloride	µg/L	- ^b	0.2	0.3
Methylene Chloride	µg/L	0.8	-	-

^a Well point elevation = 196.90 m (MSL); ground surface elevation = 209.17 m (MSL); casing material = PVC.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.22

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 units

6. GROUNDWATER PROTECTION

TABLE 6.23

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

Constituent	Standard
Alachlor	0.002
Aldicarb	0.003
Atrazine	0.003
Benzene	0.005
Benzo(a)pyrene	0.0002
Carbofuran	0.04
Carbon Tetrachloride	0.005
Chlordane	0.002
Dalapon	0.2
Dichloromethane	0.005
Di(2-ethylhexyl)phthalate	0.006
Dinoseb	0.007
Endothall	0.1
Endrin	0.002
Ethylene Dibromide	0.00005
Heptachlor	0.0004
Heptachlor Epoxide	0.0002
Hexachlorocyclopentadiene	0.05
Lindane	0.0002
2,4-D	0.07
o-Dichlorobenzene	0.6
p-Dichlorobenzene	0.075
1,2-Dibromo-3-Chloropropane	0.0002
1,2-Dichloroethane	0.005
1,1-Dichloroethene	0.007
cis-1,2-Dichloroethylene	0.07
trans-1,2-Dichloroethylene	0.1
1,2-Dichloropropane	0.005
Ethylbenzene	0.7
Methoxychlor	0.04
Monochlorobenzene	0.1
Pentachlorophenol	0.001

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TABLE 6.23 (Cont.)

Constituent	Standard
Phenols	0.1
Picloram	0.5
PCBs (decachlorobiphenyl)	0.0005
Simazine	0.004
Styrene	0.1
2,4-5-TP (Silvex)	0.05
Tetrachloroethylene	0.005
Toluene	1
Toxaphene	0.003
1,1,1-Trichloroethane	0.2
1,1,2-Trichloroethane	0.005
1,2,4-Trichlorobenzene	0.07
Trichloroethylene	0.005
Vinyl Chloride	0.002
Xylenes	10

recorded. Several wells had elevated levels of barium and manganese, but well below the WQS. Barium concentrations in these wells ranged from 0.03 mg/L to 0.12 mg/L, and manganese levels ranged from less than 0.01 mg/L to 0.08 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.¹⁷

Organic Results. Each well was sampled quarterly and analyzed for VOCs. The results for 1996 are similar to those reported for 1995 except no VOCs were noted in Wells 317061 and 319011. VOCs were detected in Wells 317021, 319031, 319032, 317052, 317101, 317111, 317121D, and 319131D. The levels of volatile organics in most of the wells are infrequent and at very low concentrations. The exception is Well 317021, which shows persistent volatile organic levels as in the past, and Well 319031, which was dry for three quarters. No organic WQSs were exceeded. Once during the year, the wells were sampled and analyzed for SVOCs, PCBs, and pesticides and herbicides. In 1996, no semivolatiles, PCBs, pesticides, or herbicides were found.

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Figure 6.3 shows the results for Well 317021. The major components are 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane, which can be a decomposition product of TCA. As can be seen, the concentrations roughly parallel each other and the levels found are remarkably constant until 1991, at which time a substantial increase is seen. The previous consistency 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 could be related to restricted flow of normal dilution water. Trace levels of carbon tetrachloride, chloroform, 1,2-dichloroethane, methylene chloride, tetrachloroethene, trichloroethene (TCE), vinyl chloride, and cis-1,2-dichloroethene were also found in this well but at levels well below the WQS; cis-1,2-dichloroethene (1,2-DCE) is a decomposition product of TCE. The well is immediately below a former sewer line that was known to be contaminated. The sewer line was permanently closed in 1986.

Well 319031 is frequently dry but contains organic constituents when water is present. During 1996, this well was sampled one quarter, and levels of VOCs were well below the WQS

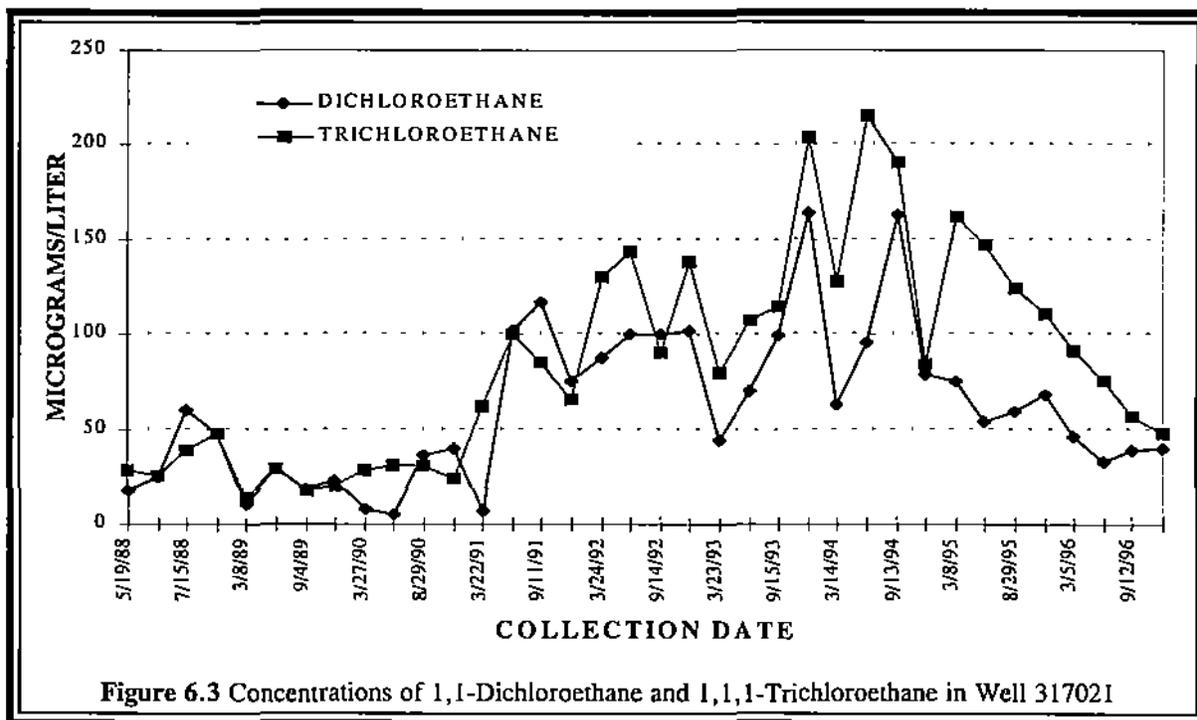


Figure 6.3 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well 317021

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where appropriate. Dolomite Well 317121D had trace levels of only acetone during only one quarter and dolomite Well 319131D infrequently showed trace levels of only carbon tetrachloride and methylene chloride. The dolomite wells could not be sampled during the second quarter because of poor road conditions.

PCB compounds were reported in several of the wells in 1990. These wells were resampled in 1991, 1992, 1993, 1994, and 1995, and no PCBs were indicated. Semivolatile organics and pesticides/herbicides were not detected in any of the wells during 1996.

Manholes E1 and E2, described in Sections 6.2.1 and 6.2.2, in the 317 Area are sampled monthly and analyzed for VOCs. The results are presented in Table 6.24. Existing foundation drains around storage vaults convey groundwater away from the structures and into manholes E1 and E2. Cis-1,2-dichloroethene is a degradation product of TCE. Vinyl chloride is a degradation product of cis-1,2-dichloroethene. Vinyl chloride was consistently (11 months) noted in Manhole E2. Chloroform is a degradation product of carbon tetrachloride. The levels of these constituents are detected at fairly consistent levels in all samples as shown in Figure 6.4. The consistency would indicate that these manholes are collecting an area of contaminated water. The fact that levels are constant and the TCE, 1,2-DCE, carbon tetrachloride, and chloroform are present in most of the samples, indicates an ongoing release of these compounds into the groundwater, such as from highly contaminated soils. Trace levels of acetone, benzene, bromochlorofluoromethane, bromodichloromethane, bromoform, 1,1-dichloroethane, trans-1,2-dichloroethene, 1,2-dichloroethane, 1,2-dibromoethene, 1,4-dioxane, trichlorofluoromethane, 4-methyl-2-pentanone, 4-methyl-2-pentanol, ethyl ether, methylene chloride, tetrahydrofuran, tribromoethene, and vinyl chloride have been found but not on a consistent basis. The source of these compounds is believed to be the French drains previously described in Section 6.2.1; however, additional characterization activities described in Section 6.5.2 will better define the nature, rate, and extent of contamination at this location.

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TABLE 6.24

Volatile Organic Compounds in 317 Area: Manholes E-1 and E-2, 1996
(Concentrations in $\mu\text{g/L}$)

Date	Chloroform		Tetra-chloroethene		Tri-chloroethene		cis-1,2-Dichloroethene		Carbon Tetrachloride	
	E-1	E-2	E-1	E-2	E-1	E-2	E-1	E-2	E-1	E-2
1/8/96	469	58	69	37	14	3	8	3	922	259
2/7/96	669	122	89	46	56	15	40	19	530	153
3/11/96	65	3	30	12	6	8	15	23	242	44
4/10/96	103	2	22	2	7	6	9	20	128	3
5/7/96	838	2	62	3	62	8	45	20	607	4
6/13/96	969	4	67	5	74	18	58	66	720	13
7/10/96	983	< 1	70	2	73	15	57	51	751	3
8/8/96	796	28	51	1	55	13	59	41	572	29
9/5/96	150	2	17	4	32	26	72	75	144	8
10/9/96	636	4	71	6	70	16	47	39	502	8
11/6/96	78	1	28	3	21	8	30	30	166	5
12/4/96	100	7	68	24	20	9	18	19	< 1	35

Radioactive Constituents. Samples collected quarterly from the monitoring wells in the 317 and 319 Areas were analyzed for hydrogen-3, strontium-90, and gamma-ray emitters. The results are presented in Tables 6.12 to 6.21. Similar to 1995 results, evidence of possible off-site migration of radionuclides is noted by the low concentrations of hydrogen-3 in Wells 319031, 319032, and 319131D, which are located near the south perimeter fence. In 1996, hydrogen-3 was also noted in Wells 317021 and 317121D, located south of the 317 Area. During one quarter, a small amount of cesium-137 was detected in Wells 317021, 317052, and 317061. These wells are located at the 317 Area south fence. A small amount of strontium-90 was also detected one quarter in Well 319031. This monitoring well is 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.

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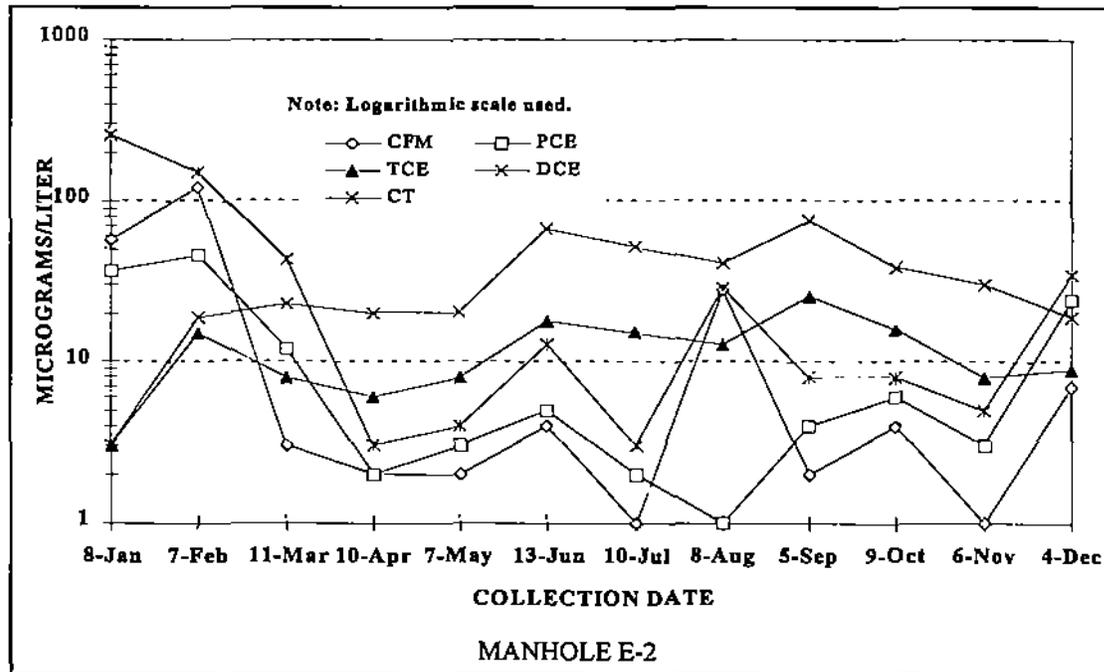
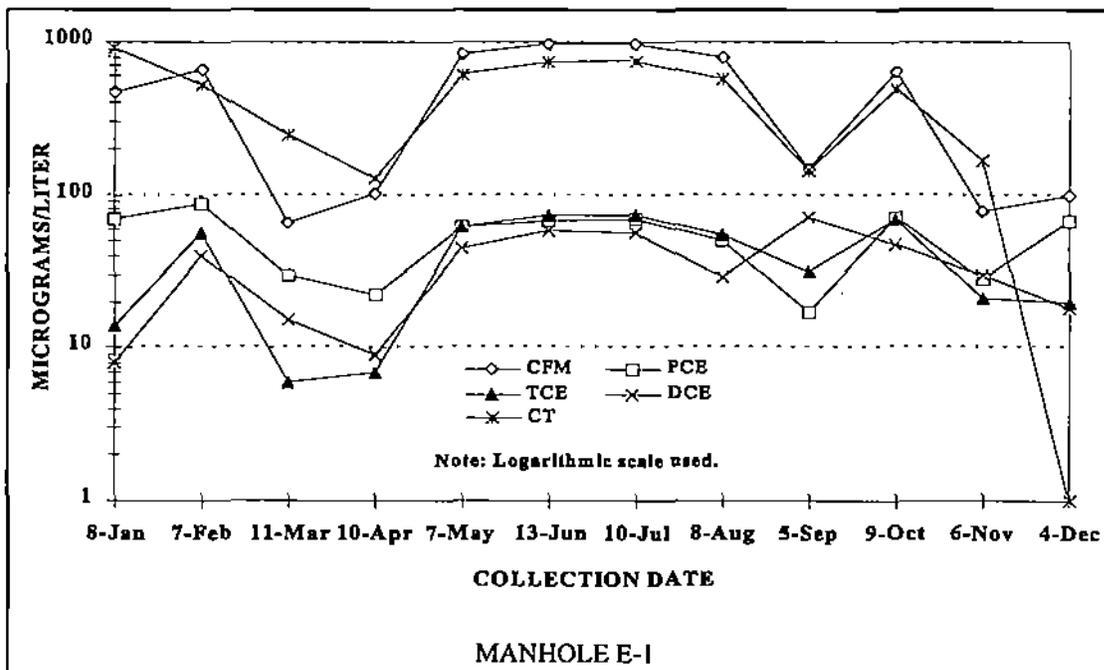


Figure 6.4 Trends of Selected Organics in 317 Area Manholes, 1996

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6.3. Sanitary Landfill

The 800 Area is the site of ANL-E's 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 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 No. 1994-506-SP.

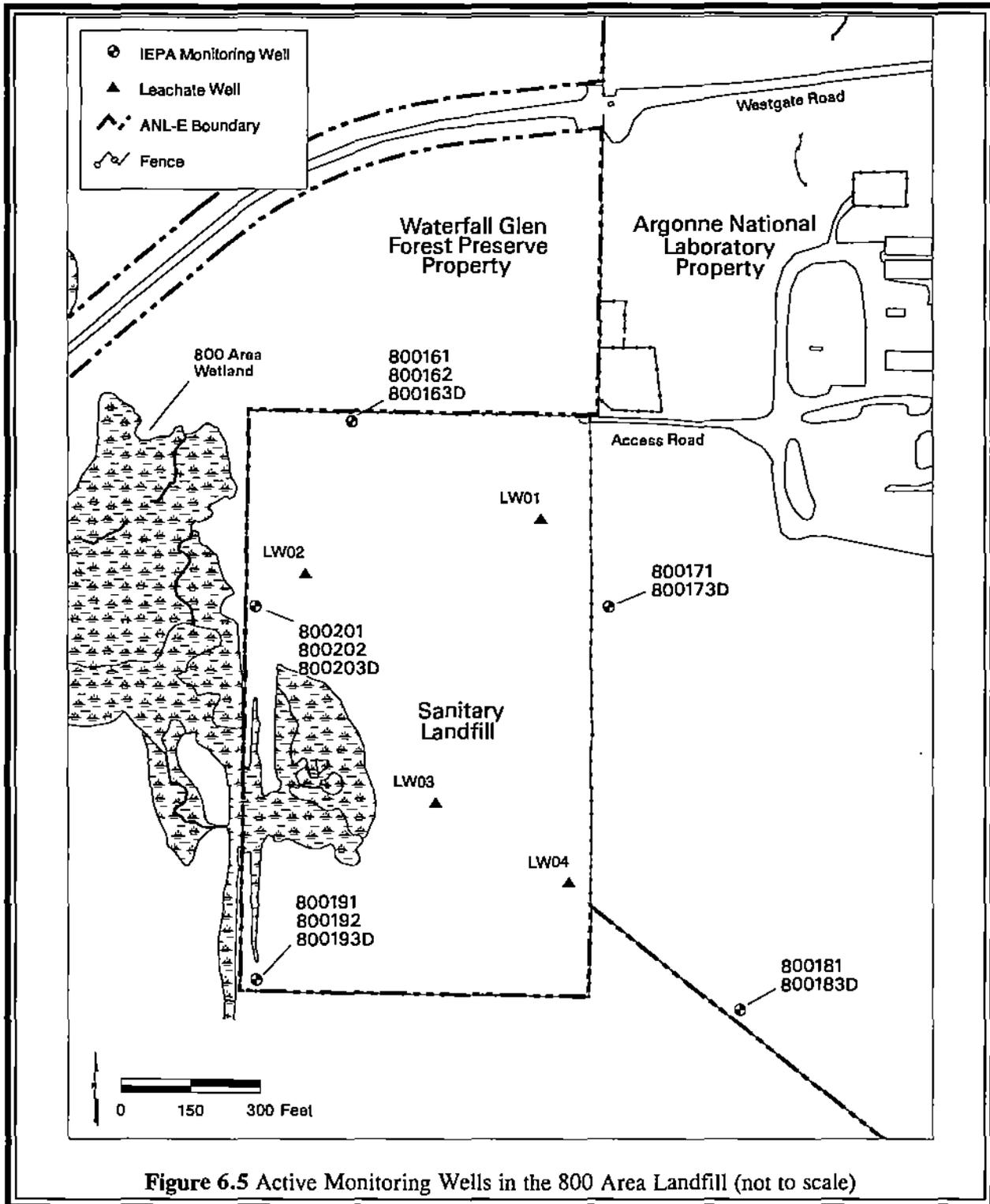
6.3.1. French Drain

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 conducted at the landfill. Measurable amounts of these materials were identified in soil vapors and in shallow groundwater of the landfill.

6.3.2. Monitoring Studies

During October 1992, 15 stainless-steel wells, Wells 800161 through 800203D, were installed around the landfill as part of the IEPA-approved closure plan. These 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 consisting of a shallow, medium, and deep well (see Figure 6.5 and Table 6.25). Wells 800172 and 800182 are consistently dry.

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TABLE 6.25

Groundwater Monitoring Wells: 800 Area Landfill

ID Number ^a	Well Depth (ft bgs)	Ground Elevation (ft AMSL)	Monitoring Zone ^b	Well Type ^c	Date Drilled	Water Elevation
800161	25	757.1	20-25/737-732	2/SS	10/92	754.53
800162	70	757.0	65-70/692-687	2/SS	10/92	718.35
800163D	154	757.1	144-154/613-603	2/SS	9/92	642.78
800171	25	749.4	20-25/729-724	2/SS	10/92	739.73
800173D	129	749.4	119-129/630-620	2/SS	10/92	632.84
800181	35	756.3	30-35/726-721	2/SS	10/92	734.65
800183D	164	755.8	154-164/602-592	2/SS	10/92	632.71
800191	15	746.0	10-15/736-731	2/SS	10/92	743.46
800192	60	746.0	55-60/691-686	2/SS	10/92	733.31
800193D	151	746.0	141-151/605-595	2/SS	10/92	632.72
800201	35	747.8	30-35/718-713	2/SS	10/92	734.42
800202	60	747.8	55-60/693-688	2/SS	10/92	718.35
800203D	126	747.8	116-126/632-622	2/SS	9/92	632.64

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

^b Depth/elevation.

^c Inner diameter (in.)/well material (SS = stainless steel).

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 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 required to be monitored only 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 the ESH-ASCH, ESH-ASCL, and ESH-ASRC. These SOP reference protocols can be found in SW-846, 3rd edition, "Test Methods for Evaluating Solid Waste."⁷ Sixteen metals were routinely determined. They were 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. PCB/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 was determined by using distillation followed by an ion-selective electrode technique.

Some analyses were performed at an off-site contracted laboratory. SW-846⁷ procedures were specified and used. Cyanide and phenol were determined by distillation followed by a spectrophotometric finish. Total organic carbon and total organic halide 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 chromatography techniques, respectively.

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

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6.3.2.3. Results of Analyses

A description of each well, a list of field parameters measured during sample collection, and the results of chemical and radiological analysis of samples from the wells in the 800 Area are contained in Tables 6.26 to 6.38. 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 $\mu\text{g/L}$. Figures 6.6 to 6.19 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 since filtered samples are collected each quarter for the constituents presented.

Inorganic Constituents. On April 24, 1992, and January 11, 1995, the IEPA issued supplemental permits to ANL-E that, in part, approved a groundwater monitoring program for the sanitary landfill. The program will be capable of identifying any releases from the facility and demonstrating compliance with the applicable groundwater quality standards. Under the January 1995 supplemental permit, the IEPA chose 13 groundwater monitoring points (800161, 800162, 800163D, 800171, 800173D, 800181, 800183D, 800191, 800192, 800193D, 800201, 800202, and 800203D) to be sampled on a quarterly basis commencing January 1995. Parameters to be monitored include field parameters, routine indicator parameters, inorganic parameters, and volatile organic parameters. Volatile organic parameters are to be monitored only during the second quarter of monitoring. Routine indicator parameters are field-filtered prior to analysis and are collected each quarter. Inorganic parameters are unfiltered prior to analysis and are collected only during the second quarter.

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 Section 620.410. The most common constituents at

6. GROUNDWATER PROTECTION

TABLE 6.26

Groundwater Monitoring Results, Sanitary Landfill Well 800161, 1996^a

Constituent	Units	Date of Sampling			
		01/09/96	04/02/96	07/01/96	10/02/96
Water Elevation	m	225.85	226.30	228.23	226.52
Temperature	°C	11.2	10.2	11.4	11.9
pH	pH	6.94	7.04	7.39	6.83
Redox	mV	73	-54	-12	-6
Conductivity	µmhos/cm	1399	1388	1217	1378
Chloride - Filtered	mg/L	95	89	69	76
Fluoride - Filtered	mg/L	185	176	151	162
Sulfate - Filtered	mg/L	814	808	844	795
TDS - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide (Total)	mg/L	NA ^b	0.0269	NA	NA
Arsenic	mg/L	NA	0.2263	NA	NA
Barium	mg/L	NA	0.2036	NA	NA
Boron	mg/L	NA	0.001	NA	NA
Cadmium	mg/L	NA	0.0323	NA	NA
Chromium	mg/L	NA	0.017	NA	NA
Cobalt	mg/L	NA	0.0624	NA	NA
Copper	mg/L	NA	37.7	NA	NA
Iron	mg/L	NA	0.0368	NA	NA
Lead	mg/L	NA	1.589	NA	NA
Manganese	mg/L	NA	< 0.0001	NA	NA
Mercury	mg/L	NA	0.051	NA	NA
Nickel	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	0.0014	NA	NA
Zinc	mg/L	NA	0.2233	NA	NA
Ammonia nitrogen - Filtered	mg/L	0.1	< 0.1	0.2	-
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.1657	0.1364	0.1423	0.1580
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	< 0.0250	0.7498	< 0.0250
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.7492	0.6237	0.4998	0.7349
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0228	0.0136	0.0461	0.0603
Nitrate	mg/L	NA	< 0.5	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	0.485	0.496	0.361	0.352
Chloride	mg/L	NA	92	NA	NA
Fluoride	mg/L	NA	0.296	NA	NA
Sulfate	mg/L	NA	170	NA	NA
Total organic carbons	mg/L	3.2	3.3	3.1	3.7
Total organic carbons	mg/L	3.4	2.9	3.1	3.7
Total organic carbons	mg/L	3.3	3.0	3.2	3.7
Total organic carbons	mg/L	3.4	2.8	3.2	3.6
Total organic halogens	mg/L	0.012	0.047	0.026	0.065
Total organic halogens	mg/L	0.010	0.041	0.027	0.059
Methylene Chloride	µg/L	0.6	- ^c	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.27

Groundwater Monitoring Results, Sanitary Landfill Well 800162, 1996^a

Constituent	Units	Date of Sampling			
		01/09/96	04/02/96	07/01/96	10/02/96
Water Elevation	m	218.11	218.00	218.84	218.45
Temperature	°C	10.8	12.0	11.8	11.3
pH	pH	6.94	6.86	7.19	6.87
Redox	mV	46	-61	1	10
Conductivity	µmhos/cm	970	1013	996	1018
Chloride - Filtered	mg/L	60	55	48	55
Fluoride - Filtered	mg/L	76	68	62	67
Sulfate - Filtered	mg/L	602	569	606	586
TDS - Filtered	mg/L	< 0.002	< 0.002	< 0.002	0.003
Cyanide (Total)	mg/L	NA ^b	0.0027	NA	NA
Arsenic	mg/L	NA	0.0448	NA	NA
Barium	mg/L	NA	0.2129	NA	NA
Boron	mg/L	NA	0.0001	NA	NA
Cadmium	mg/L	NA	< 0.02	NA	NA
Chromium	mg/L	NA	< 0.015	NA	NA
Cobalt	mg/L	NA	< 0.02	NA	NA
Copper	mg/L	NA	0.8694	NA	NA
Iron	mg/L	NA	< 0.0005	NA	NA
Manganese	mg/L	NA	0.3249	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	< 0.025	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	0.0013	NA	NA
Zinc	mg/L	NA	< 0.01	NA	NA
Ammonia nitrogen - Filtered	mg/L	0.3	0.4	0.4	0.6
Arsenic - Filtered	mg/L	0.0024	0.0024	0.0067	0.0031
Barium - Filtered	mg/L	0.0478	0.0415	0.0510	0.0567
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0002
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	0.6754	1.0180	0.1803	1.2030
Lead - Filtered	mg/L	< 0.0005	< 0.0005	0.0005	< 0.0005
Manganese - Filtered	mg/L	0.3373	0.3388	0.3756	0.3505
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/L	NA	< 0.5	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	51	NA	NA
Fluoride	mg/L	NA	0.316	NA	NA
Sulfate	mg/L	NA	66	NA	NA
Total organic carbons	mg/L	4.5	3.4	3.1	4.0
Total organic carbons	mg/L	4.2	3.5	4.0	3.6
Total organic carbons	mg/L	4.0	3.4	2.7	3.8
Total organic carbons	mg/L	4.6	3.8	2.7	3.9
Total organic halogens	mg/L	< 0.010	0.017	0.021	0.011
Total organic halogens	mg/L	< 0.010	0.017	0.022	0.015
Methylene Chloride	µg/L	2	- ^c	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.28

Groundwater Monitoring Results, Sanitary Landfill Well 800163D, 1996^a

Constituent	Units	Date of Sampling			
		01/09/96	04/02/96	07/01/96	10/02/96
Water Elevation	m	192.56	192.34	192.75	192.54
Temperature	°C	11.5	11.4	12.1	12.6
pH	pH	6.85	6.76	7.15	6.64
Redox	mV	-6	-64	2	6
Conductivity	µmhos/cm	1423	1429	1313	1353
Chloride - Filtered	mg/L	256	172	144	119
Fluoride - Filtered	mg/L	30	59	52	158
Sulfate - Filtered	mg/L	907	883	959	883
TDS - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Cyanide (Total)	mg/L	NA ^b	0.004	NA	NA
Arsenic	mg/L	NA	0.055	NA	NA
Barium	mg/L	NA	0.3582	NA	NA
Boron	mg/L	NA	< 0.0001	NA	NA
Cadmium	mg/L	NA	< 0.02	NA	NA
Chromium	mg/L	NA	< 0.015	NA	NA
Cobalt	mg/L	NA	< 0.02	NA	NA
Copper	mg/L	NA	2.33	NA	NA
Iron	mg/L	NA	< 0.0005	NA	NA
Lead	mg/L	NA	0.0651	NA	NA
Manganese	mg/L	NA	< 0.0001	NA	NA
Mercury	mg/L	NA	< 0.025	NA	NA
Nickel	mg/L	NA	< 0.002	NA	NA
Selenium	mg/L	NA	< 0.001	NA	NA
Silver	mg/L	NA	0.0212	NA	NA
Zinc	mg/L	1.0	0.5	0.5	0.3
Ammonia nitrogen - Filtered	mg/L	0.0022	< 0.0020	0.0047	< 0.0020
Arsenic - Filtered	mg/L	0.0559	0.0512	0.0594	0.0571
Barium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Beryllium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cadmium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Chromium - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Cobalt - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Copper - Filtered	mg/L	1.6750	1.0930	1.9050	0.2155
Iron - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Lead - Filtered	mg/L	0.0711	0.0578	0.0604	0.0714
Manganese - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Mercury - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Nickel - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Silver - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Thallium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0124	< 0.0100	< 0.0100	0.0111
Nitrate	mg/L	NA	< 0.5	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	194	NA	NA
Fluoride	mg/L	NA	0.376	NA	NA
Sulfate	mg/L	NA	57	NA	NA
Total organic carbons	mg/L	3.6	3.1	4.8	2.5
Total organic carbons	mg/L	3.7	3.3	5.9	2.6
Total organic carbons	mg/L	3.8	3.1	5.6	2.6
Total organic carbons	mg/L	3.7	3.0	4.9	2.5
Total organic halogens	mg/L	< 0.010	0.022	0.025	< 0.010
Total organic halogens	mg/L	< 0.010	0.027	0.027	< 0.010
Acetone	µg/L	5	- ^c	-	-
Methylene Chloride	µg/L	4	-	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well 800171, 1996^a

Constituent	Units	Date of Sampling				
		01/09/96	04/02/96	07/02/96	07/02/96	10/02/96
Water Elevation	m	225.61	226.23	226.29	226.29	225.57
Temperature	°C	11.9	10.7	9.0	9.0	12.1
pH		6.60	6.68	6.83	6.83	6.38
Redox	mV	197	42	NA ^b	NA	-51
Conductivity	µmhos/cm	2050	1998	1889	1889	1920
Chloride - Filtered	mg/L	112	94	80	72	97
Sulfate - Filtered	mg/L	239	211	222	216	241
TDS - Filtered	mg/L	1261	1215	1198	1192	1216
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	0.003
Arsenic	mg/L	NA ^b	0.0104	NA	NA	NA
Barium	mg/L	NA	0.2426	NA	NA	NA
Boron	mg/L	NA	0.2126	NA	NA	NA
Cadmium	mg/L	NA	0.0006	NA	NA	NA
Chromium	mg/L	NA	0.0424	NA	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA	NA
Copper	mg/L	NA	0.0479	NA	NA	NA
Iron	mg/L	NA	40	NA	NA	NA
Lead	mg/L	NA	0.0174	NA	NA	NA
Manganese	mg/L	NA	0.9697	NA	NA	NA
Mercury	mg/L	NA	0.0001	NA	NA	NA
Nickel	mg/L	NA	0.0464	NA	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA	NA
Silver	mg/L	NA	0.001	NA	NA	NA
Zinc	mg/L	NA	0.1067	NA	NA	NA
Ammonia nitrogen - Filtered	mg/L	NA	< 0.1	0.3	0.3	NA
Arsenic - Filtered	mg/L	< 0.0020	< 0.0020	< 0.0020	0.0022	0.0021
Barium - Filtered	mg/L	0.1253	0.0921	0.1166	0.0905	0.1198
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	0.0001	< 0.0001	0.0001	0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	0.0446	< 0.0250	< 0.0250	< 0.0250
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.3785	0.3363	0.3474	0.3020	0.3222
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0132	< 0.0100	0.0919	0.0292	0.0421
Nitrate	mg/L	NA	< 0.5	NA	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	0.360	0.368	0.252	0.235	0.269
Chloride	mg/L	NA	92	NA	NA	NA
Fluoride	mg/L	NA	0.17	NA	NA	NA
Sulfate	mg/L	NA	199	NA	NA	NA
Total organic carbons	mg/L	3.7	3.0	2.6	2.9	3.2
Total organic carbons	mg/L	3.5	3.3	2.5	3.1	3.3
Total organic carbons	mg/L	3.6	3.0	2.7	3.1	3.3
Total organic carbons	mg/L	3.7	3.1	2.5	2.8	3.3
Total organic halogens	mg/L	0.029	0.049	0.036	0.036	0.060
Total organic halogens	mg/L	0.029	0.042	0.034	0.033	0.057
Acetone	µg/L	5	- ^c	-	-	-
Chloroethane	µg/L	0.5	2.0	1.0	1.0	2.0
Methylene Chloride	µg/L	3.0	-	-	-	0.3
Trichloroethene	µg/L	0.4	0.6	0.7	1.0	0.7
cis-1,2-Dichloroethene	µg/L	-	-	0.4	0.5	0.5

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well 800173D, 1996^a

Constituent	Units	Date of Sampling				
		01/09/96	01/09/96	04/02/96	07/01/96	10/02/96
Water Elevation	m	192.48	192.48	192.29	192.71	192.49
Temperature	°C	11.0	11.0	10.8	9.2	11.8
pH	pH	6.82	6.82	6.84	6.92	6.66
Redox	mV	-31	-31	26	NA ^b	-150
Conductivity	µmhos/cm	1538	1538	1571	1601	1509
Chloride - Filtered	mg/L	294	306	269	237	212
Sulfate - Filtered	mg/L	17	18	16	16	102
TDS - Filtered	mg/L	922	881	858	950	642
Cyanide (Total)	mg/L	< 0.002	< 0.002	NA	< 0.002	< 0.002
Arsenic	mg/L	NA	NA	0.0062	NA	NA
Barium	mg/L	NA	NA	0.1084	NA	NA
Boron	mg/L	NA	NA	0.1962	NA	NA
Cadmium	mg/L	NA	NA	< 0.0001	NA	NA
Chromium	mg/L	NA	NA	0.0551	NA	NA
Cobalt	mg/L	NA	NA	0.0155	NA	NA
Copper	mg/L	NA	NA	< 0.02	NA	NA
Iron	mg/L	NA	NA	7.044	NA	NA
Lead	mg/L	NA	NA	0.002	NA	NA
Manganese	mg/L	NA	NA	0.2385	NA	NA
Mercury	mg/L	NA	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	NA	0.0453	NA	NA
Selenium	mg/L	NA	NA	< 0.002	NA	NA
Silver	mg/L	NA	NA	0.0013	NA	NA
Zinc	mg/L	NA	NA	0.0218	NA	NA
Ammonia nitrogen - Filtered	mg/L	0.4	0.7	0.6	0.5	0.3
Arsenic - Filtered	mg/L	0.0034	0.0043	0.0034	0.0039	0.0037
Barium - Filtered	mg/L	0.0981	0.0984	0.0905	0.0911	0.0862
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	2.651	3.172	2.305	2.359	0.970
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.1445	0.1431	0.1307	0.0978	0.1479
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/L	NA	NA	< 0.5	NA	NA
Phenols	mg/L	< 0.020	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	NA	250	NA	NA
Fluoride	mg/L	NA	NA	0.372	NA	NA
Sulfate	mg/L	NA	NA	17	NA	NA
Total organic carbons	mg/L	5.9	6.0	4.6	5.1	4.1
Total organic carbons	mg/L	5.8	5.6	5.4	5.3	4.3
Total organic carbons	mg/L	5.7	5.6	4.8	5.1	4.1
Total organic carbons	mg/L	5.9	6.0	4.7	5.3	4.1
Total organic halogens	mg/L	< 0.010	< 0.010	0.024	0.021	0.030
Total organic halogens	mg/L	< 0.010	< 0.010	0.023	0.019	0.021
Acetone	µg/L	- ^c	4	-	-	-
Methylene Chloride	µg/L	3	3	-	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well 800181, 1996^a

Constituent	Units	Date of Sampling			
		01/09/96	04/02/96	07/01/96	10/02/96
Water Elevation	m	221.58	222.34	222.88	222.12
Temperature	°C	9.6	10.2	10.1	10.2
pH	pH	7.00	7.14	7.11	6.79
Redox	mV	370	-45	3	-3
Conductivity	µmhos/cm	1635	1585	1389	1453
Chloride - Filtered	mg/L	5	5	4	5
Sulfate - Filtered	mg/L	197	199	183	302
TDS - Filtered	mg/L	1005	1024	955	879
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA	0.0206	NA	NA
Barium	mg/L	NA	0.7115	NA	NA
Boron	mg/L	NA	0.432	NA	NA
Cadmium	mg/L	NA	0.0006	NA	NA
Chromium	mg/L	NA	0.151	NA	NA
Cobalt	mg/L	NA	0.0584	NA	NA
Copper	mg/L	NA	0.1114	NA	NA
Iron	mg/L	NA	149.1	NA	NA
Lead	mg/L	NA	0.0525	NA	NA
Manganese	mg/L	NA	2.294	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	0.1553	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	< 0.001	NA	NA
Zinc	mg/L	NA	0.3055	NA	NA
Ammonia nitrogen - Filtered	mg/L	NA	< 0.1	0.2	2.0
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.1805	0.1209	0.1469	0.1438
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	0.0356	< 0.0200	< 0.0200	< 0.0200
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.2069	0.1437	0.1483	0.0885
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.010	< 0.010	0.011	0.072
Nitrate	mg/L	NA	< 0.5	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	5	NA	NA
Fluoride	mg/L	NA	0.326	NA	NA
Sulfate	mg/L	NA	193	NA	NA
Total organic carbons	mg/L	1.9	2.1	1.7	1.7
Total organic carbons	mg/L	1.9	2.1	1.5	1.6
Total organic carbons	mg/L	1.9	2.0	1.6	1.8
Total organic carbons	mg/L	2.0	1.9	1.6	1.7
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.019
Acetone	µg/L	3	- ^c	-	-
Methylene Chloride	µg/L	4	-	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well 800183D, 1996^a

Constituent	Units	Date of Sampling			
		01/09/96	04/02/96	07/01/96	10/02/96
Water Elevation	m	186.39	192.30	192.66	192.45
Temperature	°C	11.3	11.3	12.1	12.5
pH	pH	6.98	6.98	7.13	6.70
Redox	mV	23	-30	2	10
Conductivity	µmhos/cm	1460	1318	1216	1301
Chloride - Filtered	mg/L	139	127	109	117
Sulfate - Filtered	mg/L	163	153	151	180
TDS - Filtered	mg/L	782	767	842	801
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.004	NA	NA
Barium	mg/L	NA	0.0543	NA	NA
Boron	mg/L	NA	0.2365	NA	NA
Cadmium	mg/L	NA	0.0001	NA	NA
Chromium	mg/L	NA	< 0.02	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA
Copper	mg/L	NA	< 0.02	NA	NA
Iron	mg/L	NA	2.194	NA	NA
Lead	mg/L	NA	0.0015	NA	NA
Manganese	mg/L	NA	0.0445	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	< 0.025	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	0.0022	NA	NA
Zinc	mg/L	NA	< 0.01	NA	NA
Ammonia nitrogen - Filtered	mg/L	0.7	0.7	0.6	0.4
Arsenic - Filtered	mg/L	< 0.0020	< 0.0020	< 0.0020	0.0021
Barium - Filtered	mg/L	0.0558	0.0448	0.0426	0.0465
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	0.9691	0.7454	0.8334	0.8360
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0204	0.0185	0.0121	0.0209
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/L	NA	< 0.5	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	122	NA	NA
Fluoride	mg/L	NA	0.412	NA	NA
Sulfate	mg/L	NA	153	NA	NA
Total organic carbons	mg/L	1.9	1.7	1.6	1.8
Total organic carbons	mg/L	2.2	1.6	1.6	1.7
Total organic carbons	mg/L	2.0	1.6	1.6	1.6
Total organic carbons	mg/L	2.1	1.7	1.7	1.9
Total organic halogens	mg/L	< 0.010	0.016	0.014	< 0.010
Total organic halogens	mg/L	< 0.010	0.014	0.015	< 0.010
Methylene Chloride	µg/L	5	- ^c	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well 800191, 1996^a

Constituent	Units	Date of Sampling			
		01/11/96	04/04/96	07/02/96	10/03/96
Water Elevation	m	225.77	225.89	225.75	225.47
Temperature	°C	10.3	7.8	10.1	12.7
pH	pH	6.79	6.71	6.92	6.49
Redox	mV	136	.53	-	-23
Conductivity	µmhos/cm	1674	1932	2340	1554
Chloride - Filtered	mg/L	262	272	191	172
Sulfate - Filtered	mg/L	154	153	156	162
TDS - Filtered	mg/L	956	1205	1644	1232
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.0078	NA	NA
Barium	mg/L	NA	0.2637	NA	NA
Boron	mg/L	NA	0.2467	NA	NA
Cadmium	mg/L	NA	0.0007	NA	NA
Chromium	mg/L	NA	0.0449	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA
Copper	mg/L	NA	0.059	NA	NA
Iron	mg/L	NA	31.96	NA	NA
Lead	mg/L	NA	0.0373	NA	NA
Manganese	mg/L	NA	1.912	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	0.036	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	< 0.001	NA	NA
Zinc	mg/L	NA	0.1345	NA	NA
Ammonia nitrogen - Filtered	mg/L	0.2	0.2	0.8	0.5
Arsenic - Filtered	mg/L	< 0.0020	< 0.0020	0.0021	0.0020
Barium - Filtered	mg/L	0.0706	0.0739	0.0996	0.0902
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.0200	< 0.0200	0.0219	< 0.0200
Cobalt - Filtered	mg/L	< 0.0150	< 0.0150	0.0372	< 0.0150
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	0.0849	0.4656	2.7750	1.0640
Lead - Filtered	mg/L	0.0008	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	1.243	1.712	1.853	1.843
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0100	0.0439	0.0241	0.0739
Nitrate	mg/L	NA	< 1.0000	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	256	NA	NA
Fluoride	mg/L	NA	0.28	NA	NA
Sulfate	mg/L	NA	141	NA	NA
Total organic carbons	mg/L	6.8	5.3	5.4	6.4
Total organic carbons	mg/L	6.5	5.2	5.9	6.5
Total organic carbons	mg/L	6.7	5.3	4.9	6.4
Total organic carbons	mg/L	6.3	5.4	5.7	6.2
Total organic halogens	mg/L	0.012	0.029	0.028	0.021
Total organic halogens	mg/L	0.010	0.026	0.029	0.023
Acetone	µg/L	7	3	-	-
Methylene Chloride	µg/L	3	- ^c	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well 800192, 1996^a

Constituent	Units	Date of Sampling				
		01/11/96	04/04/96	07/02/96	10/03/96	10/03/96
Water Elevation	m	222.39	222.53	222.44	222.06	222.06
Temperature	°C	11.1	11.4	9.9	11.6	11.6
pH	pH	6.65	6.60	6.87	6.42	6.42
Redox	mV	-33	-30	-	-8	-8
Conductivity	µmhos/cm	1367	1401	1411	1422	1422
Chloride - Filtered	mg/L	47	44	36	51	51
Sulfate - Filtered	mg/L	275	234	233	339	345
TDS - Filtered	mg/L	871	875	937	888	882
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.0036	NA	NA	NA
Barium	mg/L	NA	0.348	NA	NA	NA
Boron	mg/L	NA	0.113	NA	NA	NA
Cadmium	mg/L	NA	< 0.0001	NA	NA	NA
Chromium	mg/L	NA	< 0.02	NA	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA	NA
Copper	mg/L	NA	< 0.02	NA	NA	NA
Iron	mg/L	NA	8.406	NA	NA	NA
Lead	mg/L	NA	0.0005	NA	NA	NA
Manganese	mg/L	NA	0.193	NA	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA	NA
Nickel	mg/L	NA	< 0.025	NA	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA	NA
Silver	mg/L	NA	< 0.001	NA	NA	NA
Zinc	mg/L	NA	0.012	NA	NA	NA
Ammonia nitrogen - Filtered	mg/L	0.8	1.0	2.0	1.0	1.0
Arsenic - Filtered	mg/L	0.0029	< 0.0020	0.0034	< 0.0020	< 0.0020
Barium - Filtered	mg/L	0.3731	0.3125	0.3150	0.3965	0.3926
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.0150	< 0.0150	0.0222	< 0.0150	< 0.0150
Copper - Filtered	mg/L	< 0.0200	< 0.0200	0.0275	< 0.0200	< 0.0200
Iron - Filtered	mg/L	6.409	5.343	6.865	2.374	2.417
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.2378	0.2005	0.2766	0.2274	0.2351
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.020	< 0.020	< 0.020	< 0.020	0.026
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/L	NA	< 1	NA	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020	< 0.020
Hydrogen-3 Chloride	nCi/L	0.174	0.261	0.200	0.214	0.290
Fluoride	mg/L	NA	0.238	NA	NA	NA
Sulfate	mg/L	NA	228	NA	NA	NA
Total organic carbons	mg/L	10.6	7.6	7.6	8.4	8.9
Total organic carbons	mg/L	9.8	7.6	7.3	9.3	8.1
Total organic carbons	mg/L	9.2	7.9	7.6	8.7	8.0
Total organic carbons	mg/L	9.8	7.6	7.4	9.2	8.8
Total organic halogens	mg/L	< 0.010	0.012	0.019	0.031	0.041
Total organic halogens	mg/L	< 0.010	0.013	0.015	0.031	0.045
Acetone	µg/L	- ^c	9	-	-	-
Methylene Chloride	µg/L	3.0	4.0	-	0.4	0.3

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well 800193D, 1996^a

Constituent	Units	Date of Sampling			
		01/11/96	04/04/96	07/02/96	10/03/96
Water Elevation	m	192.46	192.47	192.75	192.34
Temperature	°C	11.5	11.8	9.1	11.4
pH	pH	6.91	6.82	7.04	6.68
Redox	mV	-10	-8	-	-243
Conductivity	µmhos/cm	1378	1323	1350	1321
Chloride - Filtered	mg/L	134	141	87	119
Sulfate - Filtered	mg/L	185	182	172	167
TDS - Filtered	mg/L	873	781	888	808
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.0124	NA	NA
Barium	mg/L	NA	0.1302	NA	NA
Boron	mg/L	NA	0.2588	NA	NA
Cadmium	mg/L	NA	< 0.0001	NA	NA
Chromium	mg/L	NA	< 0.02	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA
Copper	mg/L	NA	< 0.02	NA	NA
Iron	mg/L	NA	13.87	NA	NA
Lead	mg/L	NA	0.0008	NA	NA
Manganese	mg/L	NA	0.0708	NA	NA
Mercury	mg/L	NA	0.0003	NA	NA
Nickel	mg/L	NA	< 0.025	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	< 0.001	NA	NA
Zinc	mg/L	NA	0.0199	NA	NA
Ammonia Nitrogen - Filtered	mg/L	0.6	1.5	1.0	0.3
Arsenic - Filtered	mg/L	< 0.0020	0.0023	0.0022	0.0020
Barium - Filtered	mg/L	0.0703	0.0535	0.0853	0.0603
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.0150	< 0.0150	0.0264	< 0.0150
Copper - Filtered	mg/L	< 0.0200	< 0.0200	< 0.0200	0.0202
Iron - Filtered	mg/L	0.9565	0.8046	0.5813	0.9251
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0338	0.0282	0.0372	0.0282
Mercury - Filtered	mg/L	< 0.0001	0.0003	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/L	NA	< 1	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	125	NA	NA
Fluoride	mg/L	NA	0.334	NA	NA
Sulfate	mg/L	NA	170	NA	NA
Total organic carbons	mg/L	4.8	2.3	3.6	2.8
Total organic carbons	mg/L	6.2	2.1	2.1	2.5
Total organic carbons	mg/L	4.8	2.9	3.7	2.4
Total organic carbons	mg/L	4.5	2.0	5.5	2.4
Total organic halogens	mg/L	0.016	0.019	0.017	< 0.010
Total organic halogens	mg/L	0.014	0.017	0.015	< 0.010
Acetone	µg/L	10	- ^c	-	-
Methylene Chloride	µg/L	5	1	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well 800201, 1996^a

Constituent	Units	Date of Sampling			
		01/11/96	04/04/96	07/03/96	10/03/96
Water Elevation	m	223.37	223.50	224.53	223.62
Temperature	°C	10.4	11.0	11.4	10.5
pH	pH	6.85	6.77	6.89	6.57
Redox	mV	30	-80	-	-15
Conductivity	µmhos/cm	1084	1087	1085	1082
Chloride - Filtered	mg/L	7	7	5	7
Sulfate - Filtered	mg/L	67	59	62	67
TDS - Filtered	mg/L	661	643	649	646
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.0149	NA	NA
Barium	mg/L	NA	0.257	NA	NA
Boron	mg/L	NA	0.2089	NA	NA
Cadmium	mg/L	NA	0.0001	NA	NA
Chromium	mg/L	NA	< 0.02	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA
Copper	mg/L	NA	< 0.02	NA	NA
Iron	mg/L	NA	15.09	NA	NA
Lead	mg/L	NA	0.0096	NA	NA
Manganese	mg/L	NA	0.8455	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	< 0.025	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	< 0.001	NA	NA
Zinc	mg/L	NA	0.0881	NA	NA
Ammonia nitrogen - Filtered	mg/L	4.0	4.0	4.0	0.2
Arsenic - Filtered	mg/L	0.0061	0.0032	0.0052	0.0029
Barium - Filtered	mg/L	0.2741	0.2213	0.2283	0.2649
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	1.828	1.802	2.470	1.574
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.5375	0.5414	0.3891	0.4523
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.0250	< 0.0250	< 0.0250	0.0267
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0400	0.0345	0.0960	0.0632
Nitrate	mg/L	NA	< 1	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	5	NA	NA
Fluoride	mg/L	NA	0.194	NA	NA
Sulfate	mg/L	NA	57	NA	NA
Total organic carbons	mg/L	27.6	28.0	24.2	26.9
Total organic carbons	mg/L	27.8	27.7	24.1	26.2
Total organic carbons	mg/L	28.2	27.6	26.1	26.7
Total organic carbons	mg/L	28.5	26.0	26.0	27.2
Total organic halogens	mg/L	< 0.010	0.014	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	0.012	< 0.010	< 0.010
Acetone	µg/L	4	8	- ^c	-
Methylene Chloride	µg/L	4	2	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well 800202, 1996

Constituent	Units	Date of Sampling			
		01/11/96	04/04/96	07/03/96	10/03/96
Water Elevation	m	215.87	217.50	218.22	217.76
Temperature	°C	10.7	10.9	11.4	10.8
pH	pH	6.93	6.85	7.16	6.66
Redox	mV	-54	-81	-	-35
Conductivity	µmhos/cm	117	1126	1086	1055
Chloride - Filtered	mg/L	32	30	19	20
Sulfate - Filtered	mg/L	115	70	65	72
TDS - Filtered	mg/L	682	677	669	614
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.0121	NA	NA
Barium	mg/L	NA	0.1078	NA	NA
Boron	mg/L	NA	0.2386	NA	NA
Cadmium	mg/L	NA	< 0.0001	NA	NA
Chromium	mg/L	NA	< 0.02	NA	NA
Cobalt	mg/L	NA	< 0.015	NA	NA
Copper	mg/L	NA	< 0.02	NA	NA
Iron	mg/L	NA	1.463	NA	NA
Lead	mg/L	NA	< 0.0005	NA	NA
Manganese	mg/L	NA	0.2307	NA	NA
Mercury	mg/L	NA	< 0.0001	NA	NA
Nickel	mg/L	NA	< 0.025	NA	NA
Selenium	mg/L	NA	< 0.002	NA	NA
Silver	mg/L	NA	< 0.001	NA	NA
Zinc	mg/L	NA	< 0.01	NA	NA
Ammonia nitrogen - Filtered	mg/L	1.5	2.0	1.5	0.6
Arsenic - Filtered	mg/L	0.0119	0.0097	0.0076	0.0042
Barium - Filtered	mg/L	0.1342	0.1003	0.1137	0.1580
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	1.3330	0.9667	1.8100	2.3200
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.3466	0.2397	0.2640	0.2794
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0100	< 0.0100	0.0129	< 0.0100
Nitrate	mg/L	NA	< 1	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.020
Hydrogen-3	nCi/L	0.102	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	29	NA	NA
Fluoride	mg/L	NA	0.252	NA	NA
Sulfate	mg/L	NA	70	NA	NA
Total organic carbons	mg/L	17.6	25.0	11.4	11.2
Total organic carbons	mg/L	15.1	28.5	11.0	11.5
Total organic carbons	mg/L	15.8	27.4	11.3	11.4
Total organic carbons	mg/L	17.1	27.4	11.6	10.6
Total organic halogens	mg/L	0.011	0.022	0.016	0.027
Total organic halogens	mg/L	0.012	0.028	0.014	0.030
Acetone	µg/L	- ^c	3	-	-
Methylene Chloride	µg/L	4	1	-	-

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

6. GROUNDWATER PROTECTION

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well 800203D, 1996^a

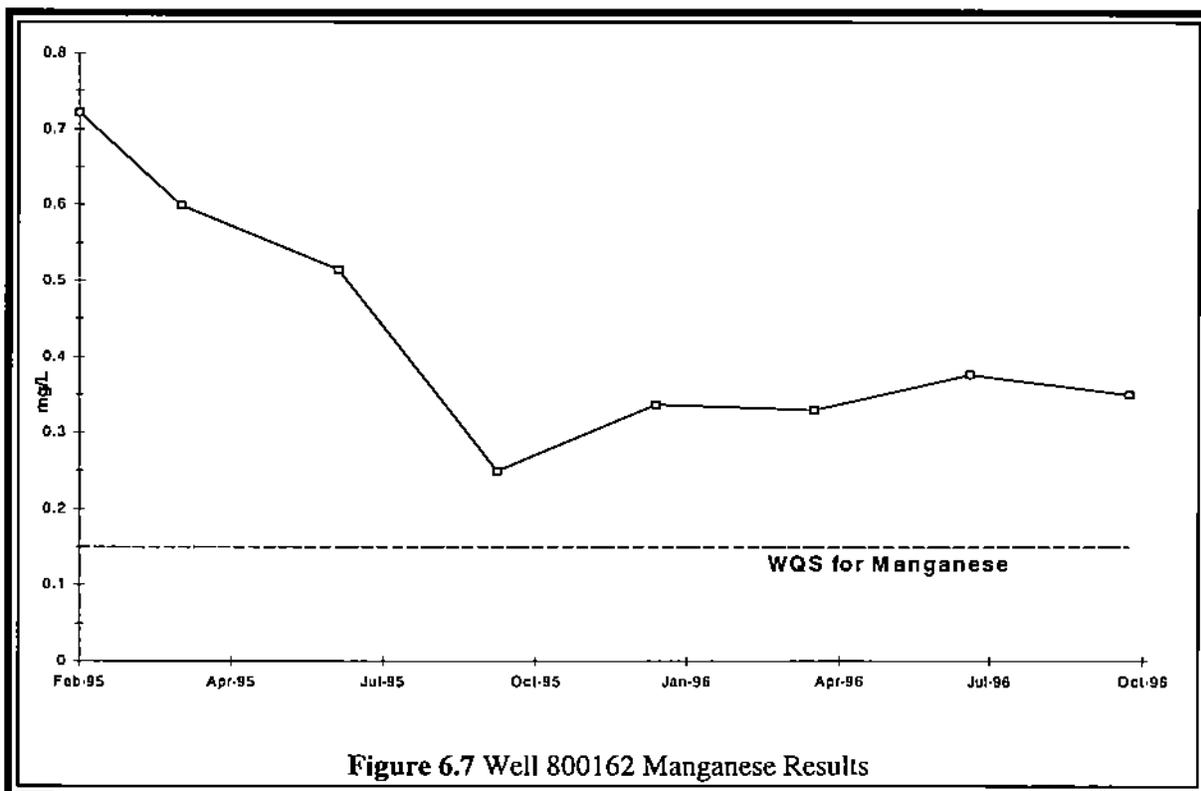
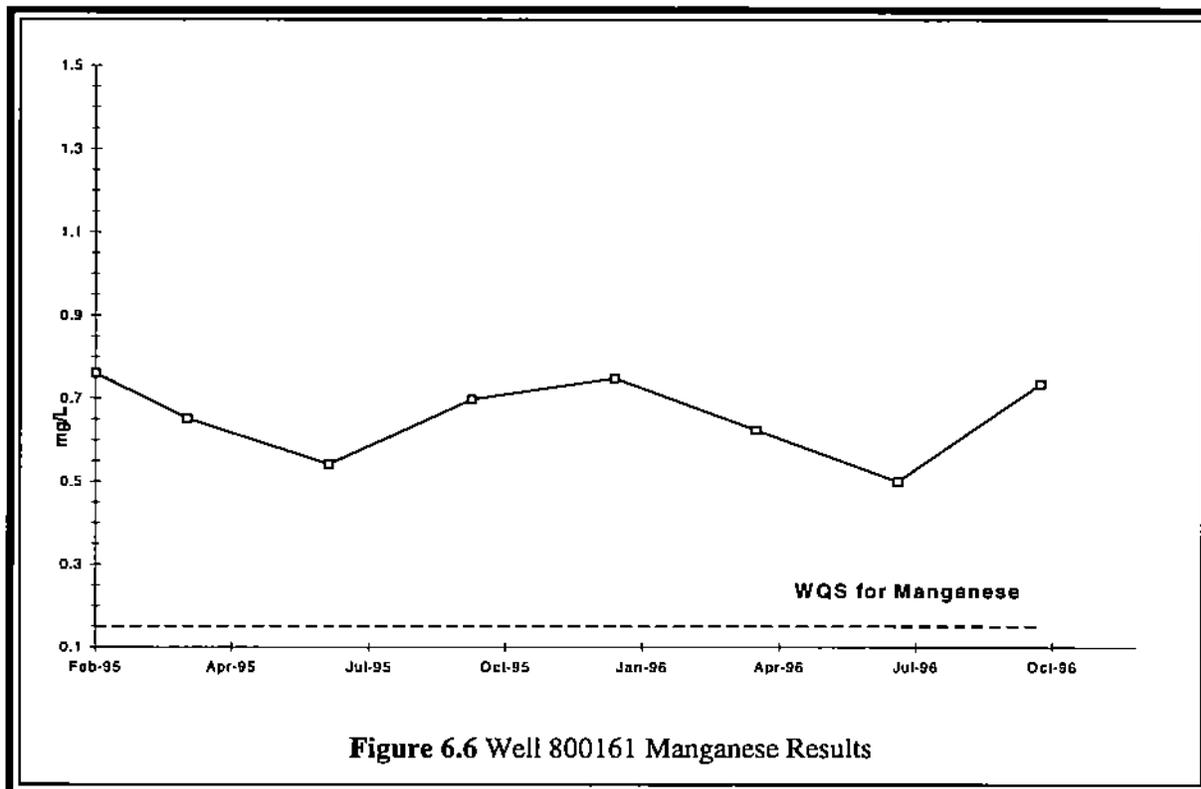
Constituent	Units	Date of Sampling				
		01/11/96	04/04/96	04/04/96	07/03/96	10/03/96
Water Elevation	m	192.50	192.53	192.53	192.82	192.40
Temperature	°C	11.6	11.2	52.2	11.8	11.1
pH	pH	6.88	6.85	6.85	7.03	6.67
Redox	mV	-76	-14	-14	-	-65
Conductivity	µmhos/cm	1252	1243	1243	1372	1224
Chloride - Filtered	mg/L	147	125	119	150	103
Sulfate - Filtered	mg/L	47	43	66	45	45
TDS - Filtered	mg/L	695	691	684	723	694
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	NA ^b	0.0058	0.0058	NA	NA
Barium	mg/L	NA	0.1313	0.1103	NA	NA
Boron	mg/L	NA	0.2833	0.3399	NA	NA
Cadmium	mg/L	NA	< 0.0001	< 0.0001	NA	NA
Chromium	mg/L	NA	< 0.02	< 0.02	NA	NA
Cobalt	mg/L	NA	< 0.015	< 0.015	NA	NA
Copper	mg/L	NA	< 0.02	< 0.02	NA	NA
Iron	mg/L	NA	4.484	3.635	NA	NA
Lead	mg/L	NA	0.0015	0.0008	NA	NA
Manganese	mg/L	NA	0.0731	0.0467	NA	NA
Mercury	mg/L	NA	< 0.0001	< 0.0001	NA	NA
Nickel	mg/L	NA	< 0.025	< 0.025	NA	NA
Selenium	mg/L	NA	< 0.002	< 0.002	NA	NA
Silver	mg/L	NA	< 0.001	< 0.001	NA	NA
Zinc	mg/L	NA	0.0319	0.0146	NA	NA
Ammonia nitrogen - Filtered	mg/L	1.0	0.7	1.5	2.5	0.8
Arsenic - Filtered	mg/L	0.0049	0.0038	0.0024	0.0044	0.0059
Barium - Filtered	mg/L	0.1422	0.1177	0.1081	0.1090	0.1366
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0005
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.015	< 0.015	0.022	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	3.536	1.765	1.056	2.184	2.895
Lead - Filtered	mg/L	0.0006	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0586	0.0594	0.0696	0.0503	0.0397
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/L	NA	< 1	< 1	NA	NA
Phenols	mg/L	< 0.020	< 0.015	< 0.015	< 0.015	< 0.020
Hydrogen-3 Chloride	nCVL	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Chloride	mg/L	NA	109	116	NA	NA
Fluoride	mg/L	NA	0.396	0.390	NA	NA
Sulfate	mg/L	NA	40	66	NA	NA
Total organic carbons	mg/L	5.0	4.1	4.6	4.6	3.8
Total organic carbons	mg/L	5.3	4.5	4.2	4.9	3.7
Total organic carbons	mg/L	5.5	5.5	5.2	4.8	3.7
Total organic carbons	mg/L	5.5	4.5	4.2	5.0	3.5
Total organic halogens	mg/L	< 0.010	0.017	0.023	0.019	0.023
Total organic halogens	mg/L	< 0.010	0.014	0.029	0.020	< 0.010
Acetone	µg/L	4	2	- ^c	-	-
Methylene Chloride	µg/L	4	2	1	-	0.4

^a Well point elevation = 223.11 m (MSL); ground surface elevation = 230.76 m (MSL); casing material = stainless steel.

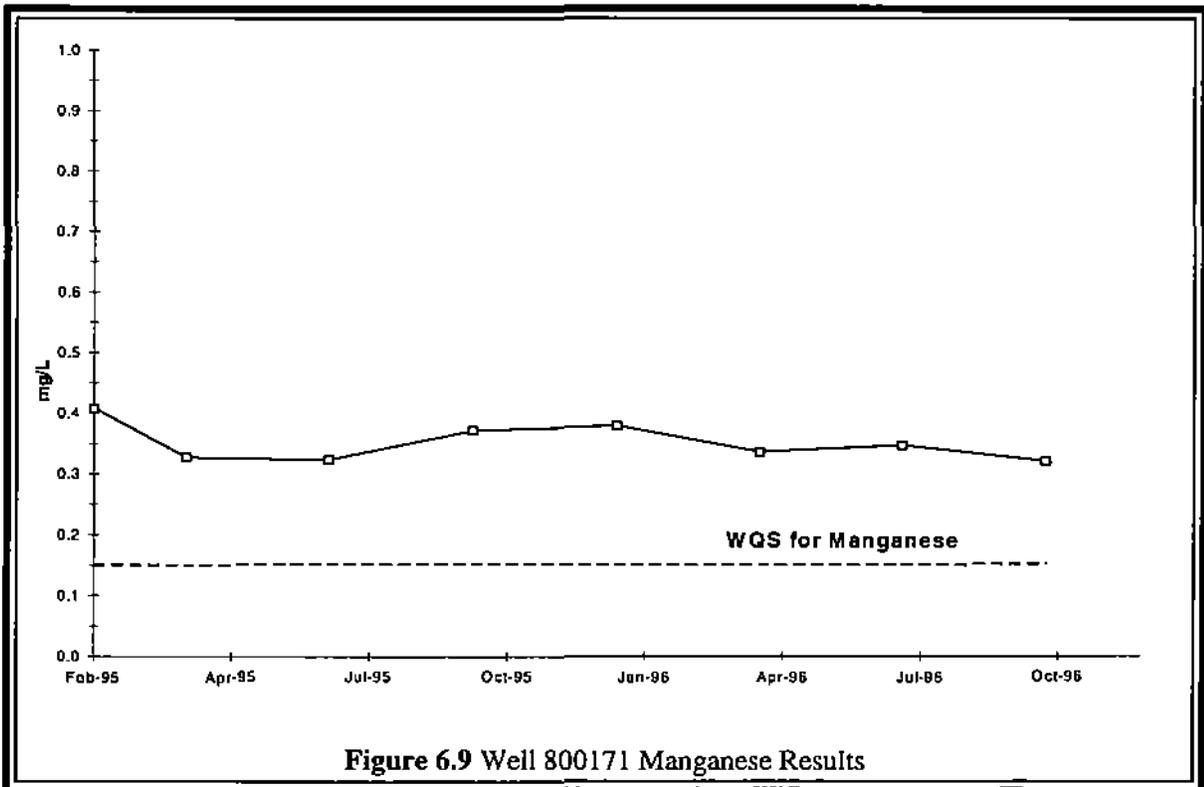
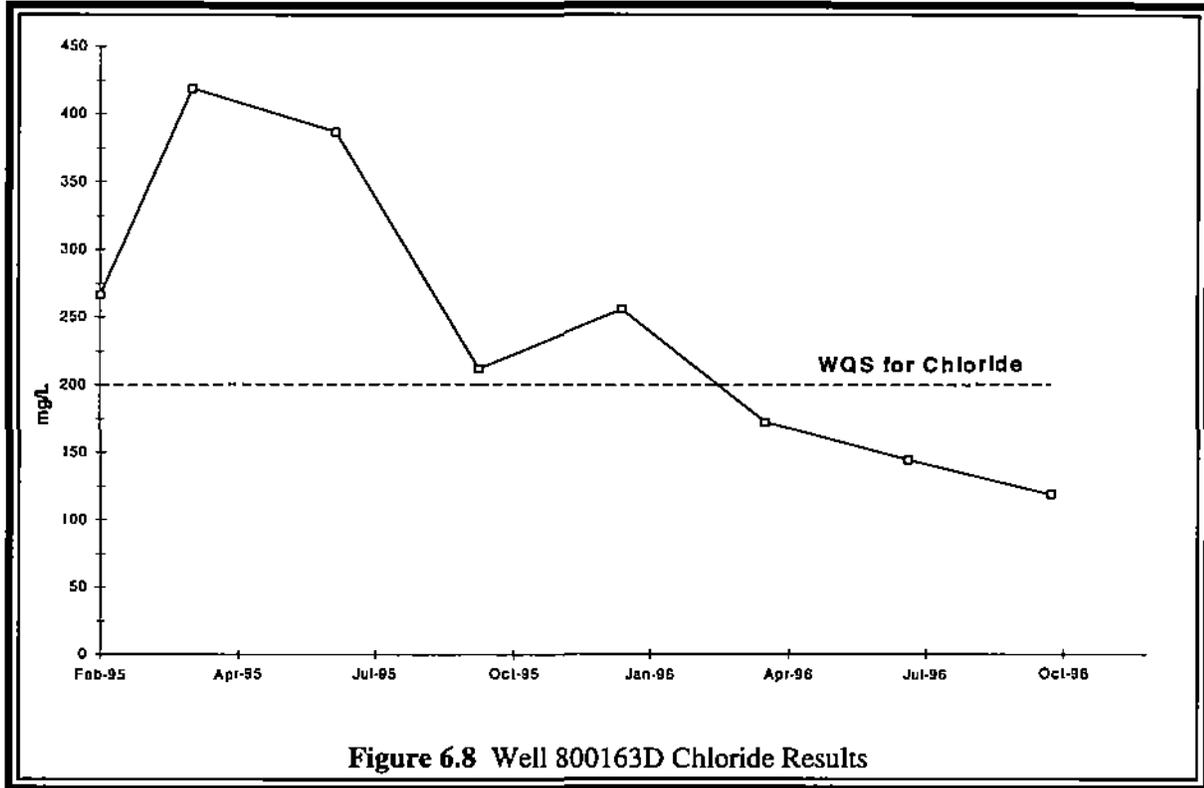
^b NA = not analyzed.

^c A hyphen indicates that the measured value was less than the detection limit.

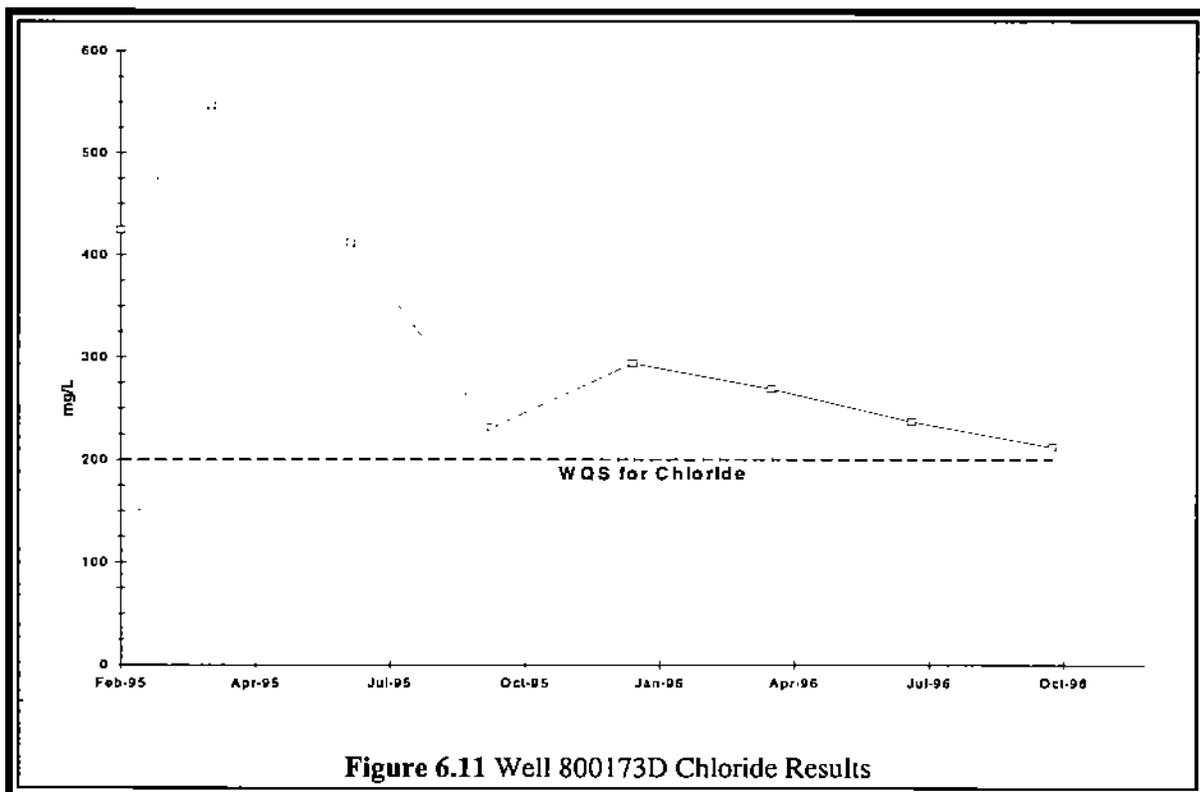
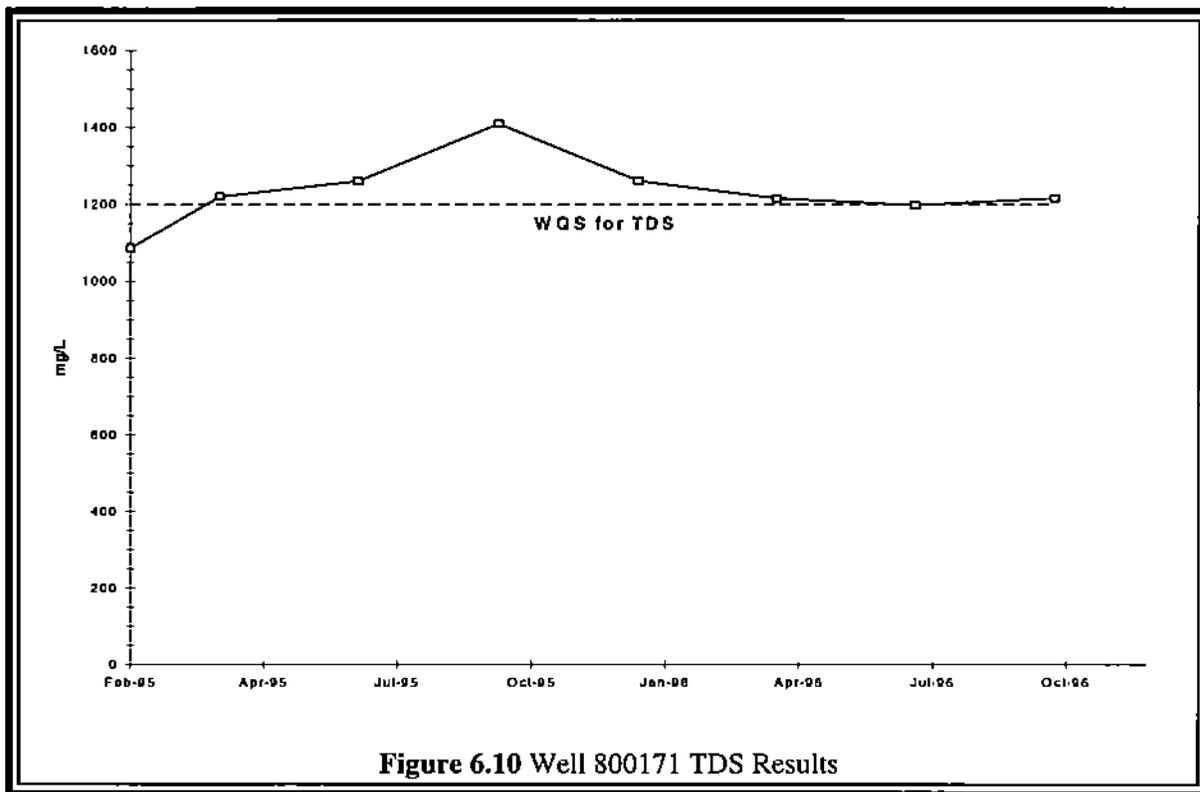
6. GROUNDWATER PROTECTION



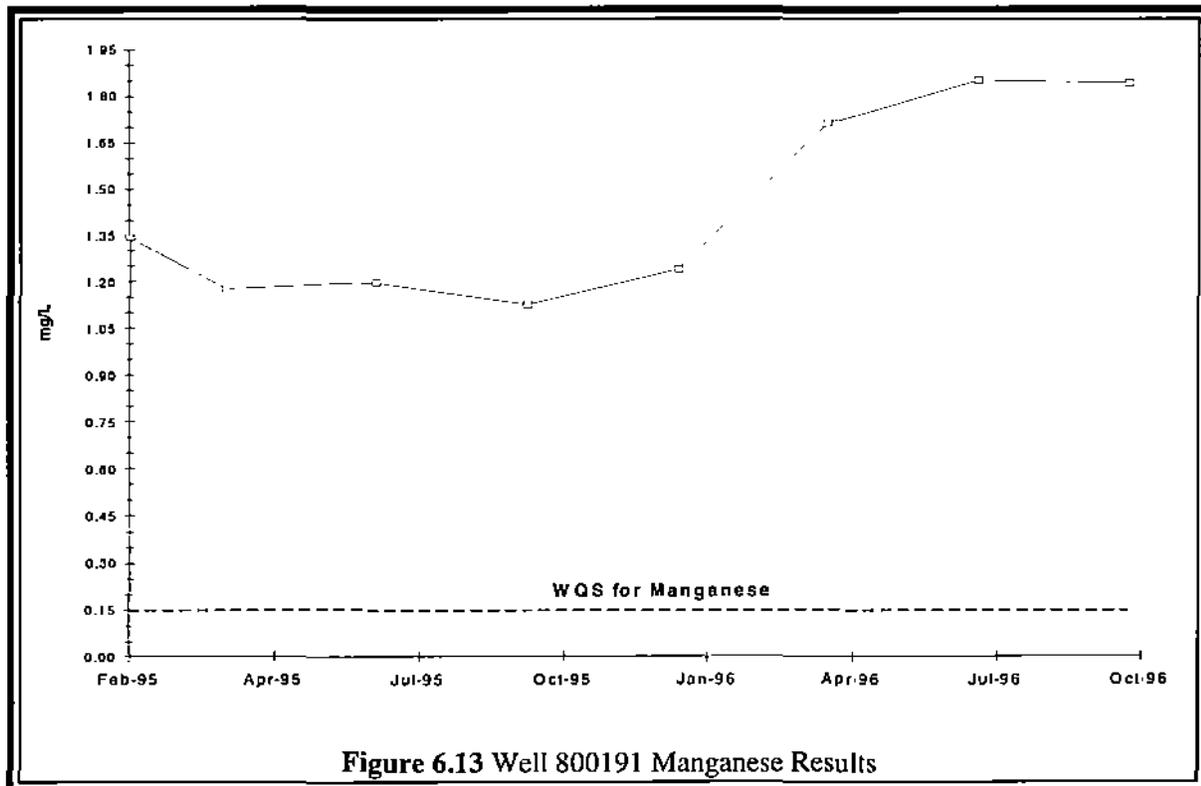
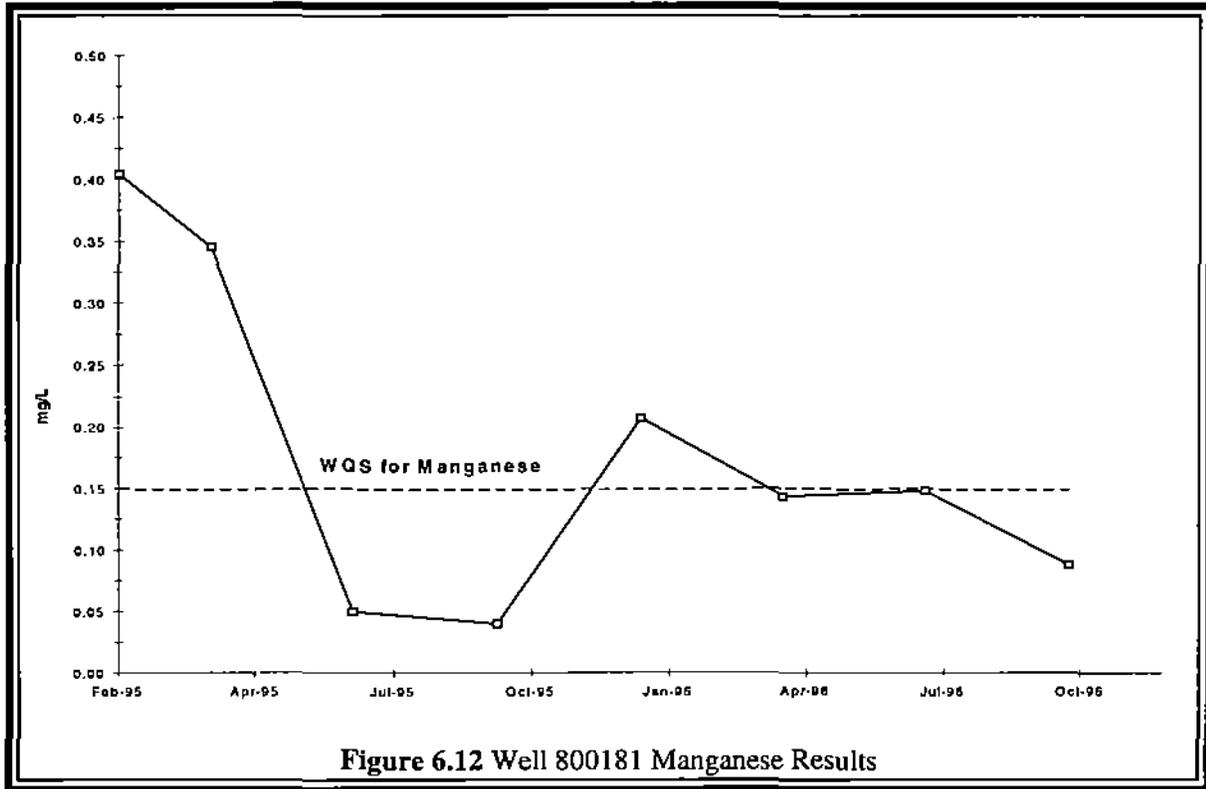
6. GROUNDWATER PROTECTION



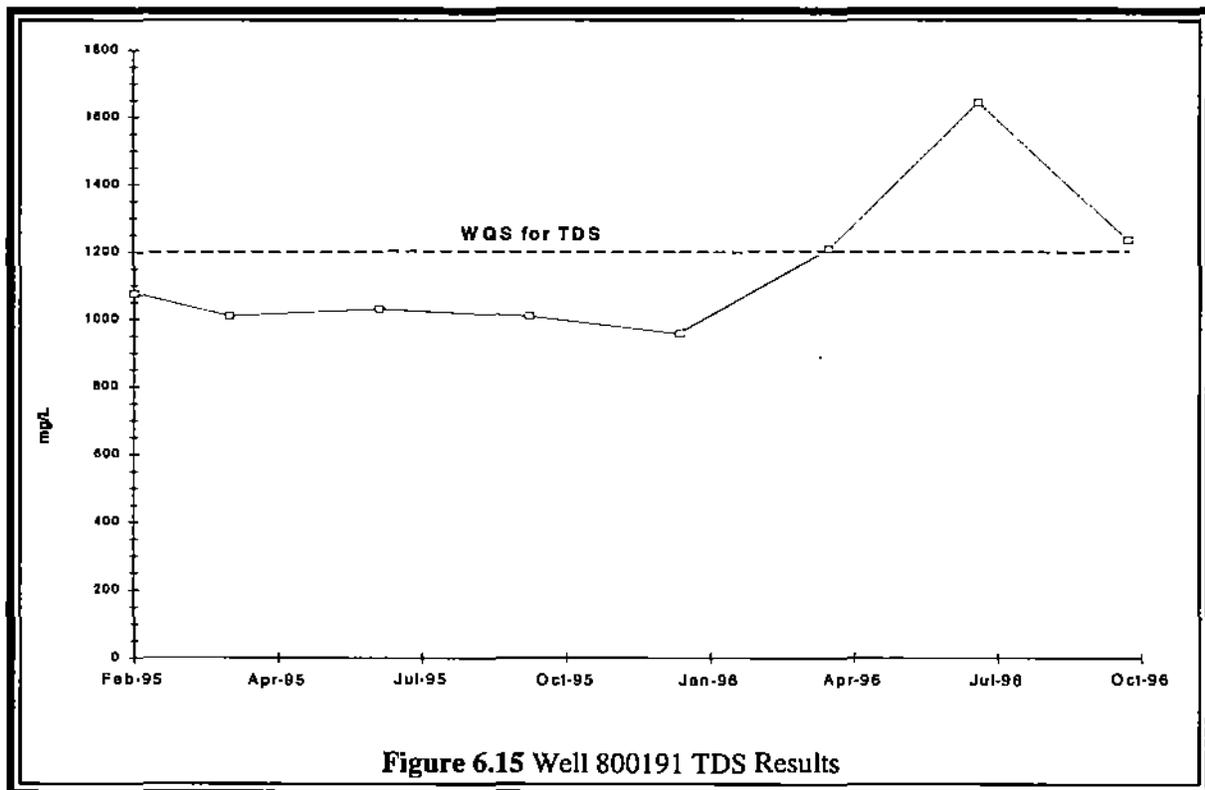
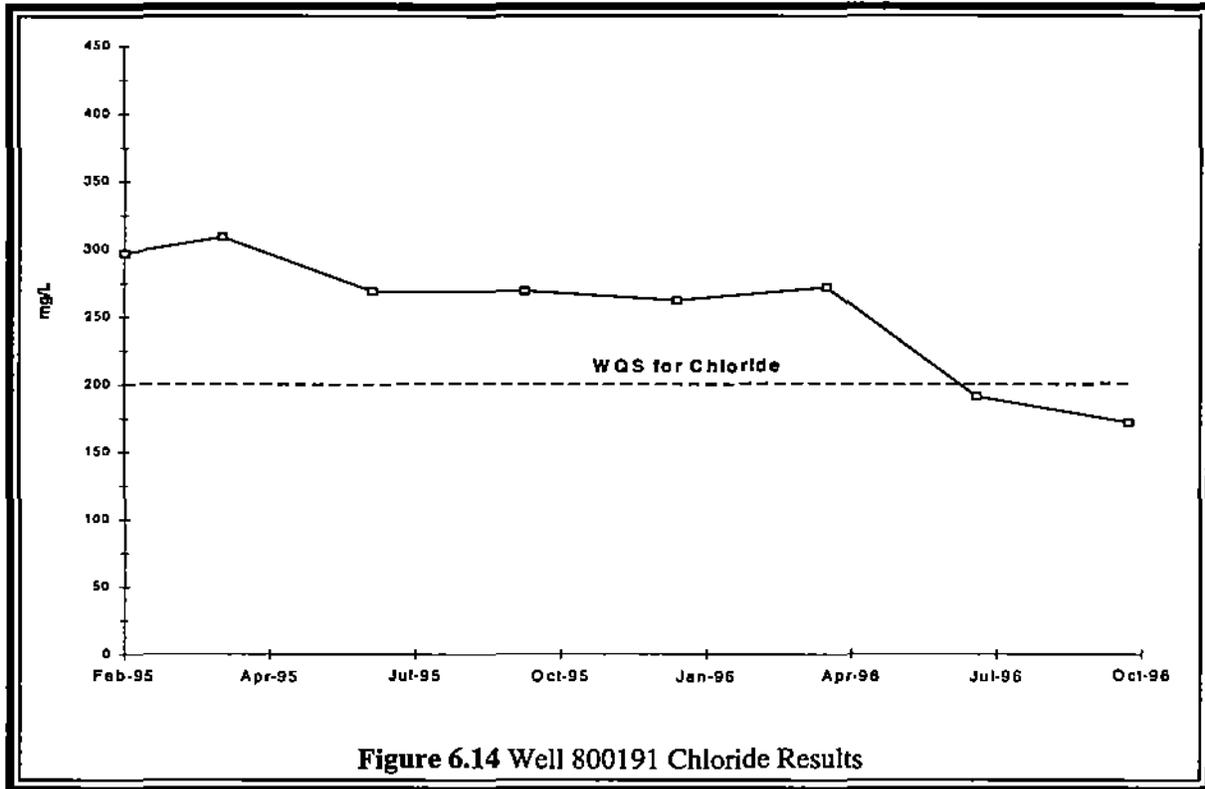
6. GROUNDWATER PROTECTION



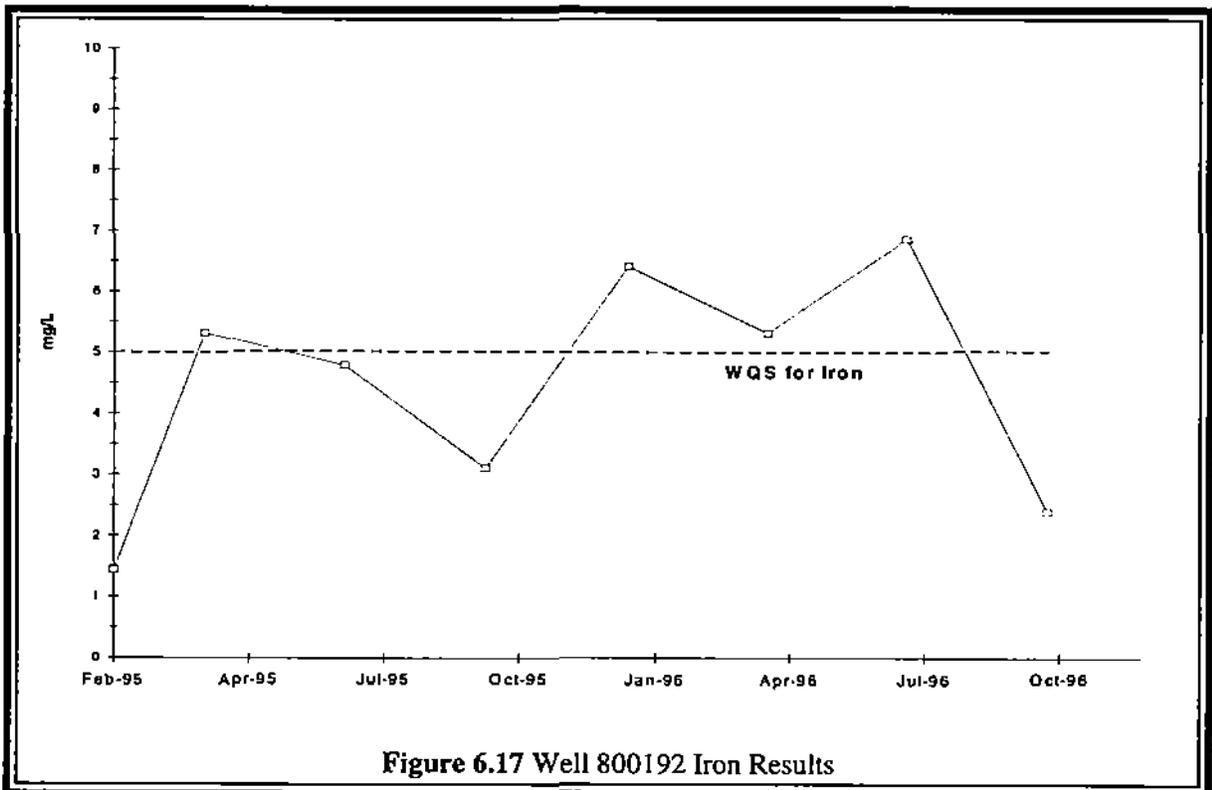
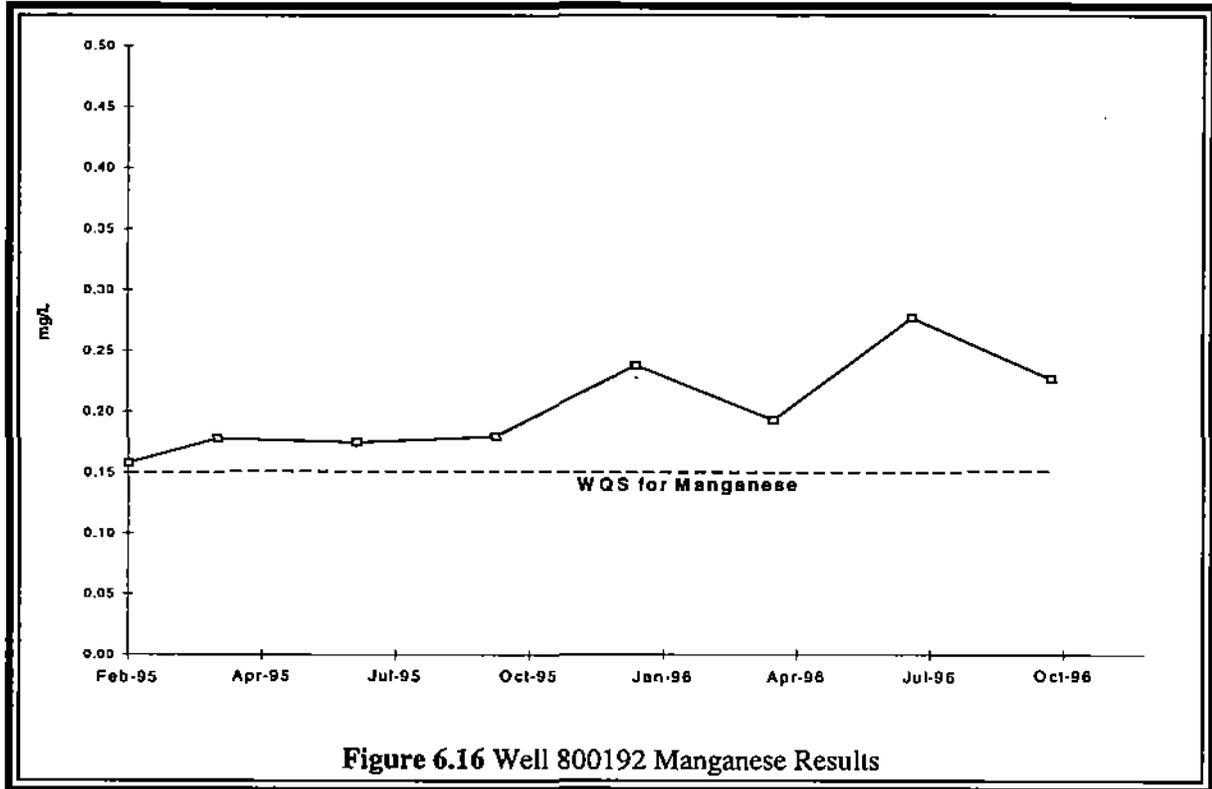
6. GROUNDWATER PROTECTION



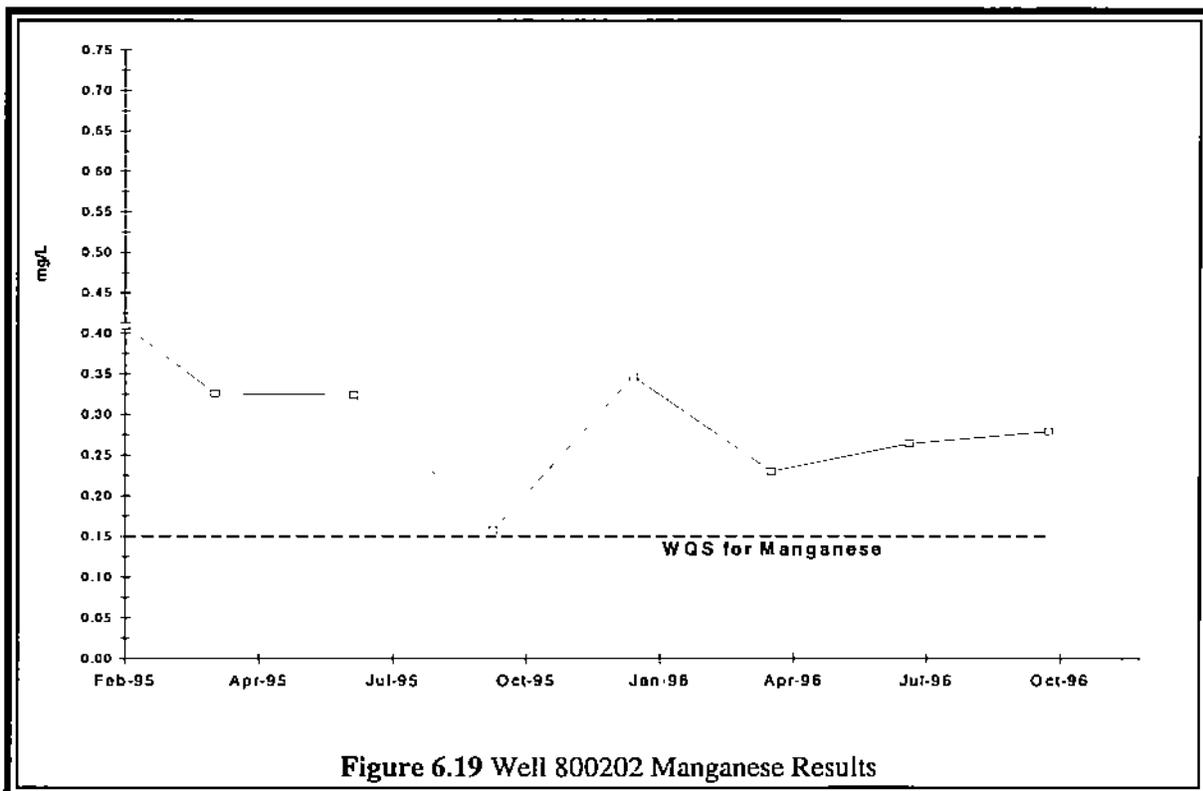
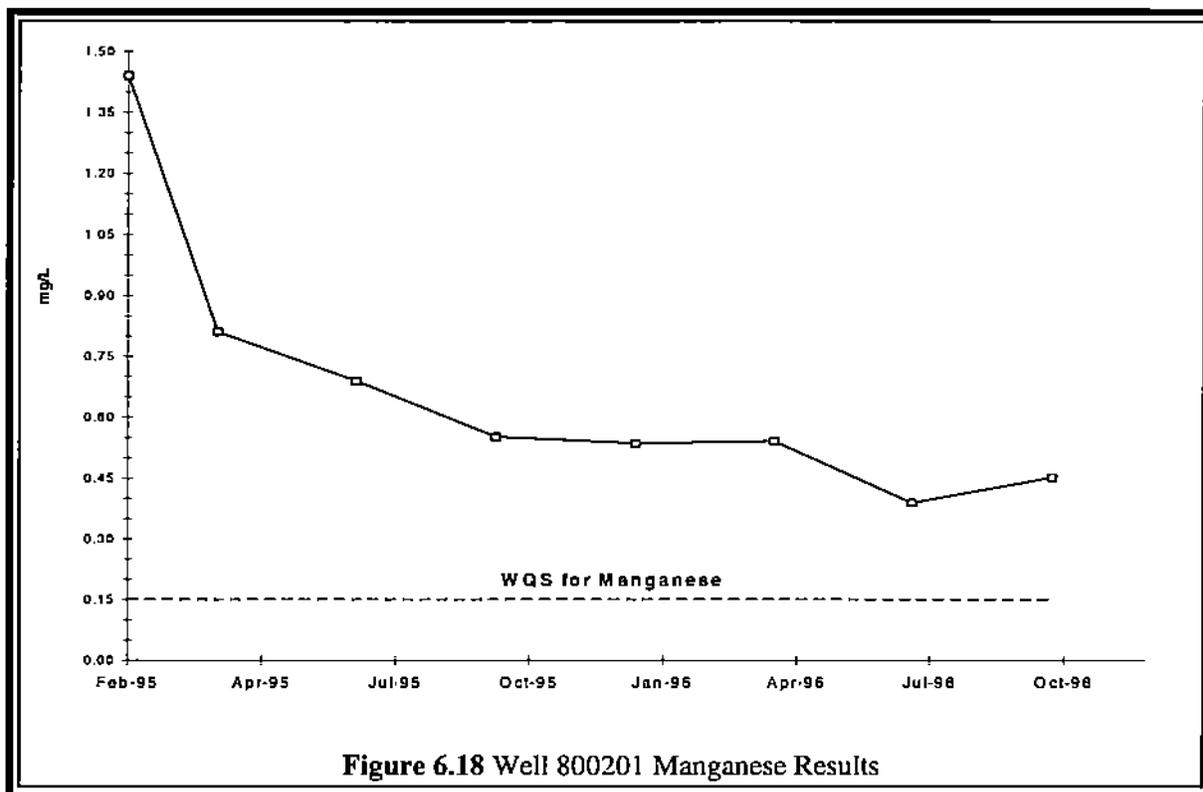
6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION



6. GROUNDWATER PROTECTION

levels above the WQS (see Table 6.22) are chloride, iron, TDS, and manganese. This is consistent with results reported in prior years using the previous well monitoring network.

Well 800173D consistently exceeded the WQS for chloride. Chloride levels ranged from 212 mg/L to 294 mg/L. The WQS for chloride was also exceeded in Well 800163D (first quarter only) and Well 800191 (second quarter only). During the second quarter when unfiltered iron samples were required, the iron WQS was exceeded in unfiltered samples for Wells 800161, 800171, 800173D, 800181, 800191, 800192, 800193D, and 800201. The iron levels ranged from 7 mg/L to 149 mg/L. The iron WQS was slightly exceeded (6 mg/L and 7 mg/L) in the filtered iron sample for Well 800192 during the first and third quarters. Similar to 1995 results, the manganese WQS was consistently exceeded in Wells 800161, 800162, 800171, 800191, 800192, 800201, and 800202. Manganese levels in these wells ranged from 0.20 mg/L to 1.9 mg/L. The total dissolved solid WQS was exceeded three quarters in Wells 800171 and 800191; levels ranged from 1,205 mg/L to 1,644 mg/L. TDS levels in the blank samples for each quarter ranged from 166 mg/L to 195 mg/L; TDS exceedances at the lower range may not accurately reflect the extent of TDS contamination.

As in 1995, the chromium and nickel WQSs were exceeded during the second quarter in Well 800181. Chromium and nickel are required to be monitored only during the second quarter. Both filtered and unfiltered lead samples are required only during the second quarter. The lead WQS was exceeded in each unfiltered sample for each shallow well (800161, 800171, 800181, 800191, and 800201) during the second quarter. Lead was not detected in the filtered samples.

Organic Constituents. No exceedances of the organic WQS were noted during 1996. Similar to 1995 results, methylene chloride was the most consistent parameter detected during 1996; it was detected in each well at least one or more quarters. Levels were low and ranged from 0.3 $\mu\text{g/L}$ to 5 $\mu\text{g/L}$. Acetone was detected infrequently in Wells 800163D, 800171, 800173D, 800181, 800191, 800192, 800193D, 800201, 800202, and 800203D. Acetone levels ranged from 2 $\mu\text{g/L}$ to 10 $\mu\text{g/L}$. Methylene chloride and acetone were also found in the blank samples during the first and second quarter, respectively; low-level methylene chloride and acetone results during these quarters may be indicative of laboratory contamination. As in 1995,

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but more frequently, chloroethane, trichloroethene, and cis-1,2-dichloroethene were detected in Well 800171. No semivolatiles, PCBs, pesticides, and herbicides were detected in the 800 Area Landfill wells during 1996.

Radioactive Constituents. Samples collected from the 800 Area sanitary landfill monitoring wells were also analyzed for hydrogen-3. The results are shown in Tables 6.26 to 6.38. Although the disposal of radioactive materials was prohibited in the sanitary landfill, very low concentrations of hydrogen-3 were detected in Wells 800161, 800171, and 800192, probably because of inadvertent disposal of radioactivity in ANL-E trash. These results are consistent with 1995 results. A trace level of tritium was also detected in Well 800202 but only during one quarter. However, 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.

6.4. CP-5 Reactor Area

The CP-5 reactor is an inactive research reactor located in Building 330 (see Figure 1.1). CP-5 was a 5-MW research reactor that was used from 1954 until operations were ceased in 1977. In addition to the reactor vessel itself, the CP-5 complex contained several large cooling towers and an outdoor equipment yard used for storage of 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. The results are shown in Tables 6.39 to 6.41. Table 6.42 characterizes all wells in this area (see Figure 6.20 for locations).

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TABLE 6.39

Groundwater Monitoring Results, 300 Area Well 330011, 1996^a

Constituent	Units	Date of Sampling				
		03/05/96	03/05/96	05/28/96	09/16/96	11/14/96
Water Elevation	m	219.34	219.34	220.06	219.34	219.29
Temperature	°C	12.6	12.6	13.6	18.3	17.9
pH	pH	7.01	7.01	6.81	7.02	6.95
Redox	mV	-19	-19	-15	-2	-26
Conductivity	µmhos/cm	1459	1459	1473	1636	1139
Chloride - Filtered	mg/L	159	172	128	166	100
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0620	0.0521	0.0662	0.0762	0.0661
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.0150	0.0625	< 0.0150	< 0.0150	< 0.0150
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025
Lead - Filtered	mg/L	< 0.0005	0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.2238	0.2976	0.8808	0.9066	0.7253
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	0.027	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	< 0.0100	< 0.0100	< 0.0100	0.0225	< 0.0100
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	10.610	10.100	6.894	9.405	4.748
Strontium-90	pCi/L	1.6	1.8	1.6	2.0	2.0
Acetone	µg/L	4	4	^b	-	-
Dichlorofluoromethane	µg/L	3	3	3	4	2
Methylene Chloride	µg/L	1	2	-	-	-
Trichlorofluoromethane	µg/L	4	4	2	6	2

^a Well point elevation = 215.70 m (MSL); ground surface elevations = 222.56 m (MSL); casing material = steel.

^b A hyphen indicates that the measured value was less than the detection limit.

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 than similar wells at other locations. As in past years, the manganese WQS was exceeded each quarter, and levels ranged from 0.22 mg/L to 0.91 mg/L. Low levels of barium and chloride were found each quarter, all well below the WQS. Barium was detected each quarter in Well 330021 and manganese was found two quarters. Manganese was found three quarters in Well 330031, and barium and zinc

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TABLE 6.40

Groundwater Monitoring Results, 300 Area Well 330021, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/28/96	09/16/96	11/14/96
Water Elevation	m	225.80	227.13	225.31	225.11
Temperature	°C	8.0	8.2	12.5	4.8
pH	pH	7.40	7.08	7.38	7.16
Redox	mV	-5	-37	-19	-124
Conductivity	µmhos/cm	772	822	833	599
Chloride - Filtered	mg/L	7	6	6	7
Arsenic- Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0260	0.0246	0.0689	0.0251
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	0.0476	< 0.0200	< 0.0200	< 0.0200
Cobalt - Filtered	mg/L	< 0.015	< 0.015	< 0.015	< 0.015
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.0250	< 0.0250	0.0322	< 0.0250
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	< 0.0100	< 0.0100	0.0579	0.0449
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	< 0.025	< 0.025	< 0.025	< 0.025
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0246	< 0.0100	0.0172	< 0.0100
Cesium-137	pCi/L	< 1.0	-	< 1.0	< 1.0
Hydrogen-3	nCi/L	0.198	0.122	0.189	0.166
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
2-Methylbutane	µg/L	- ^b	-	5	2
Benzene	µg/L	-	-	-	0.1
Methyl Chloride	µg/L	0.6	-	-	-
Toluene	µg/L	-	-	-	0.2
n-Pentane	µg/L	-	-	0.5	0.2

^a Well point elevation = 215.70 m (MSL); ground surface elevations = 222.56 m (MSL); casing material = steel.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.41

Groundwater Monitoring Results, 300 Area Well 330031, 1996^a

Constituent	Units	Date of Sampling			
		03/05/96	05/28/96	09/16/96	11/14/96
Water Elevation	m	225.61	226.15	225.00	225.63
Temperature	°C	4.0	8.6	13.6	12.9
pH	pH	7.15	6.93	7.26	7.14
Redox	mV	-25	-39	-15	-148
Conductivity	µmhos/cm	1474	1258	1289	1050
Chloride - Filtered	mg/L	105	98	92	129
Arsenic - Filtered	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Barium - Filtered	mg/L	0.0337	0.0339	0.0397	0.0442
Beryllium - Filtered	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Cadmium - Filtered	mg/L	0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium - Filtered	mg/L	0.1041	< 0.02	< 0.02	< 0.02
Cobalt - Filtered	mg/L	< 0.0150	< 0.0150	< 0.0150	0.0229
Copper - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Iron - Filtered	mg/L	< 0.025	< 0.025	< 0.025	5.118
Lead - Filtered	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Manganese - Filtered	mg/L	0.0245	< 0.0100	0.1585	0.5432
Mercury - Filtered	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel - Filtered	mg/L	0.1279	0.1042	0.2504	1.6070
Silver - Filtered	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Thallium - Filtered	mg/L	< 0.0015	< 0.0015	< 0.0015	< 0.0015
Vanadium - Filtered	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Zinc - Filtered	mg/L	0.0127	0.0125	0.0164	0.0101
Cesium-137	pCi/L	1.9	1.4	-	< 1.0
Hydrogen-3	nCi/L	0.211	0.272	0.330	0.289
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Acetone	µg/L	2	- ^b	-	-
Methylene Chloride	µg/L	0.7	-	-	-
Trichloroethene	µg/L	-	-	0.2	-

^a Well point elevation = 215.70 m (MSL); ground surface elevations = 222.56 m (MSL); casing material = steel.

^b A hyphen indicates that the measured value was less than the detection limit.

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TABLE 6.42

Groundwater Monitoring Wells: 330 Area/CP-5

ID Number	Well Depth (ft bgs)	Ground Elevation (ft AMSL)	Monitoring Zone ^a	Well Type ^b	Date Drilled
330011	20	745.5	10-20/736-726	2/PVC	8/89
330021	19	746.5	4-19/743-728	2/SS	9/93
330031	17.1	742.1	2-17/740-725	2/SS	9/93

^a Depth/elevation.

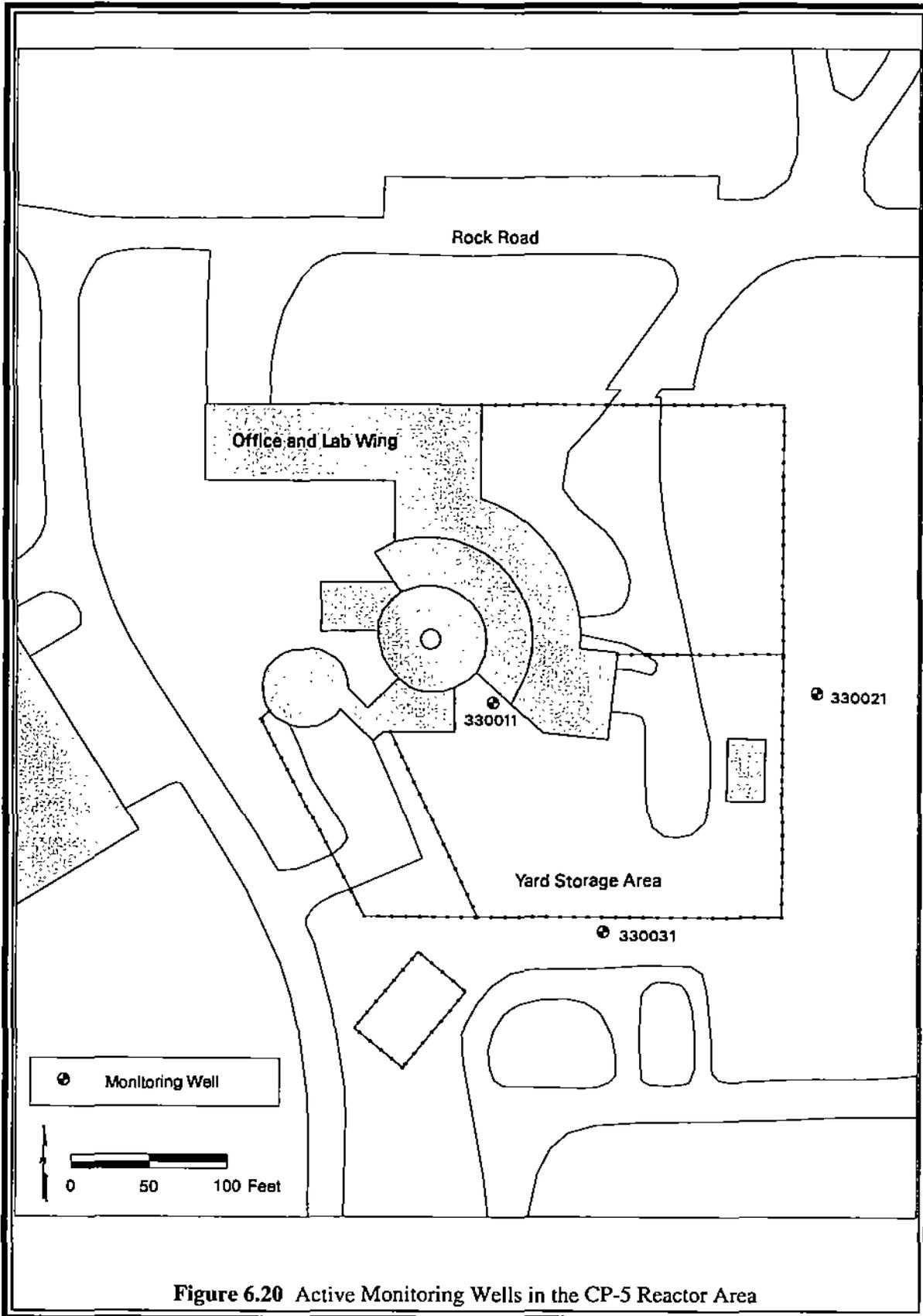
^b Inner diameter (in.)/well material (PVC = polyvinyl chloride, SS = stainless steel).

each quarter, all levels are well below the WQS. Unlike past years, the nickel WQS was exceeded three quarters. The source of nickel is unknown.

Each sample collected from Well 330011 in 1996 contained trichlorofluoromethane and dichlorofluoromethane ranging from 2 to 6 $\mu\text{g/L}$, similar to results from 1991 through 1995. These levels are significantly lower than those reported in 1991 and 1992. Methylene chloride, acetone, benzene, toluene, n-pentane, 2-methylbutane, and trichloroethene were infrequently noted at trace levels.

The levels of hydrogen-3 ranged from 0.12 to 10.6 nCi/L, and the levels of strontium-90 ranged from < 0.25 to 2.0 pCi/L and were noted only in Well 330011. Cesium-137 ranged from < 1 to 1.9 pCi/L and, unlike 1995 results, was noted during two quarters in Well 330031. 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

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responsible for the residual amounts of hydrogen-3 now found in the groundwater. The source of the strontium-90 is not known.

6.5. Site Characterization Activities

Historical information about waste disposal activities on the ANL-E site, as well as groundwater monitoring results, indicate that several sites are either currently releasing small amounts of hazardous materials to the environment or have the potential to do so in the future. Site characterization was completed, and remediation was begun several years ago at locations where waste materials are known to have been managed or disposed of. These projects have focused on the most significant sites, the 800 Area Landfill and the 317/319 Areas. The RFIs in both the 800 Area and the 317/319/ENE Areas were completed in 1996.

6.5.1. 317/319/ENE Area Characterization

6.5.1.1. RCRA Facility Investigation

Field activities for the RFI were begun in the 317/319/ENE areas in December 1994 and were completed in September 1996. The field program resulted in the installation of 33 groundwater monitoring wells and the completion of 38 soil borings. A total of 84 soil samples and 55 groundwater samples were taken and submitted for chemical analysis. Forty-nine soil samples were taken for geotechnical testing. Soil gas measurements and additional soil samples were taken during a shallow soil survey consisting of 90 split-spoon probes.

In addition to the soil borings and well installation work, a sampling program for surface soil, surface water, sediment, and seep water was also completed. A total of 26 surface soil samples were collected from throughout the project area. Surface water and sediment samples were collected at 11 locations in four separate storm drainage ditches that remove storm water from the project area.

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A program of test pit excavation and sampling was completed in the 319 and ENE Areas. A total of 11 test pit soil samples and one test pit water sample were collected and submitted for chemical analysis.

Detailed geophysical surveys conducted by using a variety of geophysical imaging technologies were completed in the 318, 319, and ENE Areas. The purposes of these surveys were to detect and delineate the presence of subsurface anomalies, which likely represent areas of disturbed earth and buried debris.

During the later stages of the RFI, ANL-E discovered a series of groundwater seeps in a network of steeply eroded ravines south and southeast of the 317 and 319 Areas. The seeps are located about 200 m (600 ft) south of the ANL-E fence line in the Waterfall Glen Forest Preserve. Seep samples collected during the RFI showed that two of five seeps identified in the ravines contained detectable levels of organic contaminants. In December 1996, ANL-E initiated an inspection and monitoring program at these seeps. This program requires that the seeps be inspected on a weekly basis to document any human or wildlife contact with the seeps and requires that the seeps be sampled on a monthly basis to record any changes in seep water chemistry. ANL-E also plans to begin a detailed characterization of the geology and hydrogeology of the seep area in 1997 in order to more appropriately manage any risks associated with the seeps and to plan for possible remedial actions.

6.5.1.2. Groundwater

Water samples from the new monitoring wells that were capable of being sampled were analyzed for common field parameters (pH, conductivity, and temperature), total and soluble metals, VOCs and SVOCs, radiochemistry (gross alpha, gross beta, hydrogen-3, and gamma spectrometry), and other parameters. The analytical results from the samples collected indicate that, of the wells in the 317/319/ENE Area, the groundwater from MW001S, which was adjacent to the reported position of the French Drain, contained the highest concentrations of chlorinated hydrocarbons, total organic halides, and chloride. Tritium levels were also slightly higher than

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in the other samples. Chlorinated and other VOCs were also detected in MW001I, MW003S, and MW006S.

Additional monitoring wells were constructed in 1996. One of the objectives of the 1996 drilling and well installation program was to establish background monitoring wells that will provide baseline groundwater chemistry against which the chemistry of the wells in the contaminated area can be compared.

The complete set of results of the chemical analyses of all samples are presented in the RFI report, which was completed in December 1996.²⁹

6.5.1.3. Soil Borings

A program of shallow soil sampling and soil boring was conducted to determine the vertical and lateral extent of soil contamination in the area of the 317 French Drain, the 318 Compressed Gas Cylinder Area, and the Map Tube Vault. Split spoons were driven at about 80 locations within a surveyed grid pattern. The split-spoon survey was conducted in an area approximately outlined by the positions of soil borings SB-A, SB-B, and SB-C.

The RFI investigation determined that in the 317 Area, soil contamination occurs throughout the area among SB-A, SB-B, and SB-C. The contamination is predominantly VOCs. The level of contamination generally decreases with depth and occurs down to between 6 to 12 m (20 to 40 ft) below ground surface in the vicinity of the 317 Area French Drain.

6.5.1.4. Surface Soil Sampling

No appreciable concentrations of contaminants were detected in the surface soils of the 318, 319, and ENE Areas. Very low levels of PCBs were found in the 317, 319, and ENE Areas.

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6.5.1.5. Surface Water and Sediment Sampling

The surface water downstream of the 317 Area was found to contain very low levels of one VOC, as well as elevated levels of tritium. The tritium emanated from a leachate seep in the 319 Landfill Area. Stopping the release of the leachate from the landfill is the objective of an interim remedial action completed in early 1996. One sediment sample contained low levels of PCBs. This sample was collected downstream of the 319 Landfill. Surface water samples collected in a stream adjacent to the two contaminated seeps south of the ANL-E site were found to contain low levels of several organic compounds. No other samples contained elevated amounts of contaminants.

6.5.1.6. South Vaults Decontamination and Demolition

The decontamination and demolition of two concrete vaults was completed. These vaults were contaminated on the inside with low levels of radioactive materials as a result of past use of the vaults. Contaminated areas inside the vaults were removed from the remaining two South Vaults, and the vaults were demolished in place. Contaminated soil, found under the cracks in the floor, was also removed prior to demolition.

6.5.1.7. 319 Area Landfill Interim Action

In early 1996, an interim corrective action was put in place south of the 319 Area Landfill. The 319 Area Landfill was used from the 1950s through 1969 as a disposal area for various solid wastes from throughout ANL-E. Though radioactive waste was not permitted in the landfill, in 1995, small amounts of tritium were discovered in the leachate emanating from the landfill waste mound. Groundwater immediately below the waste mound was also found to contain tritium. Tritium concentrations of up to 1,400 nCi/L were found in the leachate and up to 190 nCi/L in groundwater. The interim action was designed to prevent any further release of leachate and to capture the groundwater at the source, thus preventing future releases. It consisted of a below-ground barrier wall (consisting of a soil/bentonite clay mixture placed in a deep trench); a leachate collection trench that collects leachate in a shallow, gravel-filled trench; and a series of

6. GROUNDWATER PROTECTION

groundwater extraction wells that remove the groundwater before it migrates away from the landfill area. The system was put into operation in February. Since that time, there has been no evidence of the leachate seeps.

Final corrective actions for the landfill, which will include placing an impermeable cap over the waste mound, will be designed and proposed to the IEPA in 1997.

6.5.2 800 Area Characterization

The 800 Area RCRA RFI addressed 11 SWMUs, two environmental AOCs, and one area suspected of containing a former solid waste disposal area. The 800 Area RFI included a field program of soil boring, installation and sampling of groundwater monitoring and leachate wells, surface water and sediment sampling, and geophysical and soil gas surveys.

Analysis of soil samples from the Waste Oil Storage Area detected the presence of SVOCs. The SVOCs detected are all common constituents of fuel and waste oil and include fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[a]fluoranthene, and benzo[a]pyrene. Similar SVOCs were measured in the soil samples from the Waste Oil Satellite Accumulation Area, the area of the Waste Oil Spread on Roads, and the Scrap Metal Storage Area. The detection of VOCs, PCBs, pesticides, and inorganics in these areas was not at levels indicating a significant source of contamination.

Phase I sampling showed that several organic compounds exist in the soil near two removed USTs. This contaminated soil was excavated and disposed of off site as part of an interim action completed in August 1996. No contamination was found in the groundwater.

In 1995, ANL-E completed the following RFI activities at the 800 Area Landfill: installation of five shallow piezometers and staff gauges in the wetlands west of the landfill, collection of groundwater samples from monitoring wells and piezometers, and weekly monitoring of surface and groundwater levels. Analytical results of surface water samples taken in the vicinity of the 800 Area Landfill, the French Drain (Northeast corner), wetland (West side), and leachate seeps

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indicate no contamination at the time of sampling. Wetland sediments taken at the same locations as surface water samples indicated low levels of pesticides, PCBs, and several SVOCs. A sediment sample taken upstream of the landfill contained low levels of a few SVOCs and other organics. Pesticides were detected also from the wetland areas west of the landfill in sediment samples; however, pesticides were also detected in the quality control duplicate sediment sample. PCBs were detected in one sediment sample.

Analytical data from the three leachate wells sampled (one leachate well was dry) showed the presence of VOCs in all three wells (see Figure 6.5; LW02, LW-03, LW04). SVOCs were detected in samples from LW02 and LW03. PCBs were detected only in LW02. No pesticides were detected in any of the leachate wells. Elevated levels of tritium occurred in all the samples from the leachate wells.

Because the 800 Area Landfill and its leachate are a potential source of contamination for the wetland areas and because it is possible that there is a hydrologic connection between the landfill leachate, the groundwater, and the adjacent wetland, additional sampling and detailed water level mapping were conducted. The results of this investigation are discussed in greater detail in the RFI report, which is scheduled to be completed in March 1997.

6.5.3. Sitewide Hydrogeological Characterization Project

This multiphase project is characterizing the complex hydrogeology of the ANL-E site and supporting various RFI activities sitewide. The information being obtained is critical to understanding the current baseline hydrogeological conditions beneath ANL-E and the surrounding forest preserve, including the geochemical and hydrological properties of the uppermost bedrock aquifer system. The project will provide important baseline data for other, smaller scale, characterization and remediation projects. The data will also be an important resource for new construction project designs and environmental spill responses. The information will reveal whether ANL-E operations overall have impacted groundwater.

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In 1996, the dolomite bedrock topography across the site was delineated by seismic geophysical profiling techniques, and a preliminary groundwater flow model of the bedrock aquifer was completed.

The current funding plan calls for the project to be completed over several years. Funding cuts by Congress have put the project on hold for FY 1997. However, a related one-year research project to assess the effects on groundwater levels from ANL-E's conversion to a Lake Michigan water supply was funded in December 1996. The data from this research project will be incorporated into the sitewide hydrogeological characterization project findings and conclusions.

7. QUALITY ASSURANCE



QA plans exist for both radiological and nonradiological analyses. Both QA documents were prepared in accordance with DOE Order 5700.6C. The plans discuss who is responsible for QA and for auditing analyses. Both documents are supplemented by operating manuals.

7.1. 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 was not detected, the result is given as "less than" (<) the detection limit by the analytical method used. The detection limits were 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 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 about 50% of the measured value, and at 10 times the detection limit, the error is about 10%.

Average values are usually accompanied by a plus-or-minus (\pm) limit value. Unless otherwise stated, this value is the standard error at the 95% confidence level calculated from the standard deviation of the average. The \pm limit value is a measure of the range in the concentrations encountered at that location; it does not represent the conventional uncertainty in the average of repeated measurements on the same or identical samples. Since many of the variations observed in environmental radioactivity are not random but occur for specific reasons (e.g., seasonal variations), samples collected from the same location at different times are not replicates. The more random the variation in activity at a particular location, the closer the confidence limits will represent the actual distribution of values at that location. The averages and confidence limits should be interpreted with this in mind. When a \pm value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

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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	100
Lead-210	1	-
Neptunium-237	-	0.001
Plutonium-238	0.0003	0.001
Plutonium-239	0.0003	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	0.0003	0.01
Uranium-235	0.0003	0.01
Uranium-238	0.0003	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.

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Participation continued in the DOE Environmental Measurements Laboratory Quality Assurance Program (DOE-EML-QAP), a semiannual distribution of four different sample matrices containing various combinations of radionuclides that are analyzed. Table 7.2 summarizes the results for 1996. 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 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.

TABLE 7.2

Summary of DOE-EML-QAP Samples, 1996

Radionuclide	Percent Difference From EML Value			
	Air Filters	Soil	Vegetation	Water
Hydrogen-3	- ^a	-	-	15 (2)
Potassium-40	-	20 (2) ^b	20 (2)	-
Manganese-54	11 (2)	-	-	9 (2)
Cobalt-57	15 (2)	-	-	-
Cobalt-60	11 (2)	22 (1)	15 (2)	6 (2)
Strontium-90	6 (2)	3 (2)	12 (2)	9 (2)
Ruthenium-106	9 (2)	-	-	-
Antimony-125	11 (2)	-	-	-
Cesium-134	9 (2)	-	-	-
Cesium-137	10 (2)	21 (2)	24 (2)	9 (2)
Cerium-144	31 (1)	-	-	-
Uranium-234	5 (2)	27 (2)	-	4 (2)
Uranium-238	11 (2)	19 (2)	-	7 (2)
Plutonium-238	1 (2)	7 (2)	14 (1)	4 (2)
Plutonium-239	8 (1)	11 (2)	7 (2)	5 (2)
Americium-241	2 (2)	4 (2)	9 (2)	4 (2)

^a A hyphen indicates that a sample is not required for analysis.

^b The values in parentheses are the number of samples.

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7.2. Chemical Analysis

The documentation for nonradiological analyses is contained in the ESH-AS Chemistry Laboratory Procedure Manual. All samples for NPDES and groundwater are collected and analyzed in accordance with EPA regulations found in 40 CFR Part 136,²⁴ EPA-600/4-84-017,³⁰ and SW-846.⁷

Standard Reference Materials (SRM), traceable to the NIST, exist for most inorganic analyses (see Table 7.3). These are replaced annually. Detection limits are determined with techniques listed in SW-846⁷ 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 in the range of 75% to 125%. The precision, as determined by analysis of duplicate samples, must be within 20%. These measurements must be made on at least 10% of the samples. Comparison samples for organic constituents were formerly available from the EPA, but 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; the results for 1996 are shown in Table 7.5 for VOCs and Table 7.6 for SVOCs. The recoveries listed are those required by the respective methods.

TABLE 7.3

Reference Materials Used for
Inorganic Analysis

Reference Material ^a	Constituent
HPS-10002-2	Antimony
HPS-10003-1	Arsenic
HPS-10004-1	Barium
HPS-10005-1	Beryllium
HPS-10008-1	Cadmium
HPS-10009-1	Calcium
HPS-100012-1	Chromium
HPS-100013-1	Cobalt
HPS-100014-1	Copper
HPS-100026-1	Iron
HPS-100028-1	Lead
HPS-100031-1	Magnesium
HPS-100032-1	Manganese
HPS-100033-1	Mercury
HPS-100036-1	Nickel
HPS-100041-1	Potassium
HPS-100049-1	Selenium
HPS-100051-1	Silver
HPS-100052-1	Sodium
HPS-100065-1	Vanadium
HPS-100068-1	Zinc
NIST-SRM 3181	Sulfate
NIST-SRM 3182	Chloride
NIST-SRM 3183	Fluoride

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

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TABLE 7.4

Limit of Detection for Metals Analysis

Constituent	Limits of Detection mg/L	
	AA ^a	ICP ^b
Antimony	0.0030	NA ^c
Arsenic	0.0020	0.116
Barium	NA	0.0066
Beryllium	0.0002	0.0023
Boron	NA	0.066
Cadmium	0.0001	0.0095
Chromium	0.020	0.020
Cobalt	0.025	0.014
Copper	0.010	0.019
Hexavalent Chromium ^d	0.006	NA
Iron	0.020	0.022
Lead	0.0005	0.136
Manganese	0.015	0.006
Mercury	0.0001	NA
Nickel	0.020	0.023
Selenium	0.0020	0.150
Silver	0.0010	0.021
Thallium	0.0015	0.152
Vanadium	NA	0.017
Zinc	0.005	0.005

^a AA = Atomic Absorption Spectroscopy.

^b ICP = Inductively Coupled Plasma-Atomic Emission Spectroscopy.

^c NA = not analyzed.

^d Spectrophotometric measurement.

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TABLE 7.5

Quality Check Sample Results: Volatile Analyses, 1996

Compound	Recovery ^a (%)	Quality Limits (%)
Benzene	98	73-126
Bromobenzene	114	76-133
Bromodichloromethane	84	101-138
Bromoform	76	57-156
Butylbenzene	94	71-125
sec-Butylbenzene	94	71-145
t-Butylbenzene	103	69-134
Carbon Tetrachloride	93	86-118
Chlorobenzene	101	80-137
Chloroform	99	68-120
o-Chlorotoluene	102	81-146
p-Chlorotoluene	103	73-144
1,2-Dibromo-3-chloropropane	61	36-154
Dibromochloromethane	80	68-130
1,2-Dibromoethane	89	75-149
Dibromomethane	94	65-143
1,2-Dichlorobenzene	101	59-174
1,3-Dichlorobenzene	111	84-143
1,4-Dichlorobenzene	108	58-172
1,1-Dichloroethane	102	71-142
1,2-Dichloroethane	99	70-134
1,1-Dichloroethene	101	18-209
cis-1,2-Dichloroethene	107	85-124
trans-1,2-Dichloroethene	95	67-141
1,2-Dichloropropane	99	19-179
1,3-Dichloropropane	94	73-145
1,1-Dichloropropene	97	71-133
Ethyl Benzene	98	84-130
Isopropylbenzene	101	70-144
4-Isopropyltoluene	97	72-140
Methylene Chloride	99	D-197 ^b
n-Propylbenzene	115	78-139
1,1,1,2-Tetrachloroethane	89	88-133
Tetrachloroethene	110	84-132
Toluene	95	81-130
1,1,1-Trichloroethane	95	68-149
1,1,2-Trichloroethane	93	70-133
Trichloroethene	97	91-135
1,2,3-Trichloropropane	84	50-158
1,2,4-Trimethylbenzene	95	80-144
1,3,5-Trimethylbenzene	91	76-142
o-Xylene	98	79-141
p-Xylene	115	74-138

^a Average of two determinations.

^b D denotes the compound was detected.

7. QUALITY ASSURANCE

TABLE 7.6

Quality Check Sample Results:
Semivolatile Analyses, 1996

Compound	Recovery ^a (%)	Quality Limits (%)
2-Fluorophenol ^b	54.1	21-100
Phenol-d5 ^b	40.8	10-94
Phenol	38.6	17-100
2-Chlorophenol	77.4	36-120
1,4-Dichlorobenzene	56.2	37-106
n-Nitroso-n-Propylamine	40.0	24-198
Nitrobenzene-d5 ^b	99.5	35-114
1,2,4-Trichlorobenzene	66.5	57-129
4-Chloro-3-Methylphenol	86.5	41-128
2-Fluorobiphenyl ^b	87.8	43-116
Acenaphthene	89.8	47-145
2,4-Dinitrotoluene	81.1	48-127
2,4,6-Tribromophenol ^b	58.9	10-123
Pentachlorophenol	125.7	38-152
Pyrene	82.4	70-100
Terphenyl-d14 ^b	95.6	33-141

^a Average of three determinations.

^b Required surrogates.

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