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ARGONNE NATIONAL LABORATORY
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ARGONNE NATIONAL LABORATORY-EAST SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1993

by

N. W. Golchert and R. G. Kolzow

Environment and Waste Management Program

May 1994

Preceding Report in This Series: ANL-93/5

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ACRONYMS

1,2-DCE	cis-1,2-Dichloroethene
ACM	Asbestos-Containing Materials
ADS	Activity Data Sheets
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory-East
APS	Advanced Photon Source
ASTM	American Society for Testing and Materials
ATLAS	Argonne Tandem Linac Accelerating System
BAT	Best Available Technology
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CAS	Chemical Abstract
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
CP-5	Chicago Pile-Five
CRADA	Cooperative Research and Development Agreement
CRM	Cultural Resource Management
CSO	Cognizant Secretarial Office
CWA	Clean Water Act
CWDD	Continuous Wave Deuterium Demonstrator
CY	Calendar Year
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guides
DMR	Discharge Monitoring Report
DOE	U. S. Department of Energy
DOE-CH	U. S. Department of Energy - Chicago Operations Office
DOT	Department of Transportation
DPCHD	DuPage County Health Department
EA	Environmental Assessment
EBWR	Experimental Boiling Water Reactor
ECR	Environmental Compliance Representative
EH	DOE-Environment, Safety and Health
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EMS	Environmental Protection Data Management System
ENE	East-Northeast
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know
ESA	Endangered Species Act

ESH	Environment, Safety and Health
ESH/DACH	Environment, Safety and Health/Dosimetry and Analytical Services, Chemistry Laboratory
ESH/DACL	Environment, Safety and Health/Dosimetry and Analytical Services, Control Laboratory
ESH/DARC	Environment, Safety and Health/Dosimetry and Analytical Services, Radiochemistry Laboratory
EWM	Environment and Waste Management Program
FEUL	Fossil Energy Users Laboratory
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FWS	Fish and Wildlife Service
FY	Fiscal Year
GOCO	Government-Owned Contractor-Operated
HEPA	High-Efficiency Particulate
HRS	Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments
IAC	Illinois Administrative Code
ICP	Inductively Coupled Plasma
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
LEPC	Local Emergency Planning Committee
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
MHD	Magneto Hydrodynamics
MSDS	Material Safety Data Sheets
MSL	Mean Sea Level
NBL	New Brunswick Laboratory
NCRP	National Commission 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
NOAA	National Oceanic and Atmospheric Administration
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 Biphenyls
PFS	Plant Facilities and Services
PRP	Potentially Responsible Party
PCV	Polyvinyl Chloride
QA	Quality Assurance

QAP	Quality Assurance Program
RCRA	Resources Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
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 Countermeasures
SRM	Standard Reference Material
SSI	Site Screening Investigation
SWMU	Solid Waste Management Units
TCA	1,1,1-trichloroethane
TCE	Trichloroethene
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TRE	Toxicity Reduction Evaluation
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
VOC	Volatile Organic Compounds
WMO	Waste Management Operations
WQS	Water Quality Standards
ZPR	Zero Power Reactor

ARGONNE NATIONAL LABORATORY-EAST SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1993

by

N. W. Golchert and R. G. Kolzow

ABSTRACT

This report discusses the results of the environmental protection program at Argonne National Laboratory-East (ANL) for 1993. To evaluate the effects of ANL operations on the environment, samples of environmental media collected on the site, at the site boundary, and off the ANL site were analyzed and compared to applicable guidelines and standards. A variety of radionuclides was measured in air, surface water, groundwater, soil, grass, and bottom sediment samples. In addition, chemical constituents in surface water, groundwater, and ANL effluent water were analyzed. External penetrating radiation doses were measured and the potential for radiation exposure to off-site population groups was estimated. The results of the surveillance program are interpreted in terms of the origin of the radioactive and chemical substances (natural, fallout, ANL, and other) and are compared with applicable environmental quality standards. A U. S. Department of Energy (DOE) dose calculation methodology, based on International Commission on Radiological Protection (ICRP) recommendations and the CAP-88 version of the EPA-AIRDOSE/RADRISK computer code, is used in this report. The status of ANL environmental protection activities with respect to the various laws and regulations which govern waste handling and disposal is discussed. This report also discusses progress being made on environmental corrective actions and restoration projects from past activities.

EXECUTIVE SUMMARY

This report is a summary of the ongoing environmental protection program conducted by ANL in 1993. It includes descriptions of the site, the ANL 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 site and in the surrounding region. These activities document compliance with appropriate standards and permit limits, identify trends, provide information to the public, and contribute to a better understanding of ANL's impact on the environment. The surveillance program supports the ANL policy to protect the public, employees, and the environment from harm that could be caused by ANL activities and to reduce environmental impacts to the greatest degree practicable.

Compliance Summary

Radionuclide emissions, the disposal of asbestos, and conventional air pollutants from ANL facilities are regulated under the Clean Air Act (CAA). A number of airborne radiological emission points at ANL are subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations for radionuclide releases from DOE facilities (40 CFR 61, Subpart H). All such air emission sources were evaluated to ensure that the requirements are being properly addressed. The ANL individual off-site dose required to be reported by these U. S. Environmental Protection Agency (EPA) regulations was 0.014 mrem/y in 1993. This is 0.14% of the 10 mrem/y standard.

At ANL, asbestos-containing material was frequently encountered during maintenance or renovation of existing facilities and equipment. Asbestos was removed in strict accordance with the NESHAP regulations as well as with the much stricter Occupational Safety and Health Administration (OSHA) worker protection standards. All asbestos waste material was disposed of at off-site landfills in Illinois. Approximately 210 m^3 (7398 ft^3) of asbestos-containing materials were removed and disposed of off-site during 1993.

The ANL site contains several sources of conventional air pollutants. The steam plant and fuel dispensing facilities operate continuously and represent the only significant sources of conventional air pollutants. The operating permit for the steam plant requires continuous opacity and sulfur dioxide monitoring of the smoke stack from Boiler No. 5, the only boiler equipped to burn coal. Coal was burned eight months (4100 hrs) during 1993, whereas natural gas was used exclusively as a fuel for four months of the year. During the period coal was burned, which is in colder weather to supplement the gas-fired boilers, one excursion for sulfur dioxide was observed.

The principal regulatory mechanism designed to achieve the goals of the Clean Water Act (CWA) is the National Pollutant Discharge Elimination System (NPDES). The authority to implement the NPDES program has been delegated to the State of Illinois. Nine surface water discharge points are regulated by the ANL NPDES permit, which identifies the sampling locations, sampling frequency, constituents, and limits. Although there was a slight increase of NPDES exceedances (25) during 1993, overall the number of NPDES exceedances has been declining with 86 in 1990, 44 in 1991, and 19 in 1992.

ANL 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). Fourteen hazardous waste treatment and storage facilities have been identified. The Part B permit application is currently under review.

ANL has prepared and implemented a site-wide underground storage tank compliance plan. Thirty-three tanks were removed over the past several years and 22 tanks replaced or upgraded in FY 1992 and FY 1993. Three tanks in the 800 Area (Building 827) which are no longer necessary for operation remain to be removed. One additional tank (Tank No. 17) servicing Buildings 813 and 815 will be upgraded or replaced as appropriate in FY 1994 or FY 1995. 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. All but one of these contaminated sites were successfully cleaned and filled. One site completed in 1989 required a "dirty" closure due to its proximity to a building.

In 1986, ten potential Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites were identified. Under the Superfund Amendments and Reauthorization Act (SARA) of 1986, a total of 15 PA reports were submitted. In late 1990, SSI reports were completed on two individual sites and one composite submittal of three locations (317/319/ENE). Characterization studies are at various stages for a number of the identified sites. For some sites, the regulatory vehicle (CERCLA, RCRA, or some combination) has not as yet been established.

The only Toxic Substances Control Act (TSCA) compounds in significant quantities at ANL 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. A sludge drying bed, servicing the ANL wastewater treatment plant, is contaminated with PCBs of unknown origin. An extensive characterization study and appropriate remediation of this site is underway.

The DOE implementation of the National Environmental Policy Act (NEPA) regulations 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 (EA) will be required for several projects. There are currently no active projects at ANL for which an Environmental Impact Statement (EIS) is required.

The 1993 Five-Year Plan requests funds for on-site corrective action projects, environmental restoration projects, and waste management activities. The corrective action projects concentrate on upgrading or replacing existing treatment facilities. Environmental restoration activities are projects which assess and clean up inactive waste sites. These include two 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 clean up at the Experimental Boiling Water Reactor (EBWR) and Chicago Pile-Five (CP-5) research reactors. The majority of the Waste Management projects involve improvements to existing treatment or storage facilities.

Environmental Surveillance Program

Airborne emissions of gaseous radioactive materials from ANL were monitored and the effective dose equivalents were estimated at the site perimeter and to the maximally-exposed member of the public. The CAP-88 version of the EPA/AIRDOSE-RADRISK code was used. The estimated maximum perimeter dose was 0.78 mrem/y in the north direction, while the estimated maximum dose to a member of the public was 0.24 mrem/y. This is 0.24% of the DOE radiation protection standard of 100 mrem/y for all pathways. Approximately 96% of this estimated dose is due to the release of 2023 curies of radon-220 in 1993. 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 0.014 mrem/y. The estimated population dose from all releases to the approximately eight million people living within 80 km (50 mi) of the site was 13.0 man-rem.

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

The only source of radionuclides and chemical pollutants in surface water due to ANL releases was in Sawmill Creek below the waste water discharge point. At various times, measurable levels of hydrogen-3, strontium-90, cesium-137, plutonium-239, and americium-241 were detected. Of these radionuclides, the maximum annual release was 18.7 curies of hydrogen-3. The dose to a hypothetical individual using water from Sawmill Creek as his sole source of drinking water would be 0.086 mrem/y. However, no one uses this as drinking water and dilution by the Des Plaines River reduces the concentrations of the measured radionuclides to levels below their respective detection limits downstream from ANL at Lemont. Sawmill Creek is also monitored for nonradiological constituents to demonstrate compliance with State of Illinois water quality standards. Silver and copper were occasionally detected above the standard.

Surface soil and grass samples were collected at ten perimeter and ten off-site locations during 1993. 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 waste water discharge. For comparison purposes, samples were also collected from the beds of ten off-site streams and ponds. The analysis of the off-site samples for selected radionuclides established their current ambient levels. Elevated levels of cesium-137 (up to 1.34 pCi/g), plutonium-238 (up to 0.002 pCi/g), plutonium-239 (up to 0.026 pCi/g), and americium-241 (up to 0.011 pCi/g) were found in the sediment below the outfall and are attributed to past ANL releases.

Dose rates from penetrating radiation (gamma-rays) were measured at 14 perimeter and on-site locations and at five off-site locations in 1993 using thermoluminescent dosimeters. The off-site results averaged 76 ± 6 mrem/y, consistent with the long-term average. Above-background doses occurred at one perimeter location and were due to ANL operations. At the south fence, radiation from a temporary storage facility for radioactive waste resulted in an average net dose of 103 mrem/y for 1993. The estimated dose from penetrating radiation to the nearest resident south of the site was < 0.01 mrem/y.

The potential radiation doses to members of the public from ANL operations during 1993 were estimated by combining the exposure from inhalation, ingestion, and direct radiation pathways. The pathway that dominates is the airborne releases. The highest estimated dose was about 0.24 mrem/y to individuals living 500 m 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 operations are well within all applicable standards and are insignificant when compared to doses received by the public from natural radiation (~ 300 mrem/y) or other sources, e.g., medical x-rays and consumer products (~ 60 mrem/y).

Radiological and chemical constituents in the groundwater were monitored in several areas of the ANL site in 1993. The ANL domestic water supply is monitored by collecting quarterly samples from the four wells and a treated water tap. All results were less than the limits established by the Safe Drinking Water Act (SDWA) except for elevated levels of total dissolved solids (TDS). The action levels for copper and lead in drinking water were not exceeded during 1993.

Ten monitoring wells screened in the glacial till and two into the dolomite were sampled quarterly at the 317/319 Area and analyzed for radiological and for volatile organic, semivolatile, PCBs, and pesticides/herbicides constituents. The major organic contaminants detected were trichloroethene, 1,1,1-trichloroethane, carbon tetrachloride, and chloroform. Measurable levels of hydrogen-3, strontium-90, and cesium-137 were present in several of the wells. A characterization program to assess the extent of the groundwater contamination was initiated during 1993.

Eleven monitoring wells screened in the glacial till and two into the dolomite at the 800 Area sanitary landfill are sampled on a quarterly basis and analyzed for metals, volatile organic compounds, semivolatiles, PCBs, pesticides/herbicides, and hydrogen-3. Levels above Water Quality Standards (WQS) for chloride, iron, manganese, total dissolved solids, pH, arsenic, and phenols were found in some wells. Above background levels of hydrogen-

3, 1,4-dioxane, and chlorodifluoromethane were found in two of the wells. A work plan for a groundwater characterization program at this site was completed during 1993.

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 inter-laboratory cross-checks, and replicate sampling and analysis. Data were managed and tracked by a dedicated computerized data management system which assigns unique sample numbers, schedules collection and analysis, checks status, and prepares tables and information for the annual report.

1. INTRODUCTION

1.1. General

This annual report on the ANL environmental protection program provides the DOE, environmental agencies, and the public with information on the levels of radioactive and chemical pollutants in the vicinity of ANL and on the amounts, if any, added to the environment by ANL operations. It also summarizes compliance of ANL 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]

ANL 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 operations of ANL is of special interest. One important function of the program is to verify the adequacy of ANL's pollution control systems.

ANL 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 1993 included: advanced reactor development; safety studies for light water and breeder reactors; component and material development for fission and fusion 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 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 are: 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 plutonium laboratories; and several hot cells and laboratories designed for work with multi-curie 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 site.

Two activities initiated in 1984 and continued in 1993 have some potential environmental impact: (1) management of radioactive contamination remaining from the proof-of-breeding in light-water reactors project, which involved the dissolution and analysis of irradiated thorium and uranium-233 dioxide fuel elements and (2) recovery of tritium from reactor irradiated ceramic lithium compounds. The shut down 5-MW heavy water enriched uranium research reactor (CP-5) and the EBWR are in various stages of decontamination and decommissioning.

The principal nonnuclear activities at ANL in 1993 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 use of large quantities of chlorine for water treatment. The boiler, designed to burn high-sulfur (3.5%) Illinois coal to produce steam for ANL use, is equipped with a slaked lime spray scrubber and bag collector to reduce sulfur dioxide and particulate emissions. 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. Chlorine is used for wastewater treatment. 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

Argonne National Laboratory (Illinois site) occupies the central 688 hectares (1,700 acres) of a 1,514-hectare (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 826-hectare (2,040-acre) Waterfall Glen Forest Preserve surrounding the site is mostly former ANL 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 is gently rolling, partially wooded, former prairie and farmland. The grounds contain a number of small ponds and streams. The principal stream is Sawmill Creek, which runs through the site in a southerly direction and enters the Des Plaines River about 2.1 km (1.3 mi) southeast of the center of the site. The land is drained primarily by Sawmill Creek, although the extreme southern portion drains directly into the Des Plaines River, which flows along the southern boundary of the forest preserve. This river flows southwest until it joins the Kankakee River about 48 km (30 mi) southwest of ANL to form the Illinois River.

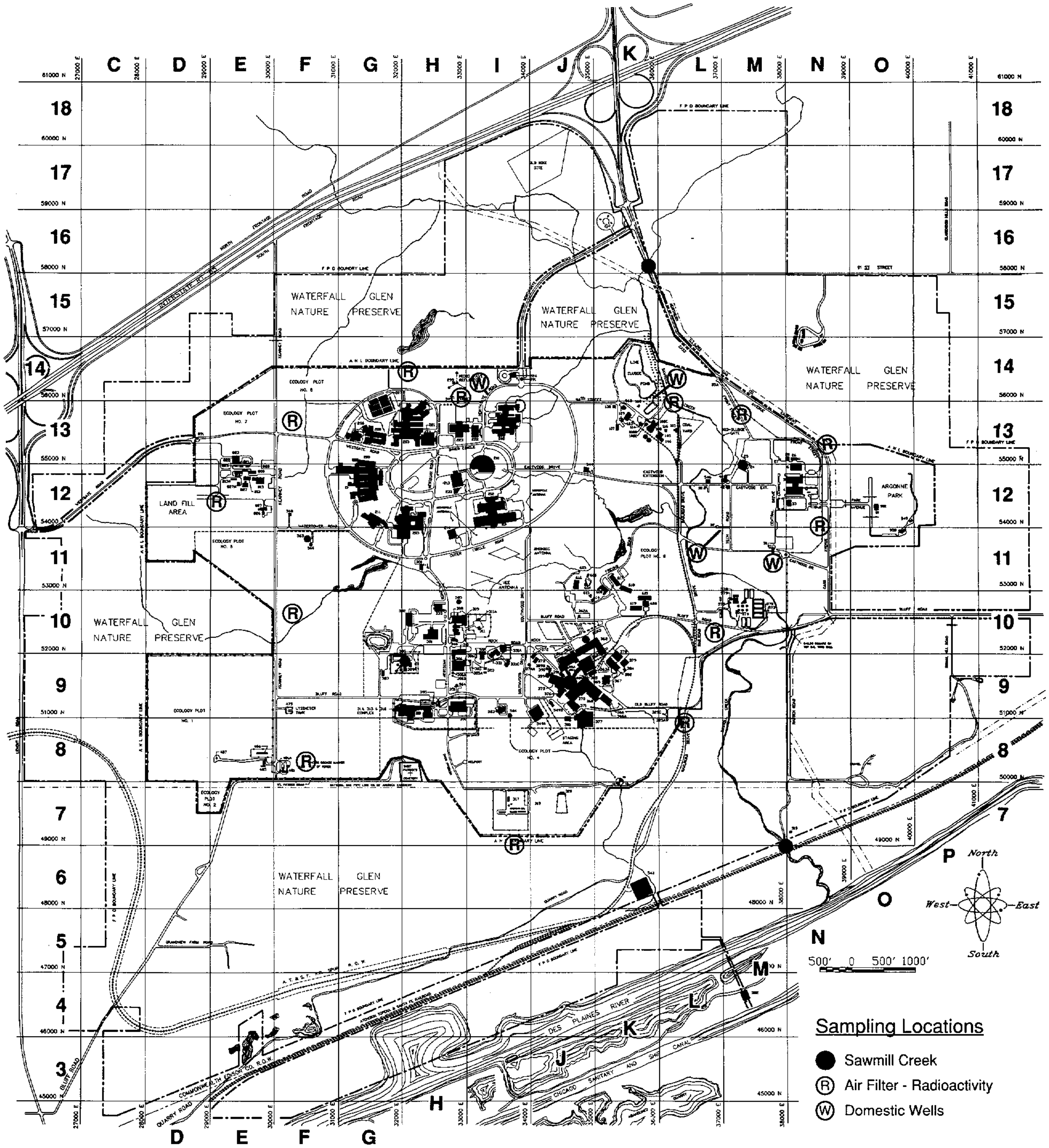


Figure 1.1 Sampling Locations at Argonne National Laboratory

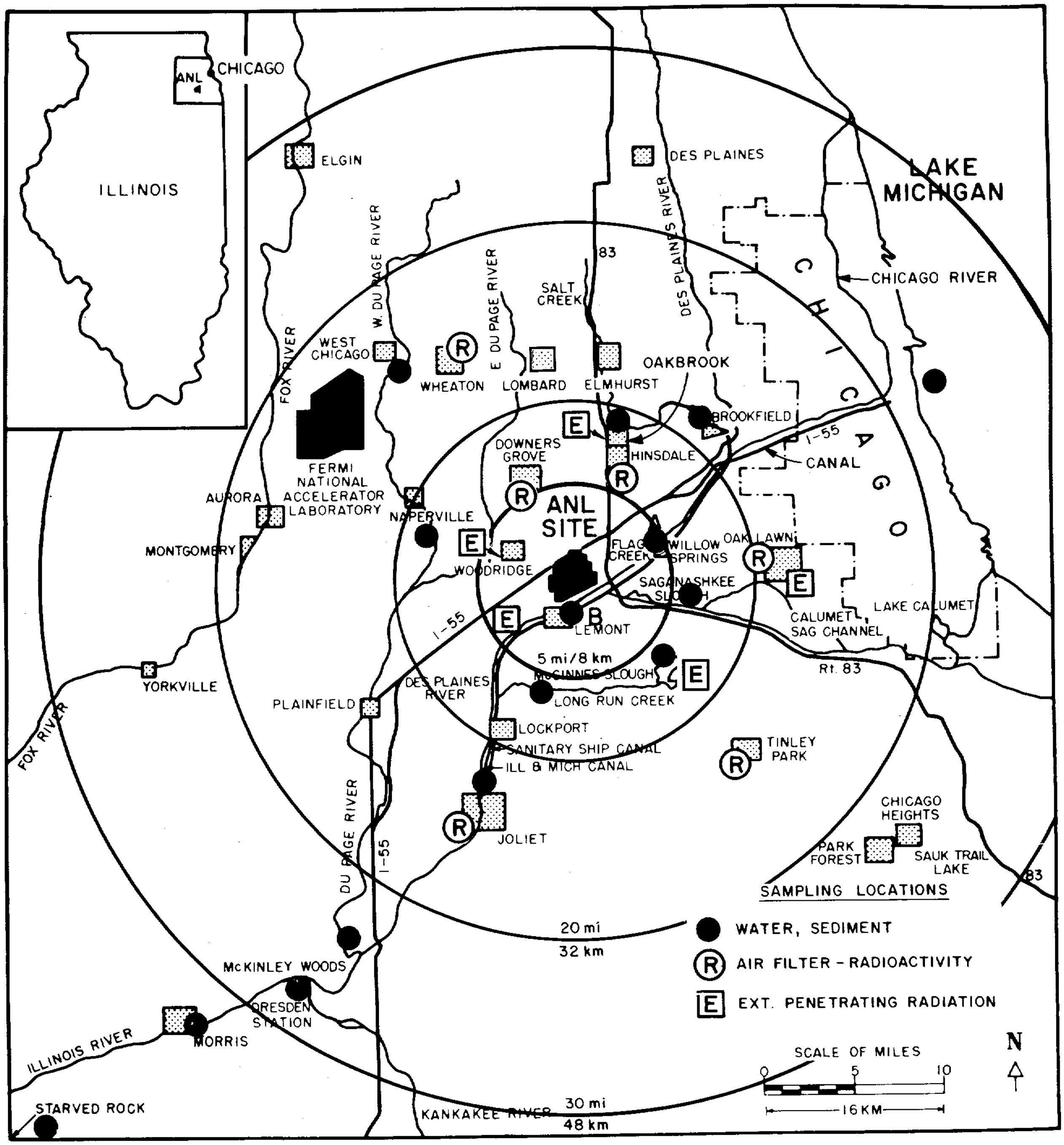


Figure 1.2 Sampling Locations Near Argonne National Laboratory

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 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 Atchison, Topeka, and Santa Fe Railroad have rights-of-way in the southern portion of the forest preserve, Additional information about the site is given in the 1982 draft Argonne Environmental Assessment.[2]

1.3. Population

The area around ANL has experienced a large population growth in the past 30 years. Large areas of farmland have been converted into housing. Table 1.1 presents 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 CP-5 reactor (Location 9G in Figure 1.1), was prepared by the Geographic Data Systems Computing and Telecommunications Division at Oak Ridge National Laboratory and represents projections to 1991 based on the 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] and provide a historical sample of the climatic conditions. The

TABLE 1.1

Population Distribution in the Vicinity of ANL, 1991

	Population (individuals) at 0-5 Miles					Population (thousands) at 5-50 Miles				
Direction	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
N	0	661	4199	5602	8783	44.7	172.1	336.7	187.5	221.3
NNE	0	22	3684	5925	5287	38.8	302.3	485.8	86.7	0
NE	0	737	2293	2431	1689	40.9	674.4	866.3	0	0
ENE	0	1117	2495	1460	1482	33.5	598.7	178.9	0	0
E	0	16	10	1	42	40.8	467.0	199.8	13.0	25.8
ESE	0	0	55	331	306	22.4	186.1	282.0	245.0	80.9
SE	0	2	219	425	198	19.8	103.2	114.2	28.6	12.2
SSE	0	72	401	221	1800	12.0	22.1	7.7	11.0	16.8
S	0	105	2298	921	860	3.7	23.4	2.0	35.3	35.0
SSW	0	33	3504	1229	759	14.7	89.8	10.8	17.6	7.1
SW	0	80	20	87	79	11.6	36.7	9.4	16.2	9.1
WSW	0	215	86	620	1646	4.8	7.6	3.7	8.0	7.2
W	0	779	1237	8338	9056	26.2	67.2	19.0	14.8	6.7
WNW	0	254	224	5867	4433	44.3	104.6	20.7	6.6	52.9
NW	0	552	2602	6979	6779	41.6	69.1	95.5	18.2	16.7
NNW	0	492	2774	4521	9390	33.4	108.5	225.2	130.6	96.5
Total	0	5137	26101	44958	52589	433.2	3112.8	2857.7	819.1	588.4
Cumulative Total	0	5137	31238	76196	128785	561.9	3674.7	6532.4	7351.5	7939.9

To convert from miles to kilometers, multiply by 1.6.

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

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 1993 data were obtained from the on-site ANL meteorological station. The 1993 average monthly and annual wind roses are shown in Figure 1.3. The wind roses are polar coordinate plots 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 each 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.

The monthly wind roses indicate that the winds are variable, so that monitoring for airborne releases must be carried out in all directions from the site. For example, the dominant wind direction in January was from the west-southwest, while in February it is northeast. The annual average wind rose for 1993 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 1993 are shown in Table 1.2. The monthly precipitation data for 1993 showed some differences from the average. For example, January, March, June, and September were above the average, while May and July were below the average. The annual total was 30% higher then the long-term average. A single storm event in June resulted in a 13-cm rainfall. Except for the first three months being warmer than normal, the temperatures were similar to the long-term averages.

1.5. Geology

The geology of the ANL 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.

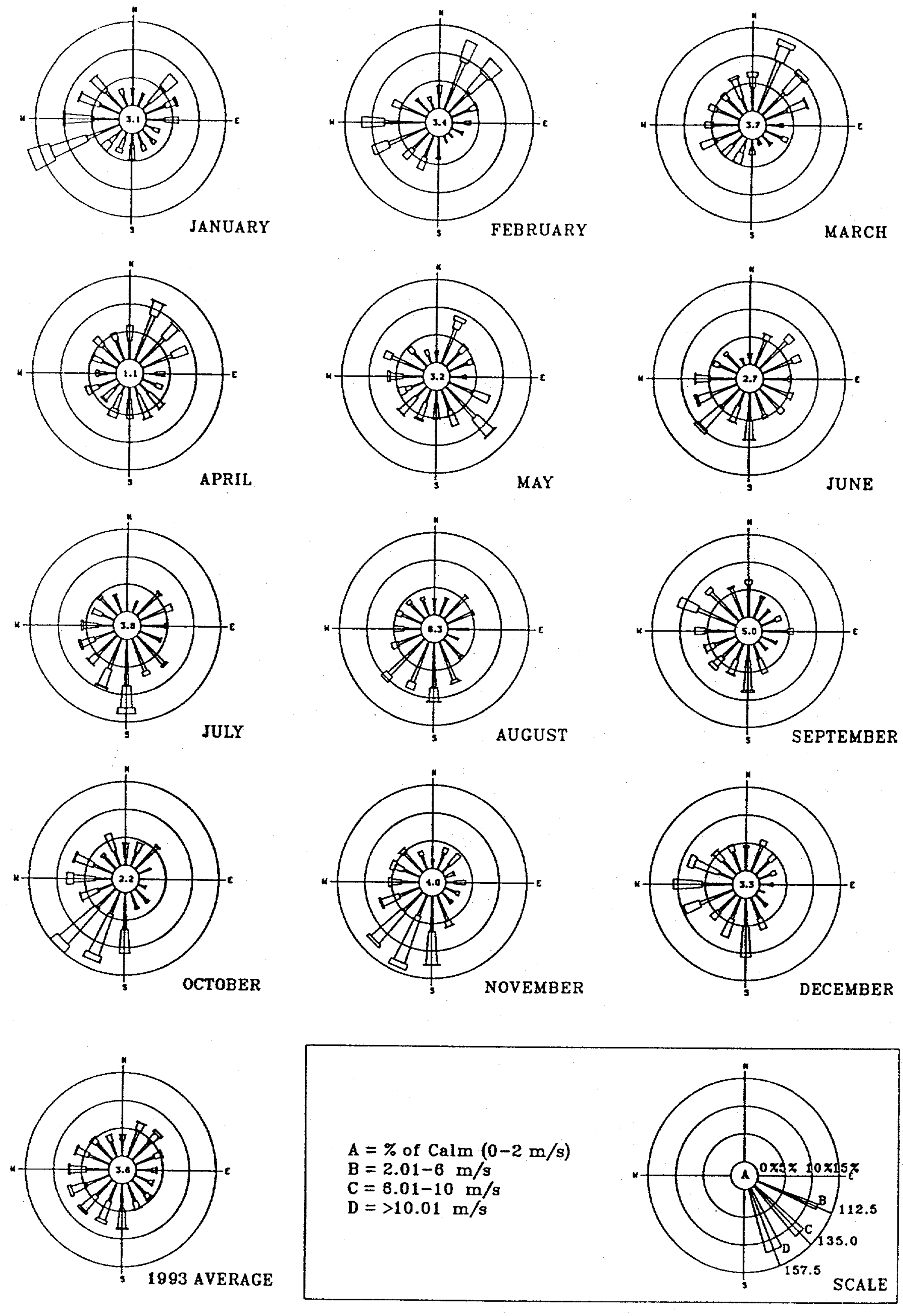


Figure 1.3 Monthly and Annual Wind Roses at Argonne National Laboratory, 1993

TABLE 1.2

ANL Weather Summary, 1993

Month	Precipitation (cm) ANL 1993	Precipitation (cm) ANL Historical Average**	Precipitation (cm) Historical Average*	Temperature (°C) ANL 1993 Monthly Average	Temperature (°C) ANL Historical Average**	Temperature (°C) Historical Average*
January	9.38	3.61	4.06	-3.1	-5.9	-5.9
February	1.70	3.38	3.33	-4.2	-3.7	-3.3
March	11.02	5.56	6.58	1.0	0.6	2.2
April	10.97	9.14	9.30	7.9	8.3	9.3
May	3.89	7.82	8.00	15.9	14.5	15.1
June	29.03	9.47	10.36	19.6	19.7	20.3
July	5.05	10.97	9.22	23.3	21.7	22.8
August	11.86	8.71	8.97	22.4	20.9	22.2
September	12.65	7.14	8.51	15.0	16.8	18.2
October	5.36	6.58	5.79	10.3	11.4	11.9
November	4.47	4.37	5.23	3.5	2.9	4.3
December	2.59	3.20	5.33	-1.7	-4.2	-2.4
Total	107.97	80.01	79.95			

*Data obtained from the National Oceanic and Atmospheric Administration (NOAA) for the weather station at O'Hare International Airport. The average is for the years 1951-1980.

**ANL data obtained from Reference 3.

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 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 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 have derived from glacial till over the past 12,000 year, most of which are of the Morley series, which are moderately well-drained upland soils with slope ranging from 2% to 20%. The surface layer is a dark grayish-brown silt loam, the subsoil is a brown silty clay, and the underlying material is a silty clay loam glacial till. Morley soils have a relatively low organic content in the surface layer, moderately slow subsoil permeability, and a large water capacity. These soils are well-suited to growing crops, if good erosion control practices are used. The remaining soils along creeks, intermittent streams, bottomlands, and a few small upland areas are of the Sawmill, Ashkum, Peotone, and Beecher series, which are generally poorly drained. They have a black to dark gray or brown silty clay loam surface layer, high organic-matter content, and a large water capacity.

1.6. Seismicity

No tectonic features within 135 km (62 mi) of ANL 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.

There are several areas of considerable seismic activity at moderate distances (hundreds of kilometers) from ANL. These areas include the New Madrid Fault zone (southwestern Missouri), in the St. Louis area, the Wabash Valley Fault zone along the southern Illinois-Indiana border, and the Anna region of western Ohio. Although high-intensity earthquakes have occurred along the New Madrid Fault zone, their relationship to plate motions remains speculative at this time.

According to estimates, ground motions induced by near and distant seismic sources in northern Illinois are expected to be minimal. However, peak accelerations in the ANL area may exceed 10% of gravity (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 area are derived from the Niagaran, and to some extent, the Alexandrian dolomite bedrock. Dolomite well yields are variable, but many are near 800 gallons per minute. 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 wells do not extend beyond the site and adjacent forest preserve, ANL water use does not affect neighboring communities.

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

The four domestic water supply wells now in use on the ANL site (see Figure 1.1) are drilled about 90 m (300 ft) deep, terminating in the Niagaran dolomite. 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 remained reasonably stable under ANL pumping, dropping about 3.7 m (12 ft) between 1960 and 1980. The aquifer appears to be adequate for future ANL use, but this ground water 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 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 site is drained by Freund Brook. Two intermittent branches of Freund Brook flow from west to east, draining the interior portion of the site and ultimately discharging into Sawmill Creek. The larger, south branch originates in a marsh adjacent to the western boundary line of the site. It traverses wooded terrain for a distance of about 2 km (1.5 mi) before discharging into the south branch at Lower Freund Pond.

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 are combined and discharged into Sawmill Creek at location 7M in Figure 1.1. This effluent averaged 3.9 million liters (1.05 million gallons) per day. The combined ANL effluent consisted of 44% laboratory wastewater and 56% sanitary wastewater. The water flow in Sawmill Creek upstream of the wastewater outfall averaged about 119 million liters (32 million gallons) per day during 1993. This is a significant increase compared to the last several years and was due to the above normal precipitation.

Sawmill Creek and the Des Plaines River above Joliet, about 21 km (13 mi) southwest of ANL, receive very little recreational or industrial use. A few people fish in these waters downstream of ANL and some duck hunting takes place on the Des Plaines River. Water from the Chicago Sanitary and Ship Canal is used by ANL for cooling towers and by others for industrial purposes, such as hydroelectric generators and condensers, and for irrigation at the state prison near Joliet. The ANL usage is about 1.1 million liters (290,000 gallons) 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. 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 for drinking is at Alton, on the Mississippi River about 710 km (370 mi) downstream from ANL. At that location, water is used indirectly to replenish groundwater supplies by infiltration. In the vicinity of ANL, only subsurface water (from both shallow and deep aquifers) and Lake Michigan water are used for drinking purposes.

The principal recreational area near ANL is 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 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 site (Location 12-0 in Figure 1.1) is for the use of ANL and DOE employees. Recently, use of this park has also been provided to DuPage County.

1.9. Vegetation

ANL lies within the Prairie Peninsula of the Oak-Hickory Forest Region. The Prairie Peninsula is a mosaic of oak forest, oak openings, and tall-grass prairie occurring in glaciated portions of Illinois, northwest Indiana, southern Wisconsin, and sections of other states. Much of the natural vegetation of this area has been modified by clearing and tillage. Forests in the ANL region, which are predominantly oak-hickory forests, are somewhat limited to slopes of shallow, ill-defined ravines or of 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 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.

Crown vetch has been planted on much of the developed area since 1954, to help control soil erosion and provide low-maintenance ground cover. Other open space in developed areas has been sown to grass, which is mowed regularly.

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, cheery, and ash.

1.10. Fauna

Terrestrial vertebrates that are commonly observed or likely to occur on the site include about five species of amphibians, seven of reptiles, and about 40 species of summer resident birds, and 25 of mammals. More than a hundred other bird species occur in the area during migration or winter but do not nest on the site or in the surrounding region. An unusual species on the ANL site is the fallow deer, a European species that was introduced to the area by a private landowner prior to government acquisition of the property in 1947 and which subsequently increased to about 400 individuals. In November 1988, about 200 of the deer were removed for population control. Native white-tailed deer also occur on the ANL reservation. Invertebrate species, as well as plants and other animals, were also observed on the ANL 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 site include additional beaver ponds, artificial ponds, ditches, and Sawmill Creek.

The biotic community of Sawmill Creek is relatively depauperate, reflecting creek's high silt load, steep gradient, and historic release of sewage effluent from the Marion Brook sewage-treatment plant north of the site. The fauna consists primarily of blackflies, midges, isopods, flatworms, segmented worms, and creek chubs. A few 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 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 streams, has been rated as "poor" in terms of the fish species present, as determined by the U. S. Fish and Wildlife Service, a result of domestic and industrial pollution and stream modification.

1.11. Archaeology

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

There are 26 recorded sites including prehistoric chart quarries, special purpose camps, base camps, and historical farmsteads. The range of human occupation spans several time periods (Early Archaic through Mississipian Prehistoric to Historical). To date, one site may be eligible and 19 of the sites are not eligible for the National Register of Historic Places (NRHP); the remainder have not been formally evaluated for NRHP eligibility.

1.12. Endangered Species

Although the geographic ranges of several federally listed animal species include the northern Illinois region, no suitable habitat for these species is present on the site, with the possible exception of the Indiana bat (Myotis sodalis). An unconfirmed capture of an Indiana bat in nearby Waterfall Glen Forest Preserve indicates that the bat may occur in the ANL region. Consultation with the U. S. Fish and Wildlife Service determined that suitable habitat for this species does not exist in the area that would be affected by APS construction. The bald eagle, peregine falcon, piping plover, interior least tern, and Kirtland's warbler could occur in the ANL area as extremely rare nonbreeders during migration or winter.

Numerous species listed by the State of Illinois have been recorded in DuPage County, including one bird species and 26 plant species. The black-crowned night heron (Nycticorax nycticorax) and hairy marsh yellow cress (Rorippa islandica var. hispida) are both listed as endangered and have been documented on the ANL site. The hairy marsh yellow cress and the black-crowned night heron occur within wetland areas of the site. No other species on the state list are known to occur at ANL.

2. COMPLIANCE SUMMARY

ANL is a government owned, contractor operated (GOCO) non-production facility which 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, which establishes DOE's policy concerning environmental compliance. The status of ANL during CY 1993 with regard to these authorities is discussed in this Chapter.

To insure compliance with both the letter and spirit of these requirements, ANL has made a commitment to comply with all applicable environmental requirements,as described in the following policy statement revised during 1990:

> 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), which 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. The sections which have an immediate impact on ANL are: the estimation of emissions for the next five years; preparation of the Title V permit applicaand addressing of the various provisions regarding ozone depleting substances. In addition, some changes, such as amendments to the hazardous pollutants regulations which expand the number of hazardous air pollutants from eight to 189, could have significant impact in the future.

The primary tool for enforcing most provisions of the CAA for point source emissions is the permitting process. The IEPA requires that all point sources of air emissions, except for those specifically excluded, apply for a construction permit (for proposed new sources) and/or operating permit (for existing or newly constructed sources). The permit, when issued, contains specific requirements necessary to ensure that the point source operates within the limits of the permit.

The ANL site contains a large number of air emission point sources. The vast majority are laboratory ventilation systems which are exempt from state permitting requirements, except for those systems emitting radionuclides. By the end of 1993, a total of 31 air permits were in place covering all known emission points. Section 2.15 contains a listing (Table 2.6) of the permits in effect at ANL.

2.1.1. National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP) are 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 standards for asbestos and radionuclides are the only standards affecting ANL operations.

2.1.1.1. Asbestos Emissions

Many buildings on the ANL site contain large amounts of asbestos-containing materials (ACM), such as insulation around pipes and tanks, fire proofing, floor tile, and loose asbestos insulation from the top of ceiling tile (false ceiling). 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 non-friable materials which 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.

The standard describes accepted procedures for removal of 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 maintains an asbestos abatement program designed to assure compliance with these and other regulatory requirements. The removal of ACM at the Laboratory is done either by a specially trained Waste Management Operations (WMO) crew (for "small-scale" short-duration projects as defined by the OSHA asbestos standard for the Construction Industry - 29 CFR 1926.58) or by outside contractors specializing in ACM removal work (for larger-scale insulation removal projects lasting a day or longer). All removal work is done in strict compliance with both the NESHAP requirements as well as the 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 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 Industrial Hygiene personnel both during the removal work and after the work is completed, in order to verify that adequate precautions have been taken to prevent the release of significant amounts of asbestos. Personal exposure air samples are collected.

Asbestos fiber counts are analyzed using Phase Contrast Microscopy and selected samples are analyzed by Transmission Electron Microscopy.

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 m^2 (160 ft^2) of other material. This written notification on a State form must be forwarded to the IEPA within a prescribed time limit. A total of 120 separate removal projects were completed which generated 33 m^3 (1152 ft^3) of ACM waste. Five removal projects which generated 177 m^3 (6245 ft^3) were large enough to require notification to the IEPA. Much of the material removed and disposed of as ACM is actually not regulated ACM. However, to insure consistency and to be conservative, all ACM is treated as if it were regulated. The revised 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 above, the IEPA must be notified. In December 1993, ANL made such a notification for activities planned for 1994. It is estimated that no more than 71 m^3 (2500 ft^3) of ACM waste will be generated during 1994.

A separate portion of the standard contains requirements for waste disposal sites used for disposal 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 6 inches of non-asbestos-containing materials and maintenance of disposal records. Landfills utilized for disposal of ACM included: State Landfill Corporation, Ottawa, Illinois and Community Landfill Company, Morris, Illinois.

2.1.1.2. Radionuclide Emissions

The NESHAP standard for radionuclide emissions from DOE facilities (40 CFR 61, Subpart H) establishes the emission limits for release of radionuclides to the air and requirements for monitoring, reporting, and record keeping. This regulation was revised in late

1989, resulting in increased monitoring and reporting requirements. A number of emission points at ANL 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 New Brunswick Laboratory (Building 350). In addition, many small ventilation systems and fume hoods are occasionally used for processing of small quantities of radioactive materials. The radionuclide NESHAP requires that all air emission sources of radionuclides be evaluated to determine whether the magnitude of these emissions is above a threshold amount which would result in an effective dose equivalent to the maximally exposed individual of greater than 1% of the standard of 10 mrem/yr. Those sources with greater than this amount of emissions must be monitored in accordance with 40 CFR 61.93(b) and a report issued annually summarizing the emissions measured. Any emission point below this threshold must be measured periodically to verify the low rate. At ANL, the significant emission sources are continuously monitored to comply with this requirement. However, to satisfy the determination for monitoring requirements for the large number of smaller sources, all radionuclide air emission sources have been evaluated. The emissions from NBL are included with ANL emissions when calculating dose rates under NESHAP.

Routine continuous monitoring of the larg er emission sources has indicated that the amount of radioactive material released to the atmosphere from these sources is extremely small, resulting in a very small incremental radiation dosage to the neighboring population. The calculated potential maximum individual off-site dose to a member of the general public for 1993 was 0.014 mrem (excluding radon-220), which is 0.14% 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 site contains a number of sources of conventional air pollutants, including a steam plant, oil-fired boilers, gasoline and methanol fuel dispensing facilities, two alkali metal reaction booths, a small vapor degreaser, a number of bulk chemical tanks, a dust collection system, a medical equipment sterilization unit, fire training activities, and a research facility for combustion and power generation research (FEUL facility). The emission sources that have been granted operating permits by the IEPA are as shown in Section 2.15. During 1993, two new air permits were issued by the IEPA, three air permits were modified, and one air permit was renewed.

The operating 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 excursions beyond emission limits for this boiler [30% opacity averaged over six minutes and 1.8 lb sulfur dioxide (SO_2) per million Btu averaged over a one-hour period]. In the last few years, the air pollution control equipment associated with Boiler No. 5 has experienced numerous breakdowns and failures, usually of short duration. The SO_2 scrubber was designed and built as a demonstration test unit in 1980; however, it has operated in recent years as an operations unit. Many of the components have reached the end of their useful life, which resulted in frequent breakdowns and malfunctions. As a result, the air emissions frequently exceeded the allowable amounts. These excursions have been reported to the IEPA as required. The steam plant underwent numerous corrective activities (e.g., equipment calibrating and rehabilitation) during 1991 to prevent future excursions while operating on coal. The hours of operation during 1993 of Boiler No. 5 on high and low sulfur coal is presented in Table 2.1. During the first quarter of 1993, one excursion for SO_2 was noted. The last of the high sulfur coal was burned in January 1994. It is planned to operate Boiler No. 5 on low sulfur coal through April 1994. IEPA conducted an air emission compliance inspection of the steam plant on June 28, 1993, and no deficiencies were noted.

TABLE 2.1

Boiler No. 5 - Hours of Operation, 1993

Month	w/High Sulfur Coal	w/Low Sulfur Coal	Total
January	48	488	536
February	672	0	672
March	744	0	744
April	468	96	564
May	0	24	24
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	96	96
November	624	96	720
December	744	0	744
Total	3300	800	4100
1994			
January	504	240	744

The fuel dispensing facilities are used to service vehicles and, except for methanol vapors, have VOC emissions typical of any commercial gasoline service station.

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 substantially modified by the Water Quality Act of 1987. 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 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 is now placed on monitoring and control of toxic constituents in wastewater, the permitting of outfalls composed entirely of stormwater, and the imposition of regulations governing sewage sludge disposal. These changes in the NPDES program resulted in much stricter discharge limits and greatly expanded the number of chemical constituents monitored in the effluent. The wastewater treatment facilities on the ANL site will be upgraded to improve treatment capabilities.

2.2.1. Liquid Effluent Discharge Permit

The primary tool for enforcing the requirements of the NPDES program is through the NPDES permitting process administered by the IEPA. 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 specific and general requirements, including sampling and analysis schedules and reporting and recordkeeping requirements. Wastewater generation activities at ANL are covered by NPDES Permit IL 0034592. Although this permit expires in January 1994, the IEPA has informed ANL that the renewal permit will not be issued until mid-1994. However, ANL continues to operate under the old permit until the new one is received. The ANL NPDES permit was modified by the IEPA on July 27, 1993. Modifications to the permit included:

1) Deletion of the fecal coliform limitation at Outfall 001, based on a year-round disinfection exemption approved by the Agency on May 1, 1989;

2) Deletion of Special Condition 7 requiring compliance with Nuclear Regulatory Commission regulations for discharge and monitoring of radioactive wastewater discharges;

3) Addition of Area 317 contaminated ground water to Outfall 001B;

4) Deletion of Special Condition 9 regarding chloride control; and

5) Diversion of Outfall 006, Canal Water Treatment Plant Sludge Pond Overflow, to Outfall 001A.

Wastewater at ANL is generated by a number of activities and consists of sanitary wastewater (from restrooms, cafeteria sinks and sinks in certain buildings and laboratories, steam boiler blowdown, and drinking water filter backwash), laboratory wastewater (from laboratory sinks and floor drains in most buildings), and stormwater. Water softener regenerant is discharged to the DuPage County sewer system. Cooling water and cooling tower blowdown are currently discharged into stormwater ditches which are monitored as part of the NPDES permit. The current permit authorizes the release of wastewater from nine separate outfalls, most of which discharge directly or indirectly into Sawmill Creek. In addition, the permit requires monitoring of the wastewater at two internal sampling points that combine to form the main wastewater outfall, outfall 001. Table 2.2 describes these outfalls, and the locations are shown in Figure 2.1. Two of these outfalls, 009 and 010, are

TABLE 2.2

Description of NPDES Outfalls at ANL, 1993

Outfall* Number	Description	Status	Average Flow (Million Gallons/Day)
001	Combined discharge of 001A and 001B - main site outfall (7M)	Active	0.8-1.2
001A	Sanitary wastewater treatment plant effluent	Active - internal sampling point	0.4-0.6
001B	Laboratory wastewater treatment plant effluent	Active - internal sampling point	0.4-0.6
003	Stormwater runoff, cooling water and cooling tower blow-down	Active	0.1-0.3
004	Cooling water, stormwater	Active	0-0.05
005	Cooling water and cooling tower blowdown, stormwater	Active	0-0.2
006	Canal water treatment plant wastewater, cooling tower drainage, cooling water, stormwater	Active	0-0.12
007	Cooling water, stormwater	Active	0-0.01
008	Stormwater	Active	0-0.01
009	Lime sludge pond overflow	Emergency overflow	0
010	Coal pile runoff overflow	Emergency overflow	0

*Locations are shown in Figure 2.1.

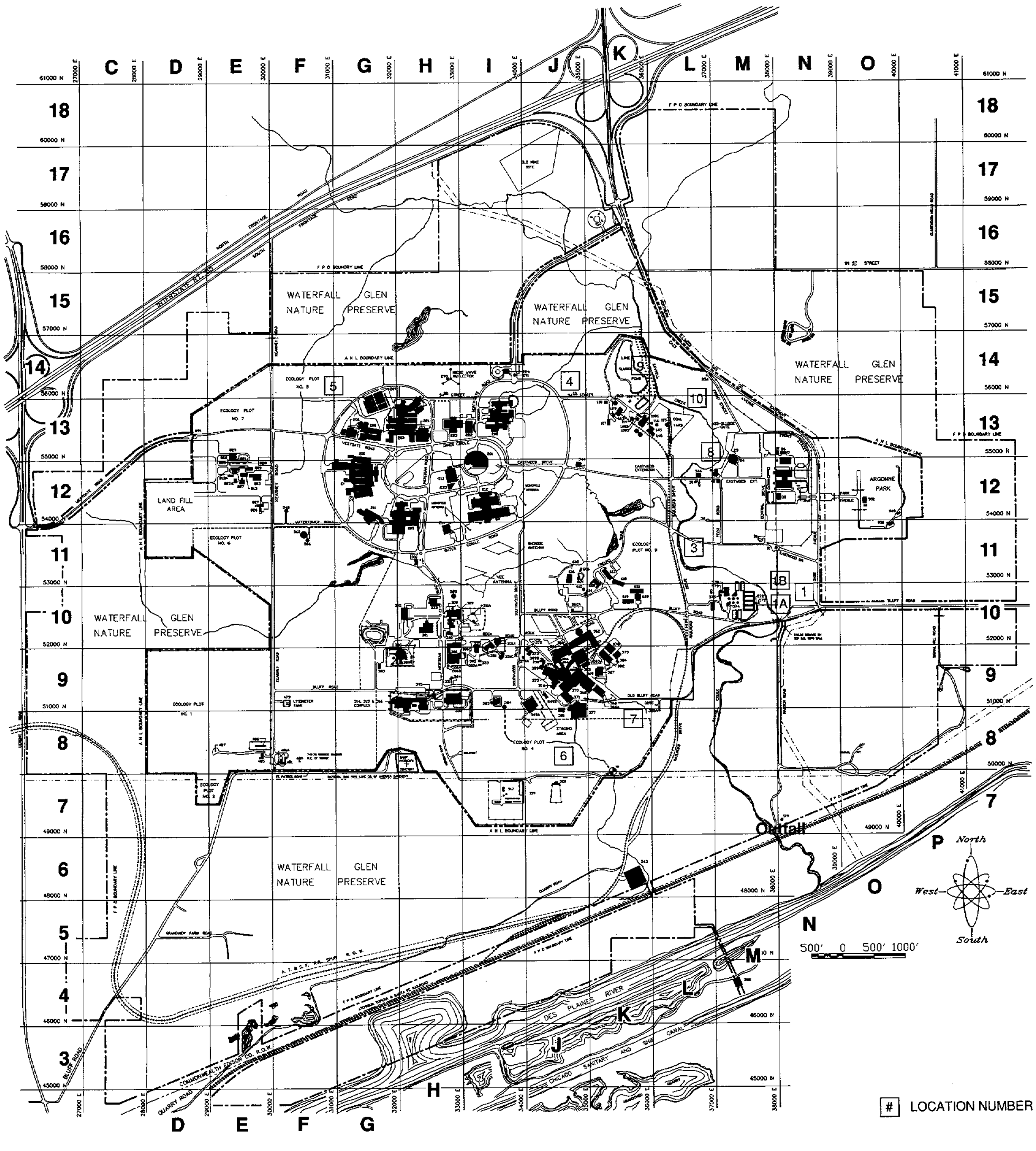


Figure 2.1 NPDES Permit Locations

used for emergency overflow discharge from the lime sludge pond and coal pile, respectively.

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 1993, there were 25 exceedances of NPDES permit limits out of approximately 1000 measurements. This represents a 97.5% compliance rate, compared to a 98% compliance rate in 1992 (19 exceedances), a 96% rate in 1991 (44 exceedances), and a 91% rate in 1990 (86 exceedances).

The types of exceedances experienced were similar to recent years with the exception of mercury and a statistical breakdown appears in Figure 2.2. About 32% (8) of the

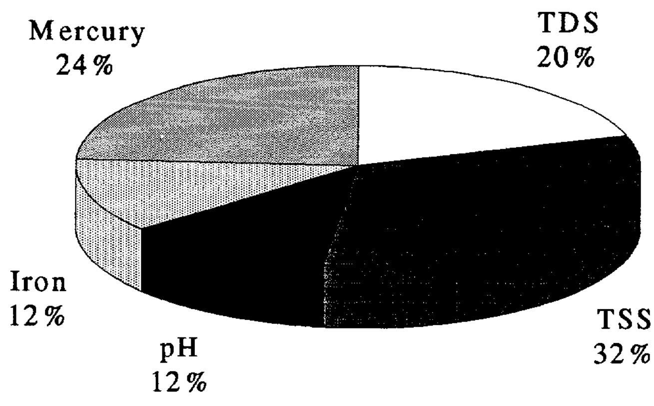


Figure 2.2 Distribution of NPDES Permit Exceedances, 1993

exceedances were of total suspended solids (TSS), primarily at outfalls 001B, 003, 006, and 010. The cause of these TSS exceedances was excessive siltation and soil erosion during heavy precipitation. The second largest category (6) is mercury exceedances at outfall 001B. The source of the mercury is under investigation, but it appears the exceedances are a carryover of mercury in the Laboratory sewer system. Five exceedances of total dissolved solids (TDS) at outfall 001 were noted. Discharge of effluents from the boiler operations (i.e, blowdown) contribute the majority of the TDS. In addition, occasional exceedances (6) of pH and iron occurred at outfall 010. There are a number of different reasons for these excursions. Chapter 5 discusses each outfall individually and presents the suspected reasons for permit exceedances.

The magnitude of the exceedances of TSS limits experienced during 1993 is thought to be caused by several factors, including erosion of soil from construction sites and drainage ditches, the siltation of several small on-site ponds which act as settling basins to remove solids from stormwater, and the operation of two small earthen sludge holding ponds which sometimes overflow following heavy rains, carrying solids into outfall 006. Projects have been planned and/or implemented during 1993 specifically to reduce TSS discharges from the sludge lagoons and other sources by removal of accumulated sediments from three on-site ponds and site-wide erosion control. During March 1993, the IEPA modified the NPDES permit for the sludge holding pond overflow project which would divert flow to the ANL sanitary sewer system for further treatment before discharge to outfall 001A.

The DuPage County Department of Public Works granted ANL permission during June 1993 to discharge the drainage of a solar pond to the County sewer system for further treatment. This specific discharge earlier in 1993 contributed to elevated levels of TDS in the ANL effluent.

As a result of heavy rains, wastewater flowed from outfall 010, the coal storage pile stormwater emergency outfall, on three different occasions during 1993. Due to the composition and highly acidic nature of the high sulfur coal stored in this area, this discharge was out of compliance with limits for pH, TSS, and iron. These three events caused 36% of the total number of exceedances during the entire year. During the summer of 1993, the retention basin was increased in size to eliminate further discharges from outfall 010. No discharges have occurred since the actions were taken.

Data regarding the total number of each type of exceedance over the past five years is presented in Figures 2.3 and 2.4. Overall, the total number of exceedances has been reduced; 50 exceedances in 1989, 86 exceedances in 1990, 44 exceedances in 1991, 19 exceedances during 1992, and 25 exceedances during 1993. The large number of exceedances during 1990 was due to extensive monitoring conducted as part of a program to characterize excessive TDS and chloride concentrations from the disposal of water softener brine solutions. These efforts and the resultant corrective action are described in previous annual reports. Since August 1991, when the spent brine solution was diverted to the DuPage County sewage system, no chloride exceedances have occurred. TSS exceedances have remained stable. Projects are underway to reduce excessive soil erosion and sediment carryover from settling ponds directly upstream from outfalls 003 and 006. Completion of these projects should result in a major reduction of TSS exceedances. TSS, iron, and pH exceedances related to coal pile overflow experienced during periods of heavy precipitation have been eliminated.

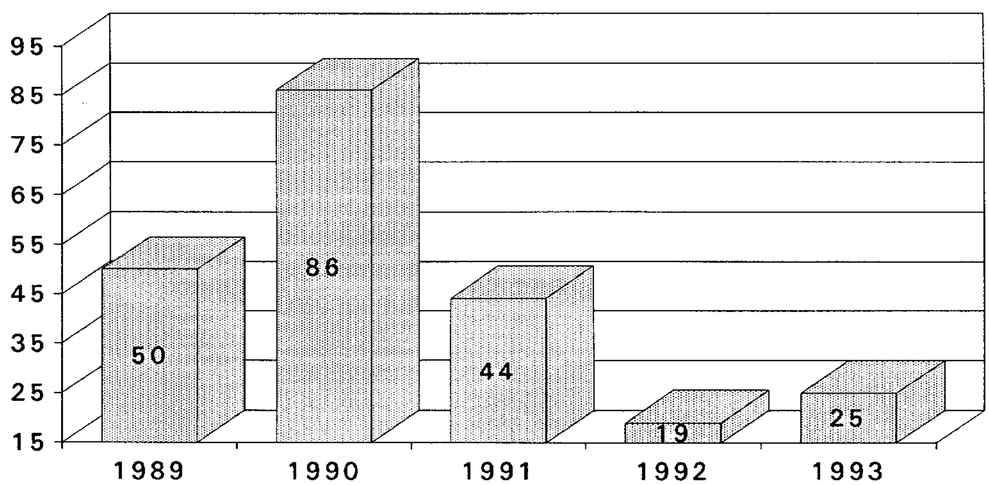


Figure 2.3 Total Number of NPDES Exceedances 1989-1993

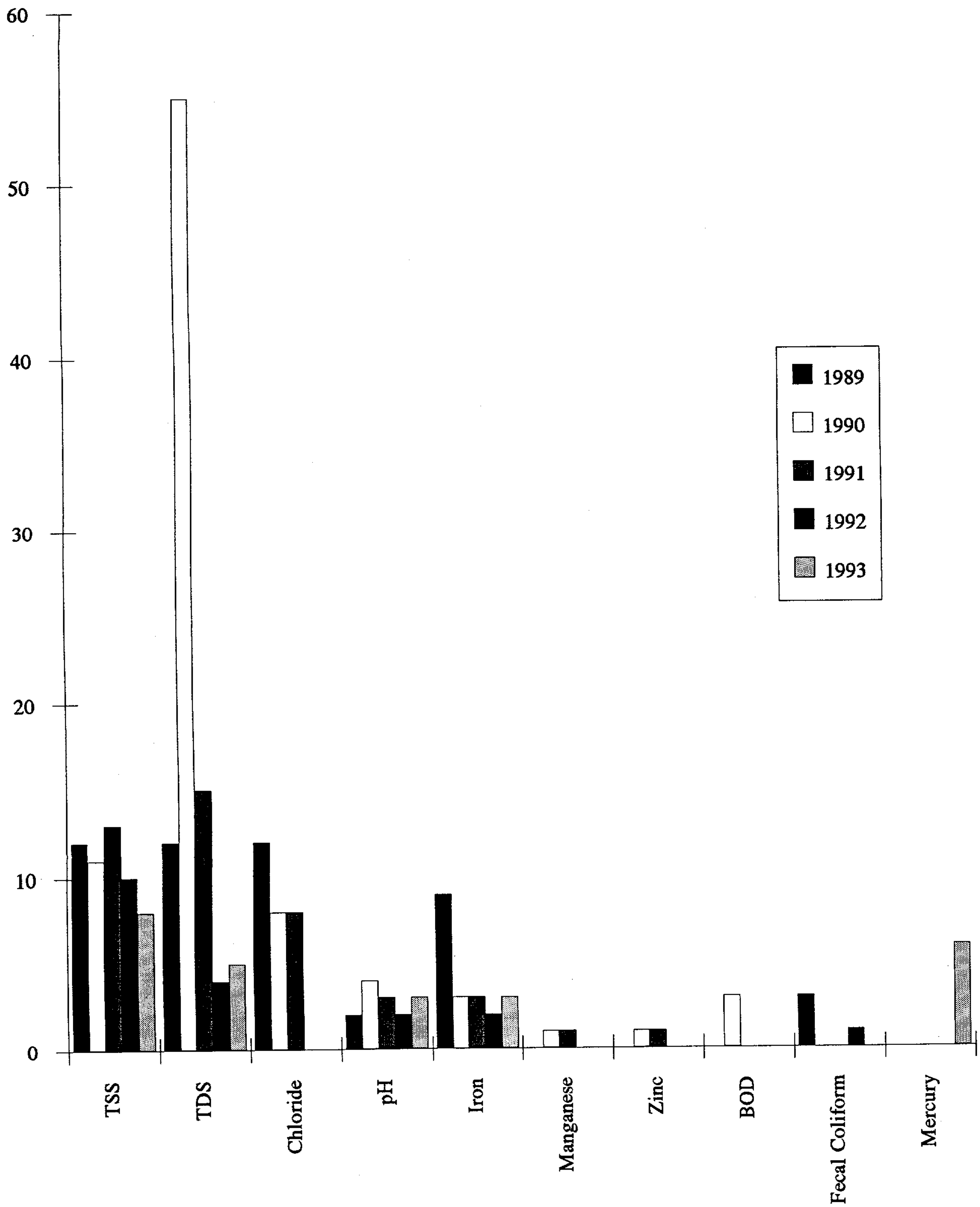


Figure 2.4 NPDES Permit Limit Exceedances 1989-1993

To improve the level of compliance with permit limits, ANL is in the fourth year of an intensive effort of building additional wastewater treatment facilities or upgrading existing facilities. Projects to upgrade and refurbish the laboratory and sanitary wastewater treatment plant are scheduled for 1994 through 1996. Upgrade and repair of a large portion of ANL's wastewater sewer system will take place during 1994. These and other corrective action projects are described in the Environmental Restoration and Waste Management Five Year Plan for ANL and identified in Chapter 3.

On June 1, 1993, the IEPA notified ANL that it was in Significant Noncompliance with the requirements of its NPDES permit. The notice was based on excessive TSS, TDS, pH, and iron exceedances between February 1992 and March 1993. ANL was required to submit to the Agency in writing, the reasons for the apparent violations and steps which have been initiated to prevent further recurrence of the violations. On June 22, 1993, a response was submitted to the IEPA identifying the reasons for the violations and the corrective actions which ANL had conducted, as well as those which were planned. No reply has been received from the IEPA.

2.2.1.2. Additional NPDES Monitoring

The current permit requires semiannual testing of outfall 001B, the laboratory wastewater treatment plant outfall, for all the priority pollutants (a list of 126 metals and organic compounds identified by the IEPA as being of particular concern). During 1993, this sampling was conducted in June and December. Chloroform (15.6 μg/L) and bromodichloromethane (3.7 μg/L) were detected in both the June and December samples at low concentrations which resulted from normal ANL operations. Low concentrations of bromoform (8.8 μg/L) and dibromochloromethane (7.9 μg/L) were noted in the June sample. 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 support operations. All semivolatiles, except for naphthalene (50 μg/L) in the June sample, were below reporting units. Zinc was detected at low concentrations (0.130 mg/L), as well as copper (0.053 mg/L). Chrysolite (asbestos) of less than 10 millimicrons in length were detected in the June and December samples. The source of this material is unknown but could be transite in sewers. Dioxins were not 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 done during June 1993. The data indicate that the acute toxicity effects of the effluent was much improved over studies conducted in 1991 and 1992. Chronic toxicity results indicate that exposure to the effluent did impact survival and growth of the fathead minnow fry similar to results obtained in 1991. Also noted was a more pronounced chronic effect on reproduction for Ceriodaphnia than had been seen in 1991 or 1992. Great improvement was noted in the algal growth test. The 1991 and 1992 results on the 001 effluent exhibited acute toxicity to the fathead minnow and Ceriodaphnia. This implies that there may be components in the effluent wastewater that affect aquatic life.

As a result of the outfall 001 effluent exhibiting acute toxicity to the fathead minnow and Ceriodaphnia for two consecutive years, on September 10, 1992, the IEPA requested that ANL continue the biomonitoring plan and initiate a Toxicity Reduction Evaluation (TRE). The purpose of the TRE is to identify the substance or substances causing whole effluent toxicity and to propose solutions to the problem. During November 1992, representatives of ANL and DOE met with the IEPA to discuss the TRE process. A Toxicity Identification Evaluation (TIE) as an initial phase to the project was completed during September 1993. A month of testing was performed in September 1993 at the sanitary, laboratory, and combined wastewater outfalls. The results showed that toxicity is present in each system, but it is not consistent and is usually at low concentrations. Two TRE toxicity screening tests were performed to determine the group of chemicals responsible for the toxicity, however, the toxicity was at low levels and the responsible group of chemicals could not be identified.

All results were submitted to the IEPA during December 1993. After IEPA review, it is anticipated that sampling to determine consistent toxicity levels will continue.

Additional TRE testing of high-level toxic discharges would be continued to determine the toxicants or class of toxicants. The majority of the time the combined sanitary and laboratory wastewater was in compliance with discharge requirements, i.e., < 50% mortality in 100% effluent.

2.2.2. Stormwater Regulations

In November 1990, the EPA promulgated new regulations governing the permitting and discharge of stormwater from industrial sites. The ANL site contains a large number of small scale operations which are considered industrial activities by the new regulation, and thus, is subject to these requirements. To satisfy the stormwater permit application information needs, an extensive stormwater characterization program began in 1991. This program measures stormwater flows and collects samples for chemical and radiological analysis. During 1991, 16 outfall points not included in the existing NPDES permit were monitored. The stormwater permit application was sent to the IEPA on September 29, 1992.

Also, during the stormwater characterization project, four non-stormwater discharges were discovered. An NPDES permit modification request to include these four discharges on the NPDES permit was sent to IEPA on August 26, 1992. IEPA has advised ANL that the NPDES permit renewal, which will incorporate the requested modifications, will be issued during mid-1994.

2.2.3. NPDES Inspections and Audits

On February 16-17, 1993, the IEPA conducted a Compliance Inspection of NPDES outfalls and related facilities, as well as associated sampling and analysis and record keeping requirements. No significant issues were identified. An NPDES Compliance Sampling Inspection was conducted during October 28-29, 1993; no significant issues were identified. An EPA Aquatic Toxicity Sampling visit occurred on December 1, 1993. No results from the sampling have been received from the EPA.

2.2.4. General Effluent and Stream Quality Standards

In addition to specific permit conditions, ANL discharges are required to comply with general effluent limits contained in 35 Illinois Administrative Code, Subtitle C, Chapter I, Part 304. Also, wastewater discharges must be of sufficient quality to insure that Sawmill Creek complies with the IEPA's General Use Water Quality Standards found in 35 Illinois Administrative Code, 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 conducts the majority of the analyses required for inclusion in the Discharge Monitoring Report. These analyses are conducted using EPA approved methods in 40 CFR 136. To demonstrate the capabilities of the ANL laboratory for these analyses, the IEPA requires the laboratory to participate in the DMR Quality Assurance program. The IEPA sends a series of control samples to ANL annually and the results of analyses of these samples are submitted to the IEPA and EPA for review. The proficiency of the laboratory is determined by how close the analytical results for the submitted samples come to the actual values. The ANL laboratory has consistently performed very well on these tests (see Chapter 7).

2.2.6. Spill Prevention Control and Countermeasures Plan

ANL maintains a Spill Prevention Control and Countermeasures (SPCC) plan as required by the Clean Water Act and EPA implementing regulations set forth 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 recordkeeping requirements mandated by the regulations. Effective use of this plan is ensured by regular training, including both classroom instruction and field exercises. This plan is due to be updated in 1995. There were no reportable spills during 1993.

2.3. Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) and its implementing regulations are intended to insure that hazardous wastes are disposed of in an environmentally safe manner and 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 wastes. In addition, HSWA also requires that releases of hazardous waste or hazardous constituents from any solid waste management unit located on the site of a RCRA-permitted facility be cleaned up, regardless of when the waste was placed in the unit or if the unit was originally intended as a waste disposal unit. As discussed below, these RCRA corrective action provisions will have a far-reaching impact on ANL. The RCRA program includes regulations governing management of underground storage tanks 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, small quantities of a large number of waste chemicals are generated. Many of these materials are classified as hazardous waste under RCRA. A number of these wastes also exhibit significant levels of radioactivity, making them "mixed wastes." The hazardous components of mixed wastes are subject to RCRA regulations by IEPA, while the radioactive component is subject to DOE regulation under the Atomic Energy Act of 1954. Hazardous wastes are collected by the ANL Waste Management Operations (WMO) Department from individual on-site generators and shipped off-site for disposal at an approved hazardous waste disposal facility. Small quantities of reactive hazardous waste are treated on-site. To provide for on-site management of hazardous and mixed wastes before off-site shipment or on-site treatment, ANL 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 identification of a disposal site. Mixed wastes generated on-site do not have any approved disposal mechanism. Some mixed waste (sludge) is being sent to Hanford for storage and disposal. The balance of the mixed waste is being stored indefinitely until a disposal mechanism becomes available. A variety of facilities are used for these activities, including several buildings formerly used for research activities which have been converted to storage facilities.

In addition to the storage areas, there are two active units used for treatment of small quantities of hazardous waste. These units are used for treatment of water reactive alkali metals. Table 2.3 lists the on-site RCRA-permitted storage and treatment units. The current Part A (interim status) permit lists two units which are now inactive. These units, also shown in Table 2.3, are the water reaction tank, used in the past for treatment of alkali metals and other water reactive materials, and the shock-sensitive treatment area, used for treatment of highly unstable or explosive materials. Both units are located in the 317 Area. These two inactive hazardous waste treatment units located in the 317 Area are currently undergoing closure activities. Closure activities include sampling and analysis of residual materials present in the units (sludge and solid waste), removal and disposal of these materials and analysis of the soil underneath and near to these units to verify that all hazardous materials have been removed. Closure should be complete in late 1994. The locations of the major hazardous and non-hazardous waste treatment, storage, and disposal areas at ANL are presented in Figure 2.5.

2.3.2. Permit Status

ANL was granted interim status under RCRA after submitting a notification of Waste Handling Activities and a Part A application in 1980. In 1990, a new Part B permit application (one had previously been sent to the EPA but not acted upon) was prepared for submittal to the IEPA, which had been granted authority to administer most of the RCRA program. The application was submitted to the IEPA and EPA on December 21, 1990.

TABLE 2.3

Hazardous Waste Treatment and Storage Facilities - 1993

Description	Location	Purpose
Current Interim Status Facilities		
Waste Treatment and Storage	Building 306	Primary facility for treatment, accumulation, packaging and short term storage of hazardous and mixed waste
Tank Storage	Building 306	Storage of mixed waste (4000 gal)
Temporary Storage Units	Building 306	Storage of mixed waste (3) Bulking nonradioactive hazardous, flammable, and corrosive liquids (1)
Container Storage Area	Building 325C	Storage of containers of waste
Mixed Waste Container Storage	Building 329	Storage of containers of mixed liquid wastes
Dry Mixed Waste Storage Area	Building 374A	Storage of containers or solid objects (e.g., lead bricks) containing hazardous or mixed waste materials
Alkali Metal Reaction Booth	Building 206	Destruction of water reactive alkali metals
Alkali Metal Reaction Booth	Building 308	Destruction of water reactive alkali metals, possibly contaminated with radionuclides
Interim Status Facilities Closed During 1993*		
Water Reaction Tank	317 Area	Destruction of water reactive alkali metals and other reactive chemicals
Shock Sensitive Treatment Area	317 Area	Treatment (detonation) of extremely reactive, or shock-sensitive wastes

*IEPA approval of final closure is expected during 1994.

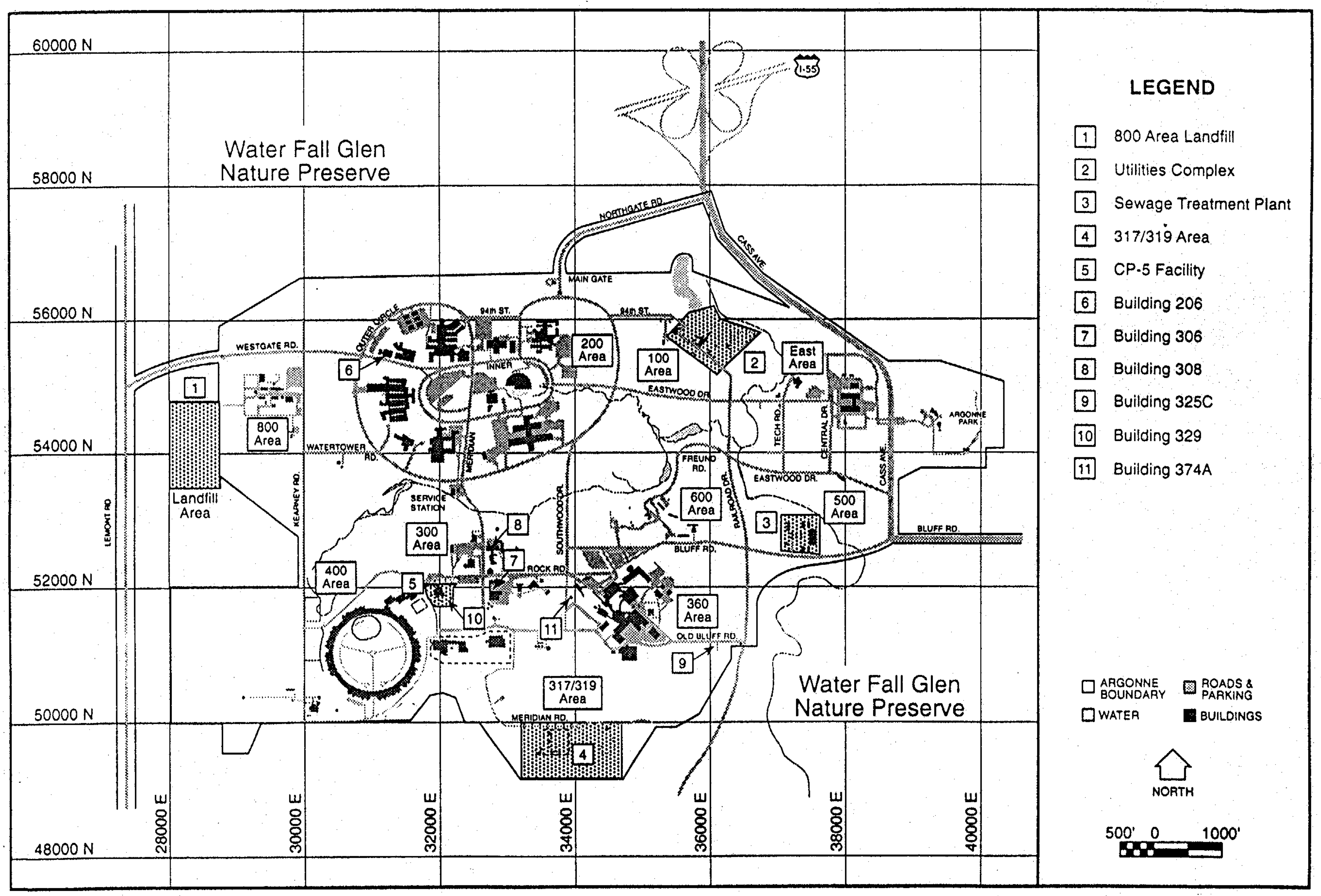


Figure 2.5 Major Waste Treatment, Storage, and/or Disposal Areas at ANL

Revisions to the permit application were submitted on June 17, 1991, and September 24, 1991, in response to IEPA and EPA comments. The application was prepared to comply with changes in RCRA and IEPA regulations, including information required to comply with the RCRA/HSWA corrective action provisions.

The RCRA Part B Permit application was revised and updated in 1993. ANL responded to EPA notice of deficiency comments regarding the alkali metal passivation booths in Buildings 308 and 206 and incorporated the response into the revised application. ANL also revised the operation by providing information to IEPA on four new portable hazardous waste storage units and a mixed waste storage tank. IEPA is currently conducting a technical review of the Part B application and may issue ANL a notice of deficiency in late 1994. A RCRA Part B draft permit may be issued in 1995.

A RCRA Facility Assessment (RFA) was completed by the IEPA during summer 1991. The RFA report from IEPA was received during late 1993 and identified more than 700 solid waste management units (SWMUs). When the Part B permit is issued, it will most likely contain requirements to characterize and assess the SWMUs. Many of the sites will not need extensive work, but some will require full characterization and remediation. ANL continues to abide by its Part A permit and the interim status standards found in 40 CFR 265 and 35 IAC Part 725.

2.3.3. Hazardous Waste Generation

ANL typically generates a wide variety of hazardous waste and mixed waste each year. The quantity of mixed wastes generated during 1993 was 28,350 liters (7500 gallons) and 100,000 kg (220,000 lbs) of solid mixed waste such as contaminated soils, debris, and metals. In 1993, 375,127 kg (825,280 lbs) of hazardous waste were shipped to a disposal site by an IEPA-permitted hazardous waste disposal company. In addition, small quantities of reactive hazardous wastes were treated on the site in the permitted treatment units. These units render the waste nonhazardous and allow disposal in the sewage system. During 1993, 1.1 kg (2.4 lbs) of waste were treated on site, primarily by thermal reaction in the alkali metal reaction booth.

2.3.4. Facility Modifications

New radioactive and hazardous waste storage facilities are being planned. Various facilities are scheduled for completion between 1995 and 1998. The mixed waste portion is currently entering the final design phase. The hazardous waste, radioactive waste, and Building 306 rehabilitation portions completed preliminary design during 1993. The Part B permit will be revised to incorporate these facilities when the final design details are known.

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 Atomic Energy Act as implemented by DOE Orders. Accordingly, facilities storing or disposing of mixed waste must comply with both DOE requirements and RCRA permitting and facility standards. ANL generates several types of mixed wastes, including acids or solvents contaminated with radionuclides. Corrosive mixed wastes are neutralized to remove the hazardous characteristic. Mixed waste sludge that cannot be rendered non-hazardous is sent to Hanford for storage and eventual disposal. Mixed waste temporarily stored at ANL is stored in compliance with all applicable requirements until such time that mixed waste treatment capacity is available to ANL. During December 1993, the first of four temporary storage units arrived at ANL. The units will be operational during early 1994. Three of the units are permitted by the IEPA for the storage of mixed waste. One unit will be used for bulking nonradioactive hazardous, flammable, and corrosive liquids. The Part B permit application addresses mixed waste management procedures.

2.3.6. RCRA Inspections

Three RCRA inspections were conducted by IEPA during 1993. A RCRA compliance inspection was conducted on January 20, 1993. No significant issues were identified. RCRA closure inspections of the Building 306 High Bay and Neutralization Booth were conducted on February 9, 1993, and May 11, 1993, respectively. No significant issues were identified. On May 19, 1993, the EPA conducted a RCRA inspection of the Building 306 air stripper operation. No significant issues were identified.

2.3.7. Underground Storage Tanks

In response to underground storage tank regulations, ANL prepared a Site-Wide Underground Tank Compliance Plan. The ANL site currently contains 22 existing upgraded or replaced underground storage tanks; 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 tanks. The Compliance Plan sets out a program for the replacement or upgrading of tanks that must remain in use. Currently, all tanks remaining in use are being monitored under a new recordkeeping program *initiated* by ANL.

During 1993, nine regulated underground tanks were upgraded to current technical requirements (secondary containment, corrosion protection, leak detection, double-walled piping, spill and overfill protection). To date, 10 in-use underground storage tanks have been replaced with new double-wall fiberglass tanks and all associated monitoring equipment. Additionally, previous tank locations were assessed for contamination.

2.3.8. Corrective Action for Solid Waste Management Units

As mentioned previously, the HSWA amendments to RCRA require that any Part B permit issued must include provisions for corrective actions for all releases of hazardous materials from any solid waste management unit (SWMU) at the site, regardless of when the waste was placed in the unit. When issued, the Part B permit will contain a compliance schedule which will govern the characterization and any required remediation of such units. The Part B permit application submitted to the IEPA identified and provided information on 56 SWMUs, both active and inactive. The recently issued RFA report from the IEPA identified more than 700 SWMUs. The great 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. Information developed by these studies was submitted to the IEPA with the Part B permit application. More extensive characterization is currently underway at a number of the sites. No new information has been submitted to the IEPA.

2.4. Solid Waste Disposal

During September 1992, ANL closed the operation of its sanitary landfill. This facility began operation in 1969. The original operating permit was issued by the IEPA in 1981. A supplemental permit addressing final elevations, a groundwater monitoring program, and closure/post closure 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 July 29, 1993, and no significant issues were identified.

The April 24, 1992, supplemental landfill permit required ANL to implement a specific groundwater monitoring program at the sanitary landfill. The program is designed to identify any releases from the landfill and demonstrate compliance with the applicable groundwater quality standards. Quarterly monitoring of 11 locations began during July 1992. Exceedances of the groundwater quality standards for chloride, iron, total dissolved solids, and manganese were noted at monitoring locations where these levels have been historically reported. One exceedance of the groundwater quality standard for phenols was noted at one location only during the first quarter of 1993.

The IEPA began requiring annual nonhazardous special waste reporting in 1991. The report is submitted by February 1 of each year and describes the activity of the previous year. It is a summation of all manifested nonhazardous and PCB wastes. Nonhazardous special waste includes such materials as waste oils, PCB-contaminated oils, contaminated soil, sludges, etc. During 1993, 118,131 liters (31,207 gallons) of nonhazardous special waste and 144,111 liters (38,070 gallons) of PCB-contaminated liquids and oils were shipped out-of-state to approved recycling or disposal facilities. In addition, 21.1 cubic meters (27.6 cubic yards) of PCB-contaminated solids including containers and transformers were disposed of at an EPA-approved disposal facility.

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 the review of the environmental impacts of a project. To ensure compliance with this policy, NEPA requires that projects with potentially significant impacts be reviewed carefully through the generation of either an Environmental Assessment (EA) or Environmental Impact Statement (EIS). This review process is designed to insure that all potential impacts are identified, all available options are considered, and all affected parties are informed and given opportunity to comment on a project.

The DOE implementation of NEPA has undergone significant change during recent years. The threshold at which projects are subject to NEPA review has been reduced to such an extent that virtually all activities are now required to undergo some sort of NEPA review and documentation. On the other hand, the list of Categorical Exclusions, which is a list of project types that normally do not require an EA or EIS, has been expanded to help streamline the process. The DOE final rule on NEPA implementing procedures and guidelines revocation was published on April 24, 1992.

The ANL NEPA compliance program is designed to ensure that all activities under consideration are reviewed to determine any significant environmental impacts. This program subjects each proposed project to a careful consideration of potential impacts to air (dust, gaseous emissions), water (liquid effluents, wetland impacts), and soil (solid waste generation, construction activity), as well as impacts involving critical wildlife habitats, historic and cultural resources, radiation, noise, workers and other considerations. A questionnaire is completed for each project and is used as documentation of the review of potential impacts. This form (DOE/CH Form 560) is submitted to DOE for review and determination of the proper level of NEPA documentation. Projects that exhibit potentially adverse impacts in any area are subject to further review, including, if necessary, preparation of an EA or EIS. Any EA or EIS prepared by ANL is reviewed by DOE according to the procedures specified in DOE Order 5440.1E and DOE/CH Order 5440.1C.

During 1993, approximately 150 projects underwent ANL NEPA review. About 17% (25) required DOE NEPA review. There were no EA or EIS determinations for projects reviewed in 1993. It is anticipated that DOE in 1994 will require EAs for several projects, such as the D&D of Building 301 Hot Cells and HVEM-Tandem II (new research facility).

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 (MCL) and Maximum Contaminant Level Goals (MCLG), as well as through imposition of wellhead protection requirements, monitoring requirements, treatment standards, and regulation of underground injection activities. The SDWA established 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

The drinking water supply at ANL consists of four on-site wells that supply raw water to the water treatment plant. The treatment plant removes iron, softens the water by ion-exchange, and adds chlorine before pumping it to the site-wide distribution system. Because of the nature of the ANL drinking water system and the persons served by it, the system is classified as a non-transient, non-community water supply, and as such is subject to the regulations applicable to such systems. The Laboratory is subject to regulations under the State of Illinois program administered by the Illinois Department of Public Health (IDPH), 77 IAC Part 900, as long as that program is at least as stringent as the EPA program (40 CFR Parts 141, 142, and 143). These regulatory programs establish a monitoring program, design, operation and maintenance requirements, and secondary water quality standards.

2.6.2. Monitoring Requirements

The primary drinking water standards establish certain monitoring and analytical requirements. Both Federal and State regulations apply to the ANL drinking water monitoring program. ANL routinely samples each of the four wells and the treated water quarterly for compliance with appreciable 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 1993, samples continued to be collected and all state and Federally-required analyses were conducted. EPA-approved procedures were employed by a certified laboratory. Monitoring results were then reported within the specified time. As a result of meeting current Federal and State drinking water standards, waivers allowing reduction in future sampling were granted to ANL by the IDPH during March and August of 1993.

During 1993, ANL continued the sampling of 40 locations throughout its water system for lead and copper. The results indicated that the "action levels" for lead and copper were not exceeded. As a result, a reduced frequency in sampling (annually) and number of locations (20) is authorized for 1994.

The IDPH and DuPage County Health Department (DPCHD) participated in a EPA multi-media inspection of ANL June 28 to July 2, 1993. IDPH and DPCHD identified no significant deficiencies during the inspection.

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 use. Within ANL, all applications of pesticides are 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 ensures that the herbicide is EPA-approved, that it is used properly and any residue is disposed of in accordance with applicable regulations. This is carried out by oversight inspections and maintenance of records.

2.8. Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) addresses the cleanup of hazardous waste disposal sites and the response to hazardous substance spills. Under CERCLA, the EPA collects data regarding sites subject to CERCLA action through generation of a Preliminary Assessment (PA) report, followed up by a Site Investigation (SI). Based on the data collected, the sites are ranked according to their potential to cause human health impacts or environmental damage. The sites with the highest ranking are placed on the National Priority List (NPL) and are subject to mandatory cleanup actions, funded either by Potentially Responsible Parties (PRPs) or by the allocation of Superfund money to the project. Federal agencies are responsible for their own cleanup costs.

2.8.1. CERCLA Program at ANL

In the past, Federal facilities were allowed to develop and manage their own independent CERCLA program subject to EPA oversight. The DOE's CERCLA program was detailed in DOE Order 5480.14. This DOE Order has since been superseded by DOE Order 5400.4. Under the provisions of DOE Order 5480.14, in July 1986, ANL submitted preliminary assessment (PA) reports to DOE for the seven inactive units on the current ANL site and one inactive unit located on land deeded to the DuPage County Forest Preserve District in 1973 as shown in Table 2.4. Because of changes in the EPA CERCLA program brought about by the Superfund Amendments and Reauthorization Act of 1986 (SARA), the EPA is now required to publish a comprehensive inventory of Federal facility sites known as the Federal Agency Hazardous Waste Compliance Docket. These sites are ranked, using the Hazardous Ranking System (HRS), and placed on the NPL list if they score high enough. However, since they are Federal facilities, Superfund money is not available to support cleanup operations. In support of this effort, the EPA required submittal of PA reports for sites at ANL (as listed in Table 2.4). These reports were submitted in April 1988. Four sites not included in the original DOE submittal were included in the subsequent submission. In late 1990, ANL prepared and submitted one additional PA for a solvent disposal site used for a number of years by the ANL 810 Area paint shop for disposal of waste paint solvents. The site in Waterfall Glen Forest Preserve is currently owned by the DuPage County Forest Preserve District and thus is no longer part of a Federal facility subject to SARA. The PA for this site was submitted in an effort to inform the EPA of past ANL activities.

During early 1990, the EPA requested that ANL submit Site Screening Investigation (SSI) reports for six of the 13 sites. Upon further discussions between the EPA and DOE, one of the six sites was eliminated from consideration and three units (317/319/ENE) were treated as a single site due to their physical proximity. As a result, three SSI reports were completed by ANL and submitted to DOE in December 1990. They were subsequently transmitted to EPA in January 1991. Table 2.4 lists those sites for which an SSI was submitted.

TABLE 2.4

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

Site Name	DOE/CERCLA	EPA/SARA	EPA/SSI
Waste Sites on Current ANL Property			
800 Area Landfill and French Drain	X	X	X
319 Area Landfill and French Drain	X	X	X (1)
Landfill East-Northeast of the 319 Area	X	X	X (1)
Compressed Gas Cylinder Disposal Area, 318 Area	X	X	X (1)
French Drain, 317 Area	X	X	X (1)
Mixed Waste Storage Vaults, 317 Area		X	X (1)
Shock Treatment Facility, 317 Area	X	X	X (1)
Wastewater Holding Basin, Sewage Treatment Plant		X	
Liquid Waste Treatment Facility, Building 34	X	X	
Decommissioned Reactor CP-5, Building 330		X	X
Gasoline Spill, Gasoline Station		X	
810 Area Paint Shop		X	
Waste Sites on Old ANL Property, Currently Waterfall Glen Forest Preserve			
Reactive Waste Disposal, Underwriters Pond	X	X	

(1) All units located in the 317/319/ENE Area were described in a single Site Screening Investigation (SSI) report.

Recent 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. Since all but one of the CERCLA sites are on the ANL site and are included as SWMUs in the RCRA Part B permit application, they may be subject to RCRA corrective action and come under the authority of the IEPA. However, since several of the sites contain radiological contamination, over which RCRA has no authority, the sites may be subject to a combined RCRA/CERCLA action.

Regardless of which regulatory vehicle is ultimately used to facilitate the cleanup of these sites, the DOE, through various initiatives put forth by the Secretary of Energy, has made the commitment to clean up all such sites voluntarily within the next 30 years, wherever possible returning them to unrestricted use. As a response to these commitments, ANL has requested funding for the characterization and remediation of all but two of these sites. The two remaining sites are the one off-site unit, which is no longer under the control of ANL or DOE, and a small gasoline spill which was completely cleaned up immediately after the spill occurred. Several of the characterization projects have already begun and will continue over the next few years.

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

Sections 311 and 312

Title III of the 1986 SARA amendments to CERCLA created EPCRA as a freestanding 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 is required to provide to applicable emergency response agencies an inventory of hazardous substances stored on the site, Material Safety Data Sheets (MSDS), and completed SARA data sheets (Tier I or II forms) for each hazardous substance stored in quantities above a certain threshold planning quantity (typically 10,000 lbs; 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 Local Emergency Planning Committee (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 the years 1989 through 1993. 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 2.5 lists hazardous compounds reported under SARA Title III for 1993.

Section 304 of SARA Title III requires that the LEPC and state emergency planning agencies be notified of accidental or unplanned releases of certain hazardous substances to the environment. The procedures for notification are described in the Argonne Comprehensive Emergency Management Plan. There were no incidents during 1993 that required notification of the LEPC and Illinois Emergency Management Agency.

<u>Section 313</u>

According to the latest DOE requirements, ANL will need to evaluate reporting on chemical usage under Section 313 of SARA Title III. Any non-R&D usage of a SARA listed chemical in excess of the reporting threshold (25,000 lbs/yr manufacture or process; 10,000 lbs/yr otherwise used) shall require completion of a Form R and submission to EPA and the IEPA. The report for 1993 will be due July 1, 1994.

TABLE 2.5

Compounds Reported Under SARA Title III - 1993

	Hazard Class				
Compound	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	
Chlorofluoro- carbon 11		X			
Sodium Carbonate				X	
Sulfuric Acid				X	
Calcium Oxide				X	
Calcium Hydroxide				X	
Oils containing PCBs					X

Sulfuric acid usage (at the ANL Boiler House) for 1993 was 97,430 lbs. Since this exceeds the 10,000 lb threshold, a Form R will be required. Any sources of manufacturing of sulfuric acid will also need to be evaluated since manufacturing is defined to include unintentional production (e.g., sulfuric acid produced from runoff of the high sulfur coal pile). It is not expected that the 25,000 lb threshold would be triggered in this category.

Chlorine usage for 1993 was 14,225 lbs and will also need to be reported under SARA 313. These are the only chemicals expected to require reporting at this time.

For R&D listed chemicals, ANL will have to determine if aggregated usage of a listed chemical exceeds 1,000 lbs/yr and if so, file a Laboratory Activity Toxic Chemical Usage Report to EH and CSO. This report is to include the name and CAS number of each chemical over the threshold; the quantity of chemical used in laboratory activities (separated between exempt and non-exempt uses). For the first year (1993), if aggregated usage does not meet or exceed the 1,000 lb/yr threshold for any listed chemical, a report to this effect is to be submitted to EH-1. This report is due August 1, 1994.

2.9. Toxic Substances Control Act

The Toxic Substances Control Act of 1976 (TSCA) provides for testing of manufactured substances to determine toxic or otherwise harmful characteristics and regulation of the manufacture, distribution, use, and disposal of regulated substances. The only TSCA-regulated compounds in significant quantities at ANL are polychlorinated biphenyls (PCBs) contained in electrical capacitors and transformer oil and PCB-contaminated sludge. Regulations governing PCB management, such as use and disposal and remediation of spills, are set forth in 40 CFR 761. These regulations provide detailed requirements for use and disposal of materials containing concentrations of PCBs above 50 ppm. Most of these regulations relate to PCBs contained in dielectric fluids within electrical equipment, such as transformers and capacitors.

2.9.1. PCBs in Use at ANL

The majority of PCBs at ANL were contained in a number of transformers, capacitors, and switches throughout the site. Starting in 1987, ANL began removing and disposing of all PCB and PCB-contaminated electrical equipment. All indoor and outdoor transformers, with the exception of one unit in Building 211, have been removed and transported off the site for proper disposal. During 1990, 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 activities. Accordingly, the equipment has been labelled to reflect their non-PCB status. Operation, removal, storage, and disposal of PCB-containing articles were conducted in compliance with applicable TSCA regulations. The PCB Annual Report for Calendar Year 1992 was prepared during June 1993. A computerized database for tracking PCB-containing articles has been developed.

Large capacitors (466) with PCBs are still present on-site. All are either in use or standby units. There are no plans to dispose of any of these units. The total weight of PCBs in these capacitors is 9,283 kg (20,466 lbs).

2.9.2. Disposal of PCBs

Disposal of PCBs from the ANL site includes material lab-packed and bulked through Waste Management Operations (WMO), bulk solids sent off-site through WMO, and bulk solids sent off-site directly from the transformer removal/retrofill projects. The total weight of PCBs shipped off-site in 1993 was 221,092 kg (486,402 lbs). These totals are reported in weight of materials shipped, not weight of PCBs shipped off-site, as the concentration of PCBs is not always available.

2.9.3. PCB Spills

There was one new PCB spill in 1993 involving transformer US 56, located at Building 362. This transformer was scheduled to be removed from service in 1993 as part of the project to retrofill/replace all PCB transformers. In the course of cleaning the spill and removing the transformer, it was noticed that the gravel in the enclosure area was stained, most likely from old, historic spills. Analytical data demonstrated the contamination to be extensive, to a depth of approximately 6 ft, and this contaminated material was removed and disposed of off-site. Spill cleanup was completed on December 7, 1993, after data demonstrated complete restoration of the area, with no further contamination present.

There were two holdover spill incidents remaining from 1992. Both of these were at transformer 543, located outside the fenceline in the southeast corner of the forest preserve. Both the spills were cleaned and contained, and analyses demonstrated the areas were uncontaminated after cleaning. One spill cleanup was completed January 4, 1993, while the second required a second cleaning and was completed March 3, 1993. This transformer had experienced numerous leaks through 1991 and 1992, and was drained, removed, and replaced in 1993.

There is only one pending spill incident, Building 108, where the old transformers have been replaced with two new, non-PCB transformers. The continuing spill cleanup is being completed in conjunction with the replacement project. This contaminated area has been defined, and will be completely removed in the early second quarter of 1994.

During late 1989, it was discovered that a small sludge drying bed at the Laboratory wastewater treatment plant was contaminated with PCBs of unknown origin. The initial sampling indicated the presence of over 50 mg/kg in the sludge and over 300 mg/kg in the sand beneath the beds. Extensive characterization of the beds was completed in the spring of 1992 which confirmed the presence of the PCBs in the sludge at concentrations between 13.7 and 101 mg/kg, while the sand concentrations dropped significantly to below 0.71 mg/kg. During 1993, ANL conducted an "alternatives evaluation" study which was submitted to DOE for approval during 1994. Site assessment, sludge and sand removal, storage, and approval by DOE and EPA of a TSCA R&D Permit are planned for 1994.

On June 30 through July 2, 1993, EPA, IEPA, IDPH, and DuPage County Health Department conducted a multi-media inspection, which included PCB management. No TSCA deficiencies were noted during the inspection.

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 insure the conservation of endangered or threatened species or critical habitat of such species. For ANL, the Fish and Wildlife Service (FWS) has been delegated authority to conduct these consultations and enforce the ESA.

To comply with the ESA, Federal agencies are required to make an assessment of 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 are then carried out to determine the extent of impact and any special actions which must be taken to minimize this impact.

At ANL, 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 Project Environmental Evaluation Form. If there is potential adverse impact, this impact will be further assessed and evaluated through the preparation of a more detailed NEPA document, such as an EA or EIS.

Currently, no Federally-listed endangered species are known to reside on ANL property. The northern Illinois region, including ANL, is considered in the range of several such species; however, no suitable habitat is known to exist on the site. Four species listed by the State of Illinois as threatened state species are known to reside on the ANL site. Impacts to these species are also assessed during the NEPA process. No project at ANL has ever had to be stopped, delayed or modified as a result of potential impact to endangered species.

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 National Registry of Historic Places. The Act also establishes a procedure for archaeological investigation activities and a system of civil and criminal penalties for unlawfully damaging or removing such artifacts.

The NHPA is implemented at ANL 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 Project Environmental Evaluation 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 digging permit must be obtained from the PFS division. This permit must be signed by the Cultural Resources Officer at ANL prior to digging to document the fact that no significant cultural resources will be impacted.

During 1993, fieldwork was completed on the archaeological survey of the ANL site. Phase I archaeological surveys were conducted to identify the location of potential historic and prehistoric sites at ANL. The results of the Phase I surveys were documented in reports which were subsequently submitted to the Illinois Historic Preservation Agency (IHPA) for their review. Upon completion of the review, the IHPA makes a determination whether or not the sites are eligible for nomination to the National Registry of Historic Places. If the sites are deemed not eligible, the area is considered "cleared" and no further archaeological review is required. If however, the IHPA believes that a site is significant and potentially eligible for nomination to the National Registry, a Phase II survey is recommended. The Phase II survey intensively characterizes the site and the reported findings are again reviewed by the IHPA to determine the site's eligibility to the National Register.

The text of the Cultural Resource Management (CRM) plan has been completed. During 1994, a final site map identifying all existing historic and prehistoric sites will be completed. The map will also indicate those areas of the ANL site which have been cleared from further archaeological review. All documents comprising the appendices will be compiled, and the final CRM Plan will be issued.

ANL currently does not contain any sites, buildings or structures included in the National Register of Historic Places. It does, however, contain several facilities which represent historically important scientific or technical achievements, such as the first experimental boiling water reactor. If it is determined that such sites are suitable for listing, they will be investigated and submitted to the Department of the Interior for possible listing.

2.12. Floodplain Management

Federal policy on managing flood plains is contained in Executive Order 11988 (May 24, 1977). This Executive Order requires Federal facilities to avoid to the extent possible adverse impacts associated with the occupancy and modifications of floodplains. A project proposed for construction in a floodplain must demonstrate that there is no reasonable alternative to the floodplain location.

The ANL site is located approximately 150 feet 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 insure that these areas are not adversely impacted, ANL has maintained a practice of not permitting new facility construction within these areas, unless there is no practical alternative. Any impact to floodplains are fully assessed and documented in the NEPA documents prepared for a proposed project.

2.13. Protection of Wetlands

Federal policy on wetland protection is contained in Executive Order 11990. In addition, 10 CFR Part 1022 describes DOE's implementation of this Executive Order. This Order requires Federal agencies to identify potential impacts to wetlands resulting from proposed activities and to minimize these impacts. Where impacts cannot be avoided, action must be taken to mitigate the damage by repairing the damage or replacing the wetlands with an equal or greater amount of a man-made wetland as much like the original wetland as possible. The current DOE policy is for no net decrease in the amount of wetland as a result of DOE activities.

Due to the topography and nature of the soil at ANL, the site contains a significant number of natural and man-made wetlands. These range from small stormwater ditches which are overgrown with cattails to natural depressions, beaver ponds and man-made ponds. The potential impact to these areas caused by a proposed action is described in the NEPA Project Environmental Evaluation Form for the project. If the potential impact is thought to be significant, the DOE will require preparation of an EA or EIS. The APS project, currently under construction, required a U. S. Army Corps of Engineers Section 404 permit and extensive wetland mitigation activities, since several small natural wetlands occupied the construction site and had to be replaced elsewhere. These actions were documented in the EA which was approved in early 1990.

During 1993, a site-wide wetlands delineation was completed of the ANL 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.* The results of the survey were delineated on a site map indicating the areal extent of all wetlands present at ANL down to 500 m^2 (1/8th acre). The findings are documented in an accompanying report which describes in detail the soil, vegetation, and hydrology of each wetlands area delineated on the map. Thirty-five (35) individual wetland areas were identified totalling approximately 45 acres. The wetlands areas were also digitized onto a computer-aided design file in order that scale maps are available to ANL engineers for planning and designing projects. The delineation will also be useful for determining project impacts under NEPA review.

In 1994, plans are to disseminate wetlands maps to all ANL staff who may require this information. Individual wetlands maps should be available to project managers in need of specific information.

2.14. Current Issues and Actions

The purpose of this section is to summarize the most important issues related to environmental protection encountered during 1993. Since preceding sections of this chapter contain detailed discussions of specific issues related to each major piece of environmental regulation, discussions of specific issues will not be repeated in this section. Please refer to the appropriate section of this chapter for these details.

2.14.1. Major Compliance Issues

The most significant ongoing issues encountered at ANL during 1993 involve wastewater discharges: compliance with existing NPDES wastewater discharge permit requirements and identification of wastewater effluent toxicants. The IEPA has identified ANL as a significant noncomplier with the requirements of its NPDES Permit. Exceedances were primarily the result of inadequate treatment to meet stringent limits. Corrective actions are underway or planned to upgrade or construct the necessary facilities. These projects are contained in the Five Year Plan, discussed in Chapter 3. ANL has begun a comprehensive TRE in order to identify the toxic substance or substances and take corrective action to remove the toxics from the effluent. The initial phase of this evaluation was completed during 1993. Continuation of the study will take place during 1994.

Identification and clean-up of environmental contamination caused by previous activities on the ANL site remains an issue. These activities will primarily come under the purview of the RCRA programs administered by the EPA and IEPA. The ANL site has a significant number of such sites which will probably require extensive remediation to remove residual contamination resulting from past activities. The Five Year Plan contains a number of projects, termed Environmental Restoration projects, to provide for characterization and remediation of the sites. Several characterization projects are ongoing, while others are planned for the next few years. Remedial actions are scheduled to begin within three years, depending on the results of the characterization studies.

The IEPA-approved sanitary landfill groundwater monitoring program has indicated that the Ground Water Quality Standards of some routine indicator parameters are being exceeded. Continued monitoring of this site may provide data showing that additional extensive characterization and remediation are required.

2.14.2. Regulatory Agency Interactions

The regulatory agency interactions with ANL during 1993 were primarily limited to site inspections regarding permit requirements and related issues. The IEPA has identified ANL as a significant noncomplier with the requirements of its NPDES Permit. A major multi-media inspection was conducted by the EPA during June 28 through July 2, 1993. Representatives from DPCHP and the IDPH participated. A final report on the multi-media inspection has not been issued by the EPA. With the exception of NPDES exceedances, there are currently no ongoing outstanding compliance issues or agreements or pending enforcement actions against ANL.

2.14.3. Tiger Team Assessment

To resolve the deficiencies identified by the Tiger Team and the ANL self assessment, an Action Plan was prepared in December 1990. This plan lists specific actions to be taken to resolve each of the 84 Tiger Team findings and many of the self assessment findings. This document was approved by DOE Headquarters in early 1991. A number of the activities listed in the Action Plan were either ongoing actions or previously planned actions, many of which appear in the Five Year Plan. In addition, a series of new activities, not previously anticipated, were identified. These activities were started in 1991, contingent on additional funding provided by the DOE. Twenty-three actions were scheduled to be completed in 1993. Three of those actions have been documented complete, 20 have been rescheduled. Also, 20 actions rescheduled for completion from 1992 to 1993 were completed as planned. A total of 140 action plans have been completed since 1991. An internal tracking system was developed to insure that the various commitments contained in the Action Plan are satisfied and the milestones are met.

2.14.4. Progress Assessment Team

The DOE conducted a Tiger Team Progress Assessment of the ANL site from October 24, 1993, through November 9, 1993. The Team consisted of 13 professionals from various DOE offices and their support contractors, with expertise in the areas of management, quality assurance, environment, safety, and health. The purpose of the assessment was to provide the Secretary of Energy and senior DOE managers with concise independent information on the following: 1) change in culture and attitude related to ES&H activities; 2) progress and effectiveness of the ES&H corrective actions resulting from previous Tiger Team Assessment; 3) adequacy and effectiveness of the ES&H self-assessment process; and 4) effectiveness of DOE and contractor management structures, resources, and systems to address ES&H problems and new ES&H initiatives effectively.

The results of the Assessment were: 12 concerns; four weaknesses; and six strengths. These were distilled into two key accomplishments (ANL and DOE-CH have effected cultural changes and there are organizational enhancements and have mobilized resources); two key concerns (inconsistent sitewide implementation of ES&H activities and DOE responsibility and accountability for integrated planning, budgeting, and resource allocation is not clearly understood or accepted); and one probable root cause (ANL and DOE have not developed and implemented integrated planning processes that define, guide, and set priorities for accomplishing the ES&H aspects of the ANL mission on the basis of sitewide risks and vulnerabilities). The conclusion of the Progress Assessment Team was that three years of intense activity on the part of ANL and DOE has resulted in substantial progress in correcting the deficiencies identified by the Tiger Team. Among the more important accomplishments are a positive culture change, an effective construction safety program, a graded approach to conduct of operations, enhanced ES&H training program, and improved ES&H related program plans.

2.15. Environmental Permits

Table 2.6 lists all environmental permits in effect at the end of 1993. 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 2.6

ANL Environmental Permits in Effect on December 31, 1993

Permit Requirement	Source Name	Building	Date Issued	Expiration Date
Air	ALEX Alkali Metal Scrubber	370	12/5/91	12/3/96
Air	Alkali Booth	308	2/15/89	2/9/94
Air	Alkali Booth	206	6/19/89	5/31/94
Air	Argonne Service Station	300	4/23/91	1/7/96
Air	Central Shops Rotoclone Dust Collection System	363	3/12/91	3/7/96
Air	Coal/Oil Fired MHD (FEUL Facility)	146	3/30/90	3/27/95
Air	Gasoline Dispensing Facility (Modified)	827	12/1/93	9/17/95
Air	Medical Department Steri-Vac Sterilizer	201	3/27/91	3/22/96
Air	Methanol/Gasoline Storage Tank	827	9/24/91	9/23/96
Air	Oil Fired Boilers	800 Area	11/1/91	10/29/96
Air	Open-Burning - Fire Training	Site-Wide	1/26/93	4/16/94
Air	Proton Decay Project Grieve Oven	366	8/8/91	8/6/96
Air	Steam Plant	108	12/28/93	12/28/98
Air	Sulfuric Acid Storage Tank	108	1/17/91	1/31/95
Air	Vapor Degreaser	363	3/13/90	3/9/95
Air	Wastewater Air Stripper	306	4/27/93*	4/27/98
Air	Wood Shop Rotoclone Dust Collection System - Operate	809	12/16/93	10/17/96
Air	Dust Collector, Wood Shop - Construct	809	12/16/93	
Air-Rad	Advanced Photon Source - Permit to Construct - EPA	400	11/2/89	-
Air-Rad	Advanced Photon Source - Operating Permit - IEPA	400	12/21/93	7/26/98
Air-Rad	Alpha-Gamma Hot Cell Facility	212	3/25/91	11/30/95
Air-Rad	Building 212 Exhausts	212	7/30/91	7/23/96
Air-Rad	Building 306 Vents and 317 Area	306	8/6/91	7/25/96
Air-Rad	Continuous Wave Deuterium Detector (CWDD)	369	5/9/91	4/30/95
Air-Rad	CP-5	330	5/10/91	1/31/95

TABLE 2.6 (Contd.)

Permit Requirement	Source Name	Building	Date Issued	Expiration Date
Air-Rad	Cyclotron	211	5/10/91	1/31/95
Air-Rad	D&D HEPA Filtration System	331	3/25/91	12/31/94
Air-Rad	Intense Pulsed Neutron Source	375	3/25/91	11/30/95
Air-Rad	JANUS Reactor	202	5/10/91	11/30/95
Air-Rad	M-Wing Hot Cells	200	3/25/91	11/30/95
Air-Rad	NBL Plutonium & Uranium Hoods	350	4/25/91	4/19/96
Air-Rad	Rad Hoods	Site-Wide	7/9/92	7/9/97
Hazardous Waste	RCRA Part A Permit	Site-Wide	4/30/82	-
Hazardous Waste	RCRA Part A Modification - Storage Units	Site-Wide	2/18/93	-
Hazardous Waste	RCRA Part A Modification - Scintillation Vials	Site-Wide	9/22/93	-
Miscellaneous	Nuisance Wildlife Control	Site-Wide	1/23/93	1/31/94
Solid Waste	Landfill	800 Area	3/31/82	-
Solid Waste	Landfill	800 Area	3/30/89	-
Solid Waste	Landfill	800 Area	4/12/89	-
Solid Waste	Landfill Leachate Test Wells	800 Area	8/31/90	-
Solid Waste	Landfill Groundwater Assessment	800 Area	9/30/91	-
Solid Waste	Landfill Leachate Characterization	800 Area	9/30/91	-
Solid Waste	Landfill Revised Closure Plan	800 Area	4/24/92**	-
Solid Waste	Landfill Supplemental Closure Plan	800 Area	9/15/92	-
Water	APS Wetland	Site-Wide	11/22/88	-
Water	Landfill Wetland	800 Area	5/20/81	-
Water	Lime Sludge Application - LPC	Site-Wide	10/23/89	10/4/94
Water	Lime Sludge Application - WPC	Site-Wide	6/4/93	12/31/93
Water	NPDES Permitted Outfalls	Site-Wide	6/7/89	1/15/94
Water	NPDES Stormwater Outfalls	Site-Wide	-	-

TABLE 2.6 (Contd.)

Permit Requirement	Source Name	Building	Date Issued	Expiration Date
Water	Canal Water Treatment Plant Overflow	Site-Wide	3/5/93	-
Water	317 Area Pump Station and Force Main	Site-Wide	3/9/93	-
Water	Outfall #008 Rehabilitation	Site-Wide	6/1/93	-
Water	Solar Pond Dischage to DuPage County	Site-Wide	6/3/93	-

*Issued in conjunction with emergency RCRA Permit (expired).
**Revised September 15, 1992, and October 22, 1992.

3. ENVIRONMENTAL PROGRAM INFORMATION

It is the policy of the DOE and ANL to conduct all operations in compliance with applicable environmental statutes, regulations, and standards and to ensure that environmental obligations are carried out consistently across all operations and organizations. Protection of the environment and human health and safety are given the highest priority. At ANL, a number of programs and organizations exist to ensure compliance with these regulations and to monitor and minimize the impact ANL operations have on the environment.

3.1. Environment and Waste Management Program

ANL management has designated the Environment and Waste Management Program (EWM) as the lead environmental support organization. The mission of EWM is to proactively support the ANL operations by conducting those activities that ensure compliance with applicable environmental statutes, regulations, DOE Orders, and ANL policies and procedures. These activities include: the technical support in the preparation of permits and compliance documents, consideration of applicable regulatory requirements, and liaison with oversight and compliance organizations; proper collection, treatment, and disposal of radioactive, hazardous, and non-hazardous waste materials; the characterization, remediation, decontamination and decommissioning of facilities, operations, and areas; and the conduct of the ANL environmental monitoring and surveillance program. These activities are carried out to minimize the potential adverse effects to the health and safety of persons at the ANL site and the general public, to property and to the environment.

EWM is divided into five major operational departments: Environmental Projects; D&D Projects; Waste Management Operations; Waste Reduction; and Monitoring, Surveillance, and Environmental Compliance. The principal function of EWM is to serve as the ANL focal point for the execution of the DOE Environmental Restoration and Waste Management Program.

In 1989, the DOE established the goal of achieving compliance with applicable regulations and assessing and cleaning up releases of hazardous materials from inactive waste sites, returning all such sites to unrestricted use within 30 years. As a management tool to improve the achievement of this goal, the DOE established the Environmental Restoration and Waste Management Program. This program identifies specific needs and established a system for allocating funds to resolve the various deficiencies. Each of the DOE facilities has prepared a set of planning documents (Activity Data Sheets, or ADSs) describing the activities necessary to bring that specific site into compliance and to identify and clean up inactive waste sites. These planning documents are contained in two reports which are updated and published annually, the Environmental Restoration and Waste Management Five Year Plan and the Site Specific Plan. Five Year Plan projects and activities are subdivided into three categories, namely, corrective activities (those actions necessary in the short term to bring a facility into compliance with environmental regulations), environmental restoration activities (those activities necessary to identify and clean up inactive waste sites and other sites potentially contaminated as a result of DOE activities) and waste management activities(designed to ensure that hazardous and radioactive wastes are stored and disposed of safely and the volume of waste is minimized).

The 1993 Five Year Plan contained information on 181 separate projects. The majority of these projects were proposed research and development or technology demonstration projects that were not directly related to ANL on-site activities. The on-site activities included nine corrective activity projects, 17 environmental restoration projects, and five waste management activities. The titles of these projects are listed in Table 3.1. Currently, a plan has been proposed to DOE to group similar ADSs into larger ADS units to improve management and operational flexibility. The Five Year Plan is a public document available upon request from the DOE.

3.1.1. Environmental Projects

The role of the Environmental Projects Department is to support ANL operations, organizations, and DOE environmental missions by managing environmental projects in

TABLE 3.1

Environmental Restoration and Waste Management Projects

ADS Number	Title
	Waste Management Operations
1300	Waste Management Operations, Defense Programs Waste
1301	Waste Management Operations, Non-Defense Programs Waste
1302	PCB Transformer Disposal
1303	Rehabilitation of Waste Management Building
1304	Waste Storage Facility Upgrade
	Corrective Actions
1305	Underground Storage Tank Upgrade and Replacement
1306	Sanitary Wastewater Treatment Plant Improvements
1307	Remedial Alternatives for the 800 Area Landfill
1308	Laboratory/Sanitary Sewage Collection System Rehabilitation
1309	Laboratory Wastewater Treatment Plant Improvements
1310	Wastewater Treatment Plant Modifications
1311	Canal Water Treatment Plant Rehabilitation
1313	Cooling Tower Blowdown Water Diversion
	Environmental Restoration
1400	Program Management
1401	800 Area Landfill
1402	East Area Sewage Treatment Plant
1403	570 Holding Pond
1404	Sawmill Creek
1405	317/319/ENE Area
1406	100 Area
1407	Outfall Area
1408	Site-Wide Well & Borehole Closure/Site-Wide Hydrogeological Study
1409	Solid Waste Management Unit Assessment
1410	Underground Storage Tanks Removal
1411	Lime Sludge Removal
	Decommissioning and Decontamination
1412	Experimental Boiling Water Reactor D&D
1413	CP-5 Reactor D&D
1414	Hot Cells D&D
1415	Juggernaut Reactor D&D
1416	Argonne Thermal Source Reactor D&D
1418	ZPR Facilities D&D

accordance with applicable DOE Orders and environmental statutes. The Department provides project management and engineering support for environmental remediation projects. Project management functions include: the development of work scopes; project budgets; and schedules. The projects implemented by this Department are designed to minimize any current or future impact to the environment or human health.

The corrective activity projects at ANL involve the construction of new or upgraded wastewater treatment facilities used for disposal of wastewater from the ANL. As discussed in Chapters 2 and 5, the site has experienced a number of violations of its NPDES wastewater discharge permit in recent years. The reason for many of these violations is the lack of appropriate treatment technology to comply with current effluent limits. These deficiencies will be resolved as these corrective action projects are completed. During 1993, design work on several facilities was started.

Environmental Restoration activities represent the projects designed to carry out the objective of assessing and cleaning up inactive waste sites. The ANL site contains a number of inactive waste sites used for disposal of waste during the early years of Laboratory operations. These sites include two inactive landfills, three French drains (which consisted of shallow pits used for disposal of liquid wastes), two inactive wastewater treatment facilities and a number of areas which may have been contaminated through the discharge of small amounts of hazardous chemicals. Several sites used from the 1940s through the 1970s for open burning of combustible waste and construction debris also exist. A series of ongoing and planned activities has been designed to foster the clean up of these sites.

The Environmental Restoration projects at ANL are typically broken down into two phases, the characterization phase and the remediation phase. Several of the characterization projects were started in 1989 and 1990. Additional characterization is required before significant remediation can be undertaken. The results of some of this early characterization work is presented in Chapter 6. Following the characterization phase, projects designed to clean up and dispose of residual contamination found during characterization will commence.

3.1.2. D&D Projects Department

The mission of the D&D Projects Department is to proactively support the ANL and DOE mission in the D&D area by conducting those activities that promote compliance with applicable DOE, ANL, Federal, and State regulations and procedures. This includes: directing and planning all D&D Program activities at the ANL site, interfacing with DOE on the ANL D&D Program, performing planning and scheduling of D&D at the ANL site and investigating new or innovative approaches to accomplish D&D project work in a more timely and cost effective manner. Conduct of the D&D Program at ANL shall be done in a manner with due regard for the environment and public and worker safety and health.

In addition to the inactive waste site clean up projects, the Environmental Restoration section of the Five Year Plan also contains a number of Decontamination and Decommissioning (D&D) projects for on-site nuclear facilities. The ANL site contains several inactive nuclear reactors and hot cells used in the past for processing of radioactive materials. These facilities are either currently undergoing D&D or are scheduled for D&D in the next few years. The D&D operations will remove residual radiological contamination, will dispose of radiologically contaminated materials, and will return the facilities to unrestricted use status. The largest such activities are the D&D of the Experimental Boiling Water Reactor (EBWR) and the CP-5 research reactor.

Current technology is not adequate to process and dispose properly many of the waste materials that may be generated by these activities. Much of the waste is a mixture of radioactive and chemically hazardous materials for which there are currently no recognized treatment or disposal process. The Five Year Plan contains a number of research and development projects designed to develop the necessary technologies and processes to dispose of these materials safely. Many of these projects will be carried out at ANL by several of the research divisions.

3.1.3. Waste Management Department

The mission for the Waste Management Department is to provide for treatment, storage, and disposal of all regulated waste generated at ANL in compliance with state and federal regulations at minimal cost; and to supply skilled craftspeople, uniquely trained to safely provide decontamination and operational support activities for facilities which generate radioactive, hazardous, and other special wastes.

The projects included in this section of the Five Year Plan represent activities necessary to ensure that waste materials currently being generated are properly stored, treated and disposed. A primary motivation for the improvement in waste handling and disposal operation is the need to upgrade such facilities to comply with increasingly stringent RCRA requirements as well as other state and federal regulations and DOE orders. The majority of the Waste Management projects involve improvements to existing treatment or storage facilities.

3.1.4. Waste Reduction Department

The role of the Department is to develop, promote, and implement waste reduction technologies, practices, policies, and environmental quality through training, review, culture change, and operational activities at ANL in support of Laboratory and DOE missions.

3.1.5. Monitoring, Surveillance and Environmental Compliance Department

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 which are needed to ensure the safety of the public, protection of the environment, and compliance with applicable Federal, State, and local environmental regulations and with the DOE Orders.

The mission of the Department is to define the applicable compliance requirements with assistance from the Legal Department of ANL. The Department helps to ensure that ANL is in compliance with these standards. The activities of the Department include: defining applicable Federal, State, and local regulations; define applicable DOE Orders; provide technical support in preparing permits and NEPA documents; provide technical support and guidance to the ANL programs through the ECR and ESH representatives; conduct reviews of construction projects and experiments; and act as liaison with external regulatory agencies and to coordinate with internal research and support groups. This information and services for the Department are transmitted to the programmatic and operations groups at the Laboratory.

Monitoring and surveillance are conducted to determine the effects, if any, of ANL activities on the public and on the on-site and off-site environment. Effluent monitoring is the collection and analyses of samples, or measurements of liquid and gaseous effluents for the purpose of characterizing and quantifying contaminants, assessing radiation exposures to members of the public, providing a means to control effluents at or near the point of discharge,and to demonstrate compliance with applicable standards and permit requirements. Environmental surveillance is the collection and analysis of samples or direct measurements of air, water, soil, foodstuffs, biota, and other media from the ANL site and its environs for the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposure of the public and assessing the effects, if any, of ANL operations on the local environment. The information generated by this program is compiled each year in the ANL Site Environmental Report which is distributed to ANL and DOE personnel and to the Federal, State, and local regulators.

3.2. Environmental Support Programs

3.2.1. Self-Assessment

In preparation for the 1990 Tiger Team visit, ANL conducted a formal top-down environmental self-assessment. This was followed in the next two years with self-assessments on Tiger Team findings, root causes, and action plans. For 1993, the self-assessment was expanded and formalized to document accomplishments, clarify and evaluate the organization's status, and to develop short- and long-term goals and plans for improvement. All ANL organizational units were required to participate in the 1993 assessment.

A guidance document was prepared to standardize the self-assessment process and organizational assignments were made to coordinate the effort. Thirteen topics were selected for the 1993 self-assessment and these are listed in Table 3.2. The product of the assessment was a report that briefly described the mission of the organization, the assessment process, provided a summary of the overall results of the assessment against the thirteen topics, and established goals, timelines, and milestones. Organizational unit reports were rolled-up into higher level reports. The process was completed in preparation for the Progress Assessment Team visit in October 1993.

3.2.2. Environmental Training Programs

ANL has a comprehensive environmental protection training program which includes mechanisms to identify, track, and document requirements for every employee. Environmental protection training for ANL 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, DOT, EPA, and OSHA regulations are identified by a Job Hazards Checklist form which 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. There are also options for divisionally-required training, recommended training, and elective training.

The logistics for ensuring that the training 1) meets compliance, 2) is completed, and 3) is documented is managed through the Training Management System, an "on-line" main frame computer-based system. Environmental protection training courses and course

TABLE 3.2

Topics for the 1993 ANL Self-Assessment

Generic - applicable to all ANL organizations

Module	Title
A.	Training and personnel qualification
B.	Self-assessment and reporting of events
C.	Quality
D.	Fire and life safety
E.	Emergency planning and response

ANL Support and Programmatic Organizations - as applicable to activities

F.	Safety planning for experiments and nuclear facilities
G.	Occupational safety and health
H.	Radiation protection
I.	Environmental protection
J.	Maintenance and configuration management
K.	Management of radioactive, mixed, and hazardous waste

Specialized Activities - address division-level responsibilities, if applicable

L.	Construction and subcontractors
M.	Packaging and transportation

descriptions are listed in the Training Course Catalog available from divisional representatives, the ESH Training System, or from Human Resources.

3.2.3. Pollution Prevention - Waste Minimization

Waste minimization is a policy specifically mandated by the Congress in the 1984 Hazardous and Solid Wastes Amendments to the Resource Conservation and Recovery Act (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 practic able." Hazardous waste generators, such as ANL, must certify in their waste manifest that this requirement has been fulfilled. Generators must also identify in their biennial reports to the IEPA the efforts undertaken during the year to reduce the volume and toxicity of waste generated and the changes in volume and toxicity actually achieved.

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, i.e., used, reused, or reclaimed. All waste that is nevertheless generated is to be treated to reduce volume, toxicity, or mobility before storage or disposal. Reducing or eliminating the generation of waste should be given prime consideration in research, process design, and plant operations.

DOE Orders 5400.1, 5400.3, and 5820.2A mandate that the management of radioactive wastes and other pollutants shall be accomplished in a manner that minimizes the generation of such wastes.

ANL has a long-standing history of pollution prevention and waste minimization dating back to the Manhattan Engineering District. Early activities included recycling of metals and rare materials. Although no formal pollution prevention and waste minimization plan is in place, through the efforts of the Waste Reduction Department, ANL continues to focus on pollution prevention and waste minimization activities. A few of these activities include:

- Paper, metal, and toner cartridge recycling
- Actinide recovery for re-use and recycle
- Refuse recycling through contractor service
- Use of alternate cleaning fluids for the Advanced Photon Source beam lines
- Use of alternate methods of cleaning and painting water towers
- Filtering of Central Shops aqueous lubricants
- Development of a process to concentrate human excrement samples for radiological analysis resulting in source reduction
- Adaptation of micro-experimentation techniques in chemical synthesis
- Adaptation of bacteriological testing to replace animal testing applications
- Substitution of non-hazardous scintillation flours for hazardous flours
- Specifications requiring use of retread tires and fly ash in concrete are in place
- ANL research programs order minimal quantities of material on an as needed basis
- White paper recycling campaign for reducing waste generation
- Development of a Chemical Management System for control of inventory

The level of achievement for the above-mentioned activities will be determined by the amount of funding provided to the Waste Reduction Department during Fiscal Year 1995. The coordination and development of several pollution prevention and waste minimization concepts will be provided by a Pollution Prevention Task Force that was formed during 1993.

3.3. Environmental Monitoring Program Description

As required by DOE Order 5400.1, ANL conducts a routine environmental monitoring program. This program is designed to determine the effect the operation of ANL is having on the environment surrounding the site. This section describes this monitoring program. 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 analytical techniques used. Greater detail is provided in the Environmental Monitoring Plan.

3.3.1. Air Sampling

Continuously operating air samplers are used at ANL to measure the concentrations of airborne particulate radioactivity. There is currently no monitoring of non-radiological air contaminants in ambient air. Particulate samplers are placed at 15 locations around the ANL perimeter and at six off-site locations, approximately five miles from ANL to determine the ambient or background concentrations.

Airborne particulate samples for direct radiation measurement are collected continuously at 13 perimeter locations and at five off-site locations on glass fiber filter media. Average flow rates on the air samplers are about 70 m^3/hr. Filters are changed weekly. The filters on perimeter samplers are changed by ANL staff and the filters on off-site samplers are changed and mailed to ANL by cooperating local agencies. The sampling units are serviced every six months and the flow meters are recalibrated annually.

Additional air samples, 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 which are changed every ten days by ANL staff. The flow rate calibration and servicing schedule is the same as discussed above.

Stack monitoring is conducted continuously at those emission points that have a probability of releasing measurable radioactive effluents. The results of these measurements are used for calculating the theoretical annual off-site dose using the required CAP-88 version of the EPA-AIRDOSE atmospheric dispersion computer code and dose conversion.

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 final flow rate are recorded on a label attached to the sample container. The samples are then transported to ANL where this information is then transferred to the ANL data management system.

Each air filter sample collected for direct measurement 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 two-inch circle is cut from the other half of the filter, mounted in a two-inch low-lip stainless steel planchet, and counted for alpha and for 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, and then sequentially analyzed for plutonium, thorium, uranium, and strontium.

3.3.2. Water Sampling

Water samples are collected to determine what, if any, radioactive materials or selected hazardous chemicals used or generated at ANL enter the environment by the water pathway. The samples are collected from Sawmill Creek below the point at which ANL discharges its treated wastewater and stormwater. The results of radiological analysis of water collecting at this location are compared to upstream and off-site results to determine the ANL contribution. The results of the chemical analysis 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.

In addition to surface water, subsurface water samples are also collected at approximately 32 locations. These samples are collected from monitoring wells located near sites which have the potential for adversely impacting groundwater. These sites 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 or radioactive constituents.

Surface water samples are collected from Sawmill Creek daily and manually composited into a single weekly composite sample. A continuous sampling device has been installed at this location to improve sample collection efficiency. To provide control samples, Sawmill Creek is sampled upstream of ANL once a month. The Des Plaines River is sampled twice a month below, and monthly above, the mouth of Sawmill Creek to determine if the radioactivity in the Creek had any effect on the activity in the River. Water samples are collected from remote locations in the spring and fall to serve as additional control samples.

Subsurface water samples are collected quarterly from the monitoring wells located in the 317/319 Area, 330 (CP-5), and the 800 Area Sanitary Landfill. The monitoring wells are purged and samples 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 well-heads of the four ANL wells used to provide the Laboratory 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, which accompanies it through all analyses.

After the sample has been logged in, an aliquot is removed for tritium analysis, 20 mL of conc. HNO_3 is added per gallon of water as a preservative, and the sample is filtered through Whatman #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-846 and/or CLP are met or deviations are documented. All samples are assigned a unique number which serves as a reference source for each sample. When duplicate samples are obtained, unique numbers are assigned and the indication that duplicates exist is noted in the data management system.

3.3.3. Bottom Sediment

Bottom sediment accumulates small amounts of radioactive materials which may be present from time to time in the stream and, as a result, acts as an integrator of radioactive material that was present in the water. It provides a historical record of radioactive materials in that 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 discharges its treated waste water. 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. One gallon of sediment is collected from each location with a stainless steel scoop and 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 which accompanies it through the process.

Each sample is dried for several days at 110°C, 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.

3.3.4. Soil

Soil accumulates small amounts of particulate matter and serves as an integrator 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 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 from ten locations is collected at the site perimeter (five spring and five fall) and ten at remote locations (five spring and five fall). Sampling sites are selected in reasonably level areas that represent undisturbed soil. Two one-meter 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-diameter coring tool to a depth of 5 cm. All ten cores are composited as a single sample. This procedure follows the 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 which accompanies it through the process.

The entire sample is dried at 110°C 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 taken for radiochemical analysis. Because a known area of surface soil was collected, results are calculated in terms of concentration and deposition.

3.3.5. Vegetation

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

Grass samples are collected each year from ten perimeter and ten off-site locations at the same places as the soil samples. All the grass within one of the one-meter 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 which accompanies it through the process.

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

3.3.6. External Penetrating Radiation

Measurements of direct penetrating radiation emanating from several sources within ANL are made using calcium fluoride thermoluminescent dosimeter (TLD) chips. Each measurement is the average of four chips exposed in the same packet. All calcium fluoride packets are shielded with 1/16 inch copper foil to reduce or eliminate the beta and low-energy x-ray components. The response of the chips is determined with a U. S. National Institute of Standards and Technology (NIST) standard radium-226 source.

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. Upon return to the laboratory, the information is transferred to the EMS system. Each sample is assigned a unique number which accompanies it through the process.

The individual chips are read on an Eberline Model TLR-6 TLD reader. Control chips are read and their contribution subtracted from the values of the field chips. A set of chips irradiated with a radium-226 standard source is also read and these values are used to convert the individual field readings to dose.

3.3.7. Data Management

The management of the large amount of data assembled in the environmental monitoring program is handled by ANL in a very structured manner that allows a number of reports to be generated. Basic radiological data management, including sample recordkeeping, is done with the EMS computerized recordkeeping 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-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 nonradiological monitoring for groundwater and NPDES surface water effluents. For purposes of this plan, the procedures for nonradiological sampling follow the same basic protocol as shown below.

The starting point for effluent monitoring and environmental surveillance is establishing a set of sampling locations and a sample schedule. Based on either regulatory parameters, pathway analysis, or professional judgement, 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. They are: 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 is entered into the EMS system and invoice sheets are printed for each sample. These are provided to the analytical laboratory and also serve as the chain-of-custody documents.

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 is completed on each sample and the results entered into the EMS, the completed final results sample card is retained in a file as an additional quality assurance measure.

Complete data sets for all samples are maintained by the EMS program. When all radiochemical results are complete 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 EWM computer network server. The printed final result card is filed after review, then ultimately put in DOE's archives in Chicago. Annually, EWM staff print and bind for reference the complete results, 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"[4] requires that an environmental monitoring and surveillance program be conducted, Section III-3 (k), to determine any releases or migration from low-level treatment, storage, or disposal sites. Compliance with these requirements is an integral part of the ANL site-wide monitoring and surveillance program. To cover the waste management operations in general, reliance is made on the perimeter air monitoring network and monitoring of the liquid effluent streams and the Sawmill Creek. The analytical results are collected 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, 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 15 monitoring wells with analyses for tritium, strontium-90, and gamma-ray emitters, plus selected monitoring for volatile organic compounds. The results are collected in Chapter 4 and Chapter 6 of this report.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1. Description of Monitoring Program

The radioactivity of the environment around ANL 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.

Since 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.[5] About 1,258 samples were collected and approximately 4,268 analyses were performed. The results of radioactivity measurements are expressed in terms of picocuries per liter (pCi/L) for water; femtocuries per cubic meter (fCi/m^3) and attocuries per cubic meter (aCi/m^3) for air; and picocuries per gram (pCi/g), femtocuries per gram (fCi/g), and/or nanocuries per square meter (nCi/m^2) for soil, bottom sediment, and vegetation. Penetrating radiation measurements are reported in units of millirem per year (mrem/y) and population dose in man-rem. Other units are defined in the text.

The DOE has provided guidance[6] for effective dose equivalent calculations for members of the public, based on ICRP-26 and ICRP-30.[7] Those procedures have been used in this report. The methodology requires three components to be calculated: (1) the committed effective dose equivalent from all sources of ingestion, (2) the committed effective dose equivalent 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 committed effective dose equivalent is accounted for. The primary radiation dose limit for members of the public is 100 mrem/y. The effective dose equivalents for members of the public from all routine DOE operations, natural background and medical exposures excluded, shall not exceed the values and shall be as low as reasonably achievable (ALARA), or 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.

The measured or calculated environmental radionuclide concentrations are converted to a 50-year committed effective dose equivalent with the use of the Committed Effective Dose Equivalent (CEDE) Factors[8] and compared to the annual dose limits for uncontrolled areas. The CEDE are calculated from the DOE Derived Concentration Guides (DCG)[6] for members of the public from ingested water and inhalation resulting in a radiation dose of 100 mrem/y. The numerical values of the CEDE factors used in this report are given in Table 4.30. Although the CEDE factors apply only to concentrations above natural levels, the calculated dose is sometimes given in this report for radioactivities that are primarily of natural origin for comparison purposes. Such values are enclosed in parentheses to indicate this. 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 made on samples collected continuously on laminated glass fiber filters (changed weekly) at 13 locations at the ANL site perimeter using PM-10 units 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 made on 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, providing 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.

The total alpha and beta activities in the individual weekly samples are summarized in Table 4.1. 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 24 fCi/m^3, which is the same as 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 exhibits an increase in concentration in the spring, indicating its stratospheric origin. The lead-210 in air is due to the radioactive decay of gaseous radon-222 and is similar to 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 have decreased regularly since 1987, reached a minimum in 1991, and now appear to be increasing. The

TABLE 4.1

Total Alpha and Beta Activities in Air-Filter Samples, 1993*
(concentrations in fCi/m³)

Month	Location	No. of Samples	Alpha Activity Avg.	Alpha Activity Min.	Alpha Activity Max.	Beta Activity Avg.	Beta Activity Min.	Beta Activity Max.
January	Perimeter	27	1.3	0.6	2.2	32.2	17.0	47.7
	Off-Site	12	1.9	0.7	3.6	36.3	19.6	66.8
February	Perimeter	44	1.6	0.7	2.9	30.7	20.1	40.7
	Off-Site	9	2.1	1.5	2.8	31.4	25.1	38.4
March	Perimeter	52	1.2	0.5	2.0	22.1	8.4	37.6
	Off-Site	18	1.5	0.3	2.4	23.3	10.5	36.3
April	Perimeter	32	1.2	0.4	1.8	16.6	11.0	30.0
	Off-Site	18	1.6	1.0	2.7	18.7	13.9	25.2
May	Perimeter	31	1.7	0.8	3.0	18.8	6.4	31.1
	Off-Site	19	2.0	0.3	4.1	20.0	3.2	35.5
June	Perimeter	32	1.2	0.1	2.0	15.3	5.1	21.4
	Off-Site	23	1.3	0.5	2.2	16.0	6.9	24.9
July	Perimeter	27	1.3	0.7	2.2	18.9	13.8	21.5
	Off-Site	20	1.6	0.8	2.7	21.1	14.3	32.5
August	Perimeter	7	1.5	1.2	2.1	20.8	15.4	34.0
	Off-Site	19	1.7	0.9	3.3	27.6	13.7	40.3
September	Perimeter	26	1.4	1.0	2.4	22.0	18.5	28.1
	Off-Site	25	1.3	0.4	2.6	22.0	10.1	35.7
October	Perimeter	44	1.8	1.0	2.6	29.4	17.0	37.4
	Off-Site	19	1.7	0.7	3.1	28.7	17.4	51.2
November	Perimeter	43	1.6	0.8	2.6	27.9	15.1	43.1
	Off-Site	20	1.7	0.9	2.7	27.0	15.3	45.4
December	Perimeter	48	1.7	0.7	3.0	34.7	25.1	50.6
	Off-Site	23	2.4	1.3	4.0	34.5	21.0	51.8
Annual Summary	Perimeter	413	1.5 ± 0.1	0.1	3.0	24.1 ± 4.2	5.1	50.6
	Off-Site	225	1.7 ± 0.2	0.3	4.1	25.6 ± 4.1	3.2	66.8

* 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.

TABLE 4.2

Gamma-Ray Activity in Air-Filter Samples, 1993
(concentrations in fCi/m^3)

Month	Location	Beryllium-7	Lead-210
January	Perimeter	59	26
	Off-Site	52	32
February	Perimeter	97	24
	Off-Site	77	24
March	Perimeter	62	17
	Off-Site	61	17
April	Perimeter	100	11
	Off-Site	115	19
May	Perimeter	105	12
	Off-Site	96	11
June	Perimeter	85	12
	Off-Site	66	8
July	Perimeter	87	12
	Off-Site	77	13
August	Perimeter	98	20
	Off-Site	64	20
September	Perimeter	95	18
	Off-Site	93	24
October	Perimeter	123	22
	Off-Site	81	20
November	Perimeter	76	23
	Off-Site	59	22
December	Perimeter	89	29
	Off-Site	69	26
Annual Summary	Perimeter	90 ± 11	19 ± 3
	Off-Site	76 ± 11	20 ± 4
Dose(mrem)	Perimeter	(0.00023)	(2.14)
	Off-Site	(0.00019)	(2.24)

downward trend 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.[9]

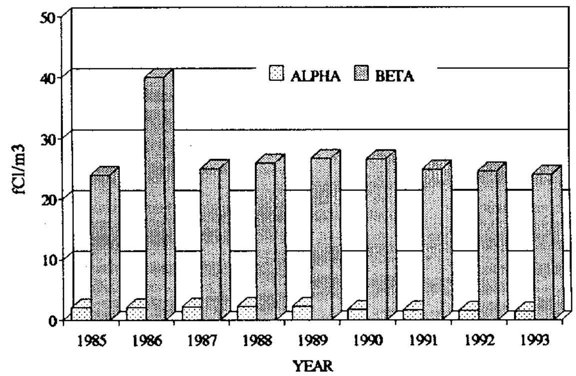


Figure 4.1 Comparison of Total Alpha and Beta Activities in Perimeter Air-Filter Samples

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 m^3 (700,000 ft^3). Samples were ignited at 600°C (1080°F) to remove organic matter and were prepared for analysis by vigorous treatment with hot hydrochloric, hydrofluoric, and nitric acids.

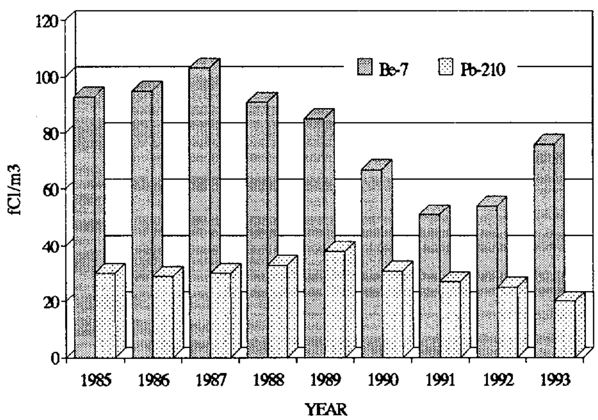


Figure 4.2 Comparison of Gamma-Ray Activity in Air-Filter Samples

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. Since alpha 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.

The strontium-90 concentrations have decreased over the past several years so that during 1993 most of the results were less than the detection limit of 10 aCi/m^3. Strontium-89 was not observed above the detection limit of 100 aCi/m^3. The plutonium-239 concentrations are similar to last year at Location 7I, Location 12N, and at the off-site sampling location.

The thorium and uranium concentrations are in the same range found 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.

The major airborne effluents released at ANL during 1993 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 released from Building 200 is due to radioactive contamination from the "proof-of-breeding" program and from nuclear medicine studies. Even though the CP-5 reactor ceased operations in 1979, hydrogen-3 continues to be emitted from Building 330. The hydrogen-3 emitted from Building 212 is from tritium recovery studies. 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.

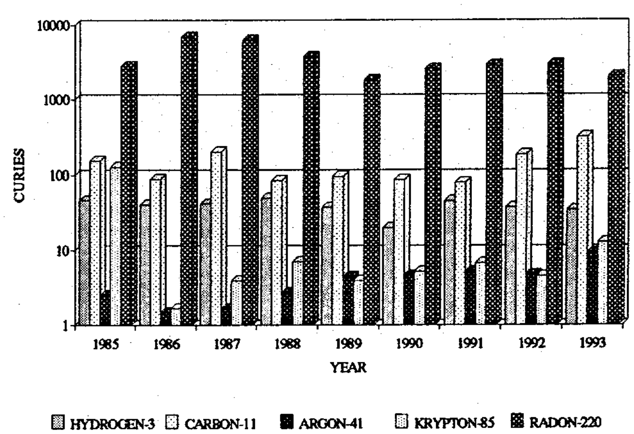


Figure 4.3 Selected Airborne Radionuclide Emissions

TABLE 4.3

Strontium, Thorium, Uranium, and Plutonium Concentrations in Air-Filter Samples, 1993 (Concentrations in Attocuries/m³)

Month	Location*	Strontium-90	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-238	Plutonium-239
January	7I	< 10	9 ± 1	14 ± 1	7 ± 1	12 ± 1	12 ± 1	0.2 ± 0.2
	12N	< 10	4 ± 1	6 ± 1	3 ± 1	7 ± 1	6 ± 1	0.8 ± 0.3
	Off-Site	< 10	7 ± 1	9 ± 1	5 ± 1	10 ± 1	9 ± 1	0.5 ± 0.3
February	7I	< 10	9 ± 1	11 ± 1	7 ± 1	14 ± 1	13 ± 1	0.3 ± 0.2
	12N	< 10	5 ± 1	5 ± 1	3 ± 0	8 ± 1	8 ± 1	0.6 ± 0.3
	Off-Site	< 10	4 ± 1	4 ± 1	2 ± 0	6 ± 1	7 ± 1	0.4 ± 0.3
March	7I	< 10	8 ± 1	9 ± 1	5 ± 1	12 ± 2	11 ± 1	0.4 ± 0.2
	12N	20 ± 2	5 ± 1	6 ± 1	3 ± 1	8 ± 1	6 ± 1	1.2 ± 0.4
	Off-Site	< 10	5 ± 1	6 ± 1	3 ± 1	8 ± 1	6 ± 1	0.3 ± 0.2
April	7I	< 10	8 ± 1	7 ± 1	4 ± 1	8 ± 1	9 ± 1	1.7 ± 0.4
	12N	12 ± 4	6 ± 1	6 ± 1	4 ± 1	9 ± 1	8 ± 1	1.3 ± 0.5
	Off-Site	< 10	4 ± 1	3 ± 6	1 ± 0	5 ± 1	6 ± 1	0.4 ± 0.2
May	7I	< 10	10 ± 2	11 ± 1	6 ± 1	10 ± 1	10 ± 1	2.4 ± 0.7
	12N	-	-	-	-	-	-	-
	Off-Site	< 10	3 ± 2	5 ± 1	3 ± 1	6 ± 1	6 ± 1	0.9 ± 0.4
June	7I	22 ± 2	-	-	-	8 ± 1	7 ± 1	1.9 ± 0.6
	12N	< 10	4 ± 2	5 ± 1	2 ± 1	4 ± 1	3 ± 1	2.3 ± 1.0
	Off-Site	< 10	5 ± 3	4 ± 1	3 ± 1	6 ± 1	4 ± 1	1.2 ± 0.9
July	7I	< 10	-	-	-	3 ± 1	3 ± 1	1.3 ± 0.4
	12N	16 ± 7	-	-	-	37 ± 5	38 ± 5	2.6 ± 1.5
	Off-Site	< 10	-	-	-	6 ± 1	5 ± 1	0.9 ± 0.3
August	7I	< 10	7 ± 1	5 ± 1	3 ± 1	8 ± 1	9 ± 1	1.3 ± 0.9
	12N	-	-	-	-	-	-	-
	Off-Site	< 10	5 ± 1	5 ± 1	4 ± 1	7 ± 1	5 ± 1	1.3 ± 0.5
September	7I	< 10	6 ± 1	7 ± 1	2 ± 1	7 ± 1	6 ± 1	0.8 ± 0.5
	12N	11 ± 2	3 ± 1	3 ± 1	2 ± 0	5 ± 1	5 ± 1	1.3 ± 0.6
	Off-Site	< 10	4 ± 1	2 ± 1	1 ± 0	3 ± 1	2 ± 1	0.2 ± 0.3
October	7I	< 10	12 ± 1	11 ± 1	7 ± 1	11 ± 1	11 ± 1	0.5 ± 0.3
	12N	21 ± 2	5 ± 1	5 ± 1	3 ± 1	8 ± 1	7 ± 1	0.6 ± 0.4
	Off-Site	< 10	2 ± 0	2 ± 0	1 ± 0	3 ± 0	3 ± 0	1.2 ± 0.5
November	7I	< 10	10 ± 2	15 ± 2	7 ± 1	16 ± 2	14 ± 2	0.3 ± 0.3
	12N	< 10	6 ± 2	17 ± 3	5 ± 1	13 ± 2	11 ± 2	0.6 ± 0.4
	Off-Site	< 10	6 ± 1	3 ± 1	1 ± 0	4 ± 1	4 ± 1	0.3 ± 0.2
December	7I	< 10	8 ± 1	8 ± 1	4 ± 1	10 ± 1	9 ± 1	0.2 ± 0.2
	12N	< 10	12 ± 1	14 ± 1	8 ± 1	17 ± 1	16 ± 1	0.3 ± 0.2
	Off-Site	< 10	6 ± 1	4 ± 1	2 ± 1	6 ± 1	6 ± 1	0.3 ± 0.2
Annual Summary	7I	< 10	9 ± 4	10 ± 7	6 ± 4	10 ± 8	10 ± 7	1.0 ± 1.7
	12N	11 ± 16	6 ± 6	7 ± 11	4 ± 4	12 ± 22	11 ± 23	1.2 ± 1.7
	Off-Site	< 10	5 ± 3	4 ± 4	2 ± 3	6 ± 5	5 ± 4	0.7 ± 0.9
Dose (mrem)	7I	< (0.00004)	(0.0216)	(0.0196)	(0.055)	(0.00049)	(0.00048)	(0.0024)
	12N	(0.00012)	(0.0138)	(0.0149)	(0.036)	(0.00058)	(0.00054)	(0.0029)
	Off-Site	< (0.00002)	(0.0115)	(0.0087)	(0.024)	(0.00029)	(0.00026)	(0.0016)

* Perimeter locations are given in terms of the grid coordinates in Figure 1.1

TABLE 4.4

Summary of Airborne Radioactive Emissions from ANL Facilities, 1993

Building	Nuclide	Half-Life	Amount Released (Ci)	Amount Released (Bq)
200	Radon-220	56 s	2023.5	7.5×10^{13}
	Radon-222	3.82 d	0.27	3.7×10^{9}
205	Hydrogen-3 (HTO)	12.3 y	0.57	2.1×10^{10}
212	Hydrogen-3 (HTO)	12.3 y	3.37	1.2×10^{11}
	Hydrogen-3 (HT)	12.3 y	26.2	9.7×10^{11}
	Krypton-85	10.7 y	12.87	4.8×10^{11}
	Antimony-125	2.71 y	0.000012	4.4×10^{5}
	Radon-220	56 s	0.57	2.1×10^{10}
330 (CP-5)	Hydrogen-3 (HTO)	12.3 y	4.57	1.7×10^{11}
350 (NBL)	Uranium-234	2.4×10^{5} y	1.12×10^{-8}	4.1×10^{2}
	Uranium-238	4.5×10^{9} y	1.12×10^{-8}	4.1×10^{2}
	Plutonium-238	87.7 y	4.03×10^{-8}	1.5×10^{3}
	Plutonium-239	2.4×10^{4} y	1.10×10^{-7}	4.1×10^{3}
	Plutonium-240	6.6×10^{4} y	6.82×10^{-8}	2.5×10^{3}
	Plutonium-241	14.4 y	2.59×10^{-5}	9.6×10^{5}
	Plutonium-242	3.76×10^{5} y	2.72×10^{-9}	1.0×10^{2}
375 (IPNS)	Carbon-11	20 m	316.8	1.2×10^{13}
	Argon-41	1.8 h	9.4	3.5×10^{11}
411 (APS)	Carbon-11	20 m	0.001	3.7×10^{7}
	Nitrogen-13	10 m	0.062	2.3×10^{9}
	Oxygen-15	122 s	0.007	2.6×10^{8}

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 non-hazardous cocktail. Analyses for transuranium nuclides were performed on 10-liter 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 americium-243 tracer. Isotopic uranium concentrations were determined by alpha spectrometry using uranium-236 as an isotopic tracer.

Argonne wastewater is discharged into Sawmill Creek, which runs through the ANL grounds, drains surface water from much of the site, and flows into the Des Plaines River about 500 m (0.3 mi) downstream from the ANL wastewater outfall. Sawmill Creek was sampled upstream from the ANL site and downstream from the wastewater outfall to determine if radioactivity was added to the stream by ANL 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.

Annual summaries of the results obtained for Sawmill Creek are given in Table 4.5. 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 operations were hydrogen-3, strontium-90, cesium-137, plutonium-239, americium-241, and occasionally neptunium-237, plutonium-238, curium-242 and/or californium-252, and curium-244 and/or californium-249. The percentage of individual samples containing activity attributable to ANL was 18% for hydrogen-3, 84% for strontium-90, 16% for cesium-137, 53% for plutonium-239, and 69% for americium-241. The concentrations of all these nuclides were 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 effluent water, the concentrations would still be below the DOE limits. This demonstrates compliance with DOE Order 5400.5 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 wastewater treatment plant 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.

At location 7M, below the ANL outfall, the annual average concentrations of most measured radionuclides were similar to recent annual averages. All the annual averages were well below the applicable standards. The annual total radioactive effluent discharged

TABLE 4.5

Radionuclides in Sawmill Creek Water, 1993

Activity	Location*	No. of Samples	Concentrations in pCi/L Avg.	Min.	Max.	Dose (mrem) Avg.	Min.	Max.
Alpha (Nonvolatile)	16K	12	1.3 ± 1.2	0.3	1.9	-	-	-
	7M	51	1.7 ± 1.0	0.2	2.5	-	-	-
Beta (Nonvolatile)	16K	12	6 ± 4	5	11	-	-	-
	7M	51	13 ± 18	7	56	-	-	-
Hydrogen-3	16K	12	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	7M	51	< 100	< 100	466	< 0.0046	< 0.0046	0.0214
Strontium-90	16K	12	0.27 ± 0.13	< 0.25	0.33	0.025	< 0.024	0.032
	7M	51	0.46 ± 1.04	< 0.25	3.82	0.043	< 0.024	0.362
Cesium-137	16K	12	< 1.0	< 1.0	< 1.0	< 0.04	< 0.04	< 0.04
	7M	50	1.5 ± 10.2	< 1.0	30.7	0.05	< 0.04	1.12
Uranium-234	16K	12	0.833 ± 0.545	0.440	1.188	0.158	0.084	0.226
	7M	51	0.671 ± 0.395	0.048	1.094	0.128	0.009	0.208
Uranium-238	16K	12	0.799 ± 0.512	0.438	1.204	0.134	0.074	0.202
	7M	51	0.589 ± 0.346	0.281	0.921	0.099	0.047	0.155
Neptunium-237	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	7M	51	< 0.0010	< 0.0010	0.0014	< 0.0028	< 0.0028	0.0038
Plutonium-238	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	7M	51	< 0.0010	< 0.0010	0.0021	< 0.0028	< 0.0028	0.0059
Plutonium-239	16K	12	< 0.0010	< 0.0010	0.0022	< 0.0031	< 0.0031	0.0068
	7M	51	0.0031 ± 0.0126	< 0.0010	0.0312	0.0096	< 0.0031	0.0980
Americium-241	16K	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
	7M	51	0.0026 ± 0.0051	< 0.0010	0.0142	0.0087	< 0.0033	0.0466
Curium-242 and/or Californium-252	16K	12	< 0.0010	< 0.0010	0.0011	< 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	< 0.0010	< 0.0010	0.0021	< 0.0034	< 0.0034	0.0071

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

to the creek in ANL wastewater can be estimated from the average net concentrations and the volume of water carried by the creek. These totals are collected in Table 4.6.

TABLE 4.6

Total Radioactivity Released to Sawmill Creek, 1993

Radionuclide	Released (Ci)	Percent
Hydrogen-3	18.70	96.5
Strontium-90	0.082	0.4
Cesium-137	0.587	3.0
Plutonium-239	0.0012	< 0.1
Americium-241	0.0010	< 0.1
Total	19.37	

Based on the results of the Stormwater Characterization Study (see Section 2.2.2), two perimeter surface water locations were identified which contained measurable levels of radionuclides. There were south of the 319 Area, Location 7J, and from the 800 Area Landfill, Location 11D in Figure 1.1. Samples were colleted quarterly and analyzed for hydrogen-3, strontium-90, and by gamma-ray spectrometry. The results are collected below:

(Concentrations in pCi/L)

Date Collected	Location 7J Hydrogen-3	Location 7J Strontium-90	Location 7J Cesium-137	Location 11D Hydrogen-3
January 22, 1993	1.60×10^4	1.8	< 1	3962
April 1, 1993	1.14×10^4	1.4	< 1	2099
August 9, 1993	< 100	2.9	< 1	6408
December 14, 1993	2.18×10^5	1.4	1.4	184

The source of the radionuclides at Location 7J appears to be leachate from the 319 Area Landfill. Interim actions are being planned to collect and divert or treat the leachate. The hydrogen-3 at Location 11D is probably also from the leachate and the decrease in the concentration during the last quarter is due to the completion of the clay cap on the Landfill.

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 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 4.7 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, 1.7 pCi/L and 11.0 pCi/L, respectively, of 26 off-site surface water samples collected in 1993 were similar to the levels found in previous years. The hydrogen-3 concentration in these surface water samples averaged 87 pCi/L.

The radioactivity levels in samples of Illinois River water, shown in Table 4.8, were similar to those found previously at these same locations. No radioactivity originating at ANL 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

TABLE 4.7

Radionuclides in Des Plaines River Water, 1993

Activity	Location*	No. of Samples	Concentrations in pCi/L Avg.	Min.	Max.	Dose (mrem) Avg.	Min.	Max.
Alpha (Nonvolatile)	A	12	1.5 ± 2.1	0.7	4.2	-	-	-
	B	24	1.1 ± 0.9	0.4	2.1	-	-	-
Beta (Nonvolatile)	A	12	13 ± 11	8	23	-	-	-
	B	24	12 ± 8	7	19	-	-	-
Hydrogen-3	A	12	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
	B	24	< 100	< 100	< 100	< 0.0046	< 0.0046	< 0.0046
Strontium-90	A	12	0.29 ± 0.28	< 0.25	0.51	0.028	< 0.024	0.048
	B	24	0.30 ± 0.20	< 0.25	0.59	0.028	< 0.024	0.056
Uranium-234	A	12	0.589 ± 0.245	0.324	0.745	0.112	0.062	0.142
	B	24	0.526 ± 0.332	0.232	0.891	0.100	0.044	0.169
Uranium-238	A	12	0.515 ± 0.265	0.300	0.770	0.086	0.050	0.129
	B	24	0.454 ± 0.332	0.199	0.816	0.076	0.033	0.137
Neptunium-237	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0028	< 0.0028	< 0.0028
	B	12	< 0.0010	< 0.0010	0.0014	< 0.0028	< 0.0028	0.0040
Plutonium-238	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-239	A	12	< 0.0010	< 0.0010	0.0034	< 0.0031	< 0.0031	0.0106
	B	12	< 0.0010	< 0.0010	0.0051	< 0.0031	< 0.0031	0.0160
Americium-241	A	12	0.0011 ± 0.0068	< 0.0010	0.0109	0.0035	< 0.0033	0.0358
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0033	< 0.0033	< 0.0033
Curium-242 and/or Californium-252	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0007	< 0.0007	< 0.0007
Curium-244 and/or Californium-249	A	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034
	B	12	< 0.0010	< 0.0010	< 0.0010	< 0.0034	< 0.0034	< 0.0034

* Location A, near Willow Springs, is upstream and location B, near Lemont, is downstream from the mouth of Sawmill Creek. See Figure 1.2

TABLE 4.8

Radionuclides in Illinois River Water, 1993
Concentrations in pCi/L

Date Collected	Location	Alpha*	Beta*	Hydrogen-3	Uranium-234	Uranium-238	Plutonium-239
May 21	McKinley Woods Park, IL	1.5 ± 0.6	15.4 ± 0.4	< 100	0.47 ± 0.12	0.48 ± 0.11	< 0.001
May 21	Dresden Lock & Dam, IL	2.0 ± 0.5	8.2 ± 0.3	412 ± 50	0.58 ± 0.12	0.64 ± 0.12	< 0.001
May 21	Morris, IL	1.3 ± 0.5	9.1 ± 0.3	381 ± 49	0.58 ± 0.11	0.50 ± 0.10	-
May 21	Starved Rock State Park, IL	1.1 ± 0.5	7.5 ± 0.3	275 ± 48	0.81 ± 0.13	0.52 ± 0.10	-
May 21	Starved Rock State Park, IL	1.0 ± 0.5	7.8 ± 0.3	254 ± 47	0.70 ± 0.12	0.60 ± 0.11	-
November 3	McKinley Woods Park, IL	1.3 ± 0.4	14.3 ± 0.4	< 100	0.36 ± 0.08	0.25 ± 0.07	< 0.001
November 3	Morris, IL	1.7 ± 0.3	8.1 ± 0.3	148 ± 47	0.59 ± 0.07	0.48 ± 0.06	-
November 3	Morris, IL	1.8 ± 0.5	11.5 ± 0.4	< 100	0.81 ± 0.11	0.68 ± 0.10	-
November 3	Starved Rock State Park, IL	0.9 ± 0.2	7.5 ± 0.3	< 100	0.64 ± 0.10	0.39 ± 0.08	-
November 9	Dresden Lock & Dam, IL	1.5 ± 0.3	6.4 ± 0.3	< 100	0.64 ± 0.07	0.50 ± 0.06	< 0.001

*Nonvolatile activity.

in determining if the radioactivity of soil near ANL is normal. For this purpose, site-selection criteria and sample collection and sample preparation techniques recommended by the American Society for Testing and Materials (ASTM) were used.[10] Sites were selected in several directions and at various distances from ANL. 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.

As part of the quality assurance program, replicate samples are taken from ten percent 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, i.e., soil, grass, or bottom sediment.

Each soil sample consisted of ten cores, totaling 864 cm^2 (134 in^2) in area by 5 cm (2 in) deep. Through 1976, samples had been collected down to 30 cm (12 in) to measure total deposition. The results of five years of sample collection at this depth has established the total deposition in the ANL 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 m^2 (10 ft^2) 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) weight.

The results for the gamma-ray emitting nuclides in soil are presented in Table 4.9. 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

TABLE 4.9

Gamma-Ray Emitting Radionuclides in Soil, 1993
(Concentrations in pCi/g)

Date Collected	Location	Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232
	<u>Perimeter*</u>					
May 12	10P	10.37 ± 0.54	0.62 ± 0.04	0.48 ± 0.05	0.66 ± 0.04	0.49 ± 0.08
May 12	14E	20.75 ± 0.74	0.78 ± 0.04	1.09 ± 0.07	1.32 ± 0.05	0.96 ± 0.10
May 12	14N	17.42 ± 0.62	0.19 ± 0.03	0.91 ± 0.05	1.13 ± 0.04	1.00 ± 0.09
May 12	4EF	18.95 ± 0.69	0.82 ± 0.04	1.17 ± 0.06	1.06 ± 0.04	0.80 ± 0.09
May 12	4EF	22.82 ± 0.79	0.15 ± 0.03	1.17 ± 0.06	1.25 ± 0.04	0.96 ± 0.10
June 1	7EF	24.53 ± 0.79	0.54 ± 0.04	1.35 ± 0.06	1.19 ± 0.04	0.87 ± 0.09
October 25	13N	20.94 ± 0.72	1.19 ± 0.04	1.15 ± 0.06	1.20 ± 0.04	0.90 ± 0.09
October 25	13N	20.18 ± 0.71	0.98 ± 0.04	1.14 ± 0.06	1.18 ± 0.04	1.00 ± 0.09
October 26	13D	19.55 ± 0.70	1.19 ± 0.04	0.98 ± 0.06	1.20 ± 0.04	0.99 ± 0.10
October 26	7M	22.34 ± 0.64	0.49 ± 0.03	1.02 ± 0.06	1.17 ± 0.04	0.85 ± 0.08
October 26	8G	19.75 ± 0.61	0.25 ± 0.02	1.20 ± 0.06	1.28 ± 0.04	0.93 ± 0.08
October 27	15H	18.05 ± 0.61	0.23 ± 0.03	1.14 ± 0.06	1.41 ± 0.05	1.02 ± 0.09
	Average	19.64 ± 7.81	0.62 ± 0.83	1.07 ± 0.48	1.17 ± 0.41	0.90 ± 0.32
	<u>Off-site*</u>					
May 14	Orland Park, IL	24.10 ± 0.77	0.56 ± 0.03	2.06 ± 0.08	1.35 ± 0.05	1.03 ± 0.10
May 14	Palos Hills, IL	22.37 ± 0.71	0.26 ± 0.03	1.34 ± 0.06	1.18 ± 0.04	0.97 ± 0.09
May 21	Dresden Lock & Dam, IL	19.58 ± 0.71	0.48 ± 0.03	1.26 ± 0.06	1.13 ± 0.04	0.83 ± 0.09
May 21	McKinley Woods Park, IL	22.23 ± 0.71	0.14 ± 0.03	1.19 ± 0.07	1.35 ± 0.05	0.98 ± 0.10
May 21	Morris, IL	14.90 ± 0.62	0.23 ± 0.03	0.85 ± 0.06	1.15 ± 0.05	0.81 ± 0.10
May 21	McKinley Woods Park, IL	22.55 ± 0.64	0.11 ± 0.02	1.23 ± 0.06	1.30 ± 0.05	0.91 ± 0.08
May 21	Palos Hills, IL	21.15 ± 0.62	0.16 ± 0.03	1.90 ± 0.07	1.44 ± 0.04	1.00 ± 0.09
November 2	Pioneer Park, Naperville, IL	17.43 ± 0.66	0.67 ± 0.03	1.11 ± 0.06	2.10 ± 0.05	1.64 ± 0.11
November 2	Pioneer Park, Naperville, IL	16.31 ± 0.56	0.48 ± 0.03	1.40 ± 0.06	2.34 ± 0.05	1.75 ± 0.10
November 3	Channahon, IL	17.42 ± 0.66	0.20 ± 0.02	1.38 ± 0.07	1.44 ± 0.05	1.08 ± 0.10
November 3	Starved Rock State Park, IL	15.68 ± 0.67	0.55 ± 0.03	1.01 ± 0.06	0.85 ± 0.04	0.74 ± 0.09
November 3	Starved Rock State Park, IL	13.62 ± 0.59	0.41 ± 0.03	0.95 ± 0.06	0.71 ± 0.04	0.61 ± 0.08
November 10	Lemont, IL	19.31 ± 0.60	0.64 ± 0.03	1.33 ± 0.06	1.37 ± 0.04	0.94 ± 0.09
November 15	Romeoville, IL	15.74 ± 0.63	0.19 ± 0.02	1.26 ± 0.06	1.31 ± 0.05	1.02 ± 0.09
	Average	18.74 ± 7.19	0.36 ± 0.43	1.30 ± 0.72	1.36 ± 0.91	1.02 ± 0.68

* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

nuclear tests over a period of many years. The elevated thorium concentration are probably due to materials that has washed down from the Kerr-McGee facility in West Chicago which in the past processed rare earths. The annual average concentrations for the perimeter and off-site samples were similar. The plutonium and americium concentrations are given in Table 4.10. 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 from the decay of the previously deposited plutonium-241. The americium-241/plutonium-239 ratio is consistent with the current estimated value for this ratio of 0.42 in fallout derived material.[11]

The radionuclide concentrations measured in grass are listed in Table 4.11. 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 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.

Results of analyses of bottom sediment samples for gamma-ray emitters and transuranics are given in Table 4.12. 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 29, 1993, from the Sawmill Creek bed, above, at the outfall, and at several locations below the point at which ANL discharges its treated waste water (location 7M in Figure 1.1). The results, as listed in Table 4.12, 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 wastewater. The changes in concentrations of these nuclides with time and location indicate the dynamic nature of the sediment material in this area.

TABLE 4.10

Transuranics in Soil, 1993

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*								
May 12	14E	< 0.1	< 0.001	17.3 ± 3.4	0.548 ± 0.107	-	6.0 ± 1.3	0.191 ± 0.042	0.348
May 12	14N	< 0.1	< 0.001	6.0 ± 1.3	0.126 ± 0.028	-	1.8 ± 0.5	0.038 ± 0.010	0.304
May 12	4EF	0.8 ± 0.5	0.029 ± 0.018	20.9 ± 2.8	0.714 ± 0.096	0.040	8.8 ± 1.0	0.299 ± 0.034	0.419
May 12	4EF	0.2 ± 0.2	0.006 ± 0.008	3.7 ± 1.0	0.114 ± 0.032	0.048	1.6 ± 0.5	0.051 ± 0.015	0.447
June 1	7EF	< 0.1	< 0.001	13.9 ± 2.1	0.474 ± 0.073	-	4.6 ± 0.8	0.156 ± 0.028	0.328
October 25	13N	0.8 ± 0.5	0.033 ± 0.023	27.5 ± 2.7	1.145 ± 0.113	0.029	10.7 ± 1.2	0.444 ± 0.050	0.388
October 25	13N	1.2 ± 0.6	0.050 ± 0.025	27.6 ± 2.7	1.120 ± 0.112	0.044	5.9 ± 1.6	0.238 ± 0.065	0.213
October 26	13D	1.0 ± 0.5	0.036 ± 0.017	29.7 ± 2.6	1.058 ± 0.093	0.034	8.5 ± 1.4	0.304 ± 0.050	0.287
October 26	7M	0.6 ± 0.6	0.023 ± 0.024	12.6 ± 2.2	0.507 ± 0.090	0.046	4.8 ± 1.1	0.192 ± 0.043	0.379
October 26	8G	0.2 ± 0.4	0.009 ± 0.020	7.1 ± 1.4	0.341 ± 0.067	0.026	3.3 ± 0.9	0.158 ± 0.045	0.462
October 27	15H	0.4 ± 0.4	0.016 ± 0.019	6.5 ± 1.2	0.280 ± 0.051	0.059	2.1 ± 0.7	0.093 ± 0.031	0.331
	Average	0.4 ± 0.4	0.016 ± 0.014	15.7 ± 6.4	0.584 ± 0.255	0.038	5.3 ± 2.0	0.197 ± 0.081	0.355
	Off-site								
May 14	Orland Park, IL	< 0.1	< 0.001	14.1 ± 2.5	0.506 ± 0.091	-	3.8 ± 0.8	0.138 ± 0.029	0.272
May 14	Palos Hills, IL	< 0.1	< 0.001	7.0 ± 1.4	0.245 ± 0.050	-	2.3 ± 0.7	0.082 ± 0.024	0.333
May 21	Dresden Lock & Dam, IL	< 0.1	< 0.001	8.4 ± 1.4	0.235 ± 0.038	-	2.6 ± 0.5	0.072 ± 0.014	0.307
May 21	McKinley Woods Park, IL	0.2 ± 0.2	0.009 ± 0.009	3.3 ± 0.8	0.117 ± 0.029	0.075	1.3 ± 0.4	0.048 ± 0.016	0.406
May 21	Morris, IL	0.3 ± 0.3	0.008 ± 0.008	6.5 ± 1.4	0.169 ± 0.036	0.045	2.3 ± 0.6	0.060 ± 0.015	0.355
May 21	McKinley Woods Park, IL	< 0.1	< 0.001	17.0 ± 2.3	0.639 ± 0.085	-	1.7 ± 0.6	0.064 ± 0.023	0.100
May 21	Palos Hills, IL	0.3 ± 0.7	0.012 ± 0.026	3.7 ± 1.5	0.133 ± 0.053	0.087	1.9 ± 0.4	0.068 ± 0.016	0.507
November 2	Pioneer Park, Naperville, IL	< 0.1	< 0.001	17.4 ± 3.0	0.633 ± 0.110	-	5.8 ± 1.4	0.210 ± 0.049	0.332
November 2	Pioneer Park, Naperville, IL	0.4 ± 0.4	0.012 ± 0.014	10.7 ± 1.9	0.358 ± 0.064	0.033	7.5 ± 1.3	0.251 ± 0.043	0.701
November 3	Channahon, IL	0.1 ± 0.3	0.003 ± 0.008	6.9 ± 1.5	0.178 ± 0.039	0.016	1.8 ± 0.7	0.045 ± 0.019	0.256
November 3	Starved Rock State Park, IL	0.2 ± 0.4	0.013 ± 0.019	12.9 ± 2.6	0.680 ± 0.137	0.019	5.0 ± 1.4	0.265 ± 0.072	0.390
November 3	Starved Rock State Park, IL	0.6 ± 0.5	0.036 ± 0.027	12.0 ± 2.1	0.710 ± 0.124	0.051	3.8 ± 1.0	0.222 ± 0.058	0.314
November 10	Lemont, IL	0.7 ± 0.6	0.032 ± 0.025	16.1 ± 2.5	0.699 ± 0.108	0.046	6.3 ± 1.3	0.276 ± 0.055	0.394
November 15	Romeoville, IL	< 0.1	< 0.001	5.4 ± 1.6	0.288 ± 0.085	-	1.7 ± 0.7	0.088 ± 0.037	0.306
	Average	0.1 ± 0.3	0.002 ± 0.012	10.1 ± 2.8	0.399 ± 0.135	0.042	3.4 ± 1.2	0.135 ± 0.052	0.355

* The perimeter locations are given in terms of grid coordinates in Figure 1.1

TABLE 4.11

Radionuclides in Grass, 1993

Date Collected	Location	Potassium-40 (pCi/g)	Cesium-137 (fCi/g)	Plutonium-239 (fCi/g)	Deposited Plutonium-239 (pCi/m2)
	Perimeter*				
May 12	10P	28.89 ± 0.71	< 10	0.1 ± 0.1	0.01 ± 0.01
May 12	14E	24.03 ± 0.59	13 ± 14	0.2 ± 0.1	0.02 ± 0.01
May 12	14N	36.32 ± 0.72	< 10	< 0.1	< 0.01
May 12	4EF	40.06 ± 0.75	< 10	0.3 ± 0.1	0.02 ± 0.01
May 12	4EF	38.30 ± 0.71	13 ± 14	0.4 ± 0.1	0.05 ± 0.01
June 1	7EF	23.63 ± 0.53	< 10	0.1 ± 0.1	0.02 ± 0.01
October 25	13N	8.80 ± 0.35	< 10	< 0.1	0.01 ± 0.01
October 25	13N	8.24 ± 0.35	< 10	0.2 ± 0.1	0.02 ± 0.01
October 26	13D	14.73 ± 0.52	13 ± 15	0.1 ± 0.1	< 0.01
October 26	7M	12.66 ± 0.46	< 10	< 0.1	< 0.01
October 26	8G	7.18 ± 0.33	< 10	< 0.1	< 0.01
October 27	15H	32.64 ± 0.61	12 ± 17	0.1 ± 0.1	0.01 ± 0.01
	Average	22.96 ± 2.37	< 10	0.1 ± 0.1	0.02 ± 0.01
	Off-site				
May 14	Orland Park, IL	32.58 ± 0.71	< 10	< 0.1	< 0.01
May 14	Palos Hills, IL	32.67 ± 0.70	24 ± 15	0.2 ± 0.1	0.02 ± 0.01
May 21	Dresden Lock & Dam, IL	39.47 ± 0.71	23 ± 18	0.3 ± 0.1	0.03 ± 0.01
May 21	McKinley Woods Park, IL	25.38 ± 0.69	< 10	< 0.1	< 0.01
May 21	Morris, IL	22.82 ± 0.70	< 10	0.4 ± 0.1	0.02 ± 0.01
May 21	McKinley Woods Park, IL	34.02 ± 0.79	18 ± 18	0.4 ± 0.1	0.03 ± 0.01
May 21	Palos Hills, IL	24.42 ± 0.55	< 10	< 0.1	< 0.01
November 2	Pioneer Park, Naperville, IL	10.69 ± 0.32	< 10	< 0.1	< 0.01
November 2	Pioneer Park, Naperville, IL	17.47 ± 0.45	17 ± 15	0.1 ± 0.1	0.01 ± 0.01
November 3	Channahon, IL	13.90 ± 0.45	< 10	0.2 ± 0.1	0.02 ± 0.01
November 3	Starved Rock State Park, IL	18.71 ± 0.54	< 10	< 0.1	< 0.01
November 3	Starved Rock State Park, IL	15.09 ± 0.46	< 10	< 0.1	< 0.01
November 10	Lemont, IL	5.51 ± 0.31	< 10	< 0.1	< 0.01
November 15	Romeoville, IL	24.36 ± 0.64	< 10	0.1 ± 0.1	< 0.01
	Average	22.65 ± 1.56	< 10	0.1 ± 0.1	0.01 ± 0.01

* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

TABLE 4.12

Radionuclides in Bottom Sediment, 1993

Date Collected	Location	Concentrations in pCi/g Potassium-40	Cesium-137	Radium-226	Thorium-228	Thorium-232	Concentrations in fCi/g Plutonium-238	Plutonium-239	Americium-241
	<u>Perimeter</u>								
July 29	Sawmill Creek 25 m Above Outfall	8.68 ± 0.48	0.01 ± 0.02	0.44 ± 0.05	0.31 ± 0.04	0.31 ± 0.07	0.2 ± 0.2	1.7 ± 0.6	0.3 ± 0.2
July 29	Sawmill Creek At Outfall	10.61 ± 0.58	1.34 ± 0.05	0.58 ± 0.06	0.41 ± 0.04	0.33 ± 0.08	1.8 ± 0.7	26.3 ± 2.8	11.4 ± 1.2
July 29	Sawmill Creek 50 m Below Outfall	7.39 ± 0.46	0.60 ± 0.04	0.43 ± 0.05	0.34 ± 0.04	0.18 ± 0.07	0.2 ± 0.3	2.6 ± 0.8	1.6 ± 0.5
July 29	Sawmill Creek 100 m Below Outfall	16.62 ± 0.65	0.94 ± 0.04	0.78 ± 0.06	0.69 ± 0.04	0.53 ± 0.09	1.6 ± 0.6	7.1 ± 1.3	2.0 ± 0.5
July 29	Sawmill Creek At Des Plaines River	18.46 ± 0.71	0.31 ± 0.04	1.16 ± 0.07	1.07 ± 0.05	0.83 ± 0.10	0.5 ± 0.4	10.7 ± 1.7	7.1 ± 1.0
	<u>Off-Site</u>								
May 14	McGinnis Slough Orland Park , IL	24.98 ± 0.80	0.03 ± 0.02	1.62 ± 0.09	1.11 ± 0.05	0.77 ± 0.09	0.2 ± 0.4	1.3 ± 0.5	1.1 ± 0.5
May 14	Saganashkee Slough Palos Hills, IL	7.43 ± 0.62	0.24 ± 0.03	1.34 ± 0.07	1.15 ± 0.05	0.79 ± 0.08	< 0.1	6.7 ± 1.3	2.6 ± 0.8
May 14	Saganashkee Slough Palos Hills, IL	7.61 ± 0.36	0.01 ± 0.01	0.28 ± 0.03	0.30 ± 0.02	0.27 ± 0.05	< 0.1	0.3 ± 0.4	0.5 ± 0.3
May 21	Illinois River Dresden Lock & Dam, IL	21.84 ± 0.71	0.37 ± 0.03	0.94 ± 0.06	1.14 ± 0.05	0.80 ± 0.10	0.2 ± 0.2	5.3 ± 1.0	1.5 ± 0.5
May 21	Illinois River McKinley Woods Park, IL	11.58 ± 0.53	0.03 ± 0.02	0.52 ± 0.05	0.52 ± 0.04	0.46 ± 0.08	0.1 ± 0.3	0.5 ± 0.5	0.5 ± 0.6
May 21	Illinois River Morris, IL	7.97 ± 0.45	0.02 ± 0.02	0.39 ± 0.05	0.35 ± 0.03	0.30 ± 0.07	0.3 ± 0.3	0.6 ± 0.4	0.7 ± 0.4
May 21	Illinois River McKinley Woods Park, IL	6.93 ± 0.45	0.01 ± 0.02	0.36 ± 0.05	0.27 ± 0.03	0.25 ± 0.07	0.1 ± 0.3	0.3 ± 0.4	< 0.1
November 2	DuPage River Pioneer Park, Naperville, IL	9.00 ± 0.50	0.01 ± 0.02	0.77 ± 0.06	0.59 ± 0.04	0.54 ± 0.08	< 0.1	0.7 ± 0.8	0.5 ± 0.4
November 2	Long Run Creek Lemont, IL	16.54 ± 0.57	0.10 ± 0.03	1.27 ± 0.06	1.09 ± 0.05	0.93 ± 0.09	0.1 ± 0.2	2.5 ± 0.9	1.2 ± 0.6
November 3	DuPage River Channahon, IL	7.29 ± 0.45	0.06 ± 0.02	0.61 ± 0.05	0.54 ± 0.04	0.51 ± 0.08	0.1 ± 0.2	1.9 ± 0.7	1.1 ± 0.6
November 3	Illinois River Starved Rock State Park, IL	12.21 ± 0.51	0.11 ± 0.03	1.01 ± 0.06	0.78 ± 0.04	0.60 ± 0.08	< 0.1	2.0 ± 0.7	1.0 ± 0.7
November 3	DuPage River Channahon, IL	15.67 ± 0.56	0.39 ± 0.02	0.93 ± 0.06	1.28 ± 0.05	0.96 ± 0.09	< 0.1	1.6 ± 0.6	0.8 ± 0.5
November 15	DesPlaines River Romeoville, IL	17.45 ± 0.67	0.34 ± 0.03	1.81 ± 0.08	1.35 ± 0.05	1.14 ± 0.10	0.9 ± 0.6	16.6 ± 2.5	5.1 ± 1.2
	Average	13.58 ± 12.88	0.13 ± 0.33	0.91 ± 1.07	0.80 ± 0.87	0.64 ± 0.63	0.1 ± 0.6	3.5 ± 10.7	1.4 ± 3.2

* The perimeter locations are given in terms of the grid coordinates in Figure 1.1

4.5. External Penetrating Radiation

Levels of external penetrating radiation at and in the vicinity of the ANL site were measured with calcium fluoride thermoluminescent dosimeter (TLD) chips. Each measurement reported represents the average of four chips exposed in the same packet. All calcium fluoride packets were shielded with 1.6 mm (1/16 in) copper foil to reduce or eliminate the beta and low-energy X-ray components. The response of the chips was determined with a U. S. National Institute of Standards and Technology (NIST) standard radium-226 source, and the results were calculated in terms of the air dose. Dosimeters were exposed at several locations at the site boundary and on the site. Readings were also taken at five off-site locations for comparison purposes. These locations are shown in Figure 1.2.

The results are summarized in Tables 4.13 and 4.14, and the site boundary and on-site readings are also shown in Figure 4.4. Measurements were made for the four successive exposure periods shown in the tables, and the results were calculated in terms of annual dose for ease in comparing measurements made for different elapsed times. The uncertainty given in the tables for an average is the 95% confidence limit calculated from the standard deviation of the average.

The off-site results averaged 76 ± 6 mrem/y and were similar to last year's off-site average of 75 ± 5 mrem/y.[12] If the off-site locations provided an accurate sample of the radiation background in the area, then annual averages at the site in the range of 76 ± 9 mrem/y may be considered normal with a 95% probability. To compare boundary results for individual sampling periods, the standard deviation of the 19 individual off-site results is useful. This value is 9 mrem/y, so individual results in the range of 76 ± 19 mrem/y may be considered to be the average natural background with a 95% probability.

TABLE 4.13

Environmental Penetrating Radiation at Off-Site Locations, 1993

	Dose Rate (mrem/year)				
	Period of Measurement				
Location	2/2-4/22	4/22-7/13	7/13-10/11	10/11-1/7	Average
Lemont	78	79	71	86	79 ± 6
Oak Brook	84	99	74	106	91 ± 14
Orland Park	65	79	64	-	69 ± 9
Woodridge	62	80	67	84	73 ± 10
Willow Springs	60	65	69	67	65 ± 4
Average	70 ± 9	80 ± 11	69 ± 3	86 ± 16	76 ± 6

In the past, two site boundary locations, 7I (south) and 14I (north), the dose rates were consistently above the average background. At 7I this was due to radiation from ANL's Radioactive Waste Storage Facility (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 103 ± 15 mrem/y, one of the lowest values since these measurements were conducted. In previous years, this value has ranged up to 941 mrem/y which was in 1985. About 300 m (0.2 mi) south of the fence in grid 6I, the measured dose dropped to 75 ± 9 mrem/y, within the normal background range. The recent decrease in dose in the 317 Area has been due to a concerted effort to transport radioactive historic waste off the site.

In the past, an elevated perimeter area was 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 not used at all since then. The perimeter dose at Location 14I, 81 ± 12 mrem/y, was within the normal background range.

TABLE 4.14

Environmental Penetrating Radiation at ANL, 1993

Location*	Dose Rate (mrem/year)				
	Period of Measurement				
	2/2-4/22	4/22-7/13	7/13-10/11	10/11-1/7	Average
14G - Boundary	77	77	98	-	84 ± 4
14I - Boundary	72	96	71	85	81 ± 12
14L - Boundary	66	84	58	77	71 ± 11
6I - 200 m N of Quarry Road	71	68	71	88	75 ± 9
7I - Center, Waste Storage Area Facility 317	1875	1095	803	1008	1195 ± 460
7I - Boundary	124	100	88	101	103 ± 15
8H - Boundary	88	73	70	86	79 ± 9
8H - 65 m S of Building 316	74	68	61	77	70 ± 7
8H - 200 m NW of Waste Storage Area (Heliport)	85	80	67	81	78 ± 8
8H - Boundary, Center, St. Patrick Cemetery	74	74	63	83	74 ± 8
9H - 50 m SE of CP-5	181	175	148	123	157 ± 26
9I - 65 m NE of Building 350, 230 m NE of Building 316	73	61	72	68	69 ± 5
9/10EF - Boundary	72	77	66	82	74 ± 7
10/11K - Lodging Facilities	70	64	78	72	71 ± 6

*See Figure 1.1

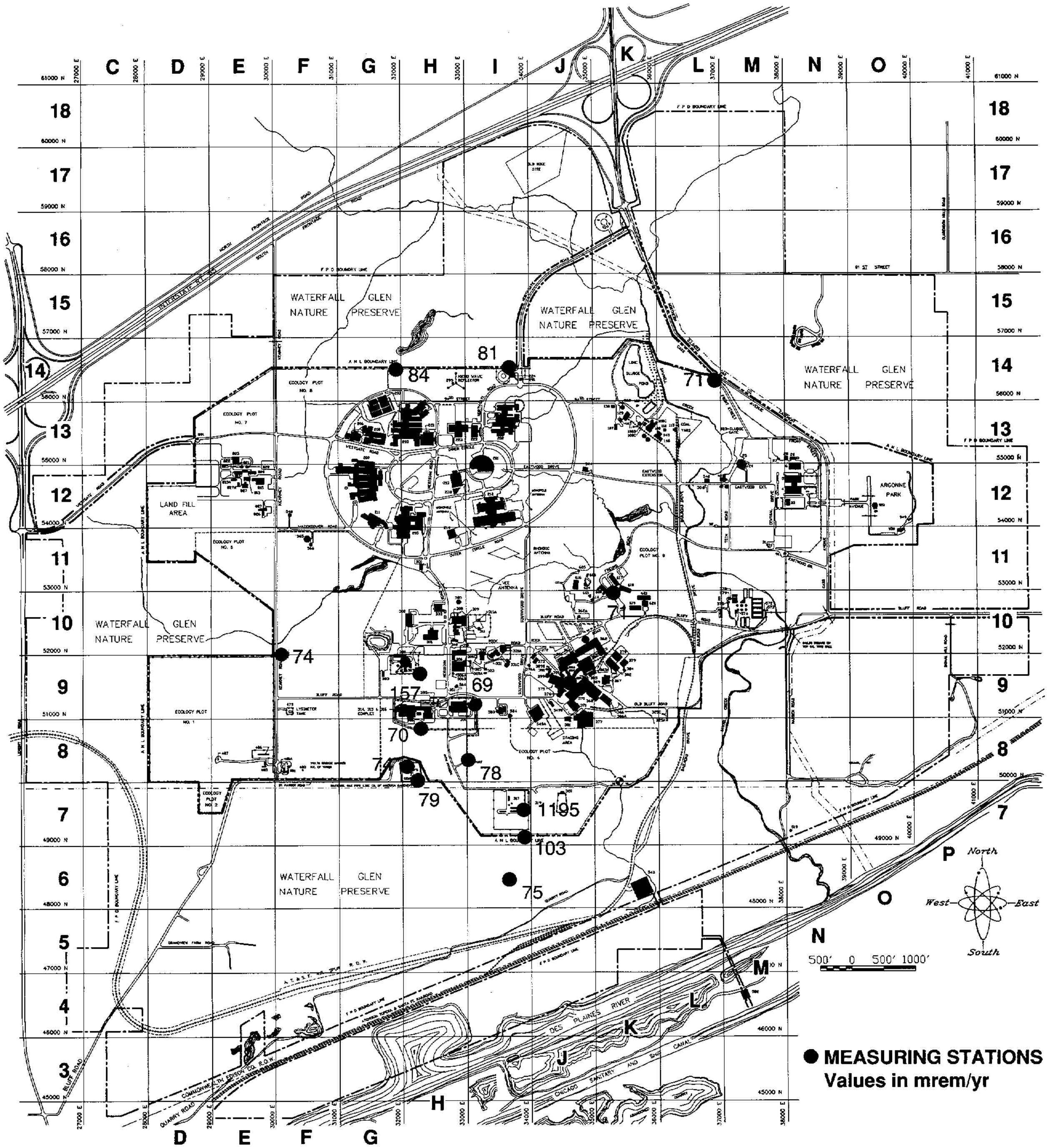


Figure 4.4 Penetrating Radiation Measurements at the ANL Site, 1993

An elevated on-site dose was measured in the past at Location 9H, next to the CP-5 facility, where irradiated hardware from CP-5 was stored. During the past few years, considerable cleanup of the CP-5 yard occurred as part of the CP-5 D&D project. The dose at Location 9H decreased from about 1200 mrem/y in 1989 to about 153 mrem/y in mid-1993. The results are displayed in Figure 4.5. By the end of CY 1993, the year clean-up was completed and the residual dose was from sources in the building.

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. These calculations were made for three exposure pathways, airborne, water, and direct radiation from external sources.

4.6.1. Airborne Pathway

Guidance issued by the DOE[6] stipulates that DOE facilities with airborne releases of radioactive materials are subject to 40 CFR Part 61, Subpart H,[13] which requires the use of the CAP-88 version 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 CY 1993 for the air pathway is 10 mrem/y effective dose equivalent. The EPA-AIRDOSE/RADRISK 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 1993, 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, and 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. Doses were calculated for an area extending out to 80 km (50 mi) from ANL. The upgraded population distribution of the 16 compass segments and ten distance increments given in Table 1.1 was used.

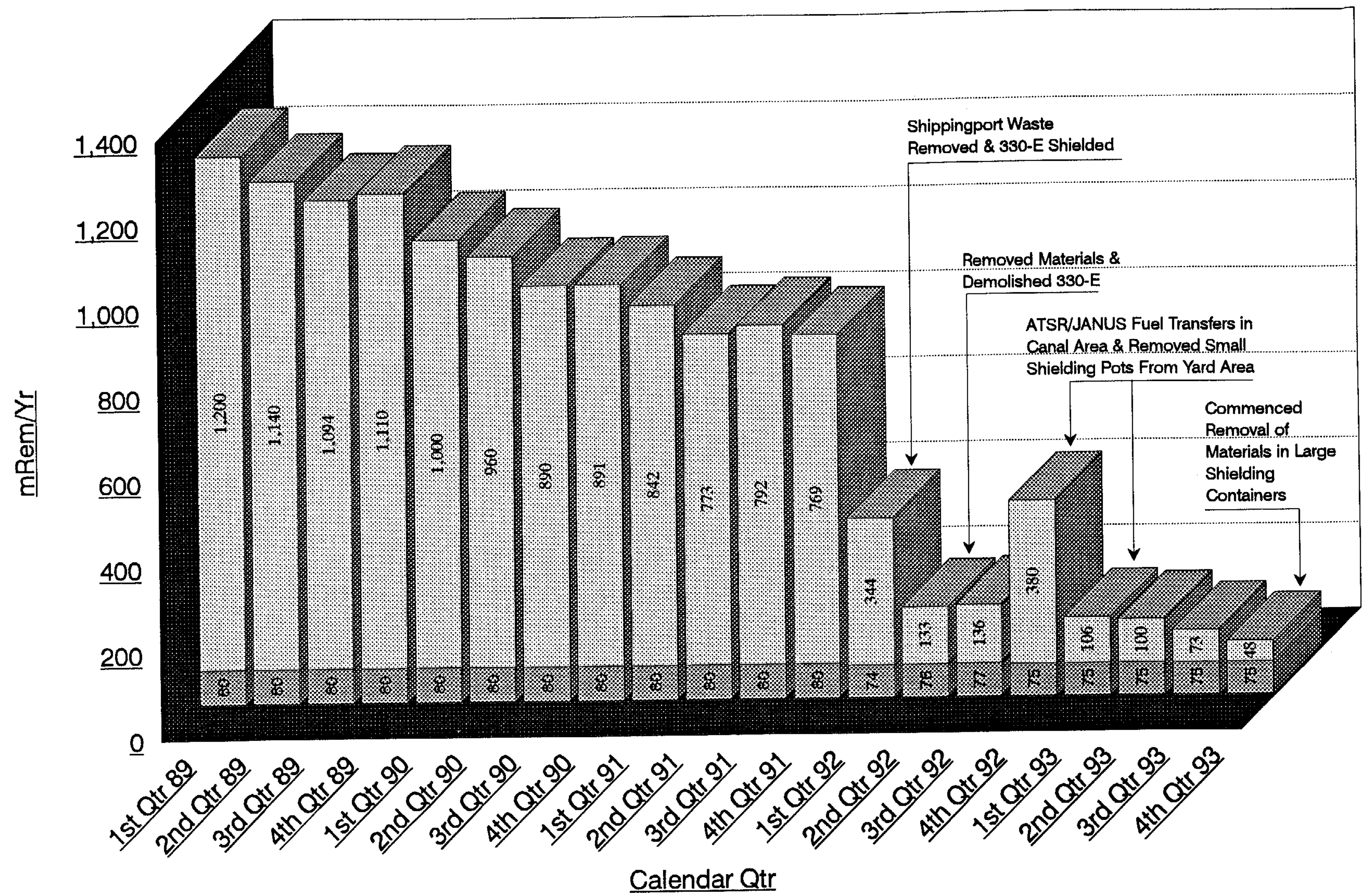


Figure 4.5 CP-5 Yard Area Dose Rate

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 fenceline (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 4.15 and 4.16), Building 205 (Tables 4.17 and 4.18), Building 212 (Tables 4.19 and 4.20), Building 330 (Tables 4.21 and 4.22), Building 350 (Tables 4.23 and 4.24), Building 375 (Tables 4.25 and 4.26) and Building 411 (Tables 4.27 and 4.28). The doses given in these tables are the committed whole body effective dose equivalents.

The dominant contributor to the calculated doses was the radon-220 and daughters released from Building 200. This accounted for 96% of the off-site dose in 1993. The highest perimeter dose rates were in the north sector with a maximum dose of 0.78 mrem/y at a fenceline location north of Building 203 (location 14H in Figure 1.1). The major contributor to this dose was inhalation of lead-212 (0.44 mrem/y) and the organs receiving the greatest dose were the lung and the bone. The releases from the other facilities are very minor contributors to the total dose.

During 1993, a significant program progressed to D&D the M-wing hot cells in Building 200, the source of the radon-220 emissions. Much of the year was spent in planning and preparation activities, although by the end of 1993, a considerable amount of waste was packaged and/or removed from the hot cells. This has resulted in a significant decrease of radon-220 emissions, 3000 Ci in 1992 to 2023 Ci in 1993.

In August of 1992, the JANUS reactor (Building 202) terminated operation 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

TABLE 4.15

Radiological Airborne Releases from Building 200, 1993

Source Term: Radon-220 = 2023.5 Ci (plus daughters)
Radon-222 = 0.1 Ci (plus daughters)

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	500	0.750	1000	0.210
NNE	600	0.560	1100	0.180
NE	750	0.360	2600	0.042
ENE	1700	0.081	3100	0.030
E	2400	0.046	3500	0.026
ESE	2200	0.047	3600	0.022
SE	2100	0.049	4000	0.018
SSE	2000	0.050	4000	0.017
S	1500	0.034	4000	0.007
SSW	1000	0.170	2500	0.037
SW	800	0.520	2200	0.100
WSW	1100	0.140	1500	0.080
W	750	0.280	1500	0.082
WNW	800	0.190	1300	0.085
NW	600	0.390	1100	0.130
NNW	600	0.390	800	0.230

TABLE 4.16

Maximum Perimeter and Individual Doses from
Building 200 Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (500 m N)	Individual (800 m NNW)
Ingestion	< 0.0001	< 0.0001
Inhalation	0.740	0.230
Air Immersion	0.0051	0.0014
Ground Surface	0.0003	0.0001
Total	0.746	0.232
Radionuclide		
Polonium-210	0.0004	0.0002
Bismuth-210	< 0.0001	< 0.0001
Lead-210	< 0.0001	< 0.0001
Thallium-208	0.0044	0.0012
Bismuth-212	0.088	0.032
Lead-212	0.441	0.164
Polonium-216	< 0.0001	< 0.0001
Radon-220	0.212	0.034
Radon-222	0.0002	< 0.0001
Total	0.746	0.232

TABLE 4.17

Radiological Airborne Releases from Building 205, 1993

Source Term: Hydrogen-3 = 0.57 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	850	< 0.0001	1300	< 0.0001
NNE	1000	< 0.0001	2100	< 0.0001
NE	1200	< 0.0001	2700	< 0.0001
ENE	2400	< 0.0001	3000	< 0.0001
E	2200	< 0.0001	2400	< 0.0001
ESE	2000	< 0.0001	3500	< 0.0001
SE	1800	< 0.0001	3900	< 0.0001
SSE	1500	< 0.0001	4000	< 0.0001
S	1300	< 0.0001	3900	< 0.0001
SSW	1100	< 0.0001	2400	< 0.0001
SW	900	< 0.0001	2100	< 0.0001
WSW	1100	< 0.0001	1800	< 0.0001
W	1300	< 0.0001	1800	< 0.0001
WNW	1100	< 0.0001	1700	< 0.0001
NW	1100	< 0.0001	1500	< 0.0001
NNW	900	< 0.0001	1500	< 0.0001

TABLE 4.18

Maximum Perimeter and Individual Doses from
Building 205 Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (900 m SW)	Individual (1300 m N)
Ingestion	< 0.0001	< 0.0001
Inhalation	< 0.0001	< 0.0001
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	< 0.0001	< 0.0001
Radionuclide		
Hydrogen-3	< 0.0001	< 0.0001

TABLE 4.19

Radiological Airborne Releases from Building 212, 1993

Source Term: Hydrogen-3 (HT) = 26.6 Ci
Hydrogen-3 (HTO) = 3.62 Ci
Krypton-85 = 4.64 Ci
Antimony-125 = 4.0×10^{-5} Ci
Radon-220 = 0.028 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	800	0.0022	2000	0.0005
NNE	1000	0.0016	2500	0.0004
NE	1300	0.0010	2000	0.0005
ENE	1500	0.0008	2500	0.0004
E	1600	0.0007	2800	0.0003
ESE	1200	0.0010	2500	0.0003
SE	1400	0.0008	3500	0.0002
SSE	1400	0.0008	4500	0.0001
S	1500	0.0003	5000	< 0.0001
SSW	1600	0.0006	5000	0.0001
SW	1400	0.0017	2400	0.0008
WSW	1300	0.0008	2300	0.0003
W	1700	0.0006	2200	0.0004
WNW	1500	0.0006	2000	0.0004
NW	1300	0.0008	2000	0.0004
NNW	1000	0.0012	2000	0.0004

TABLE 4.20

Maximum Perimeter and Individual Doses from
Building 212 Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (800 m N)	Individual (2400 m SW)
Ingestion	0.0005	0.0002
Inhalation	0.0017	0.0006
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0022	0.0008
<u>Radionuclide</u>		
Hydrogen-3	0.0022	0.0008
Krypton-85	< 0.0001	< 0.0001
Antimony-125	< 0.0001	< 0.0001
Radon-220	< 0.0001	< 0.0001
Total	0.0022	0.0008

TABLE 4.21

Radiological Airborne Releases from Building 330 (CP-5), 1993

Source Term: Hydrogen-3 (HTO) = 4.57 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1500	0.0001	2000	< 0.0001
NNE	1800	< 0.0001	3300	< 0.0001
NE	2100	< 0.0001	2800	< 0.0001
ENE	2200	< 0.0001	3300	< 0.0001
E	1500	0.0001	3100	< 0.0001
ESE	1300	0.0001	3500	< 0.0001
SE	1200	0.0002	3500	< 0.0001
SSE	1000	0.0002	3500	< 0.0001
S	500	0.0002	3000	< 0.0001
SSW	700	0.0004	3500	< 0.0001
SW	900	0.0005	2400	0.0001
WSW	1400	0.0001	2000	< 0.0001
W	700	0.0003	2000	< 0.0001
WNW	700	0.0003	1900	< 0.0001
NW	1500	0.0001	2000	< 0.0001
NNW	1600	< 0.0001	1900	< 0.0001

TABLE 4.22

Maximum Perimeter and Individual Doses from Building 330 (CP-5) Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (900 m SW)	Individual (2400 m SW)
Ingestion	0.0001	< 0.0001
Inhalation	0.0004	< 0.0001
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	0.0005	0.0001
Radionuclide		
Hydrogen-3	0.0005	0.0001

TABLE 4.23

Radiological Airborne Releases from Building 350, 1993

Source Term: Uranium-234 = 1.12×10^{-8} Ci
Uranium-238 = 1.12×10^{-8} Ci
Plutonium-238 = 4.03×10^{-8} Ci
Plutonium-239 = 1.10×10^{-7} Ci
Plutonium-240 = 6.82×10^{-8} Ci
Plutonium-241 = 2.59×10^{-5} Ci
Plutonium-242 = 2.72×10^{-9} Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1700	< 0.0001	2200	< 0.0001
NNE	1800	< 0.0001	3200	< 0.0001
NE	2200	< 0.0001	3100	< 0.0001
ENE	2000	< 0.0001	3100	< 0.0001
E	1700	< 0.0001	2500	< 0.0001
ESE	900	< 0.0001	3000	< 0.0001
SE	900	< 0.0001	3000	< 0.0001
SSE	700	< 0.0001	2700	< 0.0001
S	600	< 0.0001	2700	< 0.0001
SSW	400	< 0.0001	2500	< 0.0001
SW	600	< 0.0001	2700	< 0.0001
WSW	800	< 0.0001	2100	< 0.0001
W	900	< 0.0001	2200	< 0.0001
WNW	1000	< 0.0001	2100	< 0.0001
NW	1900	< 0.0001	2400	< 0.0001
NNW	1900	< 0.0001	2200	< 0.0001

TABLE 4.24

Maximum Perimeter and Individual Doses from
Building 350 Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (700 m SSE)	Individual (2700 m SW)
Ingestion	< 0.0001	< 0.0001
Inhalation	< 0.0001	< 0.0001
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	< 0.0001	< 0.0001
Radionuclide		
Uranium-234	< 0.0001	< 0.0001
Uranium-238	< 0.0001	< 0.0001
Plutonium-238	< 0.0001	< 0.0001
Plutonium-239	< 0.0001	< 0.0001
Plutonium-240	< 0.0001	< 0.0001
Plutonium-241	< 0.0001	< 0.0001
Plutonium-242	< 0.0001	< 0.0001
Total	< 0.0001	< 0.0001

TABLE 4.25

Radiological Airborne Releases from Building 375 (IPNS), 1993

Source Term: Carbon-11 = 316.85 Ci
Argon-41 = 9.40 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1600	0.0280	3200	0.0081
NNE	1700	0.0270	3100	0.0094
NE	1700	0.0260	2700	0.0120
ENE	1500	0.0300	2500	0.0130
E	600	0.1300	2500	0.0140
ESE	600	0.1200	2500	0.0110
SE	600	0.1200	2500	0.0100
SSE	600	0.1200	3000	0.0069
S	800	0.0300	3000	0.0029
SSW	800	0.0740	3500	0.0052
SW	800	0.1400	4000	0.0069
WSW	1500	0.0240	2700	0.0086
W	2200	0.0130	2700	0.0083
WNW	1500	0.0200	2600	0.0074
NW	2200	0.0120	2500	0.0091
NNW	1800	0.0170	2200	0.0120

TABLE 4.26

Maximum Perimeter and Individual Doses from
Building 375 (IPNS) Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (800 m SW)	Individual (2400 m E)
Ingestion	< 0.0001	< 0.0001
Inhalation	0.0059	0.0006
Air Immersion	0.1280	0.0125
Ground Surface	0.0047	0.0005
Total	0.1390	0.0136
Radionuclide		
Carbon-11	0.1330	0.0130
Argon-41	0.0057	0.0006
Total	0.1390	0.0136

TABLE 4.27

Radiological Airborne Releases from Building 411 (APS), 1993

Source Term: Carbon-11 = 0.001 Ci
Nitrogen-13 = 0.062 Ci
Oxygen-15 = 0.007 Ci

Direction	Distance to Perimeter (m)	Dose (mrem/y)	Distance to Nearest Resident (m)	Dose (mrem/y)
N	1500	< 0.001	2000	< 0.001
NNE	1600	< 0.001	2100	< 0.001
NE	2200	< 0.001	3100	< 0.001
ENE	2500	< 0.001	3300	< 0.001
E	1600	< 0.001	3400	< 0.001
ESE	1500	< 0.001	3500	< 0.001
SE	400	< 0.001	3000	< 0.001
SSE	400	< 0.001	3000	< 0.001
S	350	< 0.001	2500	< 0.001
SSW	400	< 0.001	2800	< 0.001
SW	550	< 0.001	3000	< 0.001
WSW	800	< 0.001	1400	< 0.001
W	800	< 0.001	1500	< 0.001
WNW	500	< 0.001	1400	< 0.001
NW	350	< 0.001	1600	< 0.001
NNW	1500	< 0.001	2000	< 0.001

TABLE 4.28

Maximum Perimeter and Individual Doses from
Building 411 (APS) Air Emissions, 1993

Dose (mrem/y)

Pathway	Perimeter (350 m NW)	Individual (1400 m SW)
Ingestion	< 0.0001	< 0.0001
Inhalation	< 0.0001	< 0.0001
Air Immersion	< 0.0001	< 0.0001
Ground Surface	< 0.0001	< 0.0001
Total	< 0.0001	< 0.0001
Radionuclide		
Carbon-11	< 0.0001	< 0.0001
Nitrogen-13	< 0.0001	< 0.0001
Oxygen-15	< 0.0001	< 0.0001
Total	< 0.0001	< 0.0001

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.

The full-time resident who would receive the largest annual dose (0.24 mrem/y) is located approximately 0.8 km (0.5 mi) NNW of the site boundary. The major contributor to the whole body dose is the inhalation dose from lead-212 (0.16 mrem/y). If radon-220 and daughters were excluded from the calculation, as required by NESHAP,[13] the maximally exposed resident would receive a dose of 0.014 mrem/y, primarily carbon-11 from the IPNS facility (Building 375).

The individual doses to the maximally exposed member of the public and the maximum fenceline dose is shown in Figure 4.6. The decrease in individual and population doses since 1988 are due in part to the decrease of the radon-220 emissions from the Proof-of-Breeding Program.

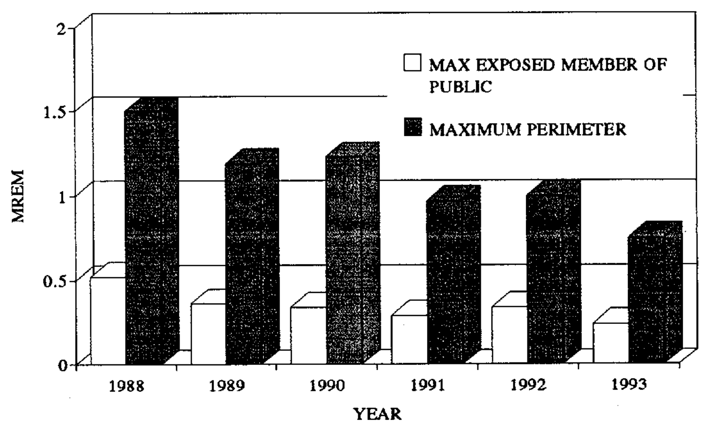


Figure 4.6 Individual and Perimeter Doses From Airborne Radioactive Emission

The population data in Table 1.1 were used to calculate the cumulative population dose from gaseous radioactive effluents from ANL operations. The results are given in Table 4.29, together with the natural external radiation dose. The natural radiation dose listed is the product of the 80-km (50-mi) population and the natural radiation dose of 300 mrem/y.[14] 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 operations, is shown in Figure 4.7.

TABLE 4.29

80 km Population Dose, 1993

Radionuclide	man-rems
Hydrogen-3	0.13
Carbon-11	0.95
Nitrogen-13	< 0.01
Oxygen-15	< 0.01
Argon-41	0.14
Krypton-85	< 0.01
Antimony-125	< 0.01
Thallium-208	< 0.01
Lead-210	< 0.01
Bismuth-210	< 0.01
Polonium-210	0.01
Lead-212	10.60
Bismuth-212	1.14
Polonium-216	< 0.01
Radon-220	< 0.01
Radon-222	< 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	13.0
Natural	2.4×10^6

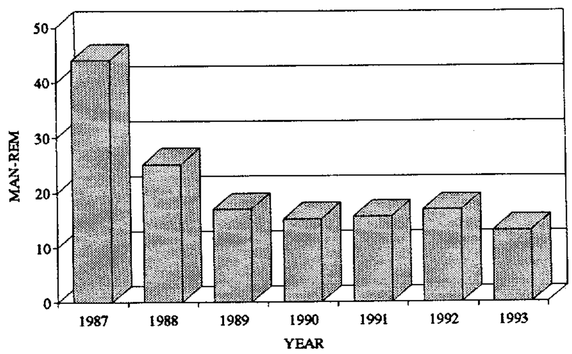


Figure 4.7 Population Dose From Airborne Radioactive Emissions

The potential radiation exposures by the inhalation pathways also were calculated by the methodology specified in DOE Order 5400.5.[6] 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/y.[15] This annual intake is then multiplied by the CEDE for the appropriate lung retention class.[8] Because the CEDE factors are in units of Rem per microcurie (Rem/μCi), this calculation gives the 50-year committed effective dose equivalent. The applicable CEDE factors are listed in Table 4.30.

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 fenceline 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 are calculated for 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, the annual intake of radionuclides (in μCi) ingested with water is obtained by multiplying the concentration of radionuclides in microcuries per milliliter (μCi/mL) by the average annual water consumption of a member of the general public (7.3×10^5 mL). This annual intake is then multiplied by the CEDE factor for ingestion (Table 4.30) to obtain the dose received in that year. This procedure is carried out for all radionuclides and the individual results are summed to obtain the total ingestion dose.

TABLE 4.30

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

Nuclide	Ingestion	Inhalation
Hydrogen-3	6.3×10^{-5}	6.3×10^{-5}
Beryllium-7	-	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	-

The only location where radionuclides attributable to ANL operations could be found in off-site water was Sawmill Creek below the waste-water 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 waste water, 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 4.31. 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 there are fish in the stream, but they do not constitute a significant source of food for any individual. Figure 4.8 is a plot of the estimated dose an individual would receive if ingesting Sawmill Creek water.

TABLE 4.31

Radionuclide Concentrations and Dose Estimates
for Sawmill Creek Water, 1993

Radionuclide	Total Released (millicuries)	Net Avg Conc (pCi/L)	Dose (mrem)
Hydrogen-3	18.7	43	0.0020
Strontium-90	0.082	0.188	0.0178
Cesium-137	0.587	1.35	0.0493
Plutonium-239	0.0012	0.0027	0.0085
Americium-241	0.0010	0.0024	0.0079
Sum	19.37		0.0855

As indicated in Table 4.5, occasional Sawmill Creek samples (fewer than ten percent) contained traces of plutonium-238, curium-242,244, or californium-249,252, but the averages were only slightly greater than the detection limit. The annual dose to an individual

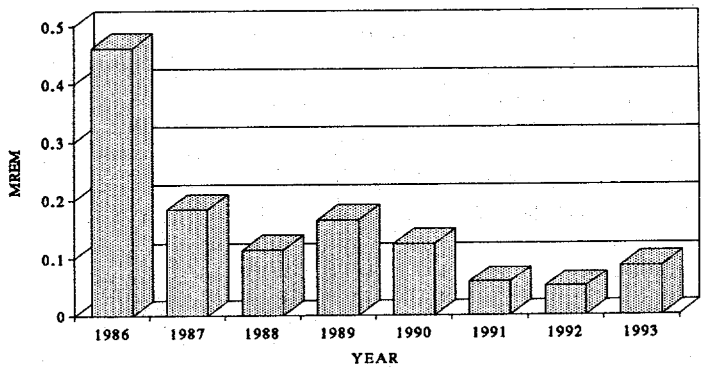


Figure 4.8 Comparison of Dose Estimates From Ingestion of Sawmill Creek Water

consuming water at these concentrations can be calculated with the same method used for those radionuclides more commonly found in creek water, but the method of averaging probably overestimates the true concentration. Annual doses range from 3 x 10^{-3} to 6 x 10^{-5} mrem/y for these radionuclides.

DOE Order 5400.5[6] 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/y. The location that could result in the highest dose to aquatic organisms is in Sawmill Creek downstream of the point where ANL discharges its treated wastewater. Based on inspection of the creek at this location, small bluegill and carp (about 100 g each) have been observed. 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 x 10^{-6} rad/y, well within the DOE standard, and therefore demonstrating compliance with that portion of the Order.

The EPA has established drinking water standards based on a maximum dose of 4 mrem/y for man-made beta particle and photon-emitting radionuclides.[16] The EPA standard is 2 x 10^4 pCi/L for hydrogen-3 and 8 pCi/L for strontium-90. The net concentrations in Table 4.31 correspond to 0.022% (hydrogen-3) and 2.4% (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 10 cfs, while the flow rate of the Des Plaines River in the vicinity of ANL is about 900 cfs. Applying this ratio to the concentration of radionuclides in Sawmill

Creek listed in Table 4.31, the dose to a hypothetical individual ingesting water from the Des Plaines River at Lemont would be about 0.0010 mrem/y. 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.

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 fenceline doses attributable to ANL operations were found at the southern boundary near the Waste Storage Facility (Location 7I).

At Location 7I, the fenceline dose from ANL was about 103 mrem/y. Approximately 300 m (0.3 mi) south of the fenceline (grid 6I), the measured dose was 75 ± 9 mrem/y, the same as the normal range of the off-site average (76 ± 6 mrem/y). No individuals live in this area. The closest residents are about 1.6 km (1 mi) south of the fenceline. At this distance, the calculated dose rate from the Waste Storage Facility was 0.003 mrem/y, if the energy of the radiation were that of 0.66 MeV cesium-137 gamma-ray, and about 0.01 mrem/y if the energy were that of 1.33 MeV cobalt-60 gamma-ray.

At the fenceline, 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 some of the time.

In addition to the permanent residences in the area, occasionally visitors may conduct activities around ANL that could result in exposure to radiation from this site. Examples of these activities could be cross country skiing, horseback riding, or running in the fire lane next to the perimeter fence. If the individual spent ten minutes per week adjacent to the 317 Area, the dose would be 0.02 mrem/y at the 317 Area fence (location 7I).

4.6.4. Dose Summary

The total effective dose equivalent received by off-site residents during 1993 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 0.24 mrem/y 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 13.0 man-rem. The dose pathways are collected in Table 4.32 and compared to the applicable standards.

TABLE 4.32

Summary of the Estimated Dose to the Public, 1993
(mrem/y)

Pathway	ANL Estimate	Applicable Standard
Air (Less radon)	0.014	10 (EPA)
Air Total	0.24	100 (DOE)
Water	0.086	100 (DOE)
Direct Radiation	0.01	100 (DOE)
Maximum Public	0.24	

To put the maximum individual dose of 0.24 mrem/y attributable to ANL 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 4.33. It is obvious that the magnitude of the doses received from ANL operations is insignificant compared with these sources. Therefore, the monitoring program results establish that the radioactive emissions from ANL are very low and do not endanger the health or safety of those living in the vicinity of the site.

TABLE 4.33

Annual Average Dose Equivalent
in the U. S. Population*

Source	Dose (mrem)
Natural Sources	
Radon	200
Internal (^{40}K and ^{226}Ra)	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

*NCRP Report No. 93.[14]

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 release of nonradiological pollutants to the air from ANL is extremely small, except for the boiler house, which is equipped with dedicated monitoring equipment for sulfur dioxide (SO_2) and opacity. One excursion for SO_2 was noted during 1993 over a period of 4100 hours of operation of Boiler No. 5, the coal-burning boiler. No opacity excursions were noted for Boiler No. 5 during 1993. As a result, the ambient air is not routinely monitored. Chapter 3 discusses the entire environmental monitoring program in more detail.

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. Besides being published in this report, the NPDES monitoring results are transmitted monthly to the IEPA in an official Discharge Monitoring Report (DMR). A summary of exceedances of permit limits during 1993 appears in Table 5.1.

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 the IAC, Title 35, Subtitle C, Chapter I.[17]

TABLE 5.1

NPDES Permit Limit Exceedances, 1993

Outfall	Parameter	Number of Exceedances
001	Total Dissolved Solids	5
001B	Total Suspended Solids	2
	Mercury	6
003	Total Suspended Solids	2
006	Total Suspended Solids	1
010	pH	3
	Total Suspended Solids	3
	Iron	3

5.1. National Pollutant Discharge Elimination System Monitoring Results

Wastewater is processed at ANL 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 which 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 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 which 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 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, chlorinated, 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 2.25 million liters per day (0.60 million gallons per day) sanitary wastewater and 1.69 millions liters per day (0.45 million gallon) laboratory process wastewater.

5.1.1. Sewage Treatment Plant Rehabilitation

Two projects to rehabilitate the existing Laboratory and Sanitary Wastewater Treatment Plant facilities are currently in design. The existing laboratory treatment facilities will be rehabilitated and additional treatment units will be provided. New facilities will provide treatment capability for heavy metals, suspended solids, and volatile and semivolatile organics. The hydraulic capacity of the plant will be expanded to enable treatment of the existing flow rate and anticipated future loadings. Existing equipment to be replaced includes flow meters, bar screens, sludge pumps and piping, sludge scrapers, and flow regulating valves and chambers for holding tanks. Major treatment process equipment areas to be provided in the rehabilitation include: oil and grease removal, grit removal, metals precipitation, suspended solids filtering, air stripping, carbon adsorption, sludge handling, flow monitoring, and process control instrumentation. This project is currently in final design.

The Sanitary Wastewater Treatment Plant will be upgraded to replace equipment that has reached its design life and to add equipment where a more efficient or environmentally-sound process applies. The equipment to be rehabilitated includes the headworks, the clarigesters, the existing trickling filters, the final clarifiers, and the intermittent sand filters. The disinfection system will not be upgraded or replaced as it is no longer used or required. An additional 1000 m^2 (10,000 sq^2) of sludge drying area will be provided with two

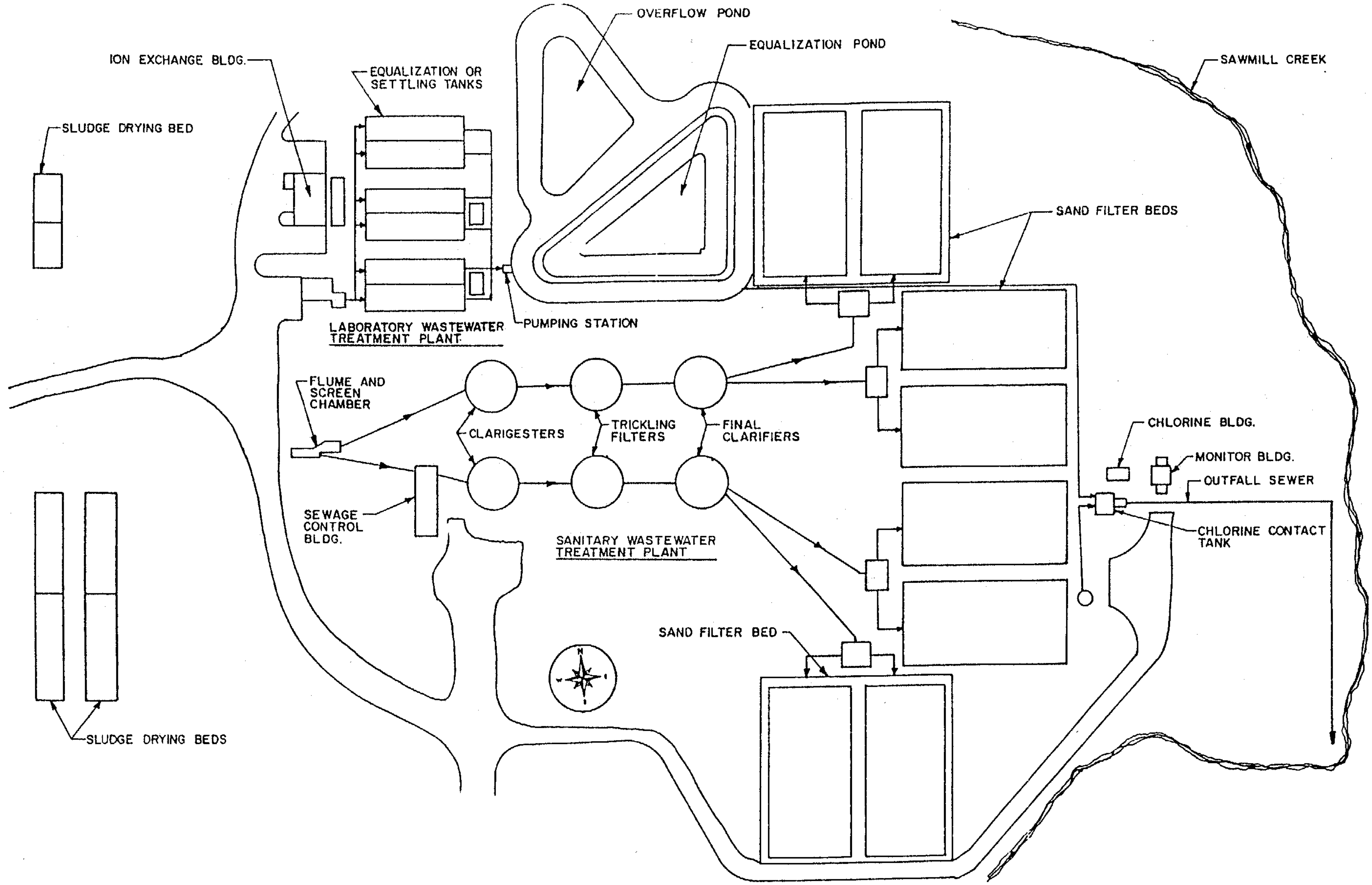


Figure 5.1 ANL Sewage Treatment Plant

additional drying beds utilizing sand with an underdrain system. The preliminary design has been completed and the final design will be initiated during FY 1994.

5.1.2. Effluent Monitoring

The two treatment plant systems process the vast majority of wastewater generated by ANL. 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. During 1993, the stormwater characterization project identified four new discharges (25,000 gallons/day total). The IEPA was notified and a formal report by ANL was made to include these discharges on the NPDES permit.

ANL-processed wastewater discharges are regulated by NPDES Permit No. IL 0034592.[18] As discussed in Section 2.2.1., this permit was renewed on July 7, 1989, and expired on January 15, 1994, (the permit will be reissued in mid-1994 by the IEPA). Nine 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 Part 136.[19] Sample collection, preservation, and holding times are also mandated by requirements stipulated in Table 2 of 40 CFR Part 136.[19]

The NPDES outfall locations are shown in Figure 5.2. To improve the clarity of this figure, the outfall numbers are shown without the leading zeroes. Thus, outfall 001A is shown as 1A. 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 wastewater treatment facility. Their flows combine to form outfall 001 which is also located at the treatment facility. The combined stream flows through an outfall pipe which discharges into Sawmill Creek approximately 1100 m (3500 ft) south of the treatment plant.

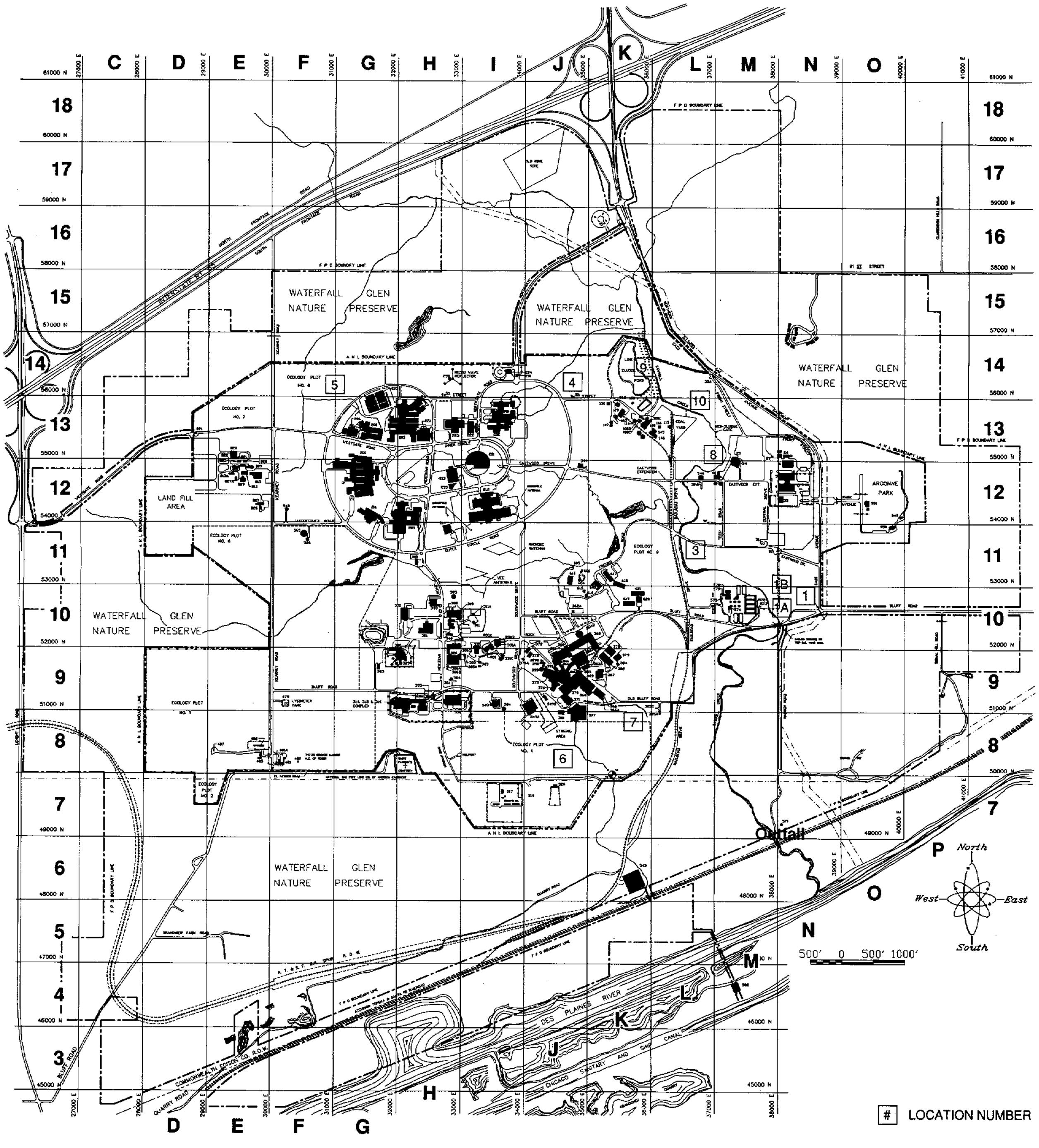


Figure 5.2 NPDES Outfall Locations

5.1.2.1. Sample Collection

NPDES samples are collected by ANL's Environment and Waste Management Program (EWM) personnel, with the exception of samples from locations 001, 001A, and 001B, which are collected by Plant Facilities and Services Division (PFS) personnel. All samples are collected using specially cleaned and labelled bottles with appropriate preservatives added. Custody seals and chain-of-custody sheets are also used. All samples are analyzed within the required holding time. Samples are collected at locations 001A and 001B on a weekly basis and at 001 twice per month. Samples are collected at the other locations on a monthly basis in accordance with the NPDES permit.

5.1.2.2. Sample Analysis - NPDES

NPDES sample analyses were performed using standard operating procedures (SOP) written, reviewed, and issued as controlled documents by members of the Environment, Safety, and Health Division, Dosimetry and Analytical Services Section, Chemistry Laboratory (ESH-DACH) and Control Laboratory (ESH-DACL). These SOP reference protocols found in 40 CFR Part 136, "Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Six metal analyses were performed using flame atomic absorption spectroscopy (CVAA). Five-day biochemical oxygen demand (BOD_5) was determined using a dissolved oxygen probe. Total suspended solids (TSS), total dissolved solids (TDS), and fats, oils, and grease were determined gravimetrically. Sulfate determination was performed using a turbidimetric technique while chloride was determined by titrimetry.

Semiannually, NPDES outfall 001B is sampled and analyzed for priority pollutant compounds. An off-site contracted laboratory performed these determinations using methods specified in 40 CFR Part 136. Volatile, semivolatile organic compounds and 2,3,7,8 tetrachlorodibenzo-p-dioxin were determined by gas chromatography systems. PCB/pesticides were determined by gas chromatography-electron capture detection. Thirteen metals were determined by graphite furnace atomic absorption, flame atomic absorption, and inductively coupled plasma-atomic emission spectrometry. Asbestos analysis was performed using transmission electron microscopy. Cyanide and phenol were determined by distillation followed by a spectrophotometric finish.

Annually, NPDES outfall 001 is sampled and analyzed for acute and chronic aquatic toxicity parameters. An off-site contracted laboratory performed both the sample collection and analyses. The methods used are indicated in USEPA/600600-4-85-013, "Measuring Acute Toxicity of Effluents to Freshwater and Marine Organisms," USEPA/560-6-82-002, "Environmental Effects Test Guidelines," and IEPA specifications given in "Effluent Biomonitoring and Toxicity Assessment-Aquatic Life Concerns." The testing is performed by using ANL effluent with Sawmill Creek receiving water, introducing species of fish, invertebrates, and aquatic plants and measuring survival, growth and/or reproduction over two to seven days. Statistically, significant mortality, inhibition of growth and/or reproduction is reported as a function of effluent concentration.

5.1.2.3. Results

During 1993, approximately 97.5% of all NPDES analyses were in compliance with their applicable permit limits as compared to 1992 and 1991 rates of 98% and 96%, respectively. Specific limit exceedances are discussed later in this section as well as in Chapter 2. A summary of the 1993 exceedances is presented in Tables 5.5, 5.7, and 5.8. 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 stormwater runoff. The effectiveness of the sanitary wastewater treatment systems is evaluated by weekly monitoring for biochemical oxygen demand (BOD), pH, and total suspended solids (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 and a monthly average of 12 mg/L. The pH must range between values of 6 and 9. There were no exceedances of these limits at outfall 001A.

The permit requires weekly monitoring for total chromium, copper, iron, lead, manganese, zinc, and oil and grease. The effluent limits for these parameters and results are shown in Table 5.2. There are two limits 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 presented in Table 5.2 are present in the coal pile runoff which discharges to the sanitary sewage system. All samples collected and analyzed for these parameters were within the permit limits during 1993. The average shown in the table is the annual average for each constituent.

TABLE 5.2

Outfall 001A Effluent Limits and Monitoring Results, 1993
(Concentrations in mg/L)

Constituent	Minimum	Average	Average Limit	Maximum	Maximum Limit
Chromium	-	< 0.02	1.00	< 0.02	2.00
Copper	0.02	0.07	0.50	0.26	1.00
Iron	0.06	0.19	2.00	0.48	4.00
Lead	-	< 0.10	0.20	< 0.10	0.40
Manganese	< 0.02	0.04	1.00	0.19	2.00
Zinc	0.03	0.09	1.00	0.18	2.00
Oil & Grease	-	< 5.0	15.0	< 5.0	30.0

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, and chemical oxygen demand (COD).

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 lbs/day as a daily maximum and 57 lbs/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 lbs/day, respectively. There were two exceedances of the concentration limit for TSS and one exceedance of the mass loading limit for TSS at this location in 1993.

The daily maximum concentration limit for mercury is 6 μg/L and the 30-day average is 3 μg/L. The corresponding loading values are 0.034 lbs/day and 0.017 lbs/day. In 1993, there were six exceedances of the concentration limit, and three exceedances of the mass loading limits.

There are no concentration limits established for COD. The once-per-week grab samples give a rough indication of the organic content of this stream. The values obtained in 1993 ranged from less than 10 mg/L to 25 mg/L.

There is a special condition for location 001B that requires the monitoring for the 126 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. In addition to the typical list of priority pollutants, fibrous asbestos and 2,3,7,8-tetrachlorodibenzo-p-dioxin (commonly called dioxin) are to be determined. Samples were collected on June 14, 1993, and December 13, 1993, 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 semivolatile organic compounds, PCBs, and pesticides were all less than the detection limits. The results for metals were similar to concentrations found in ANL treated drinking water. The samples contained several volatile organic compounds 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. While there are currently no permit limits or effluent standards for these compounds with which to compare these results, the concentrations found are believed to be of little concern because they are below acceptable standards for drinking water supplies, where such standards exist.

TABLE 5.3

Outfall 001B Priority Pollutant Monitoring Results, 1993
(Concentrations in μg/L)

Compound	Concentration in June Sample	Concentration in December Sample
Bromodichloromethane	3.7	3.4
Bromoform	8.8	< 1.0
Chloroform	4.5	15.6
Dibromochloromethane	7.9	< 1.0
Methylene Chloride	< 5.0	5.8

Results for the June sample for asbestos showed less than 0.207 million structures/L of less than 10 μm in length (chrysotile). The December sample indicated a concentration of asbestos structures of 0.062 million structures/L, all of which were less than 10 μm in length. The June sample had 50 μg/L of naphthalene, while the December sample had a nondetectable level of this compound. Neither of the samples had detectable levels of dioxin.

The laboratory wastewater treatment system consists of six 69,000 gallon equalization or settling (holding) tanks (see Figure 5.1) which are pumped to a lined equalization pond before being discharged to Sawmill Creek. During 1989, a study was performed to determine the levels of volatile organic compounds 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 volatile organic compounds. 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.

The 1993 results for the most common compounds found are shown in Table 5.4. In addition to these compounds, most samples contained very low concentrations of bromodichloromethane, dichlorobromomethane, and bromoform. These halomethanes, at the levels found, including some of the chloroform results, are thought to be due to the contact of the chlorinated supply water with organic chemicals. Chloroform levels above 10 μg/L are probably due to other causes.

Unlike previous years, acetone was found in only 50% of the samples and at lower concentrations (see Figure 5.3). The levels found ranged to 4218 μg/L. Methylene chloride was found in most of the samples and ranged to 312 μg/L, significantly lower concentrations than reported during 1992 (see Figure 5.4). Samples obtained in April, July, and August had elevated levels of tetrahydrofuran and ethyl ether. Infrequent trace levels of other chemicals, i.e., benzene,

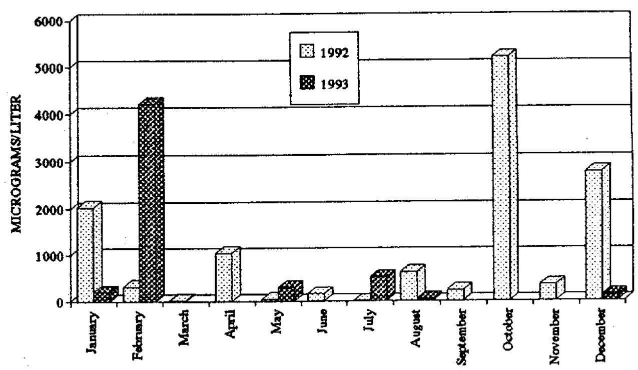


Figure 5.3 Acetone Levels in Laboratory Wastewater, 1992 vs 1993

TABLE 5.4

Volatile Organic Compounds in Laboratory Wastewater, 1993

(Concentrations in μg/L)

Month	Acetone	Chloroform	Methylene Chloride
January	202	< 1	11
February	4218	25	312
March	< 1	10	< 1
April	< 1	24	< 1
May	300	1	12
June	< 1	51	255
July	522	35	98
August	43	11	< 1
September	< 1	78	185
October	< 1	5	2
November	< 1	11	1
December	126	15	11

ethylbenzene, 1,1,2-trichloromethane, 1,2-dichloroethane, 4-methyl-2-pentanone, d-limonene, and tetrachloroethane were also noted.

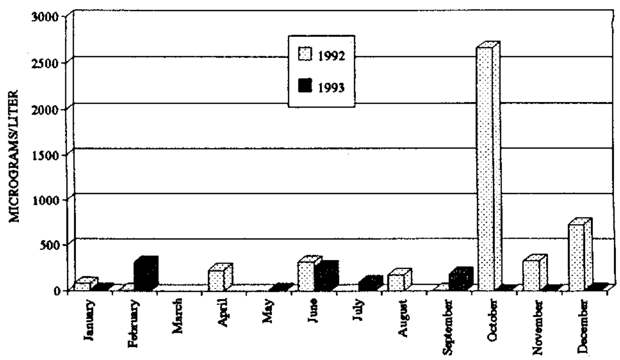


Figure 5.4 Methylene Chloride Levels in Laboratory Wastewater, 1992 vs 1993

Figures 5.5 and 5.6 present comparisons of the 1992 and 1993 laboratory wastewater results for the more persistent volatile organic compounds and show an overall reduction in the frequency and concentrations of the compounds. A waste generator education program regarding disposal of chemicals down laboratory drains has been established at ANL and may be a contributing factor to the reduction of volatile organics in the laboratory wastewater.

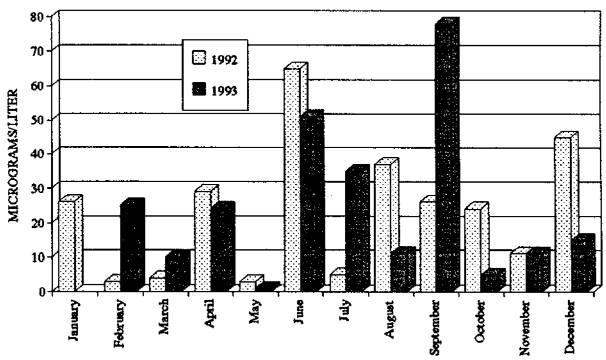


Figure 5.5 Chloroform Levels in Laboratory Wastewater, 1992 vs 1993

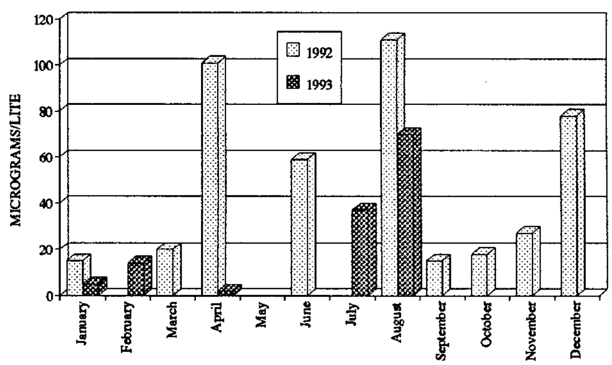


Figure 5.6 Tetrahydrofuran Levels in Laboratory Wastewater, 1992 vs 1993

<u>Outfall 001</u>

The treated wastewater streams from the two treatment systems are combined, chlorinated, and samples for analysis of most of the permit parameters are collected from a manhole downstream of the chlorine contact chamber. This combined effluent then flows through the outfall sewer to Sawmill Creek. The effluent travels through this sewer for approximately 20 minutes before being discharged. The time the chlorinated wastewater resides within this sewer pipe, before mixing with Sawmill Creek, increases the effectiveness of the chlorine added at the treatment plant. The samples used for determination of fecal coliform bacteria were collected at the outlet of this pipe. There were no exceedances of the fecal coliform limit during 1993. The requirement for fecal coliform monitoring was waived by the IEPA through a permit modification dated July 27, 1993.

The permit requires analysis of the combined effluent twice per month for TDS, chloride, and sulfate. The results, limits, and number of exceedances are presented in Table 5.5. The limit for TDS was exceeded five times in 1993. Early in 1993, discharge to the sanitary sewer from a solar pond is believed to have been a major source of the excess dissolved solids. The solar pond was drained to the DuPage County sewerage system during mid-1993. TDS exceedances (2) that occurred after that time were believed to be related to discharges from boiler operations, i.e., boiler blowdown, which are known to contain high levels of TDS, and domestic water treatment. Chemical analysis for chloride shows a close relationship between TDS levels and chloride levels. Figure 5.7 shows the results of TDS and chloride analyses for 1993. The groundwater at ANL is characterized by high TDS levels, i.e., approximately 800 ppm. This elevated concentration allows a narrow margin of added TDS (about 200-250 ppm) to the wastewater in meeting the NPDES effluent standard of 1045 ppm. Levels for sulfate and chloride were not exceeded during 1993.

TABLE 5.5

Outfall 001 Monitoring Results and Effluent Limits, 1993

(Concentrations in mg/L)

Constituent	Minimum	Average	Maximum	Limit	Exceedances
Total Dissolved Solids	779	989	1275	1045	5
Sulfates	149	224	282	575	0
Chlorides	165	242	434	550	0

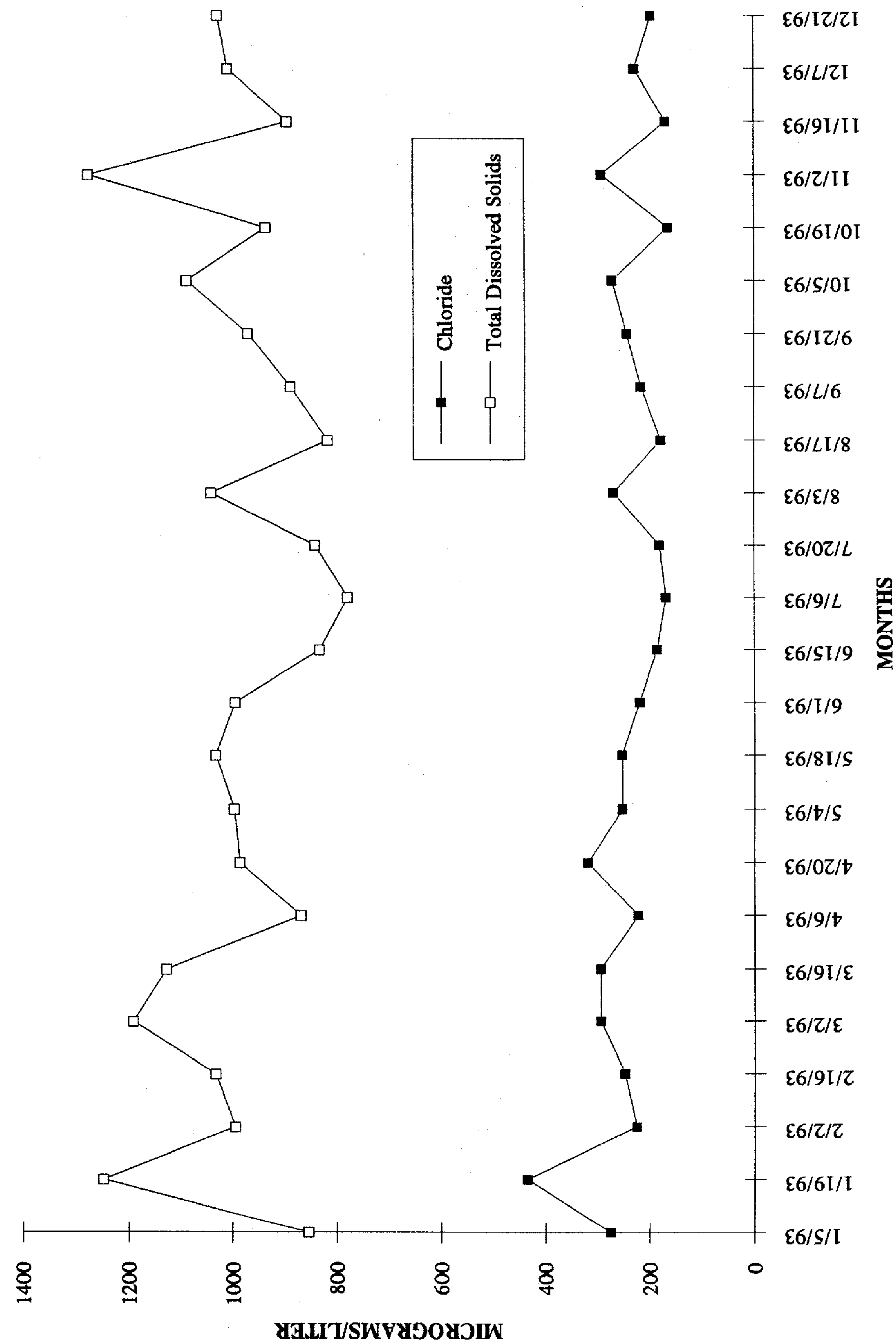


Figure 5.7 Total Dissolved Solids and Chloride in Outfall 001 Water, 1993

The permit requires that a biological toxicity screening test be performed at location 001 in June of each year. The toxicity testing is run on at least three trophic levels of aquatic species for both chronic and acute toxicity. The 1993 testing was conducted on samples collected during the period June 11 to June 26, 1993. The testing was performed during the period June 14 to June 29, 1993, using a water flea, Ceriodaphnia dubia, a fathead minnow, Pimephales promelas, and a green alga, Selenastrum capriconutum. The EPA protocol, as modified by the IEPA, was used for this test.

Acute toxicity effects of the effluent were improved over tests conducted in 1991 and 1992. Test results from chronic toxicity tests indicate that exposure to the effluent did impact survival and growth of the fathead minnow fry similar to results obtained in 1991. A more pronounced chronic effect on reproduction of Ceriodaphnia than had been seen in 1991 and 1992 was noted. Results from the algal growth test revealed that great improvement was noted in effluent toxicity to the algae. Table 5.6 summarizes the results from the various toxicity tests.

The permit also requires that weekly pH measurements be made. There were no results outside of the pH limits of 6-9 units during 1993.

Outfall 003

This outfall is the discharge point from a series of small man-made ponds and is composed primarily of stormwater, with small amounts of process wastewater, such as cooling tower blowdown. It is sampled monthly and analyzed for pH, TSS, and temperature. Permit limits exist for TSS (15 mg/L average and 30 mg/L maximum), pH (between 6 and 9 pH units) and temperature (less than 5°F temp. rise). During 1993, there were two exceedances of TSS limits. These and past TSS exceedances are probably due to excessive siltation in the ponds that has occurred over the years. Plans are being developed to dredge the excess sediment from these ponds to improve the effluent TSS levels. No other limits were exceeded. For the outfalls 003 through 009, the number of samples collected, permit constituents, and limits are shown in Table 5.7.

TABLE 5.6

Outfall 001 Aquatic Toxicity Test Results, 1993

Test	Endpoint	96/48-Hour LC_{50}*	7-Day NOEC**	7-Day LOEC***
96-Hour Fathead Minnow Acute Toxicity	Survival	> 100.0%	N/A	N/A
48-Hour Ceriodaphnia Acute Toxicity	Survival	> 100.0%	N/A	N/A
7-Day Fathead Minnow Chronic Toxicity	Survival	N/A	50.0%	100.0%
	Growth	N/A	50.0%	100.0%
7-Day Ceriodaphnia Chronic Toxicity	Survival	N/A	50.0%	100.0%
	Reproduction	N/A	25.0%	50.0%
96-Hour Algal Growth	Cell-Growth	N/A	100.0%	> 100.0%

*LC_{50} - Concentration of wastewater that produces 50% mortality in the test population.

**NOEC - No Observable Effect Concentration is the highest concentration of the effluent at which no adverse effect is observed.

**LOEC - Lowest Observable Effect Concentration is the lowest concentration of the effluent at which an adverse effect is observed.

TABLE 5.7

NPDES Effluent Summary, Outfalls 003 to 009, 1993

Discharge Location	Number of Samples Collected	Permit Constituent	Limit 30-Day Average	Limit Daily Maximum	Number Exceeding Limit
003	12	Flow	None		0
		pH	6-9		0
		TSS	15	30	2
		Temperature	< 2.8°C Rise		0
004	12	Flow	None		0
		pH	6-9		0
		TSS	15	30	0
		Temperature	< 2.8°C Rise		0
005	12	Flow	None		0
		pH	6-9		0
		Temperature	< 2.8°C Rise		0
		Oil & Grease	15	30	0
006	12	Flow	None		0
		pH	6-9		0
		TSS	15	30	1
007	6	Flow	None		0
		pH	6-9		0
		Temperature	< 2.8°C Rise		0
008	6	Flow	None		0
		pH	6-9		0
009	0	Flow	None		0
		pH	6-9		0
		TSS	15	30	0

Outfall 004

Outfall 004 consists primarily of stormwater with small amounts of cooling water from Building 202. The sampling requirements and effluent limits are in Table 5.7. There were no exceedances of TSS limits in 1993.

Outfall 005

This outfall consists of stormwater and process wastewater from the Building 206 cooling system and the 800 Area, which includes vehicle and other maintenance areas. The permit requirements include monthly sampling and analysis for oil and grease, pH, and temperature. Limits of 15 mg/L average and 30 mg/L maximum exist for oil and grease. The pH and TSS limits are the same as for outfall 003. There were no exceedances in 1993.

Outfall 006

This outfall consists of stormwater, cooling tower blowdown and overflow from settling ponds used at the Canal Water Treatment Plant. The permit requires monthly sampling for pH, TSS, and temperature. The limits are in Table 5.7. In 1993, there was one exceedance of the TSS limit, most likely due to erosion of soil from the surrounding area during heavy precipitation.

Outfall 007

Outfall 007 consists of stormwater and Building 360 cooling water. It is sampled monthly and analyzed for pH and temperature. The effluent limits are collected in Table 5.7. Six samples were obtained during 1993 except when the stream was dry or frozen. There were no exceedances at this location.

Outfall 008

Outfall 008 consists of uncontaminated stormwater runoff from the East Area. The only permit limit that applies at this point is pH. Runoff was directed through a new storm sewer system during construction of the new Transportation and Grounds Facility. Unlike past years, flow now normally occurs through this outfall. During 1993, six samples were collected; no exceedances were noted.

Outfall 009

This outfall is an emergency overflow for an inactive lime sludge lagoon near the domestic water treatment plant. This lagoon has not been used since 1986. In the event that an extremely heavy storm occurs, rainwater could flow out of this outlet. The permit contains limits for pH and TSS, as shown in Table 5.7. The permit requires monitoring monthly, when discharge is occurring. There was no discharge during 1993.

Outfall 010

This location is an emergency overflow point for the diked coal pile storage area. It discharges only under conditions of heavy rain and prevents flooding of the coal pile area. This outfall is sampled once per month when flow occurs. Analyses are performed for pH, total suspended solids, iron, lead, zinc, manganese, total chromium, copper, and oil and grease. The permit limits for these parameters are shown in Table 5.8.

Flow occurred at this site during January, March, and June 1993. As required, samples were collected and analyzed. The results are shown in Table 5.8. The iron, total suspended solids, and pH results exceeded the limits in all three samples. During mid-1993, corrective actions were implemented to prevent flow from this outfall. Since that time, even during periods of heavy precipitation, no discharges have occurred.

TABLE 5.8

Outfall 010 Effluent Limits and Monitoring Results, 1993
(Concentrations are mg/L, except for pH)

Constituent	January Results	March Results	June Results	Average Limit	Maximum Limit	Number Exceeding Limit
Chromium	< 0.02	< 0.02	< 0.02	1.0	2.0	0
Copper	0.30	0.29	0.04	0.5	1.0	0
Iron	15.5	17.3	43.5	2.0	4.0	3
Lead	< 0.1	< 0.1	< 0.1	0.2	0.4	0
Manganese	0.22	0.27	0.22	1.0	2.0	0
Oil & Grease	< 5	< 5	< 5	15	30	0
pH	3.8	3.4	3.2	6-9	6-9	3
TSS	102	44	389	15	30	3
Zinc	0.24	0.32	0.27	1.0	2.0	0

5.2. Additional Effluent Monitoring

To characterize the wastewater from the ANL site more fully, composite samples of the combined effluent are collected each week and analyzed for the constituents shown in Table 5.9. The results are then compared to the IEPA General Effluent Limits found in 35 IAC, Subtitle C, Part 304.[20]

5.2.1. Sample Collection

Samples for analysis of inorganic constituents are collected daily from outfall 001 located at the Waste Water Treatment Plant using a refrigerated time proportional sampler. A portion of the sample is transferred to a specially cleaned bottle, a security seal is affixed

TABLE 5.9

Chemical Constituents in Effluents from ANL Wastewater Treatment Plant, 1993
(Concentrations in mg/L)

Constituent	No. of Samples	Avg.	Concentration Min.	Max.	Limit
Arsenic	51	0.0025	< 0.0025	0.0038	0.25
Barium	51	0.0212	0.0145	0.0285	2.0
Beryllium*	51	-	-	< 0.1500	-
Cadmium	51	0.0004	< 0.0002	0.0009	0.15
Chromium	51	0.0100	0.0100	0.0110	1.0
Cobalt	51	-	-	< 0.0500	-
Copper	51	0.0697	0.0460	0.1480	0.5
Fluoride	24	0.3934	0.2480	0.5360	15.0
Iron	51	0.1990	< 0.0208	0.7180	2.0
Lead	51	0.1791	< 0.0010	9.0000	0.2
Manganese	51	0.0455	0.0271	0.1360	1.0
Mercury*	51	3.2372	0.1000	44.6000	0.5
Nickel	51	-	-	< 0.0400	1.0
Silver	51	< 0.0100	< 0.0100	0.0100	0.1
Thallium	51	0.0030	< 0.0030	0.0053	-
Vanadium	51	-	-	< 0.0500	-
Zinc	51	0.0873	0.0389	0.6390	1.0
pH (units)	51	-	7.3000	8.3000	6.0-9.0

* Units = $\mu g/L$

and chain-of-custody is maintained. Five daily samples are composited on an equal volume basis to produce a weekly sample, which is then analyzed.

5.2.2. Results

The results for 1993 appear in Table 5.9. With the exception of mercury and lead, the values are similar to results reported in previous years. Mercury concentrations were significant in 1993, the annual average results exceeded the General Effluent Limits.[20] The high levels were probably due to sludge carryover from the 69,000 gallon holding tanks at the influent end of the laboratory wastewater treatment plant. The sludge has been accumulating in these tanks since 1990 when it was discovered that the laboratory wastewater sludge drying beds contained sludge contaminated with PCBs (see Section 2.9.3.). During periods of high flow, the excess sludge in the tanks is probably carried through the laboratory wastewater system. Unlike previous years, NPDES monitoring results for the laboratory wastewater outfall 001B showed six mercury exceedances (see Sections 2.2.1.1. and 5.1.2.4.) during 1993. The average lead levels were only slightly elevated but within the General Effluent Limits.[20]

5.3. Sawmill Creek

Sawmill Creek is a small natural stream that is fed primarily by stormwater runoff. During periods of low precipitation, the creek above ANL has a very low flow. At these times, a major portion of the water in Sawmill Creek south of the site consists of ANL wastewater and discharges to assorted storm drains. To determine the impact ANL wastewaters have on Sawmill Creek, samples of the creek downstream of all ANL discharge points are collected and analyzed. The results are then compared to the IEPA General Use Water Quality Standards found in 35 IAC, Subtitle C, Part 302.[21]

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 effluent and Sawmill Creek water is assured. Samples are collected in precleaned, labelled 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 analyzed in the wastewater described in Table 5.9.

5.3.2. Results

The results obtained are shown in Table 5.10. One constituent, copper, was above Water Quality Standards (WQS) in all samples. The annual average concentration for copper was above the standard as well. Although the results for silver indicate that the standard was exceeded in all cases, the detection limit for the ICP method was above the WQS. It should be noted that during 1993, due to time restraints, the samples were analyzed using ICP which is less sensitive than the graphite furnace method used in the past. Historically, using the graphite furnace, the concentrations for silver were well below the standard.

5.4. Des Plaines River

Based on previous sampling results, it was determined that mercury would be the only element likely to have a measurable impact on the Des Plaines River. During previous years, the effect of Sawmill Creek on the levels of mercury in the Des Plaines River was evaluated by collecting samples in the river at Willow Springs (upstream of ANL) and at Lemont (downstream of ANL). All of the samples analyzed showed that the total mercury concentration was less than the detection limit of 0.1 μg/L. Based on these consistently low results, the decision was made to remove this specific monitoring from the ANL program during 1993.

TABLE 5.10

Chemical Constituents in Sawmill Creek, Location 7M,** 1993

(Concentrations in mg/L)

Constituent	No. of Samples	Concentrations Avg.	Min.	Max.	Limit
Arsenic	51	0.0025	< 0.0025	0.0032	1.0
Barium	51	0.0394	0.0226	0.0687	5. 0
Beryllium*	51	-	-	< 0.1500	-
Cadium	51	0.0004	< 0.0002	0.0010	0.05
Chromium	51	< 0.0100	< 0.0100	0.0100	1.0
Cobalt	51	-	-	< 0.0500	-
Copper	51	0.0521	0.0349	0.0752	0.02
Fluoride	23	0.2709	0.1700	0.4440	1.4
Iron	51	0.2391	0.1010	0.4280	1.0
Lead	51	0.0026	< 0.0010	0.0057	0.1
Manganese	51	0.0629	0.0258	0.1260	1.0
Mercury*	51	0.0980	< 0.0001	0.1000	0.5
Nickel	51	-	-	< 0.0400	1.0
Silver	51	< 0.0100	< 0.0100	0.0100	0.005
Thallium	51	-	-	< 0.0030	-
Vanadium	51	-	-	< 0.0500	-
Zinc	51	0.0484	0.0200	0.1580	1.0
pH (Units)	49	-	7.8500	8.7000	6.5-9.0

* Units = μg/L
** Location 7M is 15 m (50 ft) downstream from the ANL wastewater outfall

6. GROUNDWATER PROTECTION

The groundwater below the ANL 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 which 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. Regulations establishing comprehensive water quality standards for the protection of groundwater have been enacted, IEPA Groundwater Quality Standards, 35 IAC, Subtitle F, Part 620.[22] In addition, compliance with the groundwater protection requirements in DOE Order 5400.1, as related to sitewide characterization studies and monitoring well requirements, are demonstrated in this Chapter. The permit for the 800 Area landfill requires a groundwater monitoring program and this was initiated during July 1992.

6.1. Potable Water System

The ANL domestic water is supplied by four wells. The wells are described in Section 1.7 and Table 6.1. Their locations are shown in Figure 1.1. According to the National Primary Drinking Water Regulations,[16] ANL's system is classified as a non-transient, non-community public water system, since it regularly serves at least 25 of the same persons over six months of the year. This designation determines the parameters to be monitored and the frequency of monitoring. Monitoring of the ANL 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

The primary regulations that apply to ANL are the Illinois Department of Public Health, Drinking Water System Code 77 IAC Part 900.[23] These regulations identify the inorganic (900.50) and organic (900.65) constituents that require monitoring and set the State limits. In addition, ANL must also demonstrate compliance with 40 CFR 141.40 of the National Primary Drinking Water Regulations[16] by conducting the Special Monitoring for Organic Chemicals.

TABLE 6.1

ANL Water Supply Wells

Well No.	Location	Ground Elevation[1]	Pumping Level	Bedrock Elevation	Well Depth[2]	Diameter[3]	Year[4]
1	Building 31	670	~ 635	605	284	12	1948
2	Building 32	662	~ 605	601	300	12	1948
3	Building 163	685	~ 585	600	318	12	1955
4	Building 264	710	~ 600	595	340	14	1959

[1]feet mean sea level.

[2]feet below ground.

[3]inner diameter (inches).

[4]year drilled.

Samples were collected quarterly from each of the four ANL domestic wells and a treated tap water sample in Building 128. The samples were analyzed for nitrate/nitrite, metals, volatile organic compounds, pesticides, and herbicides by a commercial laboratory which is certified to conduct Safe Drinking Water Act analyses. The samples were analyzed for the constituents specified in the regulations by approved methods which allowed the minimum detectable limit of 0.0005 mg/L to be met for the organic chemicals. The results were provided to the DuPage County Health Department and the Illinois Department of Public Health (IDPH).

On March 17, 1993, the IDPH provided ANL with a permanent waiver for sampling for asbestos and an extension to November 24, 1995, for the testing of inorganics/metals. On July 22, 1993, ANL 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. The Federal organic list in 40 CFR 141.40 is covered under the Phase II organics and the unregulated list and, therefore, future sampling and analysis of these compounds is covered. In addition, future sampling is only required at a representative tap, however, well head sampling will be continued for information monitoring of radionuclides and volatile organic compounds.

The analytical results are summarized on the following tables. Each table includes the regulated constituents by group, the regulatory limits, and the results for each of the five ANL locations for the first two quarters of 1993. The inorganic parameters were not reported because of the waiver. Tables 6.2 and 6.3 contain the required State of Illinois organic chemicals. All results are below the respective State MCL limits. The optional organic compounds listed in Tables 6.4 and 6.5 require analysis only if the Illinois Department of Public Health determines that the system is vulnerable to contamination by any of these chemicals. No such determination has been made by the Department with respect to the ANL system. Selected analyses of compounds on this list were performed to determine if any were present. All analyzed constituents were below the maximum contaminant level. Tables 6.6 and 6.7 contain the chemicals listed in 40 CFR 141.40 of the National Primary Drinking Water Regulations identified for special monitoring of organic chemicals. All concentrations were below the analytical detection limits using the required EPA methods except for dichloromethane in the first quarter sample of the tap water (0.0018 mg/L).

All the state and Federally required analyses have been conducted, all concentrations were below the MCLs, the EPA-approved procedures were used by a certified laboratory, and the monitoring results were reported within the specified time. Therefore, ANL is in compliance with these Drinking Water regulations.

On June 7, 1991, the EPA promulgated final rules establishing National Primary Drinking Water Regulations for lead and copper. The regulations require collection of finished water samples for lead and copper analyses at selected sites and to determine if the

TABLE 6.2

State of Illinois - Required Organic Chemicals - 900.65 - February 16, 1993

	Maximum Contaminant Level	ANL Results (mg/L)				
		Well #1	Well #2	Well #3	Well #4	Tap
A) Benzene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
B) Carbon Tetrachloride	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
C) 1,2-Dichloroethane	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
D) Trichloroethylene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
E) para-dichlorobenzene	0.075 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
F) 1,1-Dichloroethylene	0.007 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
G) 1,1,1-Trichloroethane	0.20 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
H) Vinyl Chloride	0.002 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
I) cis-1,2-Dichloroethylene	0.07 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
J) 1,2-Dichloropropane	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
K) Ethylbenzene	0.7 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
L) Monochlorobenzene	0.1 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
M) o-Dichlorobenzene	0.6 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
N) Styrene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
O) Tetrachloroethylene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
P) Toluene	2 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Q) trans-1,2-Dichloroethylene	0.1 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
R) p-Xylene	10 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
m-Xylene		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
o-Xylene		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005

TABLE 6.3

State of Illinois - Required Organic Chemicals - 900.65 - May 18, 1993

	Maximum Contaminant Level	ANL Results (mg/L) Well #1	Well #2	Well #3	Well #4	Tap
A) Benzene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
B) Carbon Tetrachloride	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
C) 1,2-Dichloroethane	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
D) Trichloroethylene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
E) para-dichlorobenzene	0.075 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
F) 1,1-Dichloroethylene	0.007 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
G) 1,1,1-Trichloroethane	0.20 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
H) Vinyl Chloride	0.002 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
I) cis-1,2-Dichloroethylene	0.07 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
J) 1,2-Dichloropropane	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
K) Ethylbenzene	0.7 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
L) Monochlorobenzene	0.1 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
M) o-Dichlorobenzene	0.6 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
N) Styrene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
O) Tetrachloroethylene	0.005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
P) Toluene	2 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Q) trans-1,2-Dichloroethylene	0.1 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
R) p-Xylene	10 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
m-Xylene		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
o-Xylene		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005

TABLE 6.4

State of Illinois - Optional Organic Chemicals - 900.65 - February 16, 1993

Pesticides/Herbicides

	Maximum Contaminant Level	ANL Results (mg/L)				
		Well #1	Well #2	Well #3	Well #4	Tap
A) Alachlor	0.002 mg/L	< 0.00028	< 0.0002	< 0.0002	< 0.0002	< 0.0002
B) Aldicarb	0.01 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
C) Aldicarb Sulfone	0.04 mg/L	< 0.0008	< 0.0008	< 0.0008	< 0.0008	< 0.0008
D) Aldicarb Sulfoxide	0.01 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
E) Atrazine	0.003 mg/L	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
F) Carborfuran	0.04 mg/L	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009
G) Chlordane	0.002 mg/L	< 0.00064	< 0.00064	< 0.00064	< 0.00064	< 0.00064
H) Dibromochloropropane	0.0002 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
I) 2,4-D	0.07 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
J) Ethylene Dibromide	0.00005 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
K) Heptachlor	0.0004 mg/L	< 0.00004	< 0.00004	< 0.00004	< 0.00004	< 0.00004
L) Heptachlor Epoxide	0.0002 mg/L	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
M) Lindane	0.0002 mg/L	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
N) Methoxychlor	0.4 mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
O) PCBs - each	0.0005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
P) Pentachlorophenol	0.2 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Q) Toxaphene	0.005 mg/L	< 0.0016	< 0.0016	< 0.0016	< 0.0016	< 0.0016
R) 2,4,5-TP (Silvex)	0.05 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005

TABLE 6.5

State of Illinois - Optional Organic Chemicals - 900.65 - May 18, 1993

Pesticides/Herbicides

	Maximum Contaminant Level	ANL Results (mg/L)				
		Well #1	Well #2	Well #3	Well #4	Tap
A) Alachlor	0.002 mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
B) Aldicarb	0.01 mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
C) Aldicarb Sulfone	0.04 mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
D) Aldicarb Sulfoxide	0.01 mg/L	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
E) Atrazine	0.003 mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
F) Carborfuran	0.04 mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
G) Chlordane	0.002 mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
H) Dibromochloropropane	0.0002 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
I) 2,4-D	0.07 mg/L	< 0.070	< 0.070	< 0.070	< 0.070	< 0.070
J) Ethylene Dibromide	0.00005 mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
K) Heptachlor	0.0004 mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
L) Heptachlor Epoxide	0.0002 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
M) Lindane	0.0002 mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
N) Methoxychlor	0.4 mg/L	< 0.0005	< 0.040	< 0.040	< 0.040	< 0.040
O) PCBs - each	0.0005 mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
P) Pentachlorophenol	0.2 mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Q) Toxaphene	0.005 mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
R) 2,4,5-TP (Silvex)	0.05 mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050

TABLE 6.6

National Primary Drinking Water Regulations 141.40
Special Monitoring for Organic Chemicals - February 16, 1993

Federal Chemical Name	ANL Results (mg/L) Well #1	Well #2	Well #3	Well #4	Tap
(1) Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(2) Bromodichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(3) Chlorodibromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(4) Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(5) trans-1,2,-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(6) Chlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(7) m-Dichlorobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(8) Dichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0018
(9) cis-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(10) o-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(11) Dibromomethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(12) 1,1-Dichloropropene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(13) Tetrachloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(14) Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(15) p-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(16) o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(17) m-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(18) 1,1-Dichloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(19) 1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(20) 1,1,2,2-Tetrachloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(21) Ethylbenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(22) 1,3-Dichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(23) Styrene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(24) Chloromethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(25) Bromomethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(26) 1,2,3-Trichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(27) 1,1,1,2-Tetrachloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(28) Chloroethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(29) 1,1,2-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(30) 2,2-Dichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(31) o-Chlorotoluene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(32) p-Chlorotoluene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(33) Bromobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(34) 1,3-Dichloropropene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(35) Ethylene Dibromide (EDB)	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
(36) 1,2-Dibromo-3-chloropropane (DBCP)	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002

TABLE 6.7

National Primary Drinking Water Regulations 141.40
Special Monitoring for Organic Chemicals - May 18, 1993

	ANL Results (mg/L)				
Federal Chemical Name	Well #1	Well #2	Well #3	Well #4	Tap
(1) Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(2) Bromodichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(3) Chlorodibromomethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(4) Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(5) trans-1,2,-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(6) Chlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(7) m-Dichlorobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(8) Dichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(9) cis-1,2-Dichloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(10) o-Dichlorobenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(11) Dibromomethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(12) 1,1-Dichloropropene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(13) Tetrachloroethylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(14) Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(15) p-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(16) o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(17) m-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(18) 1,1-Dichloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(19) 1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(20) 1,1,2,2-Tetrachloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(21) Ethylbenzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(22) 1,3-Dichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(23) Styrene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(24) Chloromethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(25) Bromomethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(26) 1,2,3-Trichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(27) 1,1,1,2-Tetrachloroethane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(28) Chloroethane	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
(29) 1,1,2-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
(30) 2,2-Dichloropropane	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(31) o-Chlorotoluene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(32) p-Chlorotoluene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(33) Bromobenzene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(34) 1,3-Dichloropropene	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
(35) Ethylene Dibromide (EDB)	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
(36) 1,2-Dibromo-3-chloropropane (DBCP)	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002

concentrations are below the action level of 0.015 mg/L for lead and 1.3 mg/L for copper. The required sampling protocols maximize the opportunity for having lead and copper present. 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 first draw water where the water has stood motionless in the piping for at least six hours. For ANL, 40 sample sites are required, based on the population served. Two consecutive six-month monitoring periods are required the first year.

Samples were collected, following the above protocols, on December 3, 1992, analyzed by a laboratory certified to conduct Safe Drinking Water Act analyses, and transmitted to the Illinois Department of Public Health, through DOE-AAO, on January 5, 1993. The results indicated five of the 40 lead results exceeded the action level and therefore, ANL was required to continue lead and copper monitoring, provide public notice, analyze for water quality parameters, and develop a corrosion control plan.

To comply with these requirements, a public information notice concerning lead in drinking water was posted on March 1, 1993. Samples were collected on January 18, 1993, and analyzed for the water quality parameters (alkalinity, calcium, water temperature, pH, and conductivity). A corrosion control plan was developed and implemented by June 30, 1993; and ANL continued to conduct semi-annual sampling and analysis at 40 locations in CY 1993. Samples were collected on February 24, 1993, and August 3, 1993. The results are collected in Tables 6.8 ad 6.9, respectively. The data indicate that ANL did not exceed the action levels for lead and copper. On January 8, 1994, ANL received notification from the IDPH that the sampling frequency could be reduced to annually and the number of sampling sites reduced from 40 to 20.

6.1.2. Informational Monitoring

Samples were collected quarterly at the wellhead. These samples were analyzed for several types of radioactive constituents and volatile organic compounds to determine their

TABLE 6.8

Lead/Copper Samples Collected February 24, 1993

(Concentrations in mg/L)

	Lead	Copper
1.	< 0.005 (lowest)	0.07 (lowest)
2.	< 0.005	0.13
3.	< 0.005	0.16
4.	< 0.005	0.18
5.	< 0.005	0.20
6.	< 0.005	0.20
7.	< 0.005	0.22
8.	< 0.005	0.23
9.	< 0.005	0.25
10.	< 0.005	0.25
11.	< 0.005	0.37
12.	< 0.005	0.37
13.	< 0.005	0.39
14.	< 0.005	0.43
15.	< 0.005	0.45
16.	< 0.005	0.52
17.	< 0.005	0.57
18.	< 0.005	0.64
19.	< 0.005	0.66
20.	< 0.005	0.68
21.	< 0.005	0.71
22.	< 0.005	0.75
23.	< 0.005	0.77
24.	< 0.005	0.82
25.	< 0.005	0.82
26.	< 0.005	0.82
27.	< 0.005	0.86
28.	< 0.005	0.87
29.	< 0.005	0.87
30.	< 0.005	0.93
31.	< 0.005	1.0
32.	0.005	1.0
33.	0.006	1.0
34.	0.008	1.2
35.	0.008	1.2
36.	0.011 (90th Percentile)	1.3 (90th Percentile)
37.	0.016	1.6
38.	0.019	1.7
39.	0.023	1.8
40.	0.035 (highest)	2.1 (highest)

TABLE 6.9

Lead/Copper Samples Collected August 3, 1993

(Concentrations in mg/L)

	Lead	Copper
1.	< 0.005 (lowest)	0.05 (lowest)
2.	< 0.005	0.10
3.	< 0.005	0.14
4.	< 0.005	0.15
5.	< 0.005	0.16
6.	< 0.005	0.16
7.	< 0.005	0.16
8.	< 0.005	0.17
9.	< 0.005	0.21
10.	< 0.005	0.32
11.	< 0.005	0.36
12.	< 0.005	0.37
13.	< 0.005	0.37
14.	< 0.005	0.38
15.	< 0.005	0.43
16.	< 0.005	0.50
17.	< 0.005	0.51
18.	< 0.005	0.55
19.	< 0.005	0.55
20.	< 0.005	0.62
21.	< 0.005	0.64
22.	< 0.005	0.65
23.	< 0.005	0.69
24.	< 0.005	0.72
25.	< 0.005	0.72
26.	< 0.005	0.73
27.	0.005	0.79
28.	0.005	0.87
29.	0.006	0.92
30.	0.007	0.95
31.	0.008	1.1
32.	0.008	1.1
33.	0.010	1.2
34.	0.011	1.2
35.	0.013	1.3
36.	0.014 (90th Percentile)	1.3 (90th Percentile)
37.	0.017	1.4
38.	0.018	1.4
39.	0.032	1.7
40.	0.038 (highest)	3.2 (highest)

presence in the ANL 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. The results are presented in Table 6.10. Since ANL is a "non-transient, non-community" water system, the following EPA limits are established for the nuclides measured in Table 6.10:

Gross Alpha Particle Activity	=	15 pCi/L
Gross Beta Particle Activity	=	50 pCi/L
Hydrogen-3	=	2 x 10^4 pCi/L
Radium-226	=	5 pCi/L
Strontium-90	=	8 pCi/L

Well #1 was removed from service in 1990 and the system was not operated during 1993; however, samples were collected for monitoring. All the radiological results are in the normal range of concentrations for the various constituents and well below the EPA drinking water standards.

Although volatile organic compounds were not required to demonstrate compliance with the Drinking Water regulations for the second half of CY 1993, 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 on August 17, 1993, and November 22, 1993, and the results are collected in Table 6.11 and Table 6.12, respectively. 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 ten times the method detection limit.

No volatile organic compounds were detected in the wells with the exception of dichloromethane in Well 1 and Well 2 in the sample collected August 17, 1993. This compound was also detected in the method blank analysis. The tap water samples showed four volatile organic compounds (dichlorobromomethane, bromoform,

TABLE 6.10

Radioactivity in ANL Domestic Wells, 1993

(Concentrations in pCi/L)

Type of Activity	Location	No. of Samples	Avg.	Min.	Max.
Alpha (nonvolatile)	Well #1	4	10.3	6.6	15.3
	Well #2	4	4.7	3.8	6.2
	Well #3	4	3.3	1.7	4.0
	Well #4	4	2.9	1.9	4.1
	Tap	4	1.4	0.9	1.9
Beta (nonvolatile)	Well #1	4	19.0	13.9	22.8
	Well #2	4	9.8	9.3	10.2
	Well #3	4	9.7	9.4	10.0
	Well #4	4	9.8	9.1	10.3
	Tap	4	4.8	4.4	5.0
Hydrogen-3	Well #1	4	166	< 100	263
	Well #2	4	< 100	< 100	< 100
	Well #3	4	< 100	< 100	< 100
	Well #4	4	< 100	< 100	< 100
	Tap	4	< 100	< 100	< 100
Strontium-90	Well #1	4	0.38	< 0.25	0.62
	Well #2	4	< 0.25	< 0.25	< 0.25
	Well #3	4	< 0.25	< 0.25	< 0.25
	Well #4	4	< 0.25	< 0.25	< 0.25
	Tap	4	< 0.25	< 0.25	< 0.25
Radium-226	Well #1	1	-	-	0.55
	Well #2	1	-	-	0.77
	Well #3	1	-	-	0.76
	Well #4	1	-	-	0.66
	Tap	1	-	-	0.17
Radium-228	Well #1	1	-	-	0.33
	Well #2	1	-	-	0.87
	Well #3	1	-	-	0.56
	Well #4	1	-	-	0.42
	Tap	1	-	-	< 0.01
Uranium-234	Well #1	1	-	-	3.47
	Well #2	1	-	-	0.74
	Well #3	1	-	-	0.20
	Well #4	1	-	-	0.19
	Tap	1	-	-	0.34
Uranium-235	Well #1	1	-	-	0.11
	Well #2	1	-	-	0.02
	Well #3	1	-	-	< 0.01
	Well #4	1	-	-	< 0.01
	Tap	1	-	-	< 0.01
Uranium-238	Well #1	1	-	-	2.31
	Well #2	1	-	-	0.51
	Well #3	1	-	-	0.11
	Well #4	1	-	-	0.06
	Tap	1	-	-	0.21

TABLE 6.11

Volatile Organic Compounds in Drinking Water Collected August 17, 1993

(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	0.0142
Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0019
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	0.0107
Chloroethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0138
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

TABLE 6.11 (Contd.)

Parameter	Well #1	Well #2	Well #3	Well #4	Tap
Dichloromethane	0.0007	0.0023	< 0.0005	< 0.0005	0.0142
1,2-Dichloropropane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0019
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-Dichlorpropene	< 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
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

TABLE 6.11 (Contd.)

Parameter	Well #1	Well #2	Well #3	Well #4	Tap
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

TABLE 6.12

Volatile Organic Compounds in Drinking Water Collected November 22, 1993

(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	0.0166
Bromoform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0038
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	0.0189
Chloroethane	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chloroform	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0095
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

TABLE 6.12 (Contd.)

Parameter	Well #1	Well #2	Well #3	Well #4	Tap
Dichloromethane	0.0007	0.0023	< 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-Dichlorpropene	< 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
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

TABLE 6.12 (Contd.)

Parameter	Well #1	Well #2	Well #3	Well #4	Tap
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

chlorodibromomethane, and chloroform) present. These compounds are known to be associated with chlorination of drinking water, i.e., trihalomethanes.

6.2. Groundwater Monitoring at Waste Management Sites

ANL has occupied its current site since 1948. Since that time, waste generated by the Laboratory had been 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 which are routinely monitored are the 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 contains two RCRA permitted units which are undergoing closure. 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. A sketch of the 317/319 Area is shown in Figure 6.1.

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

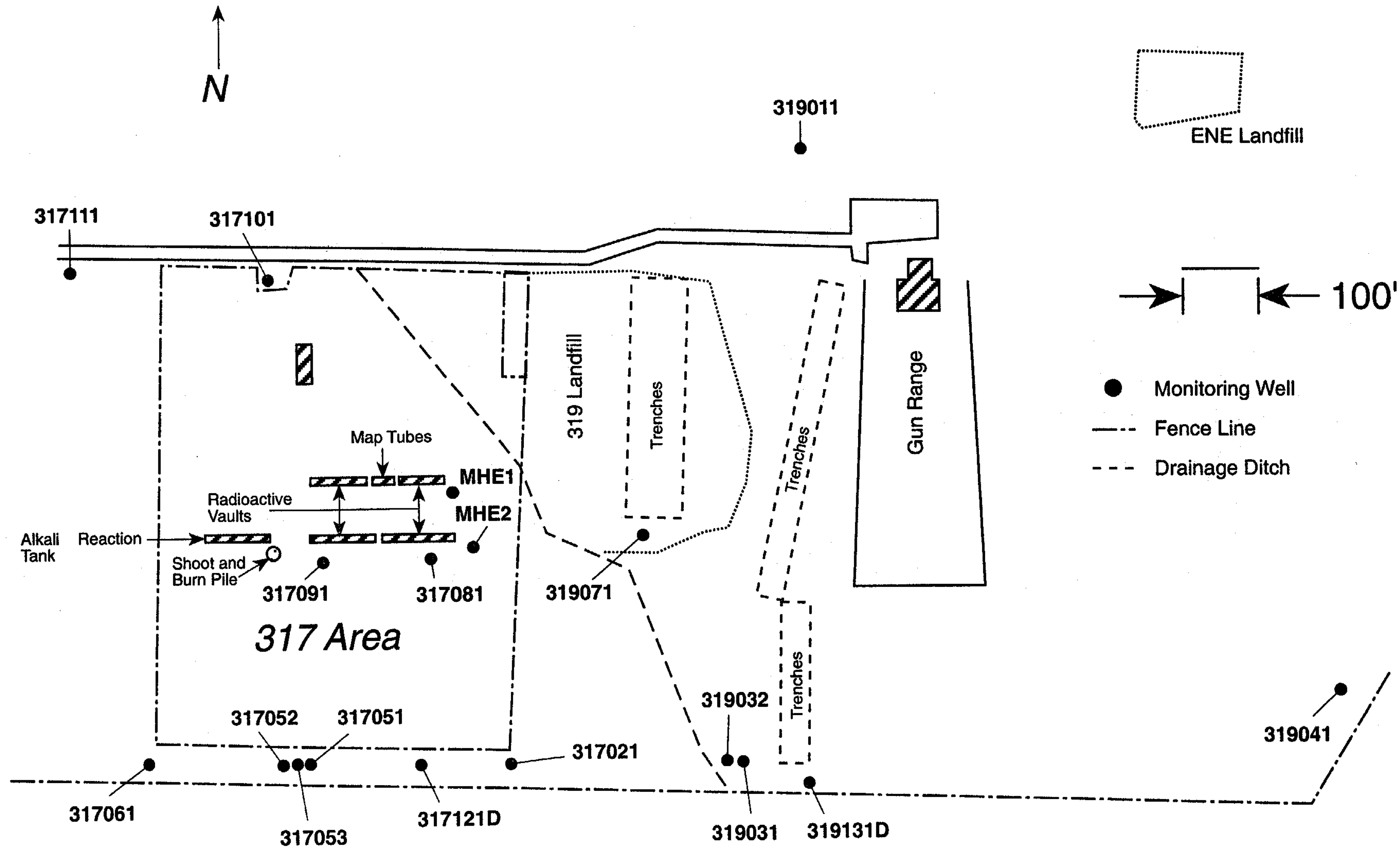


Figure 6.1 Locations of Components Within the 317/319/ENE Areas

unknown amounts of liquid chemical wastes. The landfill at 319 was operated from the mid-1950s until 1968 when the sanitary landfill in the 800 Area was put into use. 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.

The 317 Area contains six vaults used for temporary storage of solid radioactive waste. Water from footing drains and/or sumps is collected and discharged into a sewer system. This sewer system, which was designed to drain off-site, was permanently closed in 1986 after it was discovered that the water contained very small amounts of several radionuclides. Water collecting in the sewer system was periodically pumped out from manholes into portable tanks, transported to the Waste Management Building and analyzed for radioactivity before release to the laboratory sewage collection system. During August 1993, the discharge of water from these manholes to the laboratory sewer system began (see Section 5.1.2.4.). Monthly samples from two manholes associated with this system are analyzed for volatile organic compounds. The results are presented in Section 6.2.2.3.

The 319 Area currently consists of a mound created by waste fill activities. The waste consisted of noncombustible refuse, demolition and construction debris. In addition, suspect waste (material which was not known to be contaminated but which had the potential for hidden radioactive contamination which 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. A recent geophysical survey has identified at least three of these trenches.

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.

6.2.2. Groundwater Monitoring at the 317/319 Area

Twelve 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 6.13. The wide range in water level elevations shown in Table 6.13 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 Ground-Water Monitoring Technical Enforcement Guidance Document (September 1986).[24]

Groundwater monitoring in the 317/319 Area has been conducted since 1986. Wells 319011, 317021, 319031, and 319041 were installed in September 1986; 317051 and 317061 in August 1987; 319071, 317081, and 317091 in July 1988; 317101 and 317111 in September 1988; and wells 319032, 317053, 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.

Wells 317101 and 317111 are upgradient of the 317 storage area and well 319011 is upgradient of the 319 landfill area. A sand lens present at 5 to 8 m (15 to 25 ft) was recently discovered and wells 317053, 317052 and 319032 were placed at this depth. This layer is also intercepted by wells 317081, 317091, and 317101.

In addition to wells in this area, two manholes associated with the vault sewer system were monitored on a monthly basis. The locations of the manholes are shown in Figure 6.1.

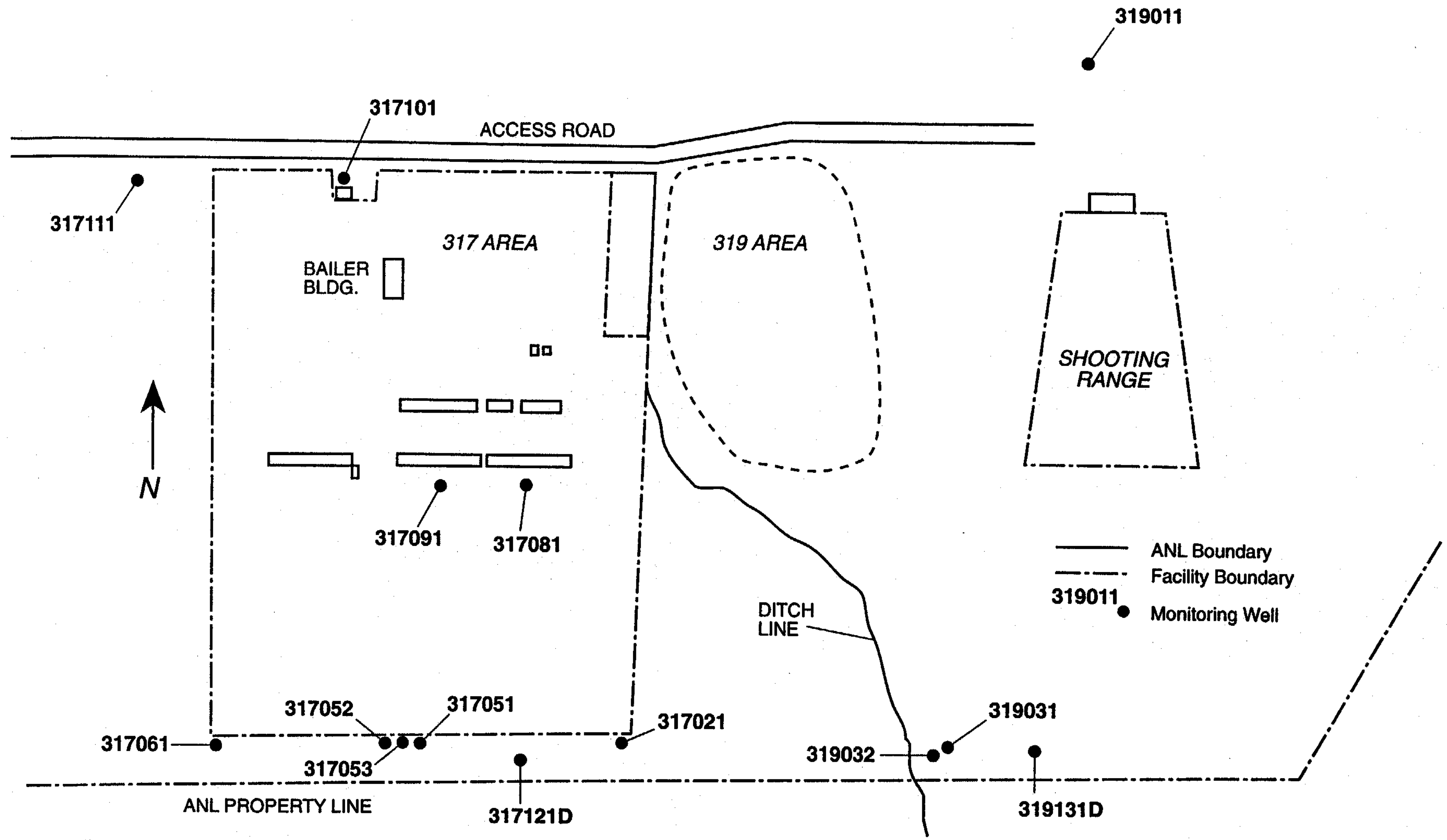


Figure 6.2 Active Monitoring Wells in the 317 and 319 Areas

TABLE 6.13

Groundwater Monitoring Wells - 317/319 Area

ID Number	Well Depth[1]	Ground Elevation[2]	Monitoring Zone[3]	Well Type[4]	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
317081	30	682.8	20-30/662-652	2/PVC	7/88	675.4
317091	30	684.0	20-30/663-653	2/PVC	7/88	674.4
317101	39	692.3	29-39/663/653	2/PVC	8/89	670.2
317111	39	698.8	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

[1]feet below ground
[2]feet mean sea level
[3]depth/elevation
[4]inner diameter (inches)/well material (PVC=polyvinyl chloride, CS=carbon steel))

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

6.2.2.1. Sample Collection

The monitoring wells are sampled using the protocols listed in the RCRA Ground-Water Monitoring Technical Enforcement Guidance Document.[24] 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 removed 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 which recharge rapidly, three well volumes are purged using dedicated submersible pumps while the field parameters are measured continuously. These parameters stabilize quickly in these wells. In the case of the dolomite wells, samples are collected as soon as these readings stabilize. Samples for volatile organics, semivolatile organics, PCB/pesticides, metals, and radioactivity are collected in that order. The samples are placed in precleaned bottles, labelled, 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 Analysis - 317/319 Area

The 317/319 groundwater chemical analyses were performed using standard operating procedures (SOPs) written, reviewed, and issued as controlled documents by members of the ESH-DACH. These SOPs reference protocols found in SW-846, 3rd edition, "Test Methods for Evaluating Solid Waste." Sixteen metals were routinely determined. Ten were done using flame atomic absorption spectroscopy and five by graphite furnace atomic absorption spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy. Chloride was determined by titrimetry. Volatile and semivolatile organic compounds were determined by gas chromatography-mass spectroscopy systems. In the case of organic compound analyses, efforts were made to identify compounds which were present, but not included on the method list. This was accomplished and standard solutions of these compounds were prepared and analyzed.

PCB/pesticides were determined by gas chromatography-electron capture detection at an off-site-contracted laboratory. SW-846 Procedure 8080 was specified and used.

The 317/319 groundwater radiological analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of the ESH-DARC. Cesium-137 was determined by gamma-ray spectrometry. Hydrogen-3 was determined by a beta liquid scintillation counting technique. Strontium-90 was determined by an ion-exchange separation followed by a proportional counting technique.

6.2.2.3 Results of Analyses

The description of each well, a listing 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 6.14 through 6.25. All radiological and inorganic analyses results are shown in these tables. The analysis methods used for organic compounds will 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 which were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 5 μg/L.

TABLE 6. 14

Groundwater Monitoring Results, 300 Area Well #319011, 1993

		m(MSL)
Well Point Elevation		196.95
Ground Surface Elevation		209.81
Casing Material:		PVC

Constituent	Units	03/23/93	06/23/93	09/08/93	09/08/93	11/15/93
Water Elevation	m	199.48	203.38	198.87	198.87	198.43
Temperature	°C	10.5	11.6	11.5	11.5	10.3
pH	pH	6.89	6.98	7.03	7.03	7.06
Redox	mV	-	108	- 230	- 230	74
Conductivity	μmhos/cm	819	835	830	830	803
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.034	0.034	0.020	0.033	0.031
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.05	< 0.05
Copper	mg/L	0.057	0.049	0.020	0.044	0.037
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.028	0.045	0.018	0.018	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	2.1	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	24	24	22	22	26
Methylene chloride	μg/L	-	5	-	-	-

TABLE 6.15

Groundwater Monitoring Results, 300 Area Well #317021, 1993

	m(MSL)
Well Point Elevation	196.90
Ground Surface Elevation	209.17
Casing Material:	PVC

Constituent	Units	03/23/93	06/23/93	09/15/93	11/15/93	11/15/93
Water Elevation	m	202.02	202.73	200.79	200.28	200.28
Temperature	°C	10.1	10.6	10.2	10.2	10.2
pH	pH	7.30	8.03	7.27	7.20	7.20
Redox	mV	3	92	24	67	67
Conductivity	μmhos/cm	538	545	527	550	550
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.034	0.031	0.034	0.032	0.031
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.042	0.037	0.034	0.027	0.027
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.016	0.018	0.019	< 0.015	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	1.3	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.100	0.103	< 0.100	0.110	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	8	10	11	19	19
1,1,1-Trichloroethane	μg/L	80	107	114	205	202
1,1-Dichloroethane	μg/L	44	70	99	162	165
1,1-Dichloroethene	μg/L	-	1	1	4	3
1,2-Dichloroethane	μg/L	15	9	12	24	25
Carbon tetrachloride	μg/L	8	8	8	14	13
Chloroform	μg/L	6	4	5	9	9
Methylene chloride	μg/L	-	6	-	1	4
Tetrachloroethene	μg/L	-	1	1	2	2
Toluene	μg/L	1	-	-	-	-
Trichloroethene	μg/L	2	2	2	3	3
cis-1,2-Dichloroethene	μg/L	-	-	-	1	1

TABLE 6.16

Groundwater Monitoring Results, 300 Area Well #319031, 1993

	m(MSL)
Well Point Elevation	192.08
Ground Surface Elevation	204.28
Casing Material:	PVC

Constituent	Units	03/23/93	06/23/93	09/15/93	11/17/93
Water Elevation	m	192.85	193.17	193.11	193.09
Temperature	°C	10.2	10.7	10.2	10.1
pH	pH	7.01	7.10	7.00	7.12
Redox	mV	3	130	23	175
Conductivity	μmhos/cm	701	685	682	683
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.059	0.052	0.056	0.052
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.053	0.043	0.040	0.034
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.016	0.018	0.018	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	< 1.0	1.1	1.6
Hydrogen-3	nCi/L	1.174	0.923	0.940	1.037
Strontium-90	pCi/L	0.40	0.46	0.42	0.41
Chloride	mg/L	33	24	24	27
1,1,1-Trichloroethane	μg/L	6	4	4	4
1,1-Dichloroethane	μg/L	4	-	-	-
Chloroform	μg/L	4	-	-	-
Trichloroethene	μg/L	6	5	6	6

TABLE 6.17

Groundwater Monitoring Results, 300 Area Well #319032, 1993

	m(MSL)
Well Point Elevation	195.82
Ground Surface Elevation	204.28
Casing Material:	PVC

Constituent	Units	03/23/93	06/23/93	09/08/93	11/17/93
Water Elevation	m	197.88	198.04	197.48	197.42
Temperature	°C	9.9	9.8	10.2	10.8
pH	pH	6.83	7.03	6.83	7.02
Redox	mV	12	140	- 168	179
Conductivity	μmhos/cm	780	778	794	795
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.057	0.057	0.061	0.068
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.055	0.045	0.042	0.038
Iron	mg/L	< 0.05	< 0.05	< 0.05	0.35
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.018	0.029	0.019	0.024
Mercury	μg/L	0.2	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	2.0	< 1.0	2.0
Hydrogen-3	nCi/L	0.756	0.780	0.773	0.754
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	26	26	29	25
Methylene chloride	μg/L	-	5	-	-

TABLE 6.18

Groundwater Monitoring Results, 300 Area Well #317052, 1993

	m(MSL)
Well Point Elevation	203.70
Ground Surface Elevation	208.32
Casing Material:	PVC

Constituent	Units	03/23/93	06/23/93	09/15/93	11/15/93
Water Elevation	m	205.65	205.88	205.65	204.90
Temperature	°C	6.8	10.2	13.9	12.5
pH	pH	7.08	7.35	7.18	7.25
Redox	mV	14	130	18	63
Conductivity	μmhos/cm	453	495	530	518
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.024	0.022	0.023	0.023
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.040	0.030	0.026	0.022
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.018	0.017	0.018	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	1.9	3.4	1.3	< 1.0
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	7	4	3	2

TABLE 6.19

Groundwater Monitoring Results, 300 Area Well #317061, 1993

	m(MSL)
Well Point Elevation	194.93
Ground Surface Elevation	207.54
Casing Material:	PVC

Constituent	Units	03/23/93	06/23/93	09/15/93	11/17/93
Water Elevation	m	200.58	201.01	198.98	198.76
Temperature	°C	10.4	11.1	10.4	10.3
pH	pH	6.95	7.14	6.89	7.16
Redox	mV	2	139	25	172
Conductivity	µmhos/cm	785	795	761	763
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.057	0.053	0.054	0.053
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.055	0.044	0.039	0.036
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.036	0.037	0.034	0.031
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	1.2	< 1.0	< 1.0
Hydrogen-3	nCi/L	< 0.100	0.194	< 0.100	0.109
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	51	51	52	53
Methylene chloride	µg/L	-	7	-	-

TABLE 6.20

Groundwater Monitoring Results, 300 Area Well #317081, 1993

	m(MSL)
Well Point Elevation	192.08
Ground Surface Elevation	208.14
Casing Material:	PVC

Constituent	Units	03/25/93	06/23/93	09/10/93	11/19/93
Water Elevation	m	205.44	205.23	203.70	203.80
Temperature	°C	9.5	10.6	11.9	12.5
pH	pH	8.04	6.89	6.62	6.84
Redox	mV	61	120	- 52	167
Conductivity	μmhos/cm	1	526	615	621
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.042	0.041	0.049	0.049
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.048	0.037	0.039	0.031
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.047	0.019	0.020	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	8.3	11.3	2.5	7.7
Hydrogen-3	nCi/L	0.231	0.125	0.322	0.224
Strontium-90	pCi/L	3.84	3.19	5.65	4.88
Chloride	mg/L	8	6	7	9
Carbon tetrachloride	μg/L	-	-	3	4
Chloroform	μg/L	5	2	3	6
Tetrachloroethene	μg/L	-	-	1	1
Trichloroethene	μg/L	164	151	-	263
cis-1,2-Dichloroethene	μg/L	6	2	3	6
trans-1,2-Dichloroethene	μg/L	-	-	-	1

TABLE 6.21

Groundwater Monitoring Results, 300 Area Well #317091, 1993

	m(MSL)
Well Point Elevation	199.16
Ground Surface Elevation	208.14
Casing Material:	PVC

Constituent	Units	03/25/93	06/24/93	09/17/93	11/15/93
Water Elevation	m	204.77	204.66	203.54	201.92
Temperature	°C	6.9	10.8	15.4	13.1
pH	pH	7.12	7.31	7.17	7.04
Redox	mV	92	103	43	53
Conductivity	μmhos/cm	475	541	570	548
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.029	0.028	0.029	0.030
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.042	0.034	0.030	0.023
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.016	0.018	0.018	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	-	1.5	-	< 1.0
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	1.62	1.06	0.39	< 0.25
Chloride	mg/L	10	6	10	5
Chloroform	μg/L	-	-	3	-
Methylene chloride	μg/L	-	8	-	-
Trichloroethene	μg/L	1	-	0.5	-

TABLE 6.22

Groundwater Monitoring Results, 300 Area Well #317101, 1993

	m(MSL)
Well Point Elevation	198.66
Ground SurfaceElevation	211.04
Casing Material:	PVC

Constituent	Units	03/23/93	06/24/93	09/15/93	11/17/93
Water Elevation	m	203.86	204.77	203.06	202.81
Temperature	°C	11.2	11.3	11.1	11.6
pH	pH	6.98	7.02	6.85	7.05
Redox	mV	14	115	23	176
Conductivity	μmhos/cm	1354	1388	1409	1329
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.067	0.060	0.055	0.056
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.057	0.045	0.045	0.037
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.033	0.034	0.034	0.090
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	1.1
Hydrogen-3	nCi/L	< 0.100	0.119	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	334	347	325	286
Methylene chloride	μg/L	-	5	-	-

TABLE 6.23

Groundwater Monitoring Results, 300 Area Well #317111, 1993

	m(MSL)
Well Point Elevation	200.72
Ground Surface Elevation	213.02
Casing Material:	PVC

Constituent	Units	03/23/93	06/23/93	09/15/93	11/17/93
Water Elevation	m	207.70	206.85	203.96	203.93
Temperature	°C	10.8	11.0	10.9	10.6
pH	pH	7.12	7.04	7.02	7.10
Redox	mV	-17	75	20	185
Conductivity	μmhos/cm	788	751	884	832
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.065	0.057	0.077	0.072
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.052	0.038	0.040	0.032
Iron	mg/L	0.19	0.12	0.63	0.63
Lead	mg/L	< 0.0010	0.0012	< 0.0010	< 0.0010
Manganese	mg/L	0.053	0.050	0.083	0.066
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	2.4	1.6	1.3
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	110	99	127	126

TABLE 6.24

Groundwater Monitoring Results, 300 Area Well #317121D, 1993

	m(MSL)
Well Point Elevation	183.17
Ground Surface Elevation	207.57
Casing Material:	STEEL

Constituent	Units	03/24/93	03/24/93	06/23/93	09/16/93	11/18/93
Water Elevation	m	186.43	186.43	186.47	186.33	185.71
Temperature	°C	11.1	11.3	13.7	14.0	11.7
pH	pH	11.52	12.00	11.60	11.60	9.12
Redox	mV	- 126	- 126	- 26	- 117	98
Conductivity	μmhos/cm	1010	560	775	698	474
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.023	0.041	0.040	0.055	0.039
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.033	0.050	0.043	0.034	0.032
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.019	0.031	0.028	0.023	0.024
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	< 1.0	< 1.0	2.0	< 1.0
Hydrogen-3	nCi/L	0.118	0.121	0.153	< 0.100	0.127
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	42	47	44	48	46
Methylene chloride	μg/L	-	-	22	-	-

TABLE 6.25

Groundwater Monitoring Results, 300 Area Well #319131D, 1993

	m(MSL)
Well Point Elevation	182.06
Ground Surface Elevation	203.56
Casing Material:	STEEL

Constituent	Units	03/24/93	06/23/93	06/23/93	09/16/93	11/17/93
Water Elevation	m	184.79	185.01	185.01	184.48	183.68
Temperature	°C	11.3	12.5	12.5	12.0	11.9
pH	pH	7.08	7.23	7.23	7.00	7.17
Redox	mV	2	125.0	125	17	182
Conductivity	µmhos/cm	795	750	750	797	798
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.066	0.070	0.070	0.074	0.070
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.047	0.047	0.046	0.045	0.037
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.024	0.022	0.022	0.019	0.016
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	0.012	0.023	0.025	0.012	< 0.010
Cesium-137	pCi/L	1.5	< 1.0	< 1.0	< 1.0	< 1.0
Hydrogen-3	nCi/L	0.863	0.743	0.730	1.128	1.322
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	37	49	48	47	45
Methylene chloride	µg/L	-	-	1	-	-

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 remain fairly constant after two well volumes are removed. The redox potential changes radically after two well volumes are removed and then becomes constant. 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.

Inorganic Results

The Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater, 35 IAC Section 620.410, were used as the standard for evaluation of the inorganic results based on evaluation of the regulations. The standards are presented in Table 6.26. In 1993, 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). Previous routine quarterly groundwater samples have historically been run for total metals analysis which requires collection of the sample in an acidified container followed by acid digestion. As a result, metal concentrations for 1993 tend to be significantly lower than concentrations reported 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. The pH changes drastically between the purging of 2 to 5 volumes of water. In each case, the last value obtained was recorded. Several wells had elevated levels of barium, copper, and manganese, but well below the WQS. Barium concentrations in these wells ranged from 0.02 mg/L to 0.07 mg/L, copper levels ranged from 0.02 mg/L to 0.06 mg/L, and manganese levels ranged from. 0.01 mg/L to 0.09 mg/L. The source of the elevated barium, copper, and manganese levels is unknown. Upgradient well 317111 had elevated levels of iron in each quarter, but the levels were well below the WQS. Elevated levels of iron and manganese have been reported in previous annual reports.[12]

TABLE 6.26

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

Constituent	Standard
Arsenic	0.05
Barium	2
Boron	2
Cadmium	0.005
Chloride	200
Chromium	0.1
Cobalt	1
Copper	0.65
Cyanide	0.2
Fluoride	4.0
Iron	5
Lead	0.0075
Manganese	0.15
Mercury	0.002
Nickel	0.2
Nitrate, as N	10
Radium-226	20 pCi/L
Radium-228	20 pCi/L
Selenium	0.05
Silver	0.05
Sulfate	400
Total Dissolved Solids	1,200
Zinc	5
pH	6.5-9.0 units

Organic Results

Each well was sampled quarterly and analyzed for volatile organic compounds. The results for 1993 are similar to those reported for 1992. Volatile organic compounds were detected in wells 319011, 317021, 319031, 319032, 317052, 317061, 3317081, 317091, 317101, and 317121D. The levels of volatile organics are persistent and appear to be indicative of different sources of contamination. Once during the year the wells were sampled and analyzed for semivolatile organic compounds, polychlorinated biphenyls (PCBs) and pesticides and herbicides. In 1993, no semivolatiles, PCBs, pesticides, or herbicides were found.

The results for well 317021 are shown in Figure 6.3. The major components are 1,1,1-trichloroethane (TCA, exceeding the WQS) 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 which is unaffected by seasonal water level changes. The large increase in the summer and fall of 1991 clearly is related to a period of intense drought and could be related to restricted flow of normal dilution water. Levels exceeding the WQS for carbon tetrachloride were also found. Trace levels of chloroform, 1,1-dichloroethene, 1,2-dichloroethane, trichloroethene (TCE), tetrachloroethene, methylene chloride, and cis-1,2-dichloroethene were also found in this well. The well is immediately below the plugged sewer line previously discussed and this sewer line is known to be contaminated with these four compounds. 1,1-dichloroethene was found in trace amounts, which can be a decomposition product of TCE.

Wells 317081 and 317091 are adjacent to the storage vaults and are close to one another. The chemical characteristics are quite dissimilar. The principal volatile organic compounds found in well 317081 are TCE and cis-1,2-dichloroethene (1,2-DCE). The results obtained from the beginning of sampling until the end of 1993 are shown in Figure 6.4. When TCE breaks down in the presence of soil bacteria, the cis isomer of 1,2-DCE

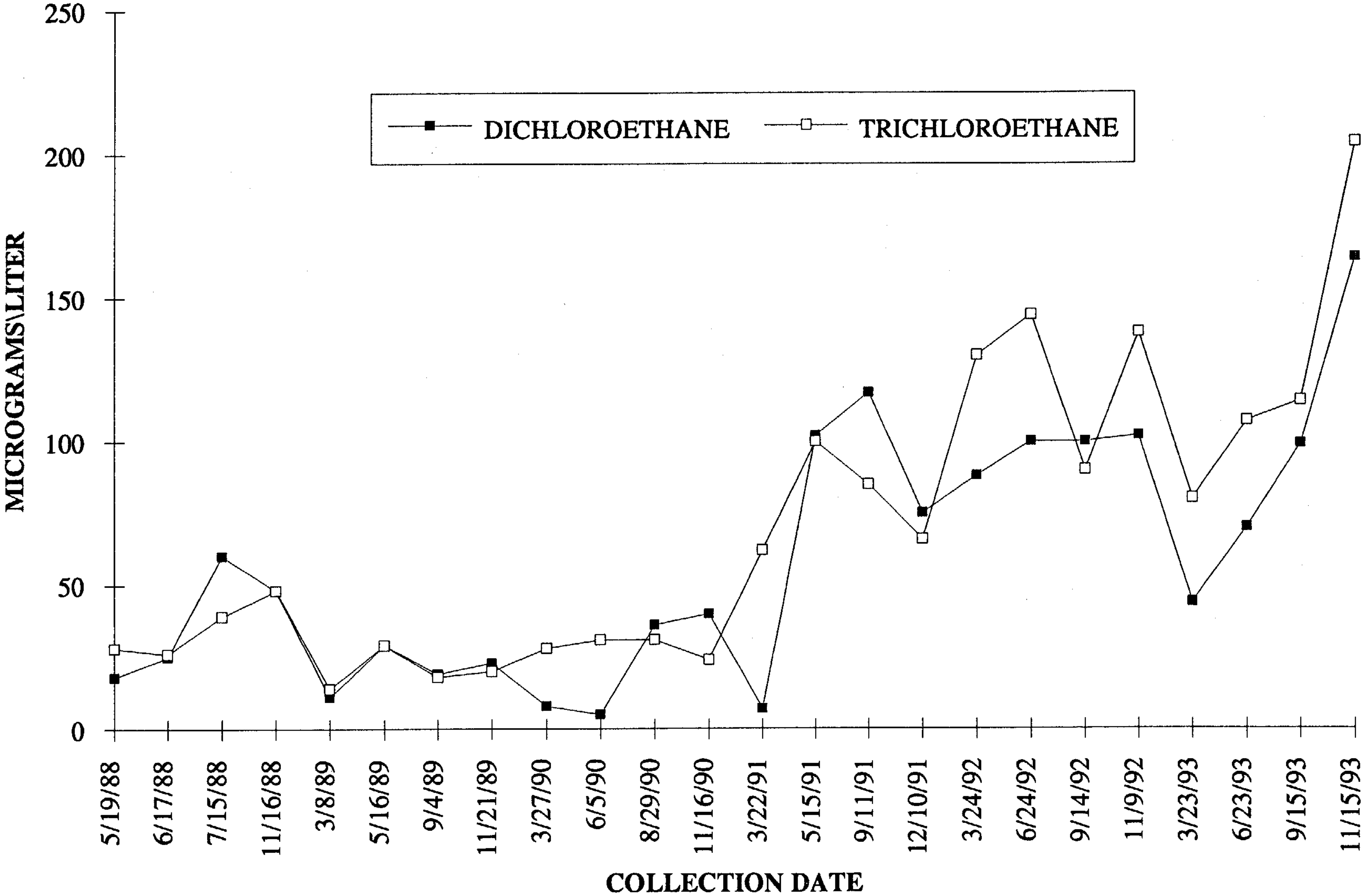


Figure 6.3 Concentrations of 1,1-Dichloroethane and 1,1,1-Trichloroethane in Well #317021

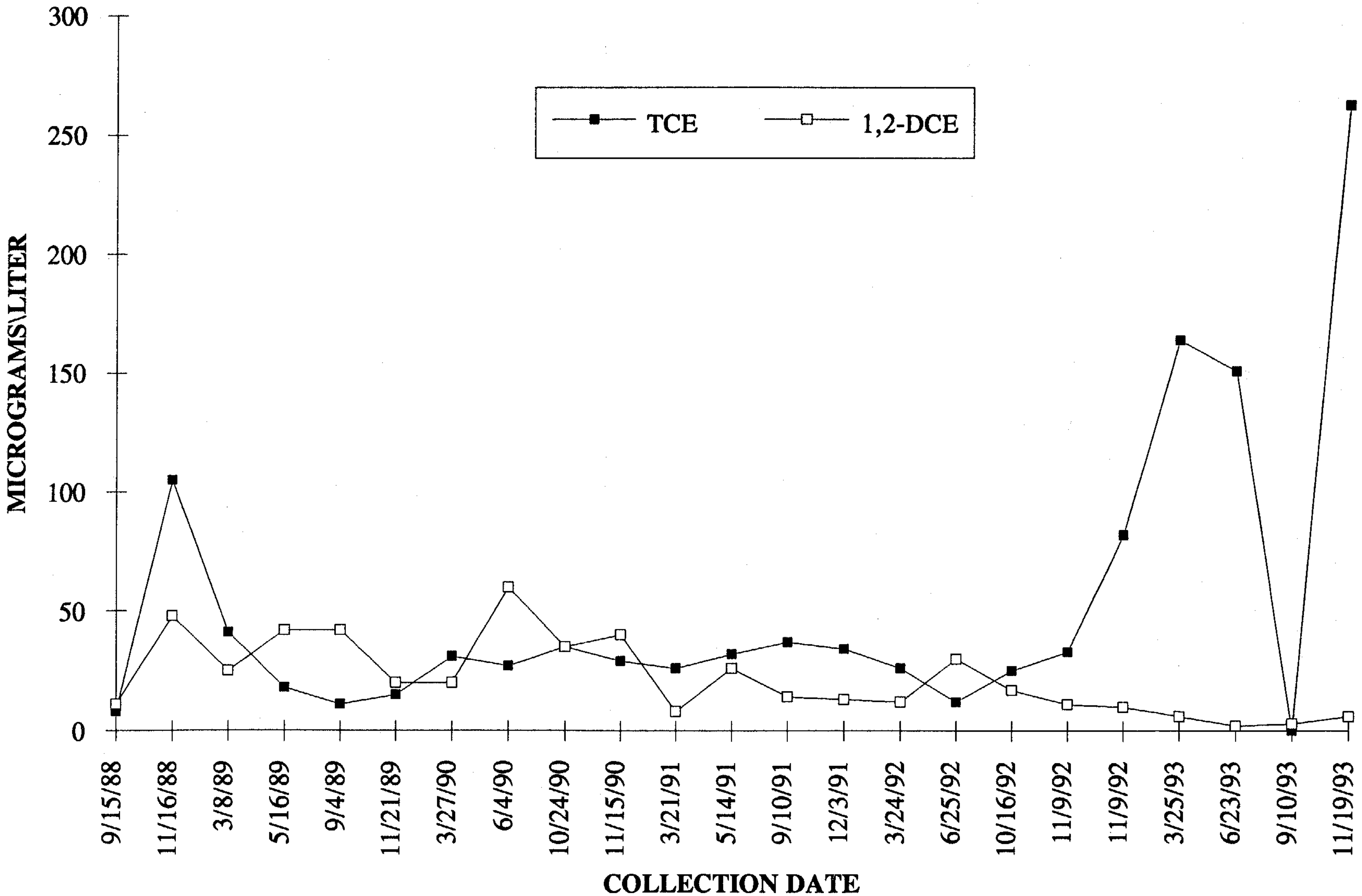


Figure 6.4 Concentrations of Trichloroethane and cis-1,2-Dichloroethane in Well #317081

is produced almost exclusively. The fact that they are both present in these samples at relatively stable concentrations indicates that there may be ongoing release of TCE into the groundwater, such as from highly contaminated soil. The half life for the conversion indicated is about 30 days. The end product of this conversion is vinyl chloride which has a half-life of 26,000 days. Vinyl chloride has never been detected in these samples. Chloroform, carbon tetrachloride, tetrachloroethane, acetone, and methylene chloride are occasionally found in trace amounts in this well. In contrast, the levels and variety of volatile organics found in well 317091 are quite variable. In the initial samples obtained in 1988, very high amounts of 1,1,1,-trichloroethane and 1,1-dichloroethane (170 and 160 μg/L, respectively) were found. In subsequent samples, values for 1,1-dichloroethane have ranged from 1 μg/L to 186 μg/L and values for 1,1,1-trichloroethane have ranged from 1 μg/L to 31 μg/L. Trichloroethene, tetrachloroethene and 1,2-dichloroethane have also been detected on occasion. During 1992, trace levels of chloroform, methylene chloride, and cis-1,2-dichloroethene were found. Methylene chloride was found often in most samples and blanks. During 1993, trace levels of chloroform, methylene chloride were found during one quarter and trace levels of trichloroethane were found during two quarters.

The dolomite wells 317121D and 319131D had only trace levels of methylene chloride during one quarter. Low levels of trichloroethene and 1,1,1-trichloroethane were detected in well 319031. This is consistent with results noted in previous reports. This well is frequently dry but it contains organic constituents when water is present.

Polychlorinated biphenyl compounds were reported in several of the wells in 1990. These wells were resampled in 1991, 1992, and 1993 and no PCBs were indicated. This confirms previous sampling results. Semivolatile organics and pesticides/herbicides were not detected in any of the wells during 1993.

Manholes E1 and E2 described in Sections 6.2.1 and 6.2.2, in the 317 Area are sampled monthly and analyzed for volatile organic compounds. The results are presented in Table 6.27. Existing foundation drains around storage vaults convey groundwater away from the structures and into manholes E1 and E2. Volatile organics are detected at fairly

TABLE 6.27

Volatile Organic Compounds in 317 Area Manholes E-1 and E-2, 1993

(Concentrations in μg/L)

Date	Chloroform		Tetra-chloroethene		Tri-chloroethene		cis-1,2-Dichloroethene	
	E-1	E-2	E-1	E-2	E-1	E-2	E-1	E-2
January 13	304	66	154	1	38	20	28	22
February 24	278	24	62	7	24	6	25	10
March 26	1	1	127	92	29	34	16	20
April 30	1	1	120	207	158	99	77	49
May 26	101	8	98	18	5	5	5	10
June 24	1	3	72	1	59	11	23	40
July 28	1	56	71	32	33	4	18	2
August 25	1	1	73	80	110	49	65	29
September 28	1	1	105	115	144	103	108	75
October 28	83	2	64	2	11	8	24	26
November 15	133	54	1	1	25	12	13	6
December 2	80	47	214	148	13	10	14	15

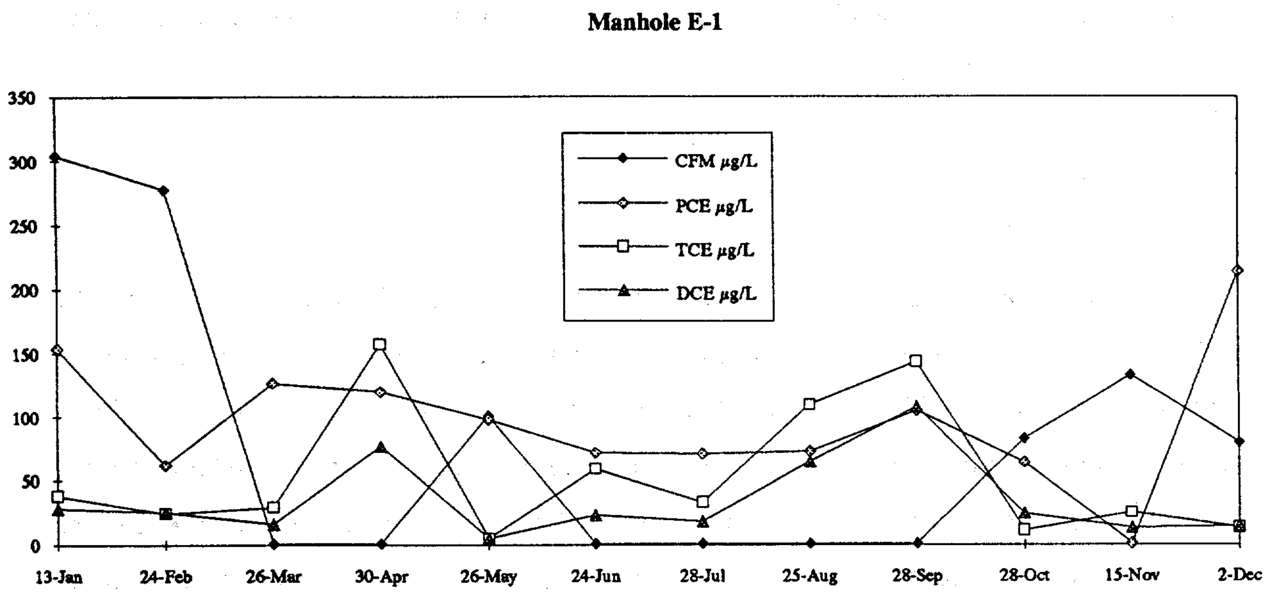
consistent levels in all samples as shown in Figure 6.5. As previously discussed for well 317081, the consistency would indicate that these manholes are collecting an area of contaminated water. The fact that levels are constant and the TCE and 1,2-DCE are present in all samples, indicates an ongoing release of these compounds into the groundwater, such as from highly contaminated soils. Trace levels of acetone, benzene, trans-1,2-dichloroethene, 1,2-dichloroethane, 1,1,1-trichloroethane, 4-methyl-2-pentanone, ethyl ether, and methylene chloride have been found but not on a consistent basis. Notably inconsistent during 1993 as compared to 1992 is carbon tetrachloride which was detected only during February, June, July, and October and only in manhole E2. The source of these compounds is believed to be the French drains previously described in Section 6.2.1 but additional characterization activities described in Section 6.5.2 will better define the nature, rate, and extent of contamination at this location.

Radioactive Constituents

Samples collected quarterly from the monitoring wells in the 317 and 319 Areas were analyzed for hydrogen-3, strontium-90, and for gamma-ray emitters. The results are presented in Tables 6.14 to 6.25 The only evidence of possible migration of radionuclides off the site is the low concentrations of hydrogen-3 in wells 319031, 319032, and 319131D, which are located near the south perimeter fence. A small amount of strontium-90 was also detected in well 319031. These monitoring wells are directly below a small drainage swale from the 319 Area that has contained water intermittently with measurable concentrations of hydrogen-3 and strontium-90. Well 317081 contains measurable levels of hydrogen-3, strontium-90, cesium-137, while well 317091 contains strontium-90. These wells are next to facilities that have stored radioactive materials in the past. All concentrations are well below any applicable standards.

6.3 Sanitary Landfill

The 800 Area is the site of ANL's sanitary landfill. The 21.8-acre landfill is located on the western edge of ANL property (Figure 1.1). The landfill has received waste since



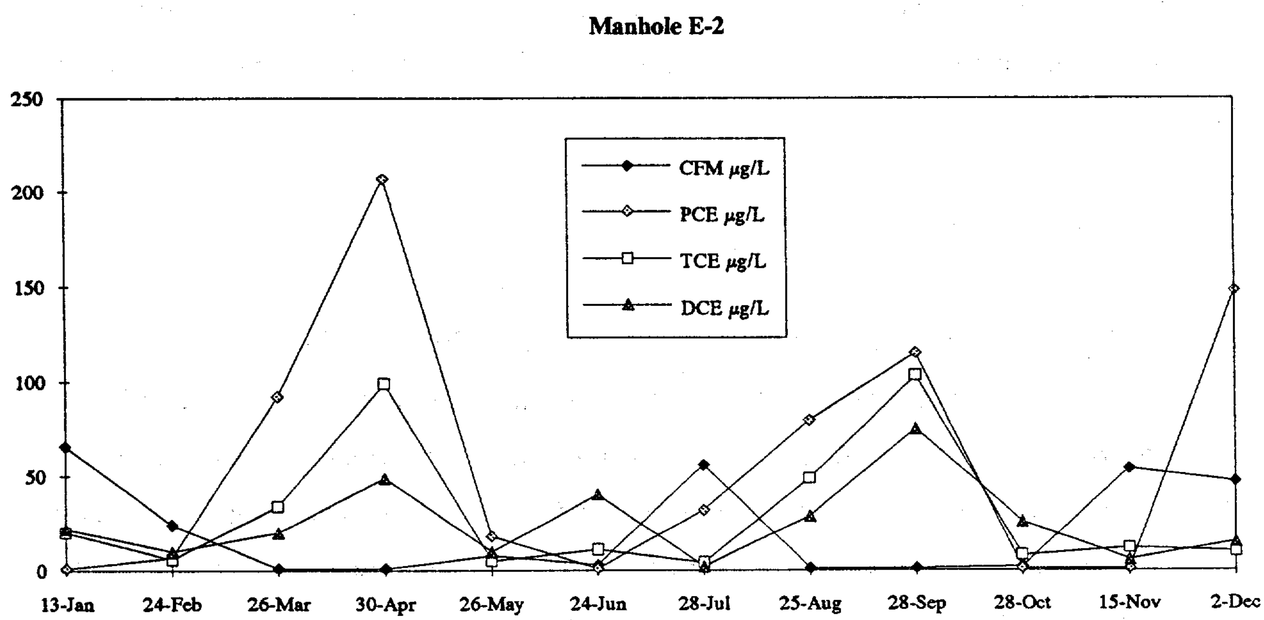


Figure 6.5 Trends of Selected Organics in 317 Area Manholes, 1993

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 number 1992-002-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 which 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. There is documentation available that indicates that 29,000 gallons of liquid waste were placed in this drain. Many 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

In 1979, an investigation was conducted to determine the subsurface characteristics of the site and to place monitoring wells around the landfill (see Figure 6.6 and Table 6.28). The topography and initial studies indicated that water flow was primarily southerly. Wells 800011R and 800051 were located outside the landfill and were meant to measure water entering and leaving the landfill. Wells 800020, 800031, and 800040 were placed at the perimeter of the landfill. In April 1980, a more comprehensive study was initiated to develop information required for the State of Illinois operating permit.[25] Three additional wells were placed at the perimeter to improve coverage as well as to measure vertical movement. Well 800061 was placed in the eastern section to sample any water flowing out of the landfill in a southeasterly direction. Wells 800070 and 800071 were located along the southern boundary and were nested. In September 1986, six new wells were installed.

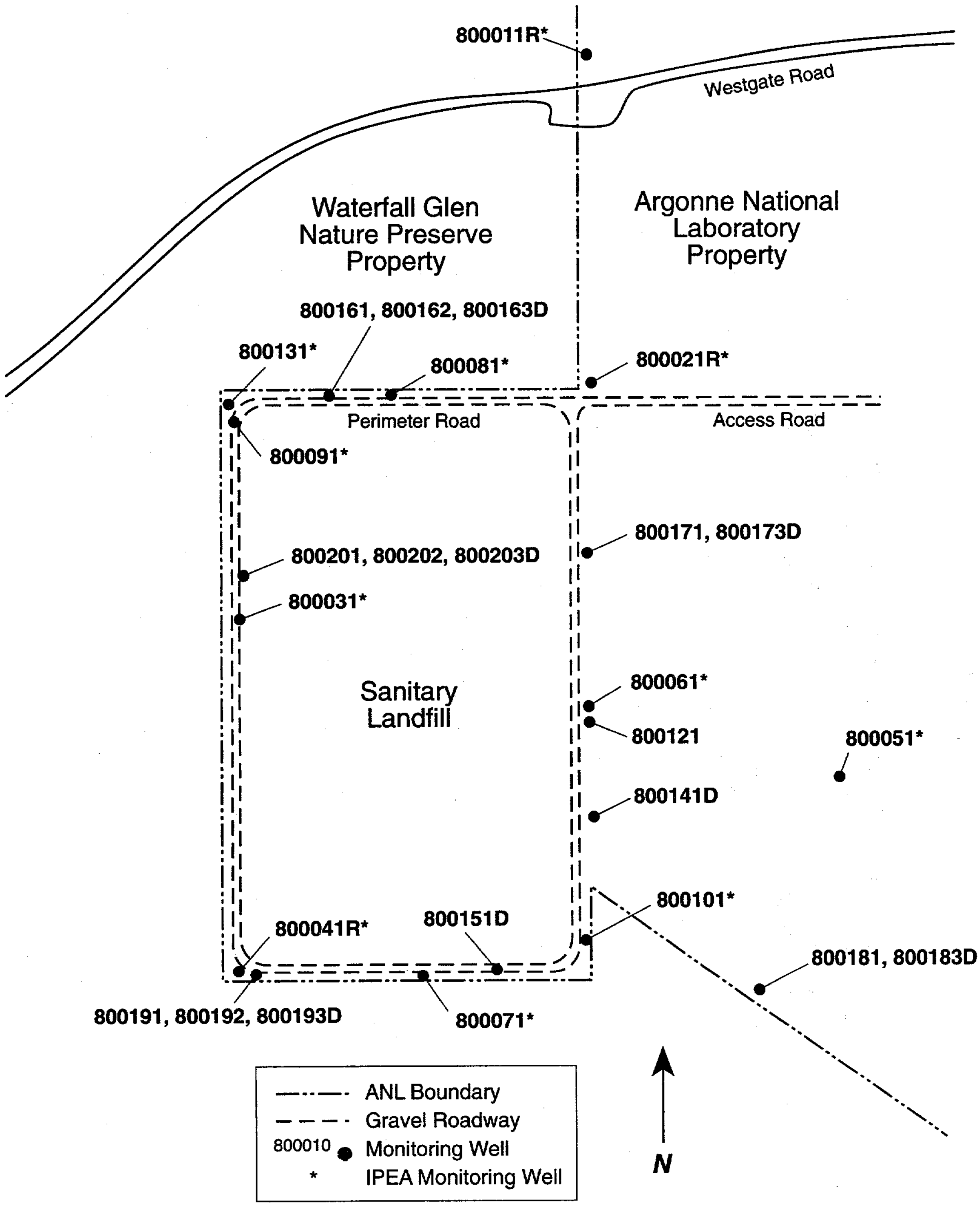


Figure 6.6 Active Monitoring Wells in the 800 Area Landfill (not to scale)

TABLE 6.28

Groundwater Monitoring Wells - 800 Area Landfill

ID Number	Well Depth[1]	Ground Elevation[2]	Monitoring Zone[3]	Well Type[4]	Date Drilled	Water Elevation
800011R	25	747.0	20-25/727-722	2/PVC	9/86	744.88
800021R	55	757.3	50-55/707-702	2/PVC	9/86	741.26
800031	27	744.0	17-27/727-717	2/PVC	10/79	737.02
800041R	25	745.5	20-25/725-720	2/PVC	9/86	740.24
800051	44	746.5	32-44/714-702	2/PVC	10/79	dry
800061	44	748.5	41-44/725-722	2/PVC	4/80	717.72
800071	25	747.4	22-25/725-722	2/PVC	4/80	733.22
800081	30	759.6	25-30/735-730	2/PVC	9/86	753.31
800091	20	754.5	15-20/739-734	2/PVC	9/86	748.06
800101	22	751.8	17-22/735-730	2/PVC	9/86	751.63
800121	32	748.5	27-32/721-716	4/SS	11/87	not measured
800131	78	754.5	68-78/686-676	4/SS	12/87	716.18
800141D	148	753.0	139-148/614-605	6/CS	9/88	not measured
800151D	151	747.4	147-151/600-596	6/CS	9/88	not measured
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

TABLE 6.28 (Contd.)

Groundwater Monitoring Wells - 800 Area Landfill

ID Number	Well Depth[1]	Ground Elevation[2]	Monitoring Zone[3]	Well Type[4]	Date Drilled	Water Elevation
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

[1]feet below ground
[2]feet mean sea level
[3]depth/elevation
[4]inner diameter (inches)/well material (PVC=polyvinyl chloride, SS=stainless steel, CS=carbon steel)

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

Wells 800010, 800020, and 800040 were suspected of being poorly sealed and were removed and replaced by 800011R, 800021R and 800041R. The replacement wells were located within 2 m (6 ft) of the original wells. In addition, wells 800081, 800091, and 800101 were constructed to improve peripheral coverage. In November 1987, additional wells were added to provide sampling at a deeper level. Well 800121 is 10 m (32 ft). Well 800131, which is next to 800091, was installed to a depth of 24 m (78 ft). Finally, in September 1989, two wells (800141D and 800151D) were placed into the dolomite at depths of 45 m (148 ft) and 46 m (151 ft), respectively.

During October 1992, 15 additional stainless steel wells, Wells Nos. 800161 through 800203D, were installed around the landfill as part of the IEPA-approved closure plan. These wells were not required to be monitored as part of the IEPA-approved groundwater monitoring program during 1993.

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. Previous water level measurements have indicated that a perched water layer exists at a depth of about 6 m (20 ft) on the north to about 7.6 m (25 ft) on the south. Wells 800011R through 800101 sample this layer. Well 800051 was dry during 1993. Wells 800121 and 800131, which are at depths of 10 m (32 ft) and 24 m (80 ft), respectively, exhibit very different characteristics. Well 800131 has an abundant supply of water [casing volume of about 100 L (27 gal)] while well 800110 is usually dry. It is not known if there is a water layer at this depth or if well 800131 is in a local body of water. The dolomite wells are at a depth of about 45 m (148 ft), and both have an abundant supply of water.

6.3.2.2. Sample Analysis - 800 Area

The 800 Area sample analyses were performed using SOPs written, reviewed, and issued as controlled documents by members of the ESH-DACH and ESH-DACL. These

SOPs reference protocols found in SW-846, 3rd edition, "Test Methods for Evaluating Solid Waste." Sixteen metals were routinely determined. Ten metals were done using flame atomic absorption spectroscopy and five metals were analyzed by graphite furnace atomic absorption spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy. Volatile and semivolatile organic compounds were determined by gas chromatography-mass spectroscopy systems. In the case of organic compound analyses, efforts were made to identify compounds which were present, but not included on the method list. This was accomplished and standard solutions of these compounds were prepared and analyzed. Total dissolved solids (TDS) were determined gravimetrically. Sulfate determination was performed using a turbidimetric technique while chloride was determined by titrimetry. Ammonia was analyzed using distillation followed by determination by specific ion electrode.

Some analyses were performed at an off-site contracted laboratory. SW-846 procedures were specified and used. PCB/pesticides were determined by gas chromatography-electron capture detection. 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.

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 beta liquid scintillation counting technique. Strontium-90 was determined by an ion-exchange separation followed by a proportional counting technique.

6.3.2.3. Results of Analyses

A description of each well, a listing 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 6.29 to 6.41. All radiological and inorganic

TABLE 6.29

Groundwater Monitoring Results, Sanitary Landfill Well #800011R, 1993

	m(MSL)
Well Point Elevation	219.91
Ground Surface Elevation	227.69
Casing Material:	PVC

Constituent	Units	01/26/93	01/26/93	04/20/93	07/20/93	10/05/93
Water Elevation	m	227.23	227.23	227.29	226.44	225.75
Temperature	°C	10.7	10.7	8.1	11.2	12.5
pH	pH	6.87	6.87	7.26	7.11	7.14
Redox	mV	81	81	69	131	- 40
Conductivity	μmhos/cm	1978	1978	2000	2060	2270
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	< 0.004	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.141	0.137	0.146	0.128	0.131
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.066	0.055	0.057	0.087	0.086
Iron	mg/L	0.09	0.61	< 0.05	< 0.05	0.60
Lead	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.310	0.280	0.279	0.248	0.240
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	0.013	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	0.4	0.1	0.2	0.1	0.8
Phenols	mg/L	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	700	725	700	669	124
Sulfate	mg/L	122	124	105	112	136
Total dissolved solids	mg/L	1640	1610	1569	1481	1595
Total organic carbons	mg/L	1.6	1.8	1.4	2.0	2.0
Total organic carbons	mg/L	1.7	1.7	1.5	2.1	2.0
Total organic carbons	mg/L	-	-	1.5	1.7	2.0
Total organic carbons	mg/L	-	-	1.5	1.7	1.7
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	0.021	0.025
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	0.023	0.011
Total organic halogens	mg/L	< 0.010	< 0.010	-	-	-
Total organic halogens	mg/L	0.010	< 0.010	-	-	-

TABLE 6.30

Groundwater Monitoring Results, Sanitary Landfill Well #800021R, 1993

	m(MSL)
Well Point Elevation	214.70
Ground Surface Elevation	230.83
Casing Material:	PVC

Constituent	Units	01/26/93	04/21/93	07/20/93	10/05/93
Water Elevation	m	225.84	225.76	225.50	225.34
Temperature	°C	10.9	10.9	11.7	11.2
pH	pH	7.10	7.12	7.20	7.12
Redox	mV	25	- 68	100	- 49
Conductivity	μmhos/cm	616	651	670	640
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	0.005	< 0.003	< 0.003
Barium	mg/L	0.108	0.120	0.115	0.116
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.088	0.039	0.063	0.062
Iron	mg/L	< 0.05	0.07	0.11	0.21
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.300	0.291	0.335	0.272
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	0.032	< 0.010	0.028	< 0.010
Ammonia nitrogen	mg/L	0.3	0.3	0.3	< 0.1
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	22	16	17	17
Sulfate	mg/L	103	115	85	95
Total dissolved solids	mg/L	530	481	501	471
Total organic carbons	mg/L	1.4	1.1	1.3	1.5
Total organic carbons	mg/L	1.3	1.2	1.5	1.3
Total organic carbons	mg/L	-	1.4	1.2	1.5
Total organic carbons	mg/L	-	1.1	1.6	2.0
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-

TABLE 6.31

Groundwater Monitoring Results, Sanitary Landfill Well #800031, 1993

	m(MSL)
Well Point Elevation	217.51
Ground Surface Elevation	226.77
Casing Material:	PVC

Constituent	Units	01/26/93	04/22/93	07/21/93	10/07/93
Water Elevation	m	224.20	224.76	224.30	224.16
Temperature	°C	10.8	9.8	10.4	10.9
pH	pH	6.47	7.04	6.82	6.72
Redox	mV	- 51	- 72	- 50	- 72
Conductivity	μmhos/cm	1305	1159	1180	1335
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	0.004	< 0.003	0.008
Barium	mg/L	0.208	0.224	0.239	0.298
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.071	0.071	0.086	0.085
Iron	mg/L	0.55	5.63	2.39	5.53
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.140	0.160	0.089	0.185
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	1.0	0.7	1.0	0.6
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	7	14	6	19
Sulfate	mg/L	191	291	186	217
Total dissolved solids	mg/L	944	1054	921	1140
Total organic carbons	mg/L	29.2	30.3	30.8	27.0
Total organic carbons	mg/L	29.3	28.3	29.4	27.6
Total organic carbons	mg/L	-	29.2	30.9	26.2
Total organic carbons	mg/L	-	29.7	30.8	27.2
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-

TABLE 6.32

Groundwater Monitoring Results, Sanitary Landfill Well #800041R, 1993

	m(MSL)
Well Point Elevation	219.48
Ground Surface Elevation	227.23
Casing Material:	PVC

Constituent	Units	01/26/93	04/21/93	07/16/93	10/05/93
Water Elevation	m	225.30	227.23	225.19	225.06
Temperature	°C	10.5	9.9	9.8	11.0
pH	pH	6.40	7.27	6.76	6.73
Redox	mV	71	103	3	- 23
Conductivity	μmhos/cm	1040	1036	1041	1037
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.224	0.242	0.225	0.020
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.058	0.060	0.087	0.089
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.030	0.024	0.021	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	8.4	0.3	0.9	0.4
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	107	109	100	99
Sulfate	mg/L	164	188	160	171
Total dissolved solids	mg/L	879	882	855	779
Total organic carbons	mg/L	4.3	4.8	4.6	4.7
Total organic carbons	mg/L	4.4	4.5	4.5	4.6
Total organic carbons	mg/L	-	4.6	4.7	4.5
Total organic carbons	mg/L	-	4.9	4.5	4.7
Total organic halogens	mg/L	< 0.010	< 0.010	0.014	< 0.010
Total organic halogens	mg/L	< 0.010	< 0.010	0.012	< 0.010
Total organic halogens	mg/L	< 0.010	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-

TABLE 6.33

Groundwater Monitoring Results, Sanitary Landfill Well #800061, 1993

	m(MSL)
Well Point Elevation	206.89
Ground Surface Elevation	229.91
Casing Material:	PVC

Constituent	Units	01/26/93	04/20/93	04/20/93	07/21/93	10/05/93
Water Elevation	m	217.40	217.72	217.72	217.37	217.20
Temperature	°C	10.5	11.0	11.0	11.8	11.2
pH	pH	6.22	6.93	6.93	6.53	6.30
Redox	mV	- 46	90	90	- 34	- 22
Conductivity	μmhos/cm	1399	1347	1347	1486	1428
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.162	0.142	0.143	0.153	0.170
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	0.0004	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.091	0.060	0.059	0.090	0.087
Iron	mg/L	0.05	0.08	0.67	< 0.05	< 0.05
Lead	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.570	0.863	0.830	0.742	0.773
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	0.036	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	0.4	0.3	0.6	0.3	0.8
Phenols	mg/L	< 0.01	< 0.05	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	0.518	0.464	0.454	0.559	0.617
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	212	200	203	222	234
Sulfate	mg/L	12	3	21	31	15
Total dissolved solids	mg/L	998	1009	1027	1143	1013
Total organic carbons	mg/L	8.8	8.5	8.7	10.0	10.2
Total organic carbons	mg/L	8.8	8.5	8.5	10.1	10.1
Total organic carbons	mg/L	-	8.6	8.3	10.0	10.1
Total organic carbons	mg/L	-	8.6	8.6	10.1	10.2
Total organic halogens	mg/L	< 0.010	0.020	0.040	0.078	0.089
Total organic halogens	mg/L	< 0.010	0.030	0.050	0.088	0.100
Total organic halogens	mg/L	< 0.010	-	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-	-
1,4-Dioxane	μg/L	-	-	-	161	227
Chlorodifluoromethane	μg/L	123	-	-	111	140
Ethyl ether	μg/L	-	-	-	6	8
Methylene chloride	μg/L	-	-	-	7	-
Tetrahydrofuran	μg/L	-	-	-	36	18

TABLE 6.34

Groundwater Monitoring Results, Sanitary Landfill Well #800071, 1993

	m(MSL)
Well Point Elevation	220.05
Ground Surface Elevation	227.80
Casing Material:	PVC

Constituent	Units	01/26/93	04/20/93	07/16/93	10/05/93
Water Elevation	m	222.17	222.87	222.69	222.51
Temperature	°C	10.4	9.1	10.5	11.1
pH	pH	6.58	7.43	6.96	6.96
Redox	mV	73	100	- 30	- 32
Conductivity	μmhos/cm	701	713	723	708
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.086	0.082	0.076	0.085
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.042	0.043	0.064	0.066
Iron	mg/L	< 0.05	< 0.05	< 0.05	0.73
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.200	0.094	0.318	0.285
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	0.2	0.4	0.2	0.5
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	0.648	0.294	0.313	0.405
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	46	28	25	32
Sulfate	mg/L	145	136	115	153
Total dissolved solids	mg/L	569	574	522	568
Total organic carbons	mg/L	2.4	2.2	2.2	3.6
Total organic carbons	mg/L	2.4	2.1	2.1	2.6
Total organic carbons	mg/L	-	2.4	2.2	2.6
Total organic carbons	mg/L	-	2.1	2.4	2.6
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-

TABLE 6.35

Groundwater Monitoring Results, Sanitary Landfill Well #800081, 1993

	m(MSL)
Well Point Elevation	218.71
Ground Surface Elevation	231.53
Casing Material:	PVC

Constituent	Units	01/26/93	04/20/93	07/16/93	10/05/93
Water Elevation	m	229.36	229.20	227.99	227.34
Temperature	°C	10.0	7.3	11.1	11.2
pH	pH	6.68	7.22	7.06	6.55
Redox	mV	81	101	22	- 9
Conductivity	µmhos/cm	1167	1135	1246	1225
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.061	0.059	0.053	0.055
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.067	0.068	0.088	0.088
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	< 0.0010
Manganese	mg/L	0.570	0.698	0.174	0.745
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	0.014	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	0.5	0.6	0.7	0.6
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	98	97	94	104
Sulfate	mg/L	270	31	296	332
Total dissolved solids	mg/L	981	1063	1048	1034
Total organic carbons	mg/L	2.8	2.9	3.1	3.2
Total organic carbons	mg/L	2.9	3.1	3.1	3.2
Total organic carbons	mg/L	-	2.8	3.3	3.0
Total organic carbons	mg/L	-	3.2	3.0	3.1
Total organic halogens	mg/L	< 0.010	0.010	0.034	0.022
Total organic halogens	mg/L	< 0.010	0.020	0.034	0.035
Total organic halogens	mg/L	< 0.010	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-
Chlorodifluoromethane	µg/L	-	-	4	5

TABLE 6.36

Groundwater Monitoring Results, Sanitary Landfill Well #800091, 1993

	m(MSL)
Well Point Elevation	223.79
Ground Surface Elevation	230.00
Casing Material:	PVC

Constituent	Units	01/26/93	04/22/93	07/19/93	07/19/93	10/07/93
Water Elevation	m	227.89	227.97	227.47	227.47	226.99
Temperature	°C	11.0	10.1	10.6	10.6	11.6
pH	pH	6.47	6.92	6.80	6.80	6.60
Redox	mV	- 102	- 82	- 36	- 36	- 85
Conductivity	μmhos/cm	1240	1161	1218	1218	1244
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	0.008	0.004	0.004	0.004	0.005
Barium	mg/L	0.225	0.239	0.260	0.256	0.268
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.065	0.061	0.087	0.088	0.087
Iron	mg/L	13.35	8.50	7.42	7.38	5.38
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	0.0027	< 0.0010
Manganese	mg/L	1.170	0.737	0.654	0.653	0.736
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	0.5	< 0.1	0.7	0.3	0.3
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02	< 0.02
Hydrogen-3	nCi/L	0.318	0.712	0.335	0.360	0.353
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	102	85	109	111	120
Sulfate	mg/L	4	26	7	7	9
Total dissolved solids	mg/L	941	886	917	903	874
Total organic carbons	mg/L	14.4	12.0	12.1	13.0	13.3
Total organic carbons	mg/L	14.5	11.9	12.7	12.8	14.5
Total organic carbons	mg/L	-	12.0	12.6	12.3	14.4
Total organic carbons	mg/L	-	12.6	12.4	12.4	12.2
Total organic halogens	mg/L	< 0.010	0.030	0.066	0.062	0.052
Total organic halogens	mg/L	< 0.010	0.030	0.067	0.057	0.051
Total organic halogens	mg/L	< 0.010	-	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-	-
1,4-Dioxane	μg/L	-	-	100	46	172
Chlorodifluoromethane	μg/L	113	-	93	98	105
Ethyl ether	μg/L	-	-	5	5	5

TABLE 6.37

Groundwater Monitoring Results, Sanitary Landfill Well #800101, 1993

	m(MSL)
Well Point Elevation	222.28
Ground Surface Elevation	229.15
Casing Material:	PVC

Constituent	Units	01/28/93	04/22/93	07/22/93	10/06/93	10/06/93
Water Elevation	m	228.66	228.78	227.81	227.81	227.81
Temperature	°C	9.9	8.4	11.4	13.5	13.5
pH	pH	6.73	7.57	7.28	7.13	7.13
Redox	mV	- 102	- 80	- 50	- 65	- 65
Conductivity	μmhos/cm	704	678	722	748	748
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	0.003	0.003	0.004	0.004
Barium	mg/L	0.070	0.067	0.066	0.067	0.065
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.036	0.036	0.055	0.057	0.056
Iron	mg/L	1.30	0.97	1.06	2.50	2.48
Lead	mg/L	< 0.0020	< 0.0020	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.110	0.093	0.103	0.130	0.133
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	0.2	0.3	0.3	0.7	< 0.1
Phenols	mg/L	< 0.01	< 0.05	< 0.02	< 0.02	< 0.02
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	5	5	5	6	6
Sulfate	mg/L	186	188	178	222	199
Total dissolved solids	mg/L	536	574	615	553	529
Total organic carbons	mg/L	1.4	1.4	1.6	2.3	1.8
Total organic carbons	mg/L	1.4	1.5	1.5	1.7	1.6
Total organic carbons	mg/L	-	1.6	1.6	2.1	1.6
Total organic carbons	mg/L	-	1.6	1.6	1.9	1.7
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total organic halogens	mg/L	< 0.010	-	-	-	-
Total organic halogens	mg/L	< 0.010	-	-	-	-

TABLE 6.38

Groundwater Monitoring Results, Sanitary Landfill Well #800121, 1993

	m(MSL)
Well Point Elevation	219.17
Ground Surface Elevation	229.91
Casing Material:	S. STEEL

Constituent	Units	03/16/93	05/10/93	08/11/93	10/18/93
Water Elevation	m	223.68	224.22	221.56	222.00
Temperature	°C	11.1	11.0	11.3	11.2
pH	pH	7.52	7.18	7.34	7.12
Redox	mV	- 83	117	- 37	144
Conductivity	μmhos/cm	632	514	677	784
Arsenic	mg/L	0.005	0.006	< 0.003	0.008
Barium	mg/L	0.022	0.020	0.030	0.036
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.020	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.041	0.036	0.037	0.038
Iron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.060	0.024	0.035	< 0.015
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Chloride	mg/L	25	13	14	24
Sulfate	mg/L	152	131	233	145
Total dissolved solids	mg/L	457	395	504	24

TABLE 6.39

Groundwater Monitoring Results, Sanitary Landfill Well #800131, 1993

	m(MSL)
Well Point Elevation	205.66
Ground Surface Elevation	230.00
Casing Material:	S. STEEL

Constituent	Units	01/28/93	04/22/93	07/22/93	10/07/93
Water Elevation	m	217.56	218.30	217.90	217.27
Temperature	°C	10.9	11.5	11.7	11.7
pH	pH	6.31	7.02	6.92	6.96
Redox	mV	- 105	72	- 9.0	- 192
Conductivity	µmhos/cm	913	985	800	738
Cyanide (Total)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
Arsenic	mg/L	< 0.004	0.003	0.003	0.004
Barium	mg/L	0.157	0.168	0.152	0.153
Beryllium	µg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	0.050	< 0.050
Copper	mg/L	0.059	0.051	0.069	0.069
Iron	mg/L	0.88	7.93	5.40	4.71
Lead	mg/L	< 0.0020	< 0.0020	0.0010	< 0.0010
Manganese	mg/L	1.160	0.570	0.230	0.130
Mercury	µg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia nitrogen	mg/L	4.0	4.5	2.5	1.0
Phenols	mg/L	0.16	< 0.05	< 0.02	< 0.02
Hydrogen-3	nCi/L	0.160	0.122	< 0.100	< 0.100
Strontium-90	pCi/L	< 0.25	< 0.25	< 0.25	< 0.25
Chloride	mg/L	55	67	35	31
Sulfate	mg/L	13	59	87	101
Total dissolved solids	mg/L	698	719	549	523
Total organic carbons	mg/L	8.7	10	6.2	5.8
Total organic carbons	mg/L	8.4	9.7	6.5	6.3
Total organic carbons	mg/L	-	10.1	6.4	6.2
Total organic carbons	mg/L	-	10.7	6.8	5.9
Total organic halogens	mg/L	0.030	0.040	0.015	0.015
Total organic halogens	mg/L	0.030	0.030	0.015	< 0.010
Total organic halogens	mg/L	0.030	-	-	-
Total organic halogens	mg/L	0.030	-	-	-
Chlorodifluoromethane	µg/L	18	-	8	3
Methylene chloride	µg/L	-	-	7	-

TABLE 6.40

Groundwater Monitoring Results, Sanitary Landfill Well #800141D, 1993

	m(MSL)
Well Point Elevation	183.13
Ground Surface Elevation	229.53
Casing Material:	STEEL

Constituent	Units	03/12/93	05/26/93	08/10/93	10/21/93
Water Elevation	m	192.65	192.95	192.96	193.02
Temperature	°C	11.1	12.2	12.4	11.5
pH	pH	7.11	7.42	7.02	7.08
Redox	mV	- 108	- 42	- 154	- 83
Conductivity	μmhos/cm	910	938	983	962
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.065	0.062	0.067	0.064
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.629	0.053	0.046	0.038
Iron	mg/L	1.17	0.85	1.22	1.15
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	0.035	0.038	0.038	0.032
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Chloride	mg/L	86	91	114	147
Sulfate	mg/L	193	186	210	137
Total dissolved solids	mg/L	669	712	733	769

TABLE 6.41

Groundwater Monitoring Results, Sanitary Landfill Well #800151D, 1993

	m(MSL)
Well Point Elevation	182.31
Ground Surface Elevation	227.81
Casing Material:	STEEL

Constituent	Units	03/11/93	05/26/93	08/10/93	10/22/93
Water Elevation	m	191.60	191.84	191.85	191.87
Temperature	°C	11.1	12.3	12.7	11.5
pH	pH	7.30	7.28	7.16	7.16
Redox	mV	- 98	- 59	- 95	- 64
Conductivity	μmhos/cm	818	938	988	929
Arsenic	mg/L	< 0.003	0.003	< 0.003	0.003
Barium	mg/L	< 0.010	0.049	0.050	0.047
Beryllium	μg/L	< 0.150	< 0.150	< 0.150	< 0.150
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	< 0.010	0.052	0.047	0.038
Iron	mg/L	< 0.05	1.32	0.61	1.04
Lead	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Manganese	mg/L	< 0.015	0.038	0.039	0.032
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Hydrogen-3	nCi/L	< 0.100	< 0.100	< 0.100	< 0.100
Chloride	mg/L	8	94	120	136
Sulfate	mg/L	5	189	206	198
Total dissolved solids	mg/L	10	683	714	799
Methylene chloride	μg/L	-	2	-	-

analysis results are shown in these tables. The analysis methods used for organic compounds will 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 which were present in amounts great enough to quantify are shown. The detection limits for the organic compounds listed were typically 1 to 5 μg/L. The IEPA-approved groundwater monitoring requires samples for metals analysis be field filtered prior to preservation with acid. Previous routine quarterly groundwater samples have historically been run for total metals analysis which requires collection of the sample in an acidified container followed by acid digestion. As a result, metal concentrations for 1993 tend to be significantly lower than concentrations reported in previous years.

Inorganic Constituents

On April 24, 1992, the IEPA issued a supplemental permit to ANL which in part approved a groundwater monitoring program for the sanitary landfill. The program is to be capable of identifying any releases from the facility and demonstrate compliance with the applicable groundwater quality standards. IEPA chose 11 groundwater monitoring points (800011R, 800021R, 800031, 800041R, 800051, 800061, 800071, 800081, 800091, 800101, 800131) to be sampled on a quarterly basis commencing July 1992. Parameters to be monitored include field parameters, routine indicator parameters, and volatile organic parameters. Volatile organic parameters are to be monitored only during the second quarter of monitoring.

The Illinois Groundwater Quality Standards for Class I: Potable Resource Groundwater, 35 IAC Section 620.410, were used as the standard for evaluation of the inorganic results. Inorganic results are fairly consistent with results reported in previous years. The most common constituents at levels above the WQS (see Table 6.26) are chloride, iron, total dissolved solids (TDS), and manganese. Wells 800030, 800091, and 800131 exceeded the WQS for iron. Iron levels ranged from less than 0.05 to 13.4 mg/L. The TDS levels in well 800011R exceeded the TDS WQS each quarter and ranged from 1481 to 1640 mg/L. The manganese WQS was exceeded in wells 800011R, 800021R, 800031, 800061, 800071, 800081, 800091, and 800131. Manganese levels ranged from less than 0.02 to 1.2 mg/L. The WQS for chloride was consistently exceeded in wells 800011R and 800061 where the levels vary from 124 to 700 mg/L. The WQS for phenols was exceeded only during the first quarter for well 800131. The inorganic results for dolomite wells 800141D and 800151D were within normal ranges. The levels of most of the inorganic constituents in well 800091 are greater than the concentrations in other wells.

Organic Constituents

The results are similar to those reported in previous years. Trace levels of methylene chloride were identified in wells 800061, 800131, and 800151D, but only during one quarter. Ethyl ether was found in trace amounts in wells 800061 and 800091. Chlorodifluoromethane was identified in wells 800061, 800081, 800091 and 8000131. As in past years, 1-4-dioxane and tetrahydrofuran were identified in well 800061.

Radioactive Constituents

Samples collected from the 800 Area sanitary landfill monitoring wells were also analyzed for hydrogen-3 and during the second half of the year, for strontium-90. The results are shown in Tables 6.29 to 6.41. Although the disposal of radioactive materials was prohibited in the sanitary landfill, very low concentrations of hydrogen-3 were detected, probably due to inadvertent disposal of radioactivity in the ANL trash. 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. No strontium-90 was detected.

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 megawatt research reactor which 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 is in the process of being decommissioned. A single exploratory monitoring well (Figure 6.7) was installed in 1989 in the yard, immediately behind the reactor building, just outside the reactor fuel storage area of the complex. This well (330011) was sampled quarterly in 1993 and analyzed for radionuclides, metals, and volatile organic compounds. A sample collected in January was also analyzed for semivolatiles, pesticides, herbicides and polychlorinated biphenyls. The results are shown in Table 6.42. Two new wells were installed as part of a full characterization study of this site which took place during 1993 (Section 6.5.3.) and will be sampled quarterly in 1994. All wells in this area are described in Table 6.43 (see Figure 6.7 for location).

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. Manganese concentrations are elevated and the WQS for manganese was exceeded during each quarter. Levels ranged from 0.74 mg/L to 0.87 mg/L. Low levels of barium, copper, and iron were found, all well below the WQS.

Similar to results in 1991 and 1992, three of the samples collected and analyzed in 1993 contained trichlorofluoromethane ranging from 4 μg/L to 12 μg/L. These levels are significantly lower than those levels reported in 1991 and 1992. Samples collected in September and November 1993 contained dichlorofluoromethane at levels ranging from 7 μg/L to 11 μg/L.

The levels of hydrogen-3 ranged from 3.5 to 8.2 nCi/L and the levels of strontium-90 ranged from 0.66 to 1.3 pCi/L. Cesium-137 ranged from < 1 to 1.7 pCi/L. CP-5 was

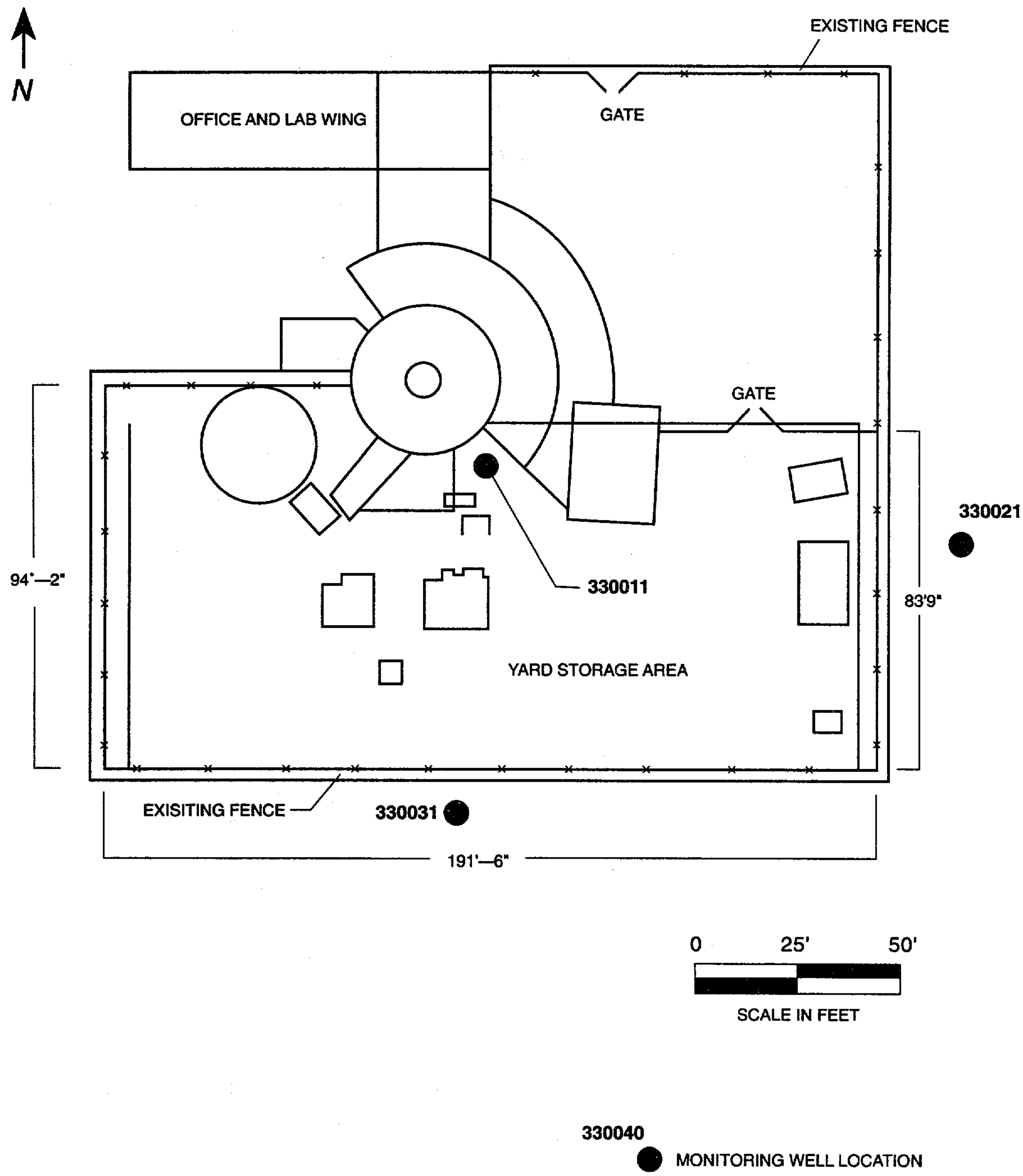


Figure 6.7 Active Monitoring Wells in the CP-5 Reactor Area

TABLE 6.42

Groundwater Monitoring Results, 300 Area Well #330011, 1993

	m(MSL)
Well Point Elevation	215.70
Ground Surface Elevation	222.56
Casing Material:	STEEL

Constituent	Units	03/24/93	06/24/93	09/20/93	11/19/93
Water Elevation	m	220.89	219.27	219.41	219.06
Temperature	°C	12.2	14.2	17.1	17.1
pH	pH	7.09	6.86	6.72	6.92
Redox	mV	- 2	76	- 59	181
Conductivity	μmhos/cm	1	959	991	1091
Arsenic	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
Barium	mg/L	0.072	0.056	0.065	0.071
Beryllium	μg/L	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cobalt	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Copper	mg/L	0.065	0.048	0.045	0.042
Iron	mg/L	0.16	0.05	0.39	< 0.05
Lead	mg/L	< 0.0010	0.0021	< 0.0010	< 0.0010
Manganese	mg/L	0.806	0.739	0.831	0.869
Mercury	μg/L	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/L	< 0.040	< 0.040	< 0.040	< 0.040
Silver	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Thallium	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050
Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010
Cesium-137	pCi/L	< 1.0	1.0	< 1.0	1.7
Hydrogen-3	nCi/L	6.809	4.026	3.530	8.244
Strontium-90	pCi/L	1.33	0.79	0.66	0.80
Chloride	mg/L	111	71	40	83
Dichlorofluoromethane	μg/L	-	-	7	11
Trichlorofluoromethane	μg/L	-	12	4	9

a heavy water-moderated reactor. During its operation life, several incidents occurred which 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 which may have condensed and fallen to the ground in the form of precipitation. These activities are believed to be responsible for the residual amounts of hydrogen-3 now found in the groundwater. The source of the strontium-90 is not known.

TABLE 6.43

Groundwater Monitoring Wells - 300 Area/CP-5

ID Number	Well Depth[1]	Ground Elevation[2]	Monitoring Zone[3]	Well Type[4]	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

[1]feet below ground

[2]feet mean sea level

[3]depth/elevation

[4]inner diameter (inches)/well material (PVC = polyvinyl chloride, SS = stainless steel)

6.5. Site Characterization Activities

Historical information about waste disposal activities on the ANL 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. As a first step to stopping these releases and cleaning up any residual contamination, a series of site characterization projects is underway. To date, these projects have focused on the most significant sites, the 800 Area landfill and the 317/319 Areas. The studies are in the characterization stage, and thus the information available is currently incomplete and may not accurately represent the actual conditions at these sites. Characterization activities are currently scheduled to extend beyond 1994.

6.5.1. 317/319 Area Characterization

Preliminary characterization conducted in the 317/319 Area indicates that two distinct areas of highly contaminated soil exist, one near the site of the French drain in the 317 Area and the other in the 319 Area landfill. A larger number of organic compounds were identified in the shallow groundwater in the 317 Area, some at very high concentrations (over 100,000 μg/L). A relatively small area of highly contaminated soil was found to exist, just north of the vaults used for storage of radioactive wastes. Significant, but much lower concentrations of volatile organics were found several hundred feet from the vault area, indicating that movement of the contamination through the soil is occurring. This is consistent with the results of the monitoring well sampling discussed in this chapter. Samples of shallow groundwater [less than 3 m (10 ft) deep] collected on Forest Preserve property south of the ANL fenceline indicate that low levels of several ketones may have moved off-site. The depth and extent of groundwater contamination is not fully defined at this point.

The 319 Area, which contained a similar French drain, was also found to contain a large number of organic compounds, although the concentrations were much lower than in the 317 Area. The French drain in this area was much deeper than the one in the 317 area. Since the techniques used in this preliminary investigation were limited to a depth of approximately 3 m (10 ft) below the surface, they may not have been able to detect contamination located deep within the 319 waste pile.

One sample recovered from the 319 area was found to contain low concentrations of two PCBs, Aroclor 1254 and Aroclor 1260 (220 μg/L total). A floating oil layer was encountered at this point, indicating the PCBs were the result of disposal of PCB-containing waste oils.

During 1993, additional characterization activities were conducted in this area to further define the extent of contamination from the French drain, inactive landfills, and other waste units in this area. A series of geophysical investigations were performed. The non-intrusive investigation techniques were able to identify the presence of buried waste material, as well as provide a description of the underlying soils. More detailed investigations of the soil were carried out using a technique called Cone Penetration Testing. This technique involved pushing an instrumented probe into the soil while recording data on soil composition, groundwater depth, and soil permeability. Samples of groundwater were also collected from porous soil layers containing water. Temporary wells were installed in the shallow surface soils near the 317 Area French drain and 319 Area landfill and additional groundwater samples were collected. The samples were analyzed for volatile organic chemicals, metals, and tritium.

The results of this work indicate that the soil beneath the 317 Area is composed primarily of low permeability clay, interspersed with isolated pockets of porous sand and gravel. Organic contamination of the groundwater present in these layers was present; however, it appears to be limited to the immediate vicinity of the 317 Area French drain. The migration of this contamination beyond the French drain area is being limited by the presence of clay soils.

Very little contamination was found beneath the 319 Area landfill. The existence of what is thought to be previously unknown waste buried east of the 319 Area landfill was confirmed. The nature of this waste materials is unknown but it is likely to be innocuous demolition debris and similar solid wastes since analysis of groundwater samples in the area did not detect significant contamination.

This characterization information was used to develop a detailed work plan for the next phase of characterization of this area. This phase, known as the RCRA Facility Investigation, will be a formal, IEPA-approved investigation which will form the basis for eventual remedial action of contamination identified. A draft work plan was written and submitted to DOE for review. Once all DOE comments are incorporated in the work plan, it will be sent to the IEPA for review and approval. Approval of the work plan is expected in late 1994, with implementation to begin in 1995.

A project to identify and clean up residual radiological contamination within certain facilities within the 317 Area was also begun. A radiological survey of all active and inactive radiological waste management facilities was performed. Based on this data, a plan was developed to begin the decontamination of those facilities which are no longer needed for programmatic purposes. The decontamination operation should begin in early 1994.

Two inactive hazardous waste treatment units located in the 317 Area are currently undergoing closure activities. Closure activities include sampling and analysis of residual materials present in the units (sludge and solid waste), and disposal of these waste materials and analysis of the soil underneath and next to these units to verify that all hazardous materials have been removed. Closure operation should be complete in late 1994.

6.5.2. 800 Area Landfill Characterization

The characterization activities at the landfill have thus far included the collection of a series of soil gas and leachate samples from in and near the fill material, the drilling of 14 soil borings, and the installation of 13 new monitoring wells around the landfill perimeter. The results of soil gas and leachate analysis have shown that volatile organic compounds are present in the fill material and leachate. A large number of the compounds detected are also listed on the log of wastes poured into the old French drain in the north end of the site. It appears that volatile organics are present throughout most of the fill material. The distribution of these chemicals throughout the fill was found to be highly variable, indicating the possibility of multiple sources within the waste.

In 1992, 14 soil borings were completed along with the installation of 13 monitoring wells around the perimeter of the landfill. The 13 monitoring wells installed in 1992 enable the measurement of vertical hydraulic gradients and groundwater quality variations at the solid waste management unit boundary and are monitored separately from the IEPA-permitted wells. The soil boring and well installation program have revealed that little in the way of groundwater contamination has migrated from the landfill itself. However, given the type and amounts of hazardous substances disposed of in the landfill, the potential still exists for future groundwater contamination. In essence, the collection of these soil borings and installation of these monitoring wells have partially completed the first phase of work for the characterization activities at the landfill. Capping of the 800 Area Landfill was completed as an interim measure prior to conducting a RCRA Facility Investigation and any corrective activities for that area. Future work to be conducted under the RCRA permit will establish the effect the landfill has had to its surrounding environment.

6.5.3. CP-5 Yard Characterization

During 1993, a site characterization project was performed at the CP-5 yard. The project was designed to provide site-specific data for evaluation of the nature and extent of soil and groundwater contamination related to past and current operations at the CP-5 facility. The project consisted of the installation of 21 soils borings and two new monitoring wells for the collection of soil and groundwater samples, respectively.

Results indicated elevated volatile organics in several soil borings. Several inorganics were found to exceed background concentrations for surface soil, but were within the normal ranges in Illinois soils. Tritium concentrations in subsurface soil were significantly elevated above background. Pesticide concentrations exceeded IEPA standards for soils. Antimony and manganese were the only metals detected in groundwater with concentrations exceeding Class I Groundwater Quality Standards. Tritium was not detected at levels above the water quality standard.

Additional surface, subsurface soil, and groundwater characterization may be necessary to define the extent of semivolatile and pesticide contamination in this area. Based on statistical analysis and comparison to naturally-occurring inorganic concentrations in Illinois soils, no inorganics in surface soils are considered to be contaminants of concern.

6.5.4. Sitewide Hydrogeological Baseline Study

The study is a multiphase project to fully characterize the ANL site and support the sitewide RCRA Facility Investigation (RFI). This study is critical to defining the baseline hydrogeological conditions beneath ANL and the surrounding Nature Preserve. The purpose of the study is to determine the principal geological and hydrogeological characteristics of the soils and aquifers beneath ANL. This information will define the groundwater quality and flow regime and provide important baseline data for other site characterization and remediation projects. It will also be a resource for new construction project designs and environmental spill responses. The data will reveal whether ANL operations overall have impacted groundwater.

In 1993, the Scope of Work and the Project Management Plan for the ANL sitewide hydrogeological study were completed. A contract to perform Phases I and II, the major field portion of the project, was negotiated and awarded. ANL met with DPCHD and began the task of locating and identifying old abandoned wells in the Waterfall Glen Nature Preserve adjacent to the ANL site.

Phase I field investigation will be completed during 1994. This include geophysical measurements, cone penetration testing, soil borings, rock corings, and monitoring well installation in the western portion of the ANL site. Water samples will be collected and analyzed to obtain information on site baseline groundwater quality.

Also during 1994, abandoned wells of record will be located and evaluated for their potential use in collecting hydrogeological information critical to the study. Wells and boreholes requiring proper closure will be identified in a report and sealed in accordance with State and county health regulations upon completion of the project.

7. QUALITY ASSURANCE

Quality Assurance (QA) plans exist for both radiological (ESH-DARC-QAP-001) and non-radiological (ESH-DACH-QAP-001) analyses. Both QA documents were prepared in accordance with ANSI/ASMC NQA-1. The plans discuss responsibilities and auditability. Both documents are supplemented by operating manuals.

7.1. Radiochemical Analysis and Radioactivity Measurements

All nuclear instrumentation is calibrated with standard sources obtained from the National Institute of Standards and Technology (NIST), if possible. If NIST standards are not available for particular nuclides, NIST traceable standards from the Amersham Corporation are used. 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 ten times the detection limit, the error is about 10%.

Average values are usually accompanied by a plus-or-minus (±) limit value. Unless otherwise stated, this value is the standard error at the 95% confidence level calculated from the standard deviation of the average. The ± limit value is a measure of the range in the concentrations encountered at that location; it does not represent the conventional uncertainty in the average of repeated measurements on the same or identical samples. 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

TABLE 7.1

Detection Limits

Nuclide or Activity	Air (fCi/m^3)	Water (pCi/L)
Americium-241	-	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
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 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 plus-or-minus value accompanies an individual result in this report, it represents the statistical counting error at the 95% confidence level.

Standard and intercomparison samples distributed by the Quality Assurance Branch of the EPA are analyzed regularly. Results of ANL's participation in the EPA program during 1993 are given in Table 7.2. In the table, the comparison is made between the EPA value, which is the quantity added to the sample by that laboratory, and the value obtained in the ANL laboratory. Certain information may assist in judging the quality of the results, including the fact that typical uncertainties for the ANL analyses are 2% to 50%, depending on the concentration and the nuclide, and the uncertainties in the EPA results are 2% to 5% (ANL estimate).

In addition, participation continued in the DOE Environmental Measurements Laboratory Quality Assurance Program (DOE-EML-QAP), a semi-annual distribution of four different sample matrices containing various combinations of radionuclides that are analyzed. Results for 1993 are summarized in Table 7.3. In the table, the EML value, which is the result of duplicate determinations by that laboratory, is compared with the average value obtained in the ANL laboratory. Information that will assist in judging the quality of the results includes the fact that typical uncertainties for ANL's analyses are 2% to 50% and that the uncertainties in the EML results are 1% to 30% (depending on the nuclide and the amount present). For most analyses for which the differences are large (> 20%), the concentrations were quite low and the differences were within the measurement uncertainties.

7.2. Chemical Analysis

The documentation for nonradiological analyses is contained in the ESH-DA Chemistry Laboratory Procedure Manual. All samples for NPDES and groundwater are collected and

TABLE 7.2

Summary of EPA Samples, 1993

Type of Sample	Analysis	Number Analyzed	Average Difference from Added (%)
Air Filter	Total Alpha	1	0
	Total Beta	1	4
	Strontium-90	1	5
	Cesium-137	1	2
Water	Total Alpha	4	10
	Total Beta	4	11
	Hydrogen-3	2	1
	Cobalt-60	3	3
	Zinc-65	2	6
	Strontium-89	3	4
	Strontium-90	3	4
	Ruthenium-106	2	20
	Iodine-131	2	1
	Cesium-134	3	6
	Cesium-137	3	4
	Barium-133	2	6
	Radium-226	1	2
	Radium-228	1	1
	Total Uranium	3	4

TABLE 7.3

Summary of DOE-EML-QAP Samples, 1993

	Percent Difference From EML Value			
Radionuclide	Air Filters	Soil	Vegetation	Water
Hydrogen-3	-	-	-	2 (2)
Beryllium-7	8 (1)	-	-	-
Potassium-40	-	15 (2)	19 (2)	-
Manganese-54	6 (2)	-		2 (2)
Cobalt-57	13 (2)	-	-	-
Cobalt-60	9 (2)	-	11 (1)	14 (2)
Strontium-90	17 (2)	3 (2)	7 (2)	15 (2)
Cesium-134	28 (2)	-	-	39 (2)
Cesium-137	6 (2)	15 (2)	6 (2)	14 (2)
Cerium-144	17 (2)	-	-	2 (2)
Uranium-234	8 (2)	11 (2)	-	4 (2)
Uranium-238	4 (2)	15 (2)	-	5 (2)
Plutonium-238	8 (2)	-	5 (2)	8 (2)
Plutonium-239	3 (2)	21 (2)	3 (2)	5 (2)
Americium-241	2 (2)	10 (2)	10 (2)	8 (2)

Note: The value in parentheses is the number of samples.

analyzed in accordance with EPA regulations found in 40 CFR Part 136,[19] EPA-600/4-84-017,[26] and SW-846.[27]

Standard Reference Materials (SRM), traceable to the NIST, exist for most inorganic analyses (see Table 7.4). These are replaced annually. Detection limits are determined with techniques listed in Report SW-846[27] and are listed in Table 7.5. In general, the detection limit is the measure of the variability (ó) of a standard material measurement at 5-10 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 (CRADA) which exists between the EPA and commercial laboratories. In addition, standards are available which are certified by the American Association for Laboratory Accreditation, under a memorandum of understanding with the EPA. Many of these standards are used in this work. At least one standard mixture is analyzed each month and the results for 1993 are shown in Table 7.6 for volatile organic compounds and Table 7.7 for semivolatiles. The recoveries listed are those required by the respective methods.

Argonne participates in the EPA Discharge Monitoring Report Quality Assurance Program. Results for 1993 are listed in Table 7.8. All results were acceptable.

TABLE 7.4

NIST-SRM Used for Inorganic Analysis

NIST-SRM	Constituent
3103	Arsenic
3104	Barium
3105	Beryllium
3108	Cadmium
3112	Chromium
3113	Cobalt
3114	Copper
3126	Iron
3128	Lead
3132	Manganese
3133	Mercury
3136	Nickel
3149	Selenium
3151	Silver
3165	Vanadium
3168	Zinc
3181	Sulfate
3182	Chloride
3183	Fluoride

TABLE 7.5

Limit of Detection for Metal Analysis

Constituent	Limit of Detection Milligrams/Liter
Arsenic	0.025
Barium	0.010
Beryllium	0.15
Cadmium	0.0002
Chromium	0.010
Cobalt	0.050
Copper	0.010
Iron	0.050
Lead	0.0010
Manganese	0.0150
Mercury	0.0001
Nickel	0.040
Silver	0.010
Thalium	0.0030
Vanadium	0.050
Zinc	0.0100

TABLE 7.6

Quality Check Sample Results, Volatile Analyses, 1993

Compound	Percent Recovery	Percent Quality Limits
Benzene	103.0	73-126
Bromobenzene	103.5	76-133
Bromodichloromethane	108.5	101-138
Bromoform	106.5	57-156
Butylbenzene	94.0	71-125
sec-Butylbenzene	90.5	71-145
t-Butylbenzene	96.5	69-134
Carbon Tetrachloride	87.1	86-118
Chlorobenzene	98.0	80-137
Chloroform	103.5	68-120
o-Chlorotoluene	105.0	81-146
p-Chlorotoluene	103.5	73-144
1,2-Dibromo-3-chloropropane	114.0	36-154
Dibromochloromethane	111.4	68-130
1,2-Dibromomethane	91.5	75-149
Dibromomethane	36.0	65-143
1,2-Dichlorobenzene	107.5	59-174
1,3-Dichlorobenzene	97.5	84-143
1,4-Dichlorobenzene	107.5	58-172
1,1-Dichloroethane	102.0	71-142
1,2-Dichloroethane	94.0	70-134
1,1-Dichloroethene	83.0	18-209
cis-1,2-Dichloroethene	97.0	85-124
trans-1,2-Dichloroethene	94.5	67-141
1,2-Dichloropropane	91.0	19-179
1,3-Dichloropropane	108.5	73-145
1,1-Dichloropropene	78.6	71-133
Ethyl Benzene	100.5	84-130
Isopropylbenzene	95.0	70-144
4-Isopropyltoluene	96.5	72-140
Methylene Chloride	110.0	D-197
n-Propylbenzene	100.5	78-139
1,1,1,2-Tetrachloroethane	97.0	88-133
Tetrachloroethene	97.0	84-132
Toluene	104.5	81-130
1,1,1-Trichloroethane	92.5	68-149
1,1,2-Trichloroethane	108.0	70-133
Trichloroethene	114.5	91-135
1,2,3-Trichloropropane	75.6	50-158
1,2,4-Trimethylbenzene	105.5	80-144
1,3,5-Trimethylbenzene	99.5	76-142
o-Xylene	106.5	79-141
p-Xylene	98.0	74-138

Note: D denotes the compound was detected.

TABLE 7.7

Quality Check Sample Results, Semivolatile Analyses, 1993

Compound	Percent Recovery[a]	Percent Quality Limits
2-Fluorophenol[b]	64.0	21-100
Phenol-d5[b]	47.3	10-94
Phenol	33.6	17-100
2-Chlorophenol	72.1	36-120
1,4-Dichlorobenzene	61.8	37-106
n-Nitroso-n-Propyl Amine	93.8	24-198
Nitrobenzene-d5[b]	107.8	35-114
1,2,4-Trichlorobenzene	66.5	57-129
4-Chloro-3-Methylphenol	87.5	41-128
2-Fluorobiphenyl[b]	110.3	43-116
Acenaphthene	93.0	47-145
4-Nitrophenol	58.3	13-107
2,4-Dinitrotoluene	112.5	48-127
2,4,6-Tribromophenol[b]	81.1	10-123
Pentachlorophenol	122.6	38-152
Pyrene	103.8	70-100
Terphenyl-d14[b]	123.8	33-141

[a]Average of 4 determinations.

[b]Required surrogates.

TABLE 7.8

Summary of EPA Nonradiological Samples, 1993

Constituent	Average Difference From Reference Value (%)
Chromium	-7.5
Copper	+4.8
Iron	+3.5
Lead	+18.7
Manganese	+2.2
Mercury	-15.6
pH	0.0 unit
Zinc	+4.7
Total Suspended Solids	-8.6
Biological Oxygen Demand	-2.8
Chemical Oxygen Demand	-3.7

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