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Paducah Gaseous Diffusion Plant environmental report for 1992

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PADUCAH GASEOUS DIFFUSION PLANT ENVIRONMENTAL REPORT FOR 1992

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Executive Summary

Scope and Purpose

This two-part report, *Paducah Gaseous Diffusion Plant Environmental Report for 1992*, is published annually. It reflects the results of an environmental monitoring program designed to quantify potential increases in the concentration of contaminants and potential doses to the resident human population.

The Paducah Gaseous Diffusion Plant (PGDP) overall goal for environmental management is to protect the environment and PGDP's neighbors and to maintain full compliance with all current regulations. The current environmental strategy is to identify any deficiencies and to develop a system to resolve them. The long-range goal of environmental management is to minimize the source of pollutants, reduce the generation of waste, and minimize hazardous waste by substitution of materials.

Monitoring Networks

Environmental-monitoring systems at PGDP include emission-monitoring networks for airborne and aqueous discharges, groundwater monitoring, solid waste characterization, and environmental surveillance networks for air, surface water, groundwater, vegetation, food crops, fish, wildlife, soil, and surface stream sediments.

Effluent and waste monitoring includes:

- regular laboratory analysis of delivered coal and a sulfur dioxide (SO₂) monitor on steam plant stacks;
- a network of 20 sampling locations for monitoring plant wastewater prior to discharge;

- a sampling program for identification and characterization of solid waste streams generated by plant operations;
- an ongoing sampling program of stored wastes and sludges to characterize these materials in support of Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities;
- 73 PGDP groundwater-monitoring wells and 57 residential wells; and
- C-310 stack sampling for radionuclide and fluoride emissions.

Environmental Surveillance networks include

- 12 air-sampling stations (4 fence-line and 8 off-site),
- 5 surface water-sampling locations,
- 18 vegetation-sampling locations (4 fence-line and 14 off-site),
- fish samples from several locations on Big and Little Bayou creeks,
- 10 soil-sampling locations [4 fence-line, 4 that are 8 km (5 miles) from PGDP, and 2 that are 13 to 15 km (8 to 9 miles) from PGDP],
- 6 stream-sediment-sampling locations,
- 15 gamma-radiation-monitoring locations (4 fence-line and 11 off-site),
- a Biological Monitoring Program with several monitoring locations, and
- 2 groundwater-monitoring wells and 18 residential wells.

The results of analyses and investigations are presented in this report, and the major findings are summarized in the following subsections.

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External Gamma Radiation

Ambient gamma radiation levels are monitored with thermoluminescent dosimeters (TLDs) at 15 locations surrounding PGDP. The mean exposure rate, as measured by the TLDs, for indicator locations at or beyond the reservation boundary is ~50 mrem/year. The average background exposure in Kentucky is 60–70 mrem/year. In 1992, there was a significantly lower difference between means observed between indicator and background exposure rates at the 95% confidence level. Because the levels of gamma radiation cannot be distinguished from background, quantifiable measurements using TLDs are difficult to obtain.

In addition to routine TLD monitoring, a special long-term radiation assessment was performed in 1991 on the off-site portions of the plant drainage system, which had previously shown elevated levels of radioactive contamination. TLDs were placed in the field for 92 to 107 days. Dose rates on Little Bayou Creek ranged from background levels to approximately twice background.

Airborne Discharges and Meteorological Monitoring

PGDP has 27 air pollution emission sources that are listed on the Kentucky Division for Air Quality (KDAQ) operating permit. Air pollution control equipment used at PGDP includes venturi scrubbers, water sprays, electrostatic precipitators, filters, and chemical traps [i.e., sodium fluoride (NaF) and aluminum oxide (Al_2O_3)].

The C-600 steam plant is the primary source of conventional pollutants. Emissions are controlled through the use of electrostatic precipitators on units 2 and 3 operating with a collection efficiency of ~97%, based on stack test data and emission information from the KDAQ. Unit 1 may be operated with natural gas or fuel oil. Units 2 and 3 may be operated with coal or fuel oil. Fugitive emissions from coal and ash handling are controlled with water sprays.

Radioactive air emission estimates are now required from all sources because of the National Emission Standards for Hazardous Air Pollutants regulation and the Federal Facilities Compliance Agreement between PGDP and the U.S.

Environmental Protection Agency (EPA). All emissions are now included in the 1992 report, both measured and estimated. Previous reports included emissions from only the C-310 purge and product building stack. During 1992, measurements and estimates showed that 1.42 kg (2.11 mCi) of uranium were released to the atmosphere from all activities at PGDP. Seventy-three percent of this increase came from estimates of releases from the C-400 decontamination building. Additional information regarding these changes in reporting can be found in Part 1, Sect. 3.5. Even though trend data are not comparable to previous years' reports, the data are shown in Fig. 1. Also, 12.3 mg (0.206 mCi) of technetium were estimated and measured in all sources of PGDP emissions. No new introductions of technetium-99 (^{99}Tc) to the cascade have occurred. The 1992 data are down from the 3.06 mCi released in 1991, even though other sources are included because the C-310 stack is the major source of ^{99}Tc emissions. Trend data are shown in Fig. 2. Air dispersion modeling performed for PGDP by Oak Ridge National Laboratory (ORNL) indicates that the 50-year committed effective dose equivalent for the most affected resident from all sources is 0.0045 mrem. This dose is small (2,222 times less) compared to the EPA standard of 10 mrem. The population collective effective dose equivalent (50-mile radius) in 1992 was 0.0017 person-rem from PGDP operations, estimated from air emission data.

Air dispersion modeling is the accepted way of predicting the impact on air quality from a source. To provide accurate meteorological data, a meteorological tower was installed at PGDP using data transferred to a computer. Wind and other meteorological parameters were monitored to provide data for dose calculations for the 1992 report.

PGDP operates 12 ambient air samplers surrounding the plant to monitor concentrations of fluorides and radioactive particulates. All fluoride concentrations measured in 1992 were well below Kentucky air quality standards.

Waterborne Discharges and Surface Water Monitoring

The Clean Water Act is administered for PGDP by the Kentucky Division of Water (KDOW) through the Kentucky Pollutant Discharge Elimination

Fig. 1. Millicuries of uranium released to the atmosphere from PGDP operations, 1988–1992.

System (KPDES) permitting program. A KPDES permit and Agreed Order allow PGDP to discharge effluents into Big and Little Bayou creeks. During 1992, PGDP experienced a compliance rate on limit exceedances of 99.5% with the KPDES Agreed Order limits. The 1991 compliance rate was also 99.5%. The number of noncompliances with limits dropped from 33 in 1990 to 24 in 1991 and to 10 in 1992. Parameters intermittently not in compliance include total residual chlorine, pH, total suspended solids, and trichloroethylene.

Sodium thiosulfate feed stations have caused the number of total residual chlorine noncompliances to decrease from 12 in 1990 to 1 in 1991 and 1992. Erosion control devices, such as silt fences, hay bales, and filter fabric, have been installed at construction sites. Improved oversight and erosion control devices have improved the control of total suspended solids. Studies have indicated that slightly elevated pH in PGDP effluents is not causing pH in the receiving streams to be elevated above water quality criteria.

Biological monitoring, a requirement of the Agreed Order, was conducted by the University of Kentucky in collaboration with ORNL. Planned and implemented by the University of Kentucky, the monitoring program was patterned after the Biological Monitoring and Abatement Program (BMAP) developed by ORNL for the three U.S. Department of Energy (DOE) facilities in Oak Ridge, Tennessee. The purpose of the BMAP is to determine

Fig. 2. Millicuries of technetium released to the atmosphere from PGDP operations, 1988–1992.

the effects of plant effluents on aquatic life in the receiving streams. The findings of the program were consolidated into a three-year report in 1990 and were submitted to KDOW. ORNL conducted an evaluation of the findings and presented its evaluation to KDOW in 1991. Another report will be published in 1993.

Radiological effluent monitoring as required by DOE Order 5400.5 was also performed during 1992. Comparisons of radiological results from upstream Big Bayou Creek with downstream Big and Little Bayou creek locations indicated elevated levels of uranium, gross alpha, and uranium-235 (^{235}U) in Little Bayou Creek, probably a result of the release of small amounts of uranium in plant effluents and gross beta in Big Bayou Creek. Total discharge estimates of uranium and ^{99}Tc in liquid plant effluents for the past five years are indicated in Figs. 3 and 4, respectively.

Groundwater Monitoring

The scope of groundwater monitoring at PGDP encompasses both effluent monitoring and environmental surveillance monitoring objectives. Effluent monitoring was conducted for solid waste management units, underground storage tanks, and a RCRA interim-status burial ground. Significant support was also provided for a groundwater investigation conducted under a CERCLA

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Fig. 3. Uranium discharges to surface water, 1988–1992.

Administrative Consent Order (ACO). Much of this investigation has components of environmental surveillance monitoring that will be continued until the conclusion of the investigation in 1992.

Several noteworthy groundwater activities were begun or completed in 1992. Groundwater Phase III field activities were completed, and a final report was issued in 1992. This project included soil borings, installation of wells, aquifer testing, and documentation of a site conceptual model. Groundwater Phase IV was initiated to design a plan to address uncertainties concerning the McNairy Formation, the next aquifer below the previously investigated regional gravel aquifer. The Phase II ACO-mandated Site Investigation was completed with the issuance of the report. A Sampling and Analysis Plan was developed to coordinate all needs for groundwater analytical data.

Other Monitoring

Biological Monitoring

Vegetation samples are collected at 18 locations surrounding the plant and are analyzed for fluorides. The primary objective of vegetation sampling is to determine the total fluorides in the vegetation for comparison with the fluoride-in-foliage section of the Kentucky air pollution control regulations. All samples taken in 1992 were well below the 60 µg/g

Fig. 4. Technetium-99 discharges to surface water, 1988–1992.

standard. Samples taken from outside the fenced area range from less than 5.2% to less than 9.3% of the standard.

During 1992, food crops and deer from the PGDP area were analyzed to determine if there was evidence of increases in the concentration of contaminants to a degree that standards were exceeded. Dose calculations were performed as outlined in Sect. 2. The dose from ingestion of each type of food crop was significantly less than 1 mrem per year. The calculated worst-case dose from ingestion of all types of food crops over a one-year period was 0.4 mrem/year. Ingestion of deer meat under the assumptions discussed in Sect. 2 would result in a dose estimated at less than natural background.

Soil and Sediment Sampling

Concentrations of uranium in the soil, annually sampled from 10 locations, showed no significant difference from past data. There was no evidence of concentrations in the predominant wind directions higher (at 95% confidence level) than concentrations upwind of the plant. No detectable concentrations of technetium-99, thorium-230, neptunium-237, or plutonium-239 were present at any of the sampling locations.

The downstream sediment-monitoring location on Big Bayou Creek indicated uranium levels 3.5 times higher than the upstream Big Bayou Creek

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location. Uranium levels at the downstream annual sediment-monitoring location on Little Bayou Creek were 36 times higher than the upstream Little Bayou Creek location. Also, polychlorinated biphenyls (PCBs) were detected in Little Bayou Creek. Big and Little Bayou creeks and KPDES outfall ditches have been investigated during ACO activities. Remedial alternatives have been drafted and are being reviewed by the EPA and the Kentucky Department for Environmental Protection.

Annual Dose Estimate

The maximum individual dose calculated using worst-case estimates for each potential pathway was 4 mrem/year. The major contributors to these

estimates were ingestion of sediments and direct radiation. Data are summarized in Part 1, Table 2.1, and are discussed in Part 1, Sect. 2.

Unusual Occurrences

During 1992, PGDP experienced 573 spills or releases of various materials. A record of each incident is kept in the plant shift superintendent's office. Most of the spills—a total of 311—were PCBs from ventilation duct gaskets. All gasket leaks were inside buildings. Troughs were installed beneath leaking gaskets immediately upon discovery. Highlights of some incidents are given in Subsects. 8.1.1 through 8.1.11.

1992 Compliance Summary Environmental Compliance Activity U.S. Department of Energy

Paducah Gaseous Diffusion Plant

Background and Overview

The Paducah Gaseous Diffusion Plant (PGDP) operates in conformance with requirements established by a number of federal and state statutes and regulations, executive orders, U.S. Department of Energy (DOE) orders, and compliance and settlement agreements. Compliance status with regard to major environmental statutes is summarized below.

DOE Order 5400.1, "General Environmental Protection Program," defines the mandatory environmental standards in effect at DOE operations. These environmental standards fall into three categories: (1) those imposed by federal statutes, regulations, and requirements; (2) those imposed by state and local statutes, regulations, and requirements applicable to DOE; and (3) those imposed by DOE directives. This summary addresses the standards that are significant for PGDP environmental compliance.

Several federal, state, and local agencies are responsible for enforcing environmental laws and regulations at PGDP. DOE itself, through directives to field offices and compliance audits, is the initiating organization. Principal among other regulating agencies are the U.S. Environmental Protection Agency (EPA) Region IV and the Kentucky Department for Environmental Protection (KDEP). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable environmental

laws and regulations. A summary of PGDP permits is shown in Table 1.

The EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed by statutes passed by the U.S. Congress. In some instances, the EPA has delegated regulatory authority to the KDEP when the Kentucky program meets or exceeds EPA requirements. Where regulatory authority is not delegated, EPA Region IV is responsible for reviewing and evaluating compliance with EPA regulations as they pertain to PGDP.

Although significant progress has been made toward achieving full regulatory compliance at PGDP, much remains to be done. Ongoing self-assessments of compliance status and implementation of corrective actions continue to identify environmental issues. These issues are discussed openly with the regulatory agencies to ensure that compliance with all environmental regulations will be attained.

Compliance Status

DOE Order Compliance for Calendar Year 1992

An assessment of DOE order compliance was completed by PGDP on September 30, 1992. Instructions for the assessment came from the Martin

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Table 1. 1992 Paducah Gaseous Diffusion Plant permit summary

Type of permit	Issuer	Expiration date	Permit number
Kentucky Pollutant Discharge Elimination System	Kentucky Division of Water		KY0004049
RCRA ^a Hazardous Waste Management Permit	Kentucky Division of Waste Management	8/19/2001	KY8890008982
RCRA Part B post-closure	Kentucky Division of Waste Management	NA ^b	KY/H35, Rev. 1
Residential landfill	Kentucky Division of Waste Management	Pending	073.14
Inert landfill	Kentucky Division of Waste Management	Pending	073.15
Air Operating Permit	Kentucky Division for Air Quality	None	0-85-110
Permit-By-Rule (applies to the following)	NA	NA	NA
C-616 chromium reduction facility			
C-400-D line precipitation unit			
C-403 neutralization pit			
Clean metal scrap yard			
Waste treatment lagoons at C-611			
Liquid pollution abatement lagoons at C-616			
C-410-C neutralization pit			
Regulated scrap metal yard			

^aResource Conservation and Recovery Act.

^bNot applicable.

Marietta Energy Systems, Inc. (Energy Systems) Standards Development and Management Office. The orders were prioritized using the Energy Systems Risk Prioritization Matrix with level A, B, and C categories. Level A comprises those orders involving environmental, safety, and health issues; safety; and quality assurance, with potential for significant risk or impact. These orders were further subdivided into requirement units (RUs) that appear to be performed by a single functional area. Overall compliance for category A orders was 59% in full compliance, 23% in partial compliance, 6% in noncompliance, and 11% not applicable. An evaluation of orders in category A that apply to environmental areas minus those not applicable showed 65% in full compliance, 24% in partial compliance, and 11% in noncompliance. All noncompliant RUs pertain to three DOE orders: 1540.2, "Hazardous Material

Packaging for Transport"; 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes"; 5480.4, "Environmental Protection, Safety, and Health Protection Standards." Funding has been requested to increase or reach full compliance with these orders but funding has not yet been made available based on risk-priority allocation of funds by program offices. More detail on the breakdown of the category A orders can be found in Part I, Sect. 1, Table I.1, of this report. The status of three major DOE orders is discussed as follows.

DOE Order 5400.1, "General Environmental Protection Program"

DOE Order 5400.1 provides directives for compliance with EPA, state, and local environmental

regulations and establishes requirements for internal environmental protection programs. PGDP maintains compliance with this order through implementation of regulatory requirements of the Clean Air Act (CAA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), Toxic Substances Control Act (TSCA), Safe Drinking Water Act (SDWA), and other federal and state environmental statutes.

Internal environmental management programs include notification and reports such as the Radioactive Effluent and On-Site Discharge Data Report submitted annually to Waste Information Systems Branch, EG&G Idaho Inc., Idaho Falls, Idaho; the 5-year plan as required by Office of Management and Budget Circular A-105; the Annual Site Environmental Report; and reports of significant nonroutine releases of hazardous substances consistent with DOE Order 5000.3A. A long-range Environmental Protection Implementation Plan (EPIP) is prepared and updated annually as is the Environmental Monitoring Plan (EMP). The EPIP defines specific environmental objectives, including the means and schedules for accomplishment. The EMP defines a comprehensive system to provide effluent monitoring and environmental surveillance at PGDP. It is designed to meet federal and state regulation requirements as well as those internal to PGDP and DOE. The environmental media in pathways significant to the exposure of man and the environment are included in the monitoring program, specifically surface water, groundwater, air, and biological media.

Quality assurance and data evaluation are primary considerations for PGDP monitoring, surveillance, and sampling activities. Independent data verification is conducted; this area is targeted for increased attention in the future. Audits of monitoring and sampling activities by state and federal regulatory agencies have been positive; no significant findings have been issued.

DOE Order 5400.5, "Radiation Protection of the Public and the Environment"

DOE Order 5400.5 provides guidance and establishes radiation protection standards and practices designed to protect the public and the

environment against undue risk from operations of DOE and DOE subcontractors. The order requires that off-site radiation doses not exceed 100 mrem/year from all exposure pathways. During 1992, the worst-case estimated dose was 3.77 mrem/year, including a 2.78 mrem dose from sediments and direct radiation in Little Bayou Creek. PGDP conducts various modeling and dose-calculation activities to address the potential for multiple-pathway exposures of the public.

PGDP surface water discharges were all below the derived concentration guides (DCGs) for specific radionuclides listed in the order. Some PGDP stormwater and wastewater discharges from areas with legacy contamination at times exceeded the internal investigation level of 10% of the DCG during 1992. These areas are targeted for further investigation and remediation under the ongoing Environmental Restoration Program.

Reporting requirements under this order are demonstrated through the occurrence reporting system and publication of the annual environmental report.

DOE Order 5820.2A, "Radioactive Waste Management"

DOE Order 5820.2A was issued in September 1988 with the following policy statement: "Radioactive and mixed wastes shall be managed in a manner that assures protection of the health and safety of the public, DOE and contractor employees, and the environment. The generation, treatment, storage, transportation, and/or disposal of radioactive wastes, and the other pollutants or hazardous substances they contain, shall be accomplished in a manner that minimizes the generation of such wastes across program office functions and complies with all applicable federal, state, and local environmental, safety, and health laws and regulations and DOE requirements."

Compliance requirements established in Chapter II, "Management of Transuranic Waste"; Chapter III, "Management of Low-Level Waste"; and Chapter VI, "Waste Management Plan Outline," are directly applicable to PGDP. Requirements covered in Chapter V, "Decommissioning of Radioactively Contaminated Facilities," are provided by the Environmental Restoration Program. A *Waste*

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Management Strategic Plan, KY/W-6, was issued in March 1992. The document details waste management program strategies and compliance requirements for PGDP to meet the intent of all applicable sections of the order.

All waste categories listed in the order require establishment of programs to segregate and minimize the generation of wastes. The PGDP program is detailed in *Paducah Gaseous Diffusion Plant Waste Minimization Plan For 1992*, KY/W-10, issued in August 1992.

Clean Air Act (CAA)

PGDP has an ongoing program to maintain compliance with all regulations resulting from the CAA. As an integral part of this program, PGDP completed a vent/stack survey that identified all the air emission points at PGDP. (Though unlikely, additional emission points may be identified during future surveys.) The vent/stack survey is the first phase of completing an air emission inventory. The second phase will be the establishment of a data base for the emission points. The third phase will be inputting into the data base the various emission parameters from each emission point. This inventory data base will provide information to indicate compliance with permit and regulatory limits.

In 1992 there were no documented fluoride emissions above permitted limits from the C-310, product withdrawal facility, purge vent stack. Emissions from the C-600, steamplant, boilers caused by malfunctions, startups, and shutdowns that temporarily exceeded the standards were reported in accordance with Kentucky Division for Air Quality (KDAQ) regulations.

PGDP received Notices of Violation (NOVs) on August 17 and 18 for opacity greater than 20% from coal-hauling activities and for failure to allow inspectors necessary entry and inspection of a building that housed shutdown air pollution sources. The coal-hauling trucks reduced speed, and water was applied to the coal-haul road to reduce the fugitive dust. The inspectors were initially denied entry to the shutdown air pollution sources apparently because of miscommunication between the inspectors and PGDP staff. The building did contain classified information, and the inspectors did not have clearances. After PGDP Security ascertained that the classified information was not accessible to the

uncleared inspectors, the inspectors entered and inspected the facility on August 19. The KDAQ was generally agreeable to minor delays in entering facilities because of reasons such as locating a key or a facility supervisor. The KDAQ has also been provided with a list of PGDP management names to contact if a KDAQ employee believes that access is being denied unreasonably. The KDAQ's final correspondence on the matter states that the KDAQ maintains its right of entry and inspection and that the inspector is reapplying for a security clearance. Coal hauling was terminated shortly after the inspection, so the KDAQ has requested that PGDP notify them to arrange a follow-up inspection for evaluation of the corrective actions after resumption of receipt of coal. The KDAQ has indicated that the delay or denial of entry for any reason is unsatisfactory. (PGDP expects to resume coal hauling in October 1993. At that time, the KDAQ will be notified so that a follow-up inspection can be performed.) The access issue was discussed at an agreement-in-principle meeting in October 1992.

The KDAQ issued PGDP an operating permit for 27 emission points on September 30, 1985. An ongoing effort to identify and evaluate air contaminant sources through the development of an air emission inventory has indicated many more sources than are listed on the 1985 permit. Therefore, as the result of developing an air emission inventory, PGDP submitted an existing source operating permit application for several sources on May 11, 1992. During 1992, a total of four applications were submitted to the KDAQ.

Clean Water Act (CWA)

The CWA applies to all nonradiological discharges to navigable surface waters. At PGDP, the regulations are applied through a Kentucky Pollutant Discharge Elimination System (KPDES) permit for effluent discharges to Big Bayou and Little Bayou creeks. The Kentucky Division of Water (KDOW) issued KPDES Permit No. KY0004049 to PGDP in September 1992. This permit became effective on November 1, 1992, and is enforced by the KDOW. At the request of PGDP, the state of Kentucky granted a stay of permit limits for pH, metals, and temperature in October 1992. PGDP is working with KDOW to approve an Agreed Order concerning the

establishment of final limits for these parameters. All other conditions stated in the permit are in effect.

Effluent discharges occur at 17 outfalls. Noncompliances in 1992 were for total residual chlorine, trichloroethylene, pH, and total suspended solids. A total of 16 noncompliances occurred in 1992, 10 exceedances of effluent limits and 6 from other sources such as holding time or oil sheen violations. A project has been completed that routes discharges from the east side of the plant to a holding lagoon to control chlorine in the effluents. All water analytical results generated from environmental restoration activities and plant operations must be reviewed and approved for discharge by the Environmental Compliance Department. High priority has been placed on erosion control at construction projects to stop suspended solids violations. Effluent limits for those parameters exceeding effluent limits have been increased, and it is expected that compliance with new limits will be maintained. The compliance rate of PGDP with KPDES permit limits during 1992 was 99.5%.

Resource Conservation and Recovery Act (RCRA)

Hazardous waste facilities at PGDP are operated under a permitted status granted by the state of Kentucky (Facility ID No. KY8890008982). The Part B permit identifies 5 storage and 15 treatment units on the plant site. The closure of the C-746-B, south warehouse, waste chemical storage area was closed in 1991. Closure of the C-720, maintenance and stores building, degreaser task began in 1992.

In calendar year (CY) 1993, the *Annual Hazardous Waste Report for CY 1992* was completed and submitted to the Kentucky Division of Waste Management (KDWM) prior to the March 1993 deadline. The annual report identifies both waste generated that was shipped off-site and waste generated that remains on-site. An NOV was issued in September 1992 for the omission of recirculating cooling water blowdown from the annual hazardous waste reports between 1984 and 1989. In response to the NOV, PGDP revised those reports.

The KDWM performed a site inspection in August and September 1992. The purpose of the inspection was to conduct PGDP's annual RCRA inspection. The inspectors spent four days reviewing documentation, conducting field investigations of

RCRA treatment and storage units, and interviewing personnel throughout the plant. No findings were discovered, and this was the first time in the history of PGDP that the annual RCRA inspection did not result in the issuance of an NOV.

RCRA permitting activities for CY 1992 include a major modification to PGDP's Hazardous Waste Management Permit. The modified Part B permit portion of the overall permit included the addition of the C-404 low-level radioactive waste landfill, 12 additional treatment units for fluorescent lamps, a new waste stream listing, and other cosmetic changes to the original permit. The KDWM issued PGDP a modified permit on October 1, 1992. The modified Hazardous and Solid Waste Amendments portion included a revised schedule reflecting new due dates for submittal of RCRA facility investigation (RFI) work plans.

Toxic Substances Control Act (TSCA)

Polychlorinated biphenyls (PCBs) are used at PGDP and are regulated under TSCA [40 CFR Pt. 761 (Title 40 Code of Federal Regulations)]. Authorized uses of PCBs under TSCA at PGDP include use in dielectric fluid in electrical transformers and capacitors. Also, PCBs at less than 50 parts per million (ppm) have been identified in lubricant and hydraulic systems on-site. To track the PCB concentration in equipment on-site, a data base was established during 1992. The eventual goal of this data base will be to account for the PCB concentration in oil-containing equipment on-site for spill and waste management purposes. The *Calendar Year 1991 PCB Annual Document* was issued on July 1, 1992, to the PGDP DOE Site Office. The document includes an inventory of all regulated PCB waste and in-service equipment. The goal of PGDP is to phase out the use of PCB-containing items to the maximum extent practicable as quickly as possible. PGDP has more than 8,000 large high-voltage PCB capacitors in-service. A replacement project has been initiated to replace all these PCB capacitors by September 1994.

On February 20, 1992, a TSCA Federal Facilities Compliance Agreement was approved between DOE Headquarters and EPA Headquarters (EPA/HQ). The compliance agreement resolved issues associated with TSCA regulations, including the reuse of PCBs in ventilation duct gaskets, historical PCB oil spills

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on process building floors, storage of uranium-contaminated PCB wastes beyond the TSCA one-year limit, the presence of PCBs above regulatory limits in three hydraulic systems in the C-340, UF₆ reduction facility (inactive), building, and leaking PCB capacitors inside switchyard potential devices. PGDP is in compliance with the terms of the TSCA compliance agreement.

Quarterly progress reports were issued during 1992 that included summaries of the reporting requirements of the TSCA compliance agreement. The quarterly reports will be combined into an annual compliance agreement report, which is due to EPA/HQ by July 1, 1993. Many activities associated with compliance measures in the TSCA FFCA were completed during 1992. Certifications regarding the on-site historic PCB disposal site investigation and personnel protective clothing and equipment were submitted to EPA/HQ on March 17, 1992. PCB waste storage compliance certifications were submitted to EPA/HQ on August 11, 1992. Replacement of all devices with potential leaking PCB capacitors was completed August 24, 1992, and notification was made to EPA/HQ on November 18, 1992. This project was completed approximately nine months ahead of schedule. Quarterly air sampling for PCB was conducted in process buildings, and no results exceeded the TSCA compliance agreement reportable quantity of 0.5 µg/m³. Also, trough installation on leaking motor exhaust duct gasket flanges is proceeding on schedule.

During February 1992, magnesium fluoride process waste in the C-340 building was found to contain detectable concentrations of PCBs. The most likely source of the contamination was a hydraulic system that is now drained but that had contained regulated PCB fluid. On June 25, 1992, the EPA granted approval to manage the waste as unregulated under TSCA, which closed this issue. The approval was based upon the contamination occurring prior to April 18, 1978; this date being the effective date of federal PCB regulations.

Two large PCB-contaminated electrical motors were declared waste during 1991, and no containers were available to properly package the motors in accordance with 40 CFR Pt. 761.65. Approval was received from the EPA regional TSCA coordinator during March 1992 for use of alternate packaging methods to store large PCB wastes. The motors were

packaged in these containers during 1992, and this issue was closed.

During June 1991, the C-746-A PCB waste storage facility was discovered to have a leaking roof. Title 40 CFR 761.65(b)(1)(i) requires these facilities to have adequate roofs and walls to prevent rainwater from reaching the stored PCBs and PCB items. A project was completed that replaced the roof on this facility during June 1992 to enable a certification of storage compliance to be submitted to the EPA. However, since this time minor leakage during periods of heavy rain has reoccurred. The same problem has been identified with the C-746-B, south warehouse, and C-733, waste oil and chemical storage facilities. These roofs are the only outstanding TSCA issue being carried as open noncompliances. An EPA Region IV interpretation of the regulations given on November 23, 1992, stated that a major storage violation could result if a situation existed that could expose PCBs to precipitation. Therefore, efforts are continuing to repair the roofs to ensure no leakage during rains.

Numerous environmental audits were conducted during 1992 at PGDP by Energy Systems Environmental Compliance, DOE/NE-33, and internal inspectors. No major findings were identified that require extensive resources to correct. The majority of the findings were marking and storage noncompliances that could be corrected within 24 hours of discovery.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

An administrative consent order (ACO) was executed in 1988 between the EPA and DOE under Sects. 104 and 106 of CERCLA. The ACO was executed in response to the discovery of off-site groundwater contamination in residential wells north of PGDP. The contaminants in the wells are trichloroethylene (TCE), a degreasing solvent used at PGDP, and technetium-99 (⁹⁹Tc), a man-made radionuclide produced during the fission of uranium. The source of ⁹⁹Tc at PGDP was the enrichment of reprocessed uranium from nuclear reactors at other DOE facilities. The major requirements of the ACO include monitoring of residential wells potentially affected by contamination; provision of alternative drinking water supplies to residents with

contaminated wells; and investigation of the nature, extent, and source of the contamination. Residential wells are sampled on a weekly, monthly, or bimonthly basis for TCE and ^{99}Tc ; wells potentially affected by the contamination are also sampled monthly for gross alpha and gross beta contamination. Samples are analyzed by the on-site laboratory, and the results are reported to the well-owners. In the event that contamination that originated at PGDP is detected above plant action levels, which are established at the analytical laboratory detection limits of 25 pCi/L or 1 mg/L of ^{99}Tc , a response is initiated by PGDP. Residents are notified immediately; state and EPA officials are also notified. Alternative water supplies are provided through connections to municipal water systems, or in the event that there is a time lag between discovery and the ability to complete connections, bottled water is made available. DOE pays the cost of installation of water systems and the monthly charges for water service to residents with contaminated wells. The plant has several programs proceeding to investigate the nature and extent of contamination. These include the investigation of solid waste management units under the Hazardous and Solid Waste Amendments Permit; the characterization of the northwest plume using direct push sampling technologies to provide data needed to select the locations for the hydraulic containment system; and investigations of the northeast plume as a part of the Groundwater Monitoring Phase IV Study. More information on environmental restoration CERCLA activities may be found in the "Current Issues" section of this summary and in Part 1, Sects. 5 and 8, particularly Sects. 5.5.13, 5.6.7.1, and 8.2.1 of the 1992 PGDP Environmental Report.

CERCLA Section 103(a)

On October 21, 1991, a request was issued to EPA Region IV and to the KDOW seeking concurrence on the reporting mechanism for oil sheens on KPDES outfall ditches and on Big and Little Bayou creeks. To date no response has been received. PGDP submitted the Spill Prevention and Control Countermeasures Plan to EPA Region IV and to the KDEP. Three releases were reportable to the National Response Center because reportable quantities were exceeded.

Emergency Planning and Community Right-To-Know Act (EPCRA)

The EPCRA [also referred to as the Superfund Amendments and Reauthorization Act Title III] requires that inventory and environmental release information of certain chemicals at a facility be reported to federal, state, and local authorities. This information is used for emergency planning and to provide information to the public. EPCRA requires that local and state emergency planning commissions be informed of the amount of hazardous and extremely hazardous substances that are present at PGDP and that a material safety data sheet (MSDS) be available for each chemical upon request. The regulation also requires that releases of toxic chemicals to the environment be reported each calendar year if chemical threshold limits are met. Two releases were reported under EPCRA Sect. 304 during 1992.

The Emergency and Hazardous Chemical Inventory Report was submitted to the state and local emergency planning commissions in March 1993. MSDSs are kept on site and are available upon request through the PGDP Hazard Communication Program. Detailed information on the *Toxic Chemical Release Report for 1992* is presented in Appendix A of the *Paducah Gaseous Diffusion Plant Environmental Report for 1992*.

National Environmental Policy Act (NEPA)

NEPA implementation is a decision making process that considers the need for a proposed action and an alternative action with emphasis on minimizing environmental impacts. It establishes policy, sets goals, and provides means for carrying out the policy. NEPA contains "action forcing" provisions to ensure that federal agencies act according to the letter and spirit of the act.

Through the implementation of NEPA, the plant has a practicable means (consistent with the requirements of the act and other essential considerations of national policy) to restore and enhance the quality of the human environment and to avoid or minimize any possible effects of its actions upon the quality of the human environment.

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NEPA compliance personnel review all engineering service orders, engineering service requests, and work orders and submit appropriate NEPA documentation to DOE for project approval. Compliance with NEPA is maintained by following the guidelines set forth by the Council on Environmental Quality, DOE, and Energy Systems.

During 1992, NEPA compliance personnel completed 95 NEPA review checklists. Categorical exclusion (CX) determinations were issued in 110 cases, and 96 CX approvals were received. Five environmental assessment (EA) determinations were submitted to DOE for review and approval: Plant Laboratory Facility—ESO 17846, CFC-114 Replacement—ESO 17977, Groundwater Pump and Treat Demonstration—18045-RA, Uranium Enrichment (UE) Waste Storage Facilities—NEPA No. 92-011, and Environmental Restoration (ER) Waste Storage Facilities—NEPA No. 92-012. One environmental impact statement determination was submitted to DOE for review and approval: CFC-114 Replacement—ESO 17977. Three EA determinations were approved by DOE: UF₆ Cylinder and Storage Yards—ESO 17628, UE Waste Storage Facilities—NEPA No. 92-011, and ER Waste Storage Facilities—NEPA No. 92-012. Four EAs were presented to DOE during the year: Solid Waste Landfill—ESO 18007, Groundwater Pump and Treat Demonstration—18045-RA, UE Waste Storage Facilities—NEPA No. 92-011, and ER Waste Storage Facilities—NEPA No. 92-012.

Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides are used by PGDP personnel. If application of a restricted-use pesticide at the plant is necessary, a certified contractor will be used to make the application. General-use pesticides applied by plant personnel are applied in a manner consistent with the product labeling. All product warnings and cautions are strictly adhered to. Applications of pesticides by plant and contractor personnel must be approved by the plant pesticide coordinator. Napchlor-G is a fungicide that was used at PGDP as a wood preservative for cooling towers. The Waste Management Operations Department at PGDP is seeking a vendor that will dispose of the Napchlor-G being held on-site.

Safe Drinking Water Act

PGDP operates a "nontransient, noncommunity" public water system subject to regulation by the KDOW. The PGDP water treatment facility is a Class II facility. Ten on-site operators have Class II or higher certification. Monthly operational reports are provided to the KDOW describing operational activity for the facility. The ongoing training required to maintain certification is provided by a program developed in-house. The state of Kentucky has approved the program as meeting KDOW requirements.

In 1992, surveys of the sanitary water supply system indicate that the plant's drinking water meets all state and federal regulations for maximum contaminant levels for the required inorganic parameters. In 1992, PGDP completed a quarterly survey of the sanitary water system for eight regulated volatile organic compounds (VOCs). In one quarter of sampling, 1,2-dichloroethane was detected, but the concentration was below the maximum contaminant limit set by drinking water regulations. Because the VOC was detected in a sample, PGDP will continue quarterly sampling of VOCs for at least three consecutive years in accordance with KDOW drinking water regulations.

Current Issues

CAA Compliance

PGDP, in conjunction with the DOE Oak Ridge Field Office (DOE-OR) and the three Oak Ridge facilities, submitted a radionuclide National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance plan to EPA Region IV in March 1990. Because of the enormous number of potential radiological air emission points (albeit small ones) and the difficulty of initially evaluating each point and periodically confirming the insignificant emissions, the plan requested approval to use ambient air samplers to collect data and demonstrate compliance with the 10-millirem (mrem) standard established in the regulation. On February 8, 1991, DOE-OR received correspondence from the EPA stating that ambient air sampling could not be used to demonstrate compliance with any portion of the regulation except computation of dose. Therefore, PGDP and the Oak Ridge facilities are required to

perform stack sampling on each emission point or submit evidence that the emissions from each stack result in a dose less than 0.1 mrem. A revised compliance plan was submitted to the EPA in May 1991.

PGDP negotiated an FFCA with EPA Region IV to comply with 40 CFR Pt. 61, Subpart H (NESHAP regulations), which pertains to airborne radionuclides from DOE facilities. The FFCA was signed by DOE and the EPA in May 1992. The FFCA stated requirements for PGDP to document compliance with the monitoring provisions of the regulation. The regulation requires continuous measurement of radionuclides from each emission point having the potential to emit radionuclides that would result in a dose of 0.1 mrem (assuming no pollution controls) to the most affected person or persons outside the plant.

At present, PGDP has documented one source, the C-310, product withdrawal facility, stack, with potential emissions that would result in the 0.1-mrem dose. PGDP has concluded that the emissions, at the point of sampling, are gaseous. The C-310 stack is sampled continuously by a potassium hydroxide impinger train, which is not an EPA-approved (isokinetic) sampling method for particulate emissions. Isokinetic stack sampling was performed in February 1992 to determine the presence or absence of particulates in the C-310 stack. Although uranium was collected on the sample filter, the concentrations were lower than comparable samples collected in the existing PGDP impinger train, indicating that PGDP is not underestimating uranium emissions. Furthermore, previous PGDP laboratory experience indicates that unless the uranium sample media—in this case a particulate filter—is “conditioned” prior to collecting a sample, the UF_6 gas will coat the sample media, thus providing a positive bias for the presence of particulates. PGDP submitted the stack sampling results to the EPA on April 4, 1992, and received a response from the EPA indicating the C-310 stack sampling system is satisfactory. Thus no upgrade is required.

PGDP has fulfilled all the obligations in the FFCA and forwarded certification to the EPA. On March 26, 1993, PGDP received correspondence from EPA Region IV acknowledging that all conditions of the NESHAP FFCA have been completed. PGDP is in compliance with 40 CFR Pt. 61, Subpart H. The 1992 dose from the PGDP air

emission sources is significantly below the 10-mrem/year standard for the most exposed member of the public. The maximum effective dose equivalent to the most affected individual from airborne emissions was 0.0045 mrem.

For some sources, compliance is demonstrated by throughput/usage information. Documentation of compliance (through implementation of throughput/usage logbooks) is increasing throughout the plant.

CAA Current Issues

On December 10, 1992, the EPA proposed a rule to implement Sect. 608 of the CAA Amendments of 1990 (the act). This section of the act contained a prohibition on the intentional release of Class I and Class II ozone-depleting compounds during maintenance activities. Certain de minimis releases associated with good faith attempts to recapture or recycle are not subject to the prohibition. The prohibition was effective July 1, 1992. According to the PGDP Chief Counsel, the recovery activities at PGDP are in compliance with the prohibition as stated in the act. However, to more explicitly implement the prohibition, the EPA, in the proposed rule, established vacuum requirements for recovery of Class I and Class II stratospheric ozone-depleting compounds during maintenance activities. CFC-114, which is used as a coolant for the enrichment cascade, is a Class I compound. The vacuum requirement for CFC-114 was established in the proposed rule at 25 inches of mercury. Whether PGDP can achieve this vacuum during CFC-114 recovery in the cascade coolant system is questionable. Furthermore, certain maintenance scenarios could result in smaller releases than if the provisions of the proposed rule were strictly followed. The final rule that will establish the vacuum requirements is expected to be published in April or May 1993. Therefore, personnel from the PGDP Air Compliance Program coordinated a meeting with EPA/HQ to discuss the potential problems. Representatives from the Paducah DOE Site Office, the Portsmouth Gaseous Diffusion Plant, the Oak Ridge K-25 Site, Energy Systems, Central Environmental, and DOE Headquarters attended the meeting. Although no formal decision was rendered, the EPA did indicate that it would favorably consider

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the issues discussed at the meeting when developing the final rule.

CWA Compliance

The Corps of Engineers (COE) PCB Source Identification Project was completed in 1992 (see Sect. 8.2.4 for more details). A report summarizing this investigation was submitted to the KDOW in November 1992. The results from the study indicated that the source of PCBs at PGDP is not from ongoing operations at the facility but from accumulation of PCBs from historical releases in creek sediment surrounding the plant. A new study to identify the areas in Little Bayou and Big Bayou creeks where PCB contamination in the sediment has occurred will be conducted by the COE. This study will be completed in fall 1993.

PGDP is working with KDOW to establish final permit limits for metals, pH, and temperature that will satisfy both parties as well as protect the environment. An Agreed Order (AO) between the state of Kentucky and PGDP is being negotiated. PGDP has contracted Oak Ridge National Laboratory to study the impact of each of the previously mentioned parameters on the waters of Little Bayou and Big Bayou creeks. The results from these studies will be presented to KDOW for the determination of permit limits. (A draft AO has been submitted by PGDP to KDOW. KDOW is still reviewing the draft AO. KDOW has concerns about the compliance schedule submitted by PGDP.)

RCRA Compliance

The Hazardous and Solid Waste Amendments (HSWA) permit became effective on August 19, 1991. To date, no violations of PGDP's HSWA permit have occurred. The HSWA permit provides a schedule for compliance for the submittal of RFI work plans to the EPA and KDWM. PGDP met its first deadline on June 12, 1992, by submitting an RFI work plan for waste area groupings 5 and 11. Other deadlines for the RFI work plans have been extended by a minor modification to the HSWA permit.

The RCRA Hazardous Waste Permit Modification, effective October 30, 1992, included conditions that require groundwater monitoring for the C-404 low-level waste facility radionuclides and a mechanism for triggering DOE into compliance

monitoring and corrective action. Because DOE takes the position that by statute radionuclides are not regulated under a RCRA permit, these permit conditions have been appealed to the Natural Resources and Environmental Protection Cabinet. The case has been assigned to a hearing officer, and at present the legal issues are being briefed by both DOE and the Commonwealth of Kentucky.

In 1992 there were three RCRA NOV's issued to DOE by the state of Kentucky:

1. On January 28, 1992, KDWM issued an NOV for the improper storage of hazardous waste in a degreaser in Building C-720, maintenance and stores building. The sludge residue in the bottom of the degreaser was hazardous for trichloroethylene. PGDP submitted a closure plan to KDWM in March 1992, to resolve the NOV. The plan was approved by KDWM, and PGDP is in the process of implementing the plan to properly clean and close the degreaser and associated units.
2. An NOV was issued for the deficient waste-reporting practices associated with the annual hazardous waste reports from 1984 through 1990. PGDP did not disclose to KDWM waste that was either treated or stored in a "permit-by-rule" unit. There was some confusion as PGDP believed it was exempt from the waste-reporting criteria associated with the permit-by-rule facilities. PGDP revised the reports from the aforementioned years and submitted them to KDWM. PGDP and KDWM recognize the NOV as resolved, and no further corrective action is warranted.
3. PGDP received an NOV on November 4, 1992, for the improper storage of hazardous waste in the C-750-C underground storage tank (UST). The tank was used to collect used oil destined for a recycling facility. However, trichloroethylene was inadvertently placed in the tank causing the unit to be subject to all hazardous waste regulations. These regulations state that a facility must have a permit to store a hazardous waste for greater than 90 days. The C-750-C UST has been inactive for more than 90 days, and PGDP has submitted a closure plan to KDWM to comply with the NOV. The plan is being reviewed by KDWM. Once the plan is approved, PGDP will implement the provisions of the plan to clean and close the unit.

The *Annual Hazardous Waste Report* was completed and submitted to the KDWM before March 1, 1993. The report contains a list of all hazardous wastes generated during CY 1992 that were either shipped off-site or that still remain on-site.

On March 29, 1990, the EPA promulgated the toxicity characteristic rule. This rule requires companies that generate or manage hazardous wastes to determine whether any of their wastes exhibit the new toxicity characteristic and to develop compliance strategies for management of this waste. The toxicity characteristic leachate procedure (TCLP) replaces the extraction procedure toxicity test that was previously used to determine the characteristic of toxicity. PGDP has wastes stored that were previously characterized with the extraction procedure toxicity procedure and that require re-characterization. PGDP also has wastes in storage and waste streams not characterized in accordance with the toxicity characteristic rule.

An FFCA for TCLP waste characterization was signed by PGDP, DOE, and the EPA. The FFCA has an effective date of April 3, 1992. An implementation plan required by the FFCA for PGDP was forwarded to the EPA by the required deadline of April 24, 1992. This plan details the roles and responsibilities for the proper characterization of certain wastes over a ten-year period. The first two years of this agreement are committed to dealing with the administrative concerns such as budget, hiring of personnel, conducting an inventory of certain wastes, and so forth. The actual characterization of the wastes will not begin until CY 1994.

TSCA Compliance

A TSCA compliance agreement between DOE and EPA/HQ was executed on February 20, 1992. Four issues covered by this agreement are being corrected through interim compliance measures identified in the agreement. The current status of implementation is outlined in the preceding Compliance Status Section.

1. Unauthorized Use of PCBs in Ventilation Duct Gaskets

Buildings at PGDP contain ventilation duct systems for heating and cooling of both personnel

space and process equipment. The gaskets in a number of these systems contain varying levels of PCBs. As a result, the gaskets constitute non-totally enclosed PCB systems, which are prohibited by 40 CFR 761.20(a). The agreement outlined a compliance schedule for replacement of the gaskets and thereby resolved this issue.

2. Historical PCB Oil Spills

In the past, oil from ventilation duct gaskets leaked onto the concrete floors of the process buildings and associated equipment under the ducts before it was discovered that the leaked oil was PCB contaminated. The agreement outlined a compliance schedule for disposal of historical PCB-contaminated oil spill material and thereby resolved this issue.

3. Unauthorized Mixed TSCA Waste Storage

Uranium-contaminated PCB mixed wastes are being stored in excess of the one-year limit imposed by TSCA because of a lack of treatment and mixed-waste disposal capabilities. The EPA issued a complaint to Energy Systems about this issue on October 3, 1990. The agreement outlined a compliance schedule for disposal of the waste and thereby resolved this issue. The complaint filed against Energy Systems has been also been resolved with no liability for PGDP.

4. Unauthorized Use of PCBs in Hydraulic Systems

Two hydraulic systems with PCB labels affixed were found in C-340 during an inspection conducted by PGDP personnel during February 1991. Because of a lack of documentation indicating that these systems were below 50 ppm PCBs, samples were taken of residual oil in the systems' reservoir. After the inspection, documentation was found indicating that the systems had been drained and placed on standby status in 1982. Results of samples taken in February 1991 showed PCB concentrations in excess of 50 ppm, which is an unauthorized use of PCBs under TSCA and is not in compliance with 40 CFR Pt. 761.30(e). The TSCA FFCA outlined a compliance schedule for demolition of the systems and thereby resolved this issue.

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Land Disposal Restrictions (LDRs)

In 1984, Congress mandated the EPA to implement a progressive schedule of restrictions on the landfilling of hazardous wastes. These restrictions, implemented in five phases beginning in 1986, prohibit the disposal of hazardous wastes unless first treated to meet regulatory treatment standards. Storage of “thirds” hazardous wastes was allowed after May 8, 1992, only if the wastes would be treated and disposed in the near future. Because many of the hazardous wastes at PGDP are subject to DOE’s May 17, 1991, moratorium on off-site shipment of radioactive hazardous waste, there is no ultimate disposal site for many of PGDP’s wastes, and their further generation became a violation of RCRA regulations. PGDP and the EPA entered into an FFCA covering all LDR wastes on June 30, 1992. The agreements set forth several deliverables to the EPA primarily dealing with treatment of LDR wastes. A waste minimization plan along with plans that detail treatability studies for wastes both with and without treatment technologies have been forwarded to the EPA. Quarterly and annual update reports are due to the EPA on these plans so that the EPA may track PGDP’s progress. PGDP has provided all data required by the FFCA. Also, a case-by-case extension for thirds mixed wastes was proposed by the EPA through notice in the *Federal Register*. The EPA allowed for an extension until May 8, 1993, for thirds mixed wastes.

Mixed and hazardous waste subject to the LDRs of RCRA have been stored in some areas of PGDP for longer than one year in violation of the regulation. These wastes are subject to LDR storage prohibitions that permit storage only for accumulation of sufficient quantities to facilitate proper treatment, recycling, or disposal. LDR waste remains in storage in the RCRA-permitted storage facilities at PGDP. LDR waste is stored only in permitted facilities.

CERCLA Compliance

In July 1988, the Kentucky Radiation Control Branch, in conjunction with the Purchase District Health Department, sampled several residential groundwater wells north of PGDP in response to concerns from a local citizen regarding the quality of water in his private well. Subsequent analyses of these samples revealed the presence of elevated gross

beta levels indicative of potential radionuclide contamination. On August 9, 1988, these results were reported to PGDP, which responded by sampling several private groundwater wells around the plant on August 10, 1988. Upon analysis, some of the samples collected by PGDP were found to contain elevated levels of both TCE and ⁹⁹Tc; it was concluded that ⁹⁹Tc was the source of the elevated gross beta levels. Subsequently, PGDP initiated a two-phased site investigation, as agreed to in an ACO drafted under Sects. 104 and 106 of CERCLA, to identify the nature and extent of off-site contamination at PGDP.

Phase I of the site investigation, which extended from summer 1989 to March 1991, evaluated the extent of off-site contamination at PGDP through extensive groundwater monitoring and surface water sampling. Results of the Phase I activities are reported in *Results of the Site Investigation, Phase I* (CH2M Hill 1991). Phase II of the site investigation, which extended from November 1990 to October 1991, focused on identification and characterization of the on-site sources contributing to the off-site contamination, determined the level of risk to human health and the environment from exposure to contaminated media and biota, and developed an initial list of remedial alternatives. Results of the Phase II site investigation are reported in *Results of Site Investigation, Phase II* (CH2M Hill 1992a). In general, the principle findings of the site investigation include:

- TCE and ⁹⁹Tc are the primary contaminants in groundwater at PGDP.
- A northwest and northeast groundwater plume extending off-site was delineated.
- PCBs and radionuclides were the primary contaminants detected in surface water and sediment in outfalls, ditches, and creeks.
- Twenty-one on-site sources were identified as contributors to the off-site contamination.

Risks to human health and the environment from exposure to contamination originating at PGDP were reported in *Results of the Public Health and Ecological Assessment, Phase II* (CH2M Hill 1992b). This report used data collected during the site investigation to quantitatively assess risks to human health and to ecological health from contaminants migrating from PGDP. A range of preliminary

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remedial alternatives that may be used to address the contamination reported in the Phase II report (CH2M Hill 1992a) was developed during the ACO activities. This material is presented in *Summary of Alternatives for Remediation of Off-Site Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (SAIC 1991).

In response to the initial report in July 1988 that samples collected by the state revealed groundwater contamination in a local residential well, PGDP immediately instituted the following interim actions:

- provided temporary bottled water to affected residences,
- sampled all surrounding residential wells to determine the extent of residential well contamination,
- extended the city water line to affected residences as a permanent source of water, and
- began routine sampling of residential wells around PGDP.

Upon completion of the site investigation and in response to the risks identified in the *Results of the Public Health and Ecological Assessment, Phase II*, PGDP initiated the development of several additional interim actions designed to prevent further off-site migration of contaminants and to reduce risks to human health and the environment. These include the proposed construction of a pilot hydraulic containment system for the northwest groundwater plume [detailed in *Technical Memorandum for the Interim Remedial Action of the Northwest Plume, and Proposed Plan for the Interim Remedial Action of the Northwest Plume (Draft)* (SAIC 1993)]; the proposed construction of institutional controls (posting and fencing) for those outfalls, creeks, and lagoons to which the public can gain access and in which there may be contaminated sediment, surface water, and/or biota [detailed in *Interim Action Workplan for Institutional Control of Offsite Contamination in Surface Water Outfalls, Creeks, and Lagoons* (SAIC 1992)]; proposed construction of sediment control devices around the scrap yards and adjacent ditches to limit sediment movement at PGDP [detailed in *Interim Corrective Measure Work Plan for Containment of Scrap Yard Sediment Runoff* (SAIC 1993)]; and proposed measures for the North-South Diversion Ditch [detailed in *Interim Corrective Measures Work Plan for the North-South*

Diversion Ditch, Virginia Ave. to C-616-C Lift Station (SAIC 1993)].

The Phase I and Phase II documentation and the proposed response actions previously identified are intended to meet the objectives of the ACO. Schedules for additional response actions pertaining to off-site contamination are outlined in the draft *Site Management Plan* (PGDP 1993). The *Site Management Plan* has been developed to serve as the primary strategy document for the Environmental Restoration Program. The schedules in the plan will become enforceable through a schedule of compliance in a federal facilities agreement (FFA), once it is finalized. The FFA is an enforcement agreement between the EPA, the state of Kentucky, and DOE that establishes the procedural and regulatory framework for remediation activities at PGDP. The draft FFA for PGDP was received from the EPA in May 1993, and is under review by PGDP, Oak Ridge, and DOE Headquarters personnel. Comments on the draft are due to the EPA and the state on August 2, 1993, with initial negotiations planned for early August.

PGDP was proposed for inclusion on the federal facilities portion of the National Priorities List (NPL) in May 1993. The facility scored a 56.9 on the Hazard Ranking System 2. A score of 28.5 is required for listing a facility on the NPL. Upon listing, CERCLA will become the primary driver for remediation at PGDP. However, federal facilities are not eligible to receive money from the federal "Superfund" for cleanup activities. An FFA, which is required to be developed for facilities listed on the NPL, is being developed by the EPA, the state of Kentucky, and DOE.

NEPA Compliance

NEPA establishes guidelines and responsibilities for addressing environmental considerations during project planning, design, and construction. PGDP will to the extent possible use all practical means, consistent with the requirements of the act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any adverse effects of its actions on the quality of the human environment.

A number of options are available to projects, depending upon their scope. When evaluating a project, NEPA compliance personnel initially

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complete a checklist to help determine the level of documentation the project may require. The checklist may lead to a request for a CX, an EA, or an environmental impact statement. DOE will determine the type of document required.

A number of executive orders and federal environmental protection statutes are integrated into NEPA programs to ensure that the resources they are concerned with are protected against any adverse environmental impacts that might result from a plant activity or project. They include Executive Order 11988, Floodplain Management; Executive Order 11990, Protection of Wetlands; the Endangered Species Act; the Fish and Wildlife Coordination Act; the Farmland Protection Policy Act; the National Historic Preservation Act, which protects national historic landmarks; the American Indian Religious Freedom Act, which protects the freedoms of Native Americans; and the Wild and Scenic Rivers Act.

Environmental Audits

In June 1992, a compliance sampling inspection was conducted at PGDP by the KDOW. No noncompliances were identified. The annual inspection to review PGDP emission points by KDAQ was conducted in August 1992. Two NOV's resulted, one concerning fugitive dust emissions from a coal-haul road and the other concerning denial of access to a restricted facility. Both violations have been addressed and are considered resolved.

The annual RCRA inspection was conducted in September 1992. RCRA training, hazardous waste storage areas, and other aspects of the RCRA Part B permit were reviewed. No noncompliances resulted from the inspection.

A team of 22 inspectors from Central Staff Environmental Compliance and Martin Marietta Corporate conducted an audit of PGDP environmental programs during the week of October 5, 1992. Twenty noncompliances and 48 negative observations resulted. Thirteen positive findings were also noted. None of these deficiencies were categorized as Priority I (i.e., a threat or a potential threat to public health or the environment).

In addition to many external (DOE, Central staff, etc.) audits, PGDP maintains an aggressive internal

self-assessment program. This program ensures continued improvements and regulatory compliance. Also, many "lessons learned" are incorporated into the assessment program.

1990 DOE Tiger Team Assessment of PGDP

Secretary of Energy James D. Watkins' ten-point initiative to strengthen safety, environmental protection, and waste management activities at DOE production, research, and testing facilities resulted in the Tiger Team Assessment of PGDP, June 18–29 and July 9–20, 1990. An action plan developed in response to the Tiger Team Assessment, *PGDP Action Plan Response to Compliance Assessment Team Findings*, was approved by Watkins on January 7, 1991.

During its assessment, the Tiger Team reported no noncompliance issues of a magnitude that would necessitate curtailing overall operations at the plant. The Tiger Team identified a total of 199 findings and 4 noteworthy practices. Of the 199 findings, 62 pertained to environmental issues, 123 involved safety and health issues, and 14 were related to management issues, 3 of which addressed DOE matters.

As of March 29, 1993, 37 of the 62 environmental findings have been closed. Completion is past due for 1 finding, and 24 findings are not scheduled for completion at this time.

A verification inspection was performed by Energy Systems on March 20, 1992, to assess the status of actions being taken to resolve findings cited in the original action plan and to document progress in implementation. Team members reviewed documents, conducted interviews, and observed activities in various facilities to determine the extent to which PGDP has implemented the actions agreed to in the original implementation plan. The verification inspection team noted that the plant is making progress in meeting the milestones of the action plan. A number of generic issues were identified that have delayed implementation of action plans. These issues were identified as staffing, temporary measures for long-term corrective actions, long-term planning, documentation, and funding.

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Acronyms and Abbreviations

ACO	Administrative Consent Order
ADI	acceptable daily intake
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
AOC	area of concern
APG	Analytical Products Group, Inc.
Av	average
AVLIS	atomic vapor laser isotope separation
BBK	Big Bayou Creek
BE	boundary east
BMAP	Biological Monitoring and Abatement Program
BMP	Biological Monitoring Program
BN	boundary north
BOD ₅	biological oxygen demand (5 day)
BTEX	benzene, toluene, ethylbenzene, and xylene
CAA	Clean Air Act
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CHR	Cabinet for Human Resources
CO	carbon monoxide
COD	chemical oxygen demand
COE	Corps of Engineers
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
DCG	derived concentration guide
DMR	Discharge Monitoring Report
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOE-ORO	U.S. Department of Energy Oak Ridge Operations
DOT	U.S. Department of Transportation
EA	Environmental Assessment
EAD	environmental assessment determination
EDE	effective dose equivalent
EMD	Environmental Monitoring Department
EML	Environmental Measurements Laboratory
EMP	Environmental Monitoring Plan

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Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERP	Environmental Restoration Program
ES&H	Environmental Safety and Health
ESD	Environmental Sciences Division
ESO	Engineering Service Order
ESP	electrostatic precipitator
FDA	Food and Drug Administration
FFCA	Federal Facilities Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FSAR	Facility Safety Analysis Report
FY	fiscal year
GC/MS	gas chromatograph/mass spectrometer
GR	Grahamville
GWPP	Groundwater Protection Program Plan
HAP	hazardous air pollutants
HARM	Hazardous Atmospheric Release Model
HEPA	high-efficiency particulate air
HF	hydrogen fluoride
HSS	Hydrogeologic Services Section
HSWA	Hazardous Solid Waste Amendments
ICP	inductively coupled plasma
ICRP	International Commission on Radiological Protection
IC25	25% inhibition concentration
IRIS	Integrated Risk Information System
KAR	Kentucky Administrative Regulations
KDAQ	Kentucky Division for Air Quality
KDEP	Kentucky Department for Environmental Protection
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
KPDES	Kentucky Pollutant Discharge Elimination System
LBC	Little Bayou Creek (also LUK)
LCR	lowest concentration reported
LDR	land disposal restricted
LDS	laboratory data system
LLD	lower limit of detection
LLW	low-level waste
LUK	Little Bayou Creek (also LBC)
MAK	Massac Creek
Max	maximum
MCL	maximum contaminant
MDL	minimum detection level
Min	minimum
MOU	memorandum of understanding
MW	monitoring well

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NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOEC	no-observed-effect concentration
NOV	Notice of Violation
NO _x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Response Center
OCB	oil circuit breaker
ODS _s	ozone-depleting substances
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
PAT	Proficiency Analytical Testing
PCB	polychlorinated biphenyl
PD	potential device
PE	plant east
PEC	Performance Evaluation Committee
PET	Proficiency Environmental Testing
PGDP	Paducah Gaseous Diffusion Plant
PIP	Plant Improvement Program
PN	plant north
PPE	personal protective equipment
PVC	polyvinylchloride
PW	plant west
QA	quality assurance
QC	quality control
QSS	Quality Support Section
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
RfD	reference dose
RFI	RCRA Facility Investigation
RGA	regional gravel aquifer
RI/FS	Remedial Investigation/Feasibility Study
RMW	radioactive mixed waste
RUs	requirement units
SARA	Superfund Amendments and Reauthorization Act
SCS	Spill Containment System
SDWA	Safe Drinking Water Act
SEN	Secretary of Energy Notice
SGS	shallow groundwater system
SIE	specific ion electrode
SMP	Site Management Plan
SO ₂	sulfur dioxide
SS	Safeguards and Security
SWMU	solid waste management unit

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Tc	technetium
TCA	trichloroethane
TCE	trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TQM/UEPIP	Total Quality Management/Uranium Enrichment Performance Improvement Project
TUc	chronic toxicity unit
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
UF ₆	uranium hexafluoride
UK	University of Kentucky
USFWA	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
VOC	volatile organic compound
WMIS	Waste Management Information System
WKWMA	West Kentucky Wildlife Management Area

Units

Bq	Becquerel	m	meter
Btu	British thermal unit	M	million
°C	degrees celsius	m ²	square meter
cfm	cubic feet per minute	m ³	cubic meter
Ci	curie	mCi	millicurie
cm	centimeter	mg	milligram
cm ²	square centimeter	Mgd	million gallons per day
cm ³	cubic centimeter	mile ²	square mile
CY	calendar year	min	minute
d	day	mL	milliliter
°F	degrees Fahrenheit	mm	millimeter
ft	foot	mrad	millirad
ft ²	square foot	mrem	millirem
ft ³	cubic foot	oz	ounces
FY	fiscal year	μCi	microcurie
g	gram	μg	microgram
gal	gallon	NTU	nephelometric turbidity unit
gpd	gallons per day	pCi	picocurie
gpm	gallons per minute	ppb	parts per billion
h	hour	ppm	parts per million
ha	hectare	ppt	parts per trillion
in.	inch	s	second
kg	kilogram	SU	standard unit
km	kilometer	temp	temperature
km ²	square kilometer	TUa	acute toxicity units
L	liter	yd ³	cubic yard
lb	pound		

Conversion Table					
Multiply	By	To obtain	Multiply	By	To obtain
acre	0.405	ha	ha	2.47	acres
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mile	1.61	km	km	0.621	mile
lb	0.4536	kg	kg	2.205	lb
liq qt-U.S.	0.946	L	L	1.057	liq qt-U.S.
ft ²	0.093	m ²	m ²	10.764	ft ²
mile ²	2.59	km ²	km ²	0.386	mile ²
ft ³	0.028	m ³	m ³	35.31	ft ³
Bq	27	pCi	pCi	0.037	Bq
nCi	1 × 10 ³	pCi	pCi	1 × 10 ⁻³	nCi
dpm/L	0.45 × 10 ⁻⁹	μCi/cm ³	μCi/cm ³	2.22 × 10 ⁹	dpm/L
pCi/L (water)	10 ⁻⁹	μCi/mL (water)	μCi/mL (water)	10 ⁹	pCi/L (water)
pCi/m ³ (air)	10 ⁻¹²	μCi/cm ³ (air)	μCi/cm ³	10 ¹²	pCi/m ³ (air)
mCi/km ²	1	nCi/m ²	nCi/m ²	1	mCi/km ²
sievert (Sv)	100	rem	rem	0.01	sievert (Sv)

PART 1: Narrative, Summaries, and Conclusions

1. Site Description and Setting

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1. Site Description and Setting

This report presents environmental data and supporting narratives for the U.S. Department of Energy's (DOE's) Paducah Reservation Environmental Monitoring Program during 1992. Part 1 includes all narrative descriptions, summaries, and conclusions and is intended to be a "stand-alone" report for the reader who does not want to review in detail all of the 1992 data. Part 2 includes the detailed data summarized in a format designed to ensure that environmental data of interest to regulators or the public are represented in the tables. Narratives are generally not included in Part 2.

1.1 Operations on the Paducah Gaseous Diffusion Plant (PGDP) Site

PGDP is an active uranium enrichment facility consisting of a diffusion cascade and extensive support facilities. Construction of PGDP began in 1951. The plant began operating in 1952 and was fully operational by 1955, supplying enriched uranium for commercial reactors and military defense reactors. Enriched uranium is uranium in which the concentration of the fissionable ^{235}U has been increased. Natural uranium is mostly ^{238}U with about 0.72% ^{235}U and 0.0051% ^{234}U . Uranium mills process the ores to produce a concentrated uranium oxide, U_3O_8 , that is then commercially converted to gaseous uranium hexafluoride (UF_6) for enrichment at a gaseous diffusion plant. The enrichment mechanism is based on the fact that a UF_6 molecule containing ^{235}U is slightly lighter than a UF_6 molecule containing ^{238}U . As the UF_6 molecules move through the miles of tubing in a cascade system, slightly more ^{235}U than ^{238}U escapes through the small holes in the tubing. As the process of cascading is repeated, the ^{235}U concentration increases. About two-thirds of the ^{235}U

in the natural ore is removed during enrichment, so there are two product streams: enriched uranium and depleted uranium tailings.

At present, uranium enriched at PGDP is further enriched at another DOE gaseous diffusion plant managed by Martin Marietta Energy Systems, Inc. (Energy Systems), in Portsmouth, Ohio. Most of the uranium from PGDP is ultimately designated for the commercial sector as fuel for nuclear power reactors in the United States and abroad. Typical ^{235}U enrichment for fuel use is 3% for commercial power reactors, 60% for the production reactor at the Savannah River site, and 97.3% for naval reactors. Depleted uranium is used for components in both nuclear and conventional weapons.

Extensive support facilities are required to maintain the diffusion process. These include a steam plant, four electrical switchyards, four sets of cooling towers, a chemical cleaning and decontamination facility, water and wastewater treatment plants, a chromium reduction facility, maintenance and laboratory facilities, and two active landfills. Several inactive facilities also are located on the plant site.

The area surrounding PGDP is predominantly rural. Residences and farms surround the plant. Immediately adjacent to PGDP is the West Kentucky Wildlife Management Area (WKWMA), which is used by a considerable number of hunters and fishers each year. Approximately 200 deer are harvested from the area each year through hunting. About 20 of the 35 ponds in the wildlife management area support fishing. One of the existing WKWMA ponds will be converted into a handicap access area. Work began in 1992 on the area's modification. PGDP was able to expedite and reduce the cost and effort of the project. An agreement allowed a subcontractor to excavate soil from the pond area for use in a plant project. This reduced the effort and time for the WKWMA in earth

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moving and fulfilled the need of the plant for clean soil while reducing transportation costs because of the pond's proximity to the plant. Figures 1.1 and 1.2 show the geographic location of PGDP.

1.2 Regional Demography

The WKWMA and lightly populated farmland are in the immediate environs of PGDP. The population within the 80-km (50-mile) radius is about 300,500 persons. Of these, about 39,500 live within 16.1 km (10 miles) of the plant; about 104,000 live within 32.2 km (20 miles). The unincorporated communities of Grahamville and Heath are located 2 to 3 km (1.24 to 1.86 miles) east of the plant. Portions of 28 counties, 11 of which are in Kentucky, 4 in Missouri, 10 in Illinois, and 3 in Tennessee, are included within an 80-km (50-mile) radius of the plant. The largest cities in the region are Paducah, Kentucky, located ~16 air kilometers (10 miles) east of the plant, and Cape Girardeau, Missouri, located ~64 air kilometers (40 miles) to the west (U.S. Department of Commerce April 1991). Figures 1.3–1.6 show the local and regional demography by sectors and annuli as well as by density.

1.3 Surface Water

PGDP is located in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is approximately 24.1 km (15 miles) upstream of the site, and the confluence of the Ohio River with the Mississippi River is approximately 90.1 km (35 miles) downstream. PGDP is located within the drainage areas of Big Bayou and Little Bayou creeks, which meet about 4.8 km (3 miles) north of the site and discharge into the Ohio River. (See Figs. 1.7 and 1.8.)

PGDP is located on a local drainage divide; surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Big Bayou Creek. Big Bayou Creek is a perennial stream whose drainage extends from approximately 4 km (2.5 miles) south of PGDP to the Ohio River. The creek flows toward the river along a 14.5-km (9-mile) course that passes along the western boundary of the plant. Little Bayou Creek, an intermittent stream, originates in the wildlife management area and flows

north toward the Ohio River along a 10.5-km (6.5-mile) course that includes parts of the eastern boundary of the plant. Big Bayou Creek has a 4819-ha (11,910-acre) drainage basin, and the watershed for Little Bayou Creek consists of about 2428 ha (6000 acres).

During dry weather much of the flow in both creeks is from liquid releases from PGDP. Effluents from PGDP operations constitute about 85% of the normal flow in Big Bayou Creek and 100% in Little Bayou Creek.

1.4 Groundwater

The regional gravel aquifer (RGA) is the uppermost aquifer underlying most of PGDP and the contiguous area north. This groundwater flow system is developed primarily in Pleistocene sands and gravels of the lower member of the Continental Deposits, occurring between 13 and 33 m (43 and 100 ft) beneath PGDP. The upper member of the Continental Deposits is predominately composed of silt and clay with interbedded sand and gravel lenses. A layer of loess 3 to 10 m (10 to 30 ft) thick overlies the Continental Deposits at the surface. The Continental Deposits rest upon terraces cut by the ancestral Tennessee and Tennessee–Ohio rivers. Terrace escarpments under the south end of PGDP form the southern limit of the RGA.

Groundwater flow in the loess and the upper member of the Continental Deposits is primarily oriented downward because of the discontinuous nature of the interbedded sand and gravel lenses and the significantly lower potentiometric surface of the RGA. Within the RGA, flow is directed north, discharging into the Ohio River.

1.5 Climate

Paducah is located in the humid continental zone. Summers are generally dry; precipitation occurs mainly in the spring and fall. Winters are characterized by moderately cold days; the average temperature during the coldest month, January, is about 1.7°C (35°F). Summers are warm and humid; the average temperature in July is about 26°C (79°F). Yearly precipitation averages about 120 cm (47 in.). The prevailing wind direction is south-southwest.

1-4 Site Description and Setting

Fig. 1.1. Map showing the location of the U.S. DOE's Paducah Reservation in Kentucky.

Fig. 1.2. Map showing the location of PGDP in relationship to the geographic region.

Fig. 1.3. Population distribution projected to 1992 in a 16-km (10-mile) radius of PGDP.

1.6 Applicable Environmental Requirements

It is PGDP policy to minimize or eliminate waste generation and to protect people and the environment. Internal procedures have been established and implemented to accomplish these tasks. Under the authority of the Atomic Energy Act, DOE has issued numerous environmental orders covering waste minimization, pollution control, effluent and environmental monitoring, and periodic reporting.

These orders are listed in Table 1.1 and are discussed in Sect. 1.7. Federal regulations that are designed to implement various federal laws and that apply to PGDP include the Clean Air Act; the Clean Water Act; the Toxic Substances Control Act (TSCA); the National Emissions Standards for Hazardous Air Pollutants; the Resource Conservation and Recovery Act (RCRA); the Safe Drinking Water Act; the Superfund Amendments and Reauthorization Act; the National Environmental Policy Act; and the Comprehensive Environmental Response,

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ORNL-DWG 93-10163

Fig. 1.4. Population density projected to 1992 in a 16-km (10-mile) radius of PGDP.

ORNL-DWG 93-10618

Fig. 1.6. Population density projected to 1992 in an 80-km (50-mile) radius of PGDP.

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ORNL-DWG 87M-8429R

Fig. 1.7. Local PGDP surface hydrology systems. (Broken lines represent wet-weather streams.)

ORNL-DWG 87M-8431R

Fig. 1.8. The regional area primary surface hydrology system.

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Table 1.1. Environmental Department of Energy (DOE) order compliance status

DOE Order ^a	Total RUs ^b	Full compliance	Partial compliance	Noncompliance	Not applicable
1540.2	24	0	6	13	5
5400.1	20	17	0	0	3
5400.3	1	0	0	0	1
5400.4	6	4	2	0	0
5400.5	29	17	0	0	12
5440.1E	1	1	0	0	0
5480.1B	1	0	0	0	1
5480.3	66	1	17	8	40
5480.4	132	61	13	2	56
5484.1	20	12	0	0	8
5500.1B	7	7	0	0	0
5500.2B	23	20	2	0	1
5700.6B	12	0	12	0	0

^a1540.2, "Hazardous Material Packaging for Transport"; 5400.1, "General Environmental Protection Program"; 5400.3, "Hazardous and Radioactive Mixed Waste Program"; 5400.4, "Comprehensive Environmental Response, Compensation, and Liability Act Requirements"; 5400.5, "Radiation Protection of the Public and the Environment"; 5440.1E, "National Environmental Policy Act Compliance Program"; 5480.1B, "Environmental, Safety, and Health Programs"; 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes"; 5480.4, "Environmental Protection, Safety, and Health Protection Standards"; 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements"; 5500.1B, "Emergency Management System"; 5500.2B, "Emergency Categories, Classes, and Notification and Reporting Requirements"; and 5700.6B, "Quality Assurance."

^bRequirement units.

Compensation, and Liability Act. Kentucky environmental laws are implemented by regulations of the Cabinet for Natural Resources and Environmental Protection. Wastewater discharges; hazardous waste treatment, storage, and disposal; and waste management facilities are all permitted by the Cabinet for Natural Resources and Environmental Protection.

1.7 Environmental Program Information

1.7.1 Waste Minimization Program

Waste minimization is defined as any action that minimizes the volume or toxicity of a waste by avoiding or reducing its generation or by recycling it. Waste reduction is defined as waste minimization plus treatment that reduces the volume or toxicity of the waste. The PGDP Waste Minimization Program will include both waste minimization and waste reduction efforts.

RCRA requires the minimization of hazardous wastes; annual reporting on the progress of the

program is required. DOE Order 5400.3 requires implementation of a waste minimization program for hazardous and mixed wastes. DOE Order 5820.2A requires DOE facilities to establish an auditable waste minimization program for all low-level waste (LLW) generators. DOE Order 5400.1 requires the preparation of a waste reduction program plan that must be reviewed annually and updated every 3 years. A new report required by Secretary of Energy Notice (SEN)-37-92, "Waste Minimization Crosscut Plan," will replace the DOE Order 5400.1 reporting requirements in 1993.

1.7.1.1 Program Objectives

The PGDP Waste Minimization Program was started in 1987. The program was given additional emphasis in 1992 through the creation of a full-time position of plant Waste Minimization Program manager. The Pollution Prevention Awareness Program will include the Waste Minimization Program.

The Waste Minimization Program includes both waste minimization and waste reduction activities and has the following objectives:

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- the identification of waste minimization and reduction opportunities,
- the establishment of waste minimization and reduction goals,
- the prioritization of waste minimization and reduction efforts,
- the initiation of waste minimization and reduction projects (including pilot projects),
- the identification of waste minimization and reduction responsibilities and resource requirements, and
- the tracking and reporting of waste minimization and reduction projects and results.

1.7.1.2 Program Organization

The PGDP Waste Minimization Program is administered by the plant Waste Minimization Program manager in the Environmental and Waste Management Division. Record keeping and reporting are accomplished through the Waste Management Operations Department, which is also in the Environmental and Waste Management Division.

1.7.1.3 Program Implementation

In conjunction with the environmental policy departments and the Waste Management Operations Department, the Waste Minimization Program manager identifies waste streams that are high-priority minimization or reduction candidates based on the following factors:

- availability of storage space,
- waste stream hazard,
- availability of treatment and disposal facilities (both on- and off-site),
- regulatory compliance issues, and
- management and disposal costs.

Following the identification and prioritization of projects, the project listing is divided into two categories: projects that can be accomplished with existing resources and those that require additional resources. A project team for each individual project is established and chaired by the Waste Minimization Program manager. The project teams include members from the responsible organizations or facilities: Technical Operations and Technical Services divisions, the Process and Long-Range

Technical Support programs, the Waste Management Operations Department, and other organizations when necessary.

Large projects may take the form of a formal Total Quality Management (TQM) project. This is most likely to be the case when a significant investment in funding may be required or when the project could result in significant changes in facilities, systems, or operational procedures.

Following completion of the TQM or pilot project, the project team will make a recommendation to the Waste Minimization Program manager and to plant management concerning the project. Management will then make the final decision on whether to fully implement the project.

Projects undertaken for the Waste Minimization Program during 1992 are discussed in Subsect. 8.2.4 of this report.

1.7.2 1993 Program Plan

1.7.2.1 FY 1993 Program Goals

The following plant milestones have been established for PGDP for FY 1993:

- Reduce PGDP waste generation as follows:
 - Polychlorinated biphenyl (PCB),
 - PCB/radioactive waste 10%
 - Hazardous/mixed:
 - Waste oil 20%
 - Aerosol cans 20%
 - Solvent-laden rags 20%
 - Photography wastes 20%
 - Liquid paint wastes 20%
- Update the FY 1992 Waste Minimization Plan to reflect FY 1992 program changes.
- Submit an action plan identifying the necessary steps to eliminate use of Trichloroethylene and Trichloroethane from PGDP.

1.7.2.2 Method of Accomplishing 1993 Goals

During the latter part of 1992, each division was asked to appoint a person to serve as a waste minimization coordinator. The job function of the division coordinator will be to assist the Waste Minimization Program manager in accomplishing

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tasks within each division. Information flow for waste reduction projects and waste reduction project documentation will also be required from each coordinator.

A waste minimization implementation plan was issued that details divisional waste reduction and recycling project goals. Commitment dates were set, and persons responsible for implementation of each action were assigned. All projects will be tracked through the corrective actions data base, which issues monthly reminders of actions due to correct deficiencies and meet milestones.

The Waste Minimization Program manager will work with the Waste Management Operations Department to develop and implement an improved tracking procedure for reporting requirements. This effort will be coordinated with the various site representatives and with the TQM team that is developing the multisite data base.

1.7.3 Long-Term Program Strategy

The long-term strategy for the Waste Minimization Program includes working toward the FY 1993 goals on an ongoing basis. Several other long-term goals and strategies have also been identified.

1.7.3.1 LLW Minimization

The strategy for minimizing LLW includes

- establishment of nonradioactive material management areas,
- prevention of packaging material from entering radiological areas,
- replacement of pallets used in radiological areas,
- compaction or incineration of combustible LLW,
- compaction of noncombustible LLW,
- movement of metal working and equipment repair out of radiological areas where possible,
- decontamination of contaminated scrap metal, and
- investigation of wet-scrubbing for floor cleaning and elimination of the use of solid floor-sweeping compounds.

1.7.3.2 Hazardous and Mixed Wastes

Mixed waste streams are highly variable at PGDP—a large number of small-quantity waste streams exist. The major wastes include chlorinated solvents, aerosol cans, paint wastes, and laboratory wastes. The mixed waste reduction strategy includes

- establishment of nonradioactive material management areas (involving the reclassification of mixed wastes to hazardous wastes),
- elimination of chlorinated solvents in process buildings and shops,
- elimination of chlorinated solvents in the C-400 cleaning building's large vapor degreasers,
- paint waste recycling, and
- aerosol can replacement.

Although most of these projects are specific to a particular waste stream, a detailed review of all mixed waste streams will also be conducted to identify other potential minimization opportunities.

1.7.3.3 PCB and PCB/Radioactive Wastes

PCB and PCB/radioactive waste generation is controlled by regulatory requirements. The most significant waste generation activities include spill cleanup, site cleanups (under the Environmental Restoration Program), and equipment removal. Little opportunity exists for waste minimization in these areas, although some compaction of trash may be feasible. For the foreseeable future, however, efforts will be concentrated on the identification of technologies for the treatment of PCB/radioactive solid wastes. Liquid wastes will continue to be disposed of at the Oak Ridge TSCA incinerator.

1.7.3.4 Residential Wastes

Minimization of the generation of residential waste is unlikely. Increases in plant population will result in waste increases. However, disposal volume may be minimized through off-site recycling (of paper, cardboard, etc.) and through the continued

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compaction of wastes prior to landfilling. The off-site disposal of some residential wastes such as cafeteria food wastes will reduce PGDP landfill usage but will not be true waste minimization or reduction.

1.7.3.5 Data Management

Better data management techniques will be required to track Waste Minimization Program and waste reduction results. A method of identifying causes for waste generation is essential. At present it is not possible to differentiate between spill cleanup, site cleanup, special projects, and routinely generated wastes with sufficient accuracy. Setting definitive waste minimization goals will be difficult until wastes over which PGDP has no control can be distinguished from those over which the plant does have control. The development of a better tracking and reporting system will take 1 to 2 years and is a long-term goal of the Waste Minimization Program.

1.7.4 Pollution Prevention Program

The PGDP Pollution Prevention Program is also directed by the plant Waste Minimization Program manager. Although the Waste Minimization Program focuses on the reduction of contained and solid wastes requiring handling by the Waste Management Department and on- or off-site disposal, the Pollution Prevention Program focuses on the reduction of direct discharges of wastes to the environment through air and water discharges.

The first step in implementing the program was taken in mid FY 1992—a review of air and water discharge point inventories and the Superfund Amendments and Reauthorization Act reporting requirements for chemical releases. This review identified opportunities for discharge reductions through process and operational improvements.

1.7.5 1992 Environmental Self-Assessments

The Environmental Self-Assessment Program at PGDP is a multi-faceted program that includes internal environmental audits conducted by plant audit teams, internal audits conducted by audit teams from outside the plant, as well as programmatic audits and surveillances conducted by PGDP's Environmental and Waste Management Division.

During CY 1992, two internal audits were performed to determine the effectiveness of PGDP's RCRA, TSCA, Clean Air Act, Clean Water Act, asbestos, and related sampling and record keeping programs. The first audit was conducted by a plant team in July 1992, and the second was conducted by a corporate team from Oak Ridge in October 1992. No major findings were discovered during the audits, and both teams indicated the audited programs had shown noticeable improvement.

During March 1992, a complete file and record audit of the RCRA Training Program was conducted. In addition, record audits for RCRA Part B—required tank inspections and for RCRA-required air emissions sampling were conducted during the months of June and July, respectively. Deficiencies discovered during these audits were corrected, strengthening the overall compliance capabilities of each program.

Another important segment of the overall self-assessment program is the monthly surveillances performed by personnel within the Environmental and Waste Management Division. These surveillances focus on specific segments of the various environmental programs and are performed on an unannounced basis.

An assessment of DOE order compliance was completed by Energy Systems for PGDP on September 30, 1992. Instructions for the assessment came from the Standards Development and Management Office. The orders were prioritized using the Energy Systems Risk Prioritization Matrix with level A, B, and C categories, with level A comprising those orders involving environmental, safety, and health issues; safety; and quality assurance with potential for significant risk or impact. These orders were further subdivided into requirement units (RUs) that appear to be performed by a functional area. Overall compliance for category A orders was 47% in full compliance, 9% in partial compliance, 5% in noncompliance, and 18% not applicable. An evaluation of orders in category A that apply to environmental areas minus those not applicable showed 65% in full compliance, 24% in partial compliance, and 11% in noncompliance. All noncompliant RUs occurred in three DOE orders: 1540.2, "Hazardous Material Packaging for Transport"; 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous

Materials, Hazardous Substances, and Hazardous Wastes”; and 5480.4, “Environmental Protection, Safety, and Health Protection Standards.” More detail on the breakdown of the category A orders can be found in Table 1.1.

1.7.6 PCB Program

The PCB Program at PGDP exists to ensure full compliance with regulations under TSCA by providing oversight for all plant operations. PCB-related compliance problems will exist at PGDP until all sources of PCBs are removed or eliminated. Several steps have been taken toward this goal, including the reclassification or removal of electrical equipment and hydraulic systems containing PCBs, the use of dedicated equipment to prevent “cross-contamination,” and the sampling of incoming oils and oil-containing equipment.

Although the program is geared primarily toward eliminating the sources of PCB compliance problems, PCBs and PCB items are used extensively at PGDP, especially in electrical equipment. Therefore, the program also must oversee the proper storage of PCB materials and wastes, the cleanup of PCB spills, the proper uses of PCB equipment and materials, and the implementation of compliance agreements such as the U.S. Environmental Protection Agency (EPA)-DOE Headquarters TSCA Federal Facilities Compliance Agreement.

Many systems, both electrical and otherwise, contain PCBs from detectable quantities to percentage levels. Seventy-two process transformers contain PCBs in concentrations above 500 ppm. One process lubricant oil system and several smaller systems contain detectable quantities of PCBs. Large, high-voltage PCB capacitors are used extensively throughout the process buildings and electrical switchyards. However, as previously stated, steps to reclassify or eliminate these items are under way. Many switchyard transformers have been treated to remove or lower the PCB concentrations through EPA-approved methods or have been taken out of service completely. An engineering project is under way to remove all switchyard capacitors and process capacitors containing PCBs. An engineering service

order has been initiated to perform a risk assessment on the continued use of PCB transformers in the process buildings. Guidance is provided to line organizations, and procedures have been revised to ensure that incoming “new” oils and oil-containing systems continue to be certified as non-PCB by analysis before acceptance at the plant.

1.8 Environmental Training

CY 1992 saw full implementation of RCRA training as required by the PGDP Part B Permit and 401 KAR 34:020, Sect. 7.

Through a Part B Permit modification approved by the Kentucky Division of Waste Management, the list of plant personnel requiring RCRA training was revised and entered into a data base tracking system. A list is generated periodically from the data base that identifies individuals who are due training and the deadline date by which they must receive the training.

Using this system, PGDP was able to bring the required RCRA training into full compliance as evidenced by a September 1992 Kentucky Division of Waste Management audit confirming that compliance had been accomplished.

In addition, 1992 saw the implementation of an improved data base tracking system for RCRA training and the initiation of a revision to the RCRA training procedure directed at clarifying roles and responsibilities and improving documentation.

Training for Environmental and Waste Management staff was provided through off-site classes covering such topics as a RCRA overview, regulations, emergency response, spill cleanup, health hazard recognition, and safety associated with PCBs and various environmentally pertinent issues.

1.9 Reference

U.S. Department of Commerce, Bureau of the Census. April 1991. *1990 Census of Population and Housing Public Law 94-171 Data*, Washington, D.C.

2. Potential Radiation Dose to the Public

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2. Potential Radiation Dose to the Public

Paducah Gaseous Diffusion Plant (PGDP) discharges effluents, some of which are radioactive and some of which are chemically or biologically reactive. Waste minimization and pollution abatement systems reduce these effluents, and emission and environmental monitoring is used to evaluate these controls, to determine compliance with regulations, and to allow estimates of the radiation and chemical doses received by members of the public.

U.S. Department of Energy (DOE) Order 5400.5 limits the dose to members of the public to less than 100 mrem/year effective dose equivalent from all pathways resulting from the operation of a DOE facility. Knowledge of the demography and land use of the area surrounding the plant and identification of on-site sources have indicated certain radionuclides and exposure pathways by which groups of people can be exposed to radiation. Figures 2.1 and 2.2 give a comprehensive view of the pathways between radioactive materials released to the environment and human beings. In practice, only a few pathways are the major sources of exposure in any given situation. A preliminary assessment of risk from PGDP contaminants to the health of the public living off-site was conducted by CH2M Hill for the Phase I Site Investigation (CH2M Hill 1990). This study identified four primary pathways that could potentially contribute greater than 1% to the total off-site dose: groundwater ingestion, sediment ingestion, ingestion of wildlife and food crops, and exposure to direct radiation. To assess fully the potential dose to the public, a hypothetical group of extreme characteristics is used to postulate an upper limit to the dose of any real group. The assumptions used to calculate the dose from those exposures are summarized in Tables 2.1 through 2.6 in Part 2. In addition, the dose from all pathways from

atmospheric releases is also calculated as required for compliance with the National Emission Standards for Hazardous Air Pollutants regulations. All dose estimates were rounded to approximate significant figures.

2.1 Terminology

Committed effective dose equivalent (CEDE) is the total internal dose (measured in mrem) received over a 50-year period resulting from the intake of radionuclides in a 1-year period. The CEDE is the product of the annual intake (pCi) and the dose conversion factor for each radionuclide (mrem/pCi).

Collective effective dose equivalent is a measure in person-rem of long-term radiation effects over a wide area. It is calculated by multiplying the average dose within defined areas by the number of persons living in that area.

Effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the dose from penetrating radiation from sources external to the body. This is a risk-equivalent value and can be used to estimate the health-effects risk to the exposed individual.

2.2 Waterborne Radionuclides

Liquid effluents are monitored to determine the total quantity of waterborne radionuclides released to the environment. The concentrations of various radionuclides are measured in the creeks and in groundwater near the plant. A survey of surface water and groundwater users in the vicinity of PGDP was conducted in 1990 to determine the number of residents using water wells within a 4-mile radius of PGDP and to determine the number of surface water

Fig. 2.1. Pathways between radioactive material released to the atmosphere and to individuals.

Fig. 2.2. Pathways between radioactive material released to the groundwater and to individuals.

intakes on the Ohio River within 15 miles downstream of the plant.

No residents or businesses that responded to the questionnaire reported using a private surface water intake on the Ohio River or on Little or Big Bayou creeks for any part of their water supply. Private groundwater wells were the major water supply of residents surrounding PGDP. Most residents reported using water from their residential wells for drinking, irrigation, and domestic uses.

A dose to the maximally exposed individual from consuming well water can be calculated using the assumptions outlined in Table 2.1 in Part 2. Under conditions of continuous exposure, members of the public are assumed to ingest 730 L of drinking water per year. Based on this criterion, the dose to the maximally exposed individual from drinking well water contaminated with technetium at the PGDP detection limit (25 pCi/L) would be 0.024 mrem/year. This dose can be compared with the dose from ingestion of water contaminated at the Safe Drinking Water Act level of 900 pCi/L ^{99}Tc . This dose would be 0.85 mrem/year. A risk estimation was prepared for the Phase I Site Investigation to assess the potential risk to individuals who might have been previously exposed to contaminated groundwater.

2.3 Direct Radiation

The exposure pathway for external gamma radiation was evaluated using the results of a 1991 thermoluminescent dosimeter survey covering the banks of Little Bayou Creek. The banks were determined to have elevated radioactive contamination or elevated count rates. The dose values are the product of the exposure rate (mR/h) from the radiological survey and the exposure time at a particular location.

To determine a realistic exposure time for the Little Bayou Creek area, several assumptions were used. During 1992, the West Kentucky Wildlife Management Area (WKWMA) allowed hunting and dog trials in this area for a period ranging from September 1 to March 30 (213 days). For exposure in the creeks, an individual was assumed to hunt every day during this period and spend a total of one-half hour in the Little Bayou Creek bed. This exposure time is probably exaggerated because signs are posted in this area stating that prolonged exposure

could result in a dose above background. Using the maximum exposure rate measured in the Kentucky Pollutant Discharge Elimination System 011 ditch that discharges into Little Bayou Creek as the worst-case estimate for Little Bayou Creek, the dose above background to this maximally exposed individual would be 2 mrem/year. These assumptions are summarized in Table 2.5 in Part 2. Even using these extreme assumptions, the dose is within the guideline value of less than 10 mrem/year from any one pathway.

2.4 Contaminated Sediment in Little Bayou Creek

Exposure to contaminated sediment in Little Bayou Creek could occur during fishing, hunting, or other recreational activities. Contact and exposure may occur primarily through incidental ingestion of contaminated sediment or inhalation of contaminated particles. According to the exposure assumptions in Table 2.2 in Part 2, and the maximum detected concentration of each radionuclide in the sediment samples, the worst-case dose would be received by an individual who was assumed to spend time in the WKWMA every day during the season as in Sect. 2.3. The estimated total dose above background would be 2 mrem/year from this pathway.

2.5 Ingestion Of Terrestrial Foodstuffs

Terrestrial wildlife, such as deer, can come into contact with contaminated soil, ingest plants that have taken up contaminants or have become coated with contaminated dust, or ingest contaminated water. Hunting is permitted in the WKWMA surrounding PGDP, and the limit for deer harvest is two deer per person per season. Assuming that an individual kills two average-weight deer and consumes the edible portions of those deer during the year, the dose to this individual based on the maximum detected concentrations of each radionuclide in the deer muscle would be 10.4 mrem/year. The only radionuclides present above the detection limits were uranium isotopes. This ingestion dose can be compared to the calculated background dose of 16.6 mrem/year, which includes radionuclides that are naturally occurring.

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Background deer were taken from TVA Land Between the Lakes, an area unaffected by PGDP operations. Therefore, when the analyzed dose occurring naturally is subtracted from the WKMA dose the contribution to dose from PGDP operations is negligible, in this case, zero. Dose calculations are summarized in Table 2.3 in Part 2.

Similarly, ingestion doses from homegrown fruits and vegetables were calculated using the assumptions summarized in Table 2.4 in Part 2. Using the maximum detected concentrations of each radionuclide in all three food types, the worst-case individual dose above background is calculated to be 0.4 mrem/year. This assumes that an individual ate a portion of each food crop every day of the year.

2.6 Airborne Radionuclides

In addition to the primary pathways, radioactive emissions to air are monitored to determine the extent to which the general public could be exposed and to demonstrate compliance with U.S. Environmental Protection Agency (EPA) regulations and DOE directives on radiation exposure to the public. The airborne radioactivity from PGDP operations is normally too low to be detected in the presence of natural background radiation in the environment. Therefore, potential doses to the public are calculated through use of a dispersion model. This model calculates how measured quantities of released radionuclides mix with the atmosphere, where they travel, how they are diluted, and where they may deposit. Once the dispersion is calculated, population data and concentration/dose conversion factors are used to calculate individual and population doses. These doses include exposure from all pathways represented in Fig. 2.1.

The calculations were made using the AIRDOS-EPA suite of computer codes, which are part of the CAP-88 assessment package recommended by the EPA. The computer codes used plant-specific radionuclide emission data for 1992, meteorological data collected during 1992 at the 60-m station at the Paducah site, and dose conversion factors specified in the CAP-88 codes. Organ weighing factors used in estimating effective dose equivalents are also based on International Commission on Radiological Protection (ICRP) recommendations (ICRP 1977).

The calculated 50-year committed effective dose equivalent to the maximally exposed individual is estimated to be 0.0045 mrem (well below the 10-mrem limit). The dose to the maximally exposed individual, who, under most circumstances, is the person living closest to the plant in the predominant wind direction, is calculated each year. The maximally exposed individual for 1992 is located 2097 m (6700 ft) north of the plant site.

The primary pathway of exposure is inhalation. The primary contributors to the inhalation dose are the uranium isotopes ^{234}U and ^{238}U .

The collective dose equivalent is a good measure of long-term radiation effects over a wide area. The collective effective dose equivalent in 1992 for the 500,502 persons residing within 80 km (50 miles) of the plant site was estimated to be 1.7×10^{-3} person-rem from PGDP emissions. This can be compared with a collective dose for the same population of 2×10^5 person-rem/year from natural background radiation.

2.7 Conclusions

Table 2.1 summarizes the annual dose from radiological contaminants that could potentially be received by a member of the public living near PGDP, assuming worst-case exposure from all major pathways. The calculated maximum combined dose to an individual is 4 mrem/year. This level is well below the DOE annual dose limit of 100 mrem/year. The major contributors to the dose are direct external radiation from and ingestion of sediment in or near the Little Bayou Creek bed. This area has been posted to notify the public of the elevated radiation levels.

2.8 References

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- Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. January 1991. DOE/EH-0173T, U.S. Department of Energy.
- International Commission on Radiological Protection (ICRP). 1977. *Annals of the ICRP 1*, ICRP Publication 26, Pergamon, Oxford, N.Y.

2-6 Potential Radiation Dose to the Public

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Table 2.1. Summary of annual dose from radiological contaminants

Worst-case combined exposure pathways		
Pathway	Dose (mrem/year) ^a	Portion of total
Ingestion of well water	0.024	<0.01
Ingestion of sediments	2	0.5
Ingestion of food crops	0.4	0.1
Ingestion of deer meat	0 ^b	0
Direct radiation—		
Little Bayou Creek	2	0.5
Atmospheric releases	0.0045	<0.01
Total annual dose above background—all pathways	4 ^a	

^aDose values were rounded to yield the correct number of significant digits based on the data from Tables 2.1 through 2.5 in Part 2 and from estimated significant figures in atmospheric releases per DOE/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*.

^bCalculated dose for reservation deer was less than the background or reference deer; therefore, the dose was assumed to be zero.

3. Airborne Discharges, Ambient Air Monitoring, Meteorological Monitoring, and External Gamma Radiation

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3. Airborne Discharges, Ambient Air Monitoring, Meteorological Monitoring, and External Gamma Radiation

Environmental monitoring is an integral part of the Paducah Gaseous Diffusion Plant (PGDP) air pollution control program. The federal Clean Air Act (CAA), Kentucky Division for Air Quality (KDAQ) regulations, and U.S. Department of Energy (DOE) orders require identification of potential and actual sources of air pollution, controls to abate pollution to within specified limits, and measurements to demonstrate the results. The identification, controls, and emission or throughput limits are included in the regulatory agency's permit. Twenty-seven sources are listed on the PGDP operating permit; however, not all sources were operated in 1992. Table 3.1 in Part 2 lists the permitted sources and the types of control equipment used for air pollution prevention.

The primary goal of the Air Compliance Program is to identify each air contaminant emission point at PGDP, to quantify the emissions from the source, to document compliance with the applicable regulation, and to submit this information, usually in the form of a permit application or registration, to the appropriate regulatory agency. In October 1992 PGDP completed a vent/stack survey, which is the first phase of the establishment of an Air Emission Inventory. The goal of the vent/stack survey was to identify all potential air contaminant emission points at PGDP. The second phase of the Air Emission Inventory is to establish a computer data base to compile and track data pertaining to each emission point. Additional employees have been added to the PGDP air program whose initial responsibility will be the establishment of the data base. The third phase of the inventory will be to obtain and input into the data base all pertinent information from each emission point. The data base will contain information such as (but not limited to)

location, potential pollutants, permit status, stack parameters, estimate of emissions, and basis of the estimate. The emission estimates from this data base will be useful in budgetary concerns because the CAA Amendments of 1990 will require the KDAQ to impose a fee on sources based on tons of pollutant emitted.

From the vent/stack survey, PGDP has identified additional emission points that require permit review. Additional employees have been hired whose primary responsibility is preparation of permit applications for submittal to the KDAQ. PGDP has not received an updated operating permit since January 1986. However, PGDP will continue to submit application addenda to the KDAQ to ensure compliance with KDAQ regulations. After promulgation of the Air Toxics Regulations in November 1986, PGDP submitted an additional comprehensive Air Toxics Review application to the KDAQ in May 1988. PGDP submitted a permit application for the sources identified in the 1991 vent/stack survey in May 1992. These applications increased the number of emission points that had been evaluated at PGDP to 133, and each evaluation has indicated compliance with the Air Toxics Regulations in terms of emission limits and ambient air impact. PGDP emission points increased to 133 after submittal of the May 1992 application. After the vent/stack survey was completed in October 1992, PGDP found no additional existing sources that required permit applications.

PGDP submitted two construction permit applications in 1992, but after review the KDAQ determined that no construction permits would be required to operate these sources. One permit

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application was submitted on the C-728 steam/motor cleaning facility to update the original registration submitted in December 1990. By the end of the year, a total of 142 emission points had been evaluated at PGDP.

The release of contamination into the atmosphere is minimized by avoiding any unnecessary waste generation and by applying effective control technology to meet all permit conditions and the DOE requirement to maintain radionuclide emissions as low as reasonably achievable (ALARA). This control program to reduce emissions is evaluated continually. Table 3.4 in Part 2 compares selected actual emissions with limits or standards set by regulations or permits. The primary basis for evaluating the control achieved is by emissions sampling and ambient air monitoring. Performance of control devices also may be checked by state or federal inspections. The data generated by stack emissions sampling were used to calculate radiation doses to the nearest neighbors and the surrounding population (see Sect. 2).

3.1 Airborne Discharges

The CAA of 1977 requires the U.S. Environmental Protection Agency (EPA) to administer through the states a program that requires operators of air contaminant sources to obtain permits to construct and operate. After receiving and reviewing an application for a plant-wide operating permit, the KDAQ issued permit No. 0-85-110 to PGDP on September 30, 1985, granting operation of an air contaminant source. The permit lists 27 emission points and has no expiration date. Not all of the emission points were active in 1992; the major sources in operation (see Fig. 3.1) were

- the cascade purge vent/stack at the C-310 purge and product building,
- two vapor degreasers in the C-400 cleaning building, and
- two coal- and oil-fired boilers and one gas- and oil-fired boiler in the C-600 steam plant.

Fig. 3.1. Location of major air emissions sources at PGDP.

3-4 Airborne, Ambient Air, Meteorological, and External Gamma

Other air emissions reported include those resulting from boiler startup and shutdown, fire-training exercises, chemical spills, process leaks, paint spray booths, or emissions above normal levels (i.e., accidental releases).

The pollution parameters that must be quantified to demonstrate compliance with permits or the DOE ALARA policy are particulates, opacity, sulfur dioxide, volatile organic compounds (VOCs), radionuclides, and fluorides. Certain processes also are regulated by throughput limits and usage rates. The 1992 cumulative radiological emissions and steam plant emissions are tabulated by source in Table 3.1. Beginning with this year's report, this tabulation also includes minor grouped radionuclide sources, which are required to be reported to the EPA by the radionuclide National Emission Standards for Hazardous Air Pollutants (NESHAP) regulation. Emissions from these minor group sources were estimated using methods contained in the NESHAP regulation. These methods are extremely conservative and in all likelihood overestimate the actual emissions by a great deal. C-600 steam plant emissions routinely reported are sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulates, carbon monoxide, nonmethane VOCs, and methane. The SO_2 is continuously monitored in the stack in terms of pounds of SO_2 per million Btu input to the boiler. Data from the continuous SO_2 monitor and fuel usage data are combined to determine monthly and annual emissions. Emissions other than SO_2 are calculated from fuel usage using emission factors from EPA guidance document AP-42, *Compilation of Air Pollution Emission Factors*. The excess combustion air averages about 20% and is minimized to control NO_x in the flue gases and to optimize boiler efficiency. Monitoring is not required for total suspended particulates. The KDAQ permit limit of 20% opacity is achieved by use of electrostatic precipitators (ESPs) operating at 97% efficiency for particulate removal. Performance tests and emission factor calculations have shown emission levels of less than 0.05 kg (0.1 lb) of total suspended particulates per million Btu boiler input. A PGDP procedure requires monthly visible emission evaluations of boiler stack effluent by EPA method 9 for documentation of the 20% opacity limit.

The ESPs provide minimal stack particulate emissions while the boilers are operating, but visible

emissions occur during malfunctions, startups, shutdowns, and some maintenance activities. These periods are brief and infrequent and by regulation are reported to the KDAQ prior to the activities if possible. Table 3.1 shows the total steam plant emissions. Tables 3.2 and 3.3 in Part 2 present monthly emissions of selected parameters as well as annual and historical data.

The C-310 stack is used as the vent for the cascade system. Gases of low molecular weight travel up the cascade to be released through the C-310 stack. Gaseous fluorides and traces of radionuclides are released in small quantities. High-speed centrifugal separation and chemical traps are used to control stack emissions. The stack gases are continuously sampled, and samples are analyzed daily, except on weekends and holidays. Tables 3.2 and 3.3 in Part 2 list monthly and annual emission rates and historical data for selected parameters.

Stack-sampling trend analysis performed on the C-310 stack indicates a dramatic decrease in uranium emissions since 1983. In 1983 the average monthly uranium emission was 336 g. Discounting anomalous averages caused by system upsets and testing, this monthly average decreased each year to an average monthly emission of 0.4 g in 1991. Because of operational difficulties in the product withdrawal building alumina traps, the uranium emissions increased to an average of 2.3 g/month for 1992. In September 1990, as a result of a statistical study, the lower limit of detection of uranium was established at 0.07 g per day. For the remainder of 1990 all emissions that were reported as <0.07 g per day were included in the calculations of dose resulting from uranium emissions. In other words, if the sample result was reported as <0.07 g of uranium, 0.07 g of uranium was included in the dose calculation. For 1991 and subsequent years, only those emissions that were actually detected (i.e., equal to or greater than 0.07 g per day) were reported. If the sample result indicated <0.07 g of uranium, no uranium was detected in that sample. This method of reporting uranium emissions for dose calculations is consistent with the method of calculating dose from ingestion of food crops, sediment, water, and wildlife in the area of PGDP. Section 7.3.4 of the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*

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Table 3.1. 1992 PGDP stack emissions summary

Stack or grouped source ^a	Control equipment	Emission		
		Effluent	kg/year	Curies ^b
Source 1 C-310 cascade vent stack	Chemical traps	²³⁴ U	4.8E-6	2.49E-5
		²³⁵ U	5.4E-4	1.17E-6
		²³⁸ U	2.67E-2	8.93E-6
		⁹⁹ Tc	1.20E-5	2.02E-4
		F	6541	
<i>Grouped minor sources</i>				
Source 2 Seal exhausts (2) Wet air exhausts (1) Wet air/seal exhaust (4)	Chemical traps	²³⁴ U	3.11E-6	1.94E-5
		²³⁵ U	3.53E-4	7.62E-7
		²³⁸ U	1.73E-2	5.81E-6
		²³⁹ Pu	3.65E-8	2.26E-6
Source 3 Cylinder valve connection operations	HEPA ^c	Not distinguishable from zero.		
	HEPA vacuums			
Source 4 Cylinder valve connection not included above (i.e., not served by a stack)		²³⁴ U	1.22E-7	7.62E-7
		²³⁵ U	1.38E-5	2.99E-8
		²³⁸ U	6.79E-4	2.28E-7
Source 5 C-400 decontamination activity	None	²³⁴ U	2.04E-4	1.27E-3
		²³⁵ U	2.31E-2	4.99E-5
		²³⁸ U	1.13E+0	3.80E-4
		²³⁷ Np	5.41E-7	3.81E-7
		²³⁹ Pu	1.66E-9	1.03E-7
		²³⁰ Th	1.38E-8	2.66E-7
		⁹⁹ Tc	2.35E-7	3.95E-6
Source 6 C-710 laboratory hoods	None	²³⁴ U	4.26E-5	2.66E-4
		²³⁵ U	4.81E-3	1.04E-5
		²³⁶ U	1.34E-6	8.85E-8
		²³⁸ U	2.15E-1	7.23E-5
Source 7 Building ventilation	None	No curie emission was determined for this source. However, based on Health Physics Building air samples, all radionuclide concentrations were ≤2% of the most stringent derived air concentrations (DACs) listed in DOE Order 5480.11. Based on this DAC, and a 1992 dilution factor for off-site exposure, building ventilation emissions result in an off-site dose of only 0.0000079 mrem (0.18% of the plant-wide dose).		
Source 8 C-600 steam plant	Use of low-sulfur coal, control of excess air, electrostatic precipitators	Sulfur dioxide	388,648	
		Nitrogen oxides	258,696	
		Particulates	22,550	
		Carbon monoxide	8,164	

^aSee Fig. 3.1 for major sources.

^bBased on a product assay of 2.0% ²³⁵U.

^cHigh-efficiency particulate air.

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addresses less-than-detectable values; however, this guidance specifically addresses statistical analyses, not dose assessment.

PGDP operates two vapor degreasers in the C-400 cleaning building. One of the degreasers is large enough [$1.5 \times 6.9 \times 5.4$ m ($5 \times 23 \times 18$ ft)] to accommodate the largest components of gaseous diffusion process equipment. This degreaser uses trichloroethylene (TCE) as a cleansing agent. The TCE is contained in troughs at the north and south ends of the degreaser. The troughs also contain steam coils that vaporize the TCE. The TCE vapor then migrates to the center of the degreaser (between the troughs) where the equipment to be cleaned is situated. Condensing coils are located near the top of the degreaser to condense and to recycle the vaporized TCE after it has been used to degrease the equipment.

The smaller degreaser [$1.5 \times 1.8 \times 1.5$ m ($5 \times 6 \times 5$ ft)] uses 1,1,1-trichloroethane (TCA) as the degreasing agent. Steam coils that vaporize the 1,1,1-TCA are located in the bottom of the degreaser. Condensing coils are used to condense and to recycle the vaporized 1,1,1-TCA after use.

Both degreasers have movable covers that minimize degreasing agent losses except during equipment insertion or removal. However, losses of degreasing agents are inevitable because of the large area exposed and the high volatility of the agents. These losses are calculated and reported as plant emissions. The Air Toxics Operating Application (submitted to the KDAQ in 1988) assumed that 90% of the agents are lost to the atmosphere and the rest are contained in the degreaser sludge. A less volatile aqueous degreaser is being tested at various locations in the plant as an alternative. PGDP's 3-year hazardous air pollutant reduction plan, which was submitted in March 1993, and takes credit for the elimination of TCE and TCA use in the vapor degreasers at C-400. This is part of an action plan to eliminate plant-wide TCE and TCA usage by the end of March 1994.

In November 1986 the KDAQ promulgated two Air Toxics Regulations. These regulations established emission limits for specific substances considered toxic. The first regulation applies to facilities constructed before November 11, 1986, and lists 92 regulated substances. The second regulation applies to facilities constructed after November 11, 1986, and

lists more than 730 regulated substances. In conjunction with an environmental subcontractor, PGDP submitted an Operating Permit Application with Air Toxics Review to the KDAQ on April 27, 1988. This application contained calculations stating that PGDP's toxic emissions are either below the significant emission level and thus exempt from the regulations or below the threshold ambient limit as shown by computer modeling and in compliance with the regulations. The KDAQ Permit Review Branch has this application for review; however, it is far behind in reviewing its backlog of operating permit applications. Air Toxics Compliance will be tracked by the Air Emission Inventory Data Base.

1992 data compiled to fulfill requirements of the Superfund Amendments and Reauthorization Act of 1986 are included in the Appendix.

3.2 Ambient Air Monitoring

PGDP maintains and operates an ambient air monitoring system to assess the impact on the ambient air of various air contaminants emitted by PGDP. The results of the data generated by the ambient air monitoring system are also used to demonstrate compliance with the ambient air quality standards for gaseous fluorides established by the KDAQ.

Ambient air is sampled continuously for gaseous fluorides and radioactive particulates at the following locations:

- plant north (PN), plant south (PS), plant east (PE), and plant west (PW) within the plant fence;
- boundary north (BN) and boundary east (BE) at the plant boundary;
- one north (1N), one south (1S), one west (1W), one east (1E), and one southeast (1SE) at 1 mile from the plant fence; and
- Grahamville (GR), the nearest community.

Figure 3.2 shows these locations. The sample collectors (consisting of filters treated with sodium carbonate for ambient collection of fluorides) are exchanged and analyzed each week for alpha and beta activity and for fluoride concentrations. To ensure data accuracy, samples are discarded without analysis if final sample flow decreases more than 40% from the initial flow rate, if the sampler is found not to be

Fig. 3.2. Location of air-sampling and meteorological monitoring station at PGDP.

running, or if upon opening the filter holder the analyst finds the filter cracked (Coker 1988).

After the sample filters have been collected from the ambient air monitoring stations, they are stored for at least 168 h to permit decay of the short-lived daughters of naturally occurring radon and thoron. They are then analyzed for alpha and beta activity by an automatic low-background alpha/beta proportional counter (PGDP 1990). After the radioactivity measurements have been made, the filters are leached with water and fluoride content is measured by specific ion electrode analysis (PGDP 1979). The results of the analyses are logged into a computer data base and used to demonstrate compliance with KDAQ gaseous fluoride ambient air quality standards. In response to the Tiger Team Assessment performed in 1990, PGDP has proposed some improvements in the ambient air monitoring program. An ambient air monitoring plan has been developed to implement these improvements to the monitoring system. An engineering project has been approved to purchase and install new monitoring equipment in 1993. Tables 3.2 and 3.3 provide a summary of 1992 ambient air measurements. All fluoride samples were well below the Kentucky ambient air quality standards for fluorides. The highest annual average for fluorides was 0.147 ppb at the PN site. This concentration was well below the annual arithmetic mean standard of 500 ppb for fluorides. The maximum weekly concentration of fluorides of 0.631 ppb at the plant north location was 32% of the KDAQ secondary fluoride maximum weekly standard of 2 ppb.

3.3 Meteorological Monitoring

Representative meteorological data are required at DOE facilities by DOE Order 5400.1 to support environmental monitoring activities. This information is essential to characterize atmospheric transport and diffusion conditions in the vicinity of PGDP and to represent other meteorological conditions (e.g., precipitation, temperature, and atmospheric moisture) that are important to environmental surveillance activities such as air quality and radiation monitoring.

On-site meteorological data are used at PGDP in calculating radiation doses to the public (see Sect. 2). In addition, on-site meteorological data are used by various groups within the plant—for example, by

Environmental Restoration to correlate precipitation with groundwater flow and by Power Operations to investigate electrical equipment failures.

A 60-m tower located south of the C-100 administration building contains instrumentation at heights of 10 m and 60 m (32.8 ft and 196.9 ft). Appropriate meteorological parameters such as wind speed and direction, temperature, barometric pressure, relative humidity, and rainfall are monitored to provide both valuable data on atmospheric stability and also other data essential to reliable atmospheric dispersion modeling. Figures 3.3 and 3.4 show wind roses generated by the tower (see Subsect. 3.5).

Computer-aided atmospheric dispersion modeling uses emission and meteorological data to determine the impacts of plant operations. It is used to simulate the transport of air contaminants and to predict the effects of abnormal airborne emissions from a given source. In addition, PGDP can postulate a multitude of emergency scenarios and estimate effects of unplanned releases on employees and population centers downwind of the source. PGDP uses the Hazardous Atmospheric Release Model II computer program for predicting off-site concentrations of unplanned heavy-gas releases.

3.4 External Gamma Radiation Monitoring

One of the potential pathways of exposure for population groups living within the vicinity of DOE facilities is exposure to external radiation. Dose rates from penetrating radiation (gamma rays) were measured at a number of locations in the PGDP environs during 1992. Long-term measurements were made using thermoluminescent dosimeters (TLDs). Instantaneous dose rates were also measured with hand-held meters during radiation surveys conducted at numerous locations on and around the PGDP site.

3.4.1 Thermoluminescent Dosimeter Sampling Program

During 1992 TLDs were placed in the environment to obtain data on external gamma radiation. These TLDs react to gamma and neutron radiation and, to some extent, to cosmic radiation. Fifteen monitoring dosimeters were in use during

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Table 3.2. 1992 PGDP environmental air sampling for fluorides

Point ^a	Number of samples	Concentration (ppb)			
		Min	Max ^b	Percent of standard	Av ^c
PN	53	0.053 ^d	0.631	31.5	0.147
PE	52	0.052	0.330	16.5	0.125
PS	52	0.055	0.150	7.5	0.080
PW	51	0.062	0.275	13.8	0.086
BN	52	0.058	0.141	7.1	0.084
BE	52	0.055	0.128	6.4	0.074
IN	53	0.055	0.116	5.8	0.072
IE	49	0.051	0.097	4.8	0.063
ISE	52	0.049	0.126	6.3	0.066
IS	53	0.048	0.114	5.7	0.066
IW	53	0.050	0.121	6.1	0.068
GR	52	0.046	0.139	7.0	0.073

^aSee Fig. 3.2.

^bKentucky Secondary Air Quality Standard (401 KAR 53:010) for maximum 1-week average is 2.0 ppb as hydrogen fluoride.

^cKentucky Primary Air Quality Standard (401 KAR 53:010) for annual arithmetic mean is 500 ppb.

^dSeveral samples at every location were below detection limits. In these cases, the detection limit is used as the minimum value.

Table 3.3. 1992 PGDP environmental air sampling for radioactivity

Point ^a	Number of samples	Gross alpha ($\mu\text{Ci}/\text{mL} \times 10^{-14}$)			Gross beta ($\mu\text{Ci}/\text{mL} \times 10^{-13}$)		
		Min ^b	Max	Av	Min ^b	Max	Av
PN	53	-0.71	0.62	0.13	-0.30	0.58	0.20
PE	52	-0.38	0.76	0.14	-0.35	0.47	0.19
PS	52	-0.41	0.74	0.15	-0.20	0.14	0.20
PW	51	-0.22	1.07	0.16	-0.23	0.46	0.15
BN	52	-0.50	1.65	0.16	-0.20	1.28	0.23
BE	52	-0.22	0.51	0.12	-0.34	0.55	0.18
IN	53	-0.97	1.17	0.26	-0.30	0.13	0.22
IE	49	-0.24	0.90	0.15	-0.01	1.30	0.23
ISE	52	-0.04	0.85	0.13	-0.29	0.76	0.22
IS	53	-0.33	0.69	0.13	-0.19	1.72	0.23
IW	53	-0.28	0.69	0.15	-0.20	1.15	0.22
GR	52	-0.41	1.55	0.20	-0.33	0.69	0.21

^aSee Fig. 3.2.

^bBecause of fluctuation in the instrument used to analyze for radioactivity, the background count is higher than that for the sample; this accounts for the negative counts.

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ORNL-DWG 92M-4972R

Fig. 3.3. Wind rose (10-m level) showing the wind speed frequency distribution data (with 93.1% of possible data) used for the 1992 estimates.

ORNL-DWG 92M-4973R

Fig. 3.4. Wind rose (60-m level) showing the wind speed frequency distribution data (with 93.1% of possible data) used for the 1992 estimates.

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1992. Figure 3.5 provides the locations of the monitoring dosimeters. Ten quality control TLDs were also in use during each quarter; Fig. 3.6 shows their locations.

The external gamma radiation program is conducted using guidance from American National Standards Institute Standard N545-1975. The TLDs are identified, annealed, calibrated, packaged, and shipped by Oak Ridge National Laboratory (ORNL). When they arrive at PGDP, they are promptly positioned in the PGDP environment approximately 1 m (3 ft) above the ground. The TLD packages are placed in four types of locations: along the plant perimeter fence, at the reservation boundary, at nearby residences or communities, and at two background locations more distant from the site. After the quarterly exposure period, the TLDs are collected and returned to ORNL for exposure determination.

Although the TLD exposures were measured in microroentgens per hour ($\mu\text{R/h}$), measured doses are also reported in dose equivalent units (mrem) to allow comparison with dose standards and dose equivalents reported elsewhere in this document. To convert to mrem/year, some exposure period must be assumed. To allow for comparison, continuous exposure has been assumed at all locations. In reality, exposure will vary depending on public access to a particular location. Table 3.4 shows the average exposure rates for each TLD location. Table 3.5 lists quality control data for the TLDs. The mean exposure rate for indicator locations as measured by the TLDs (excluding perimeter fence data) is approximately $5.8 \mu\text{R/h}$. When that rate is compared with the mean background exposure rates, the indicator locations are significantly lower at the 95% confidence level. Assuming continuous exposure at this level ($5.8 \mu\text{R/h}$), the external whole body dose would be approximately 50 mrem/year. This corresponds to the average external whole body dose estimated to be received by people throughout Kentucky and Tennessee, which is between 60 and 70 mrem/year (Klement et al. August 1972). Dose rates at the plant perimeter were somewhat higher than the background rates. The higher exposure rates at locations near the perimeter fence were attributed to direct radiation from the uranium cylinder storage and handling areas. Although the rates are elevated, these areas

have only limited access and actually allow for very low exposure periods.

Because of the extremely small amounts of gamma radiation emitted by PGDP compared with natural background radiation, accurate measurements using TLDs are difficult to obtain. Therefore, the exposure rates measured by the TLD system during 1992 have a high level of uncertainty. However, the data indicate that levels of gamma radiation both at and beyond the plant perimeter have not increased significantly over time. Figure 3.7 compares the trend over a 5-year period at each location. The radiation fields surrounding the cylinder storage yard are also somewhat static. The change seen in Table 3.4 and Fig. 3.7 for location 2 occurred because the TLD was inadvertently placed in a shielded position in 1990 and 1991. 1992 data returned to the expected level when this was corrected.

3.4.2 Special TLD Survey

In addition to the routine TLD monitoring, a special long-term radiation assessment was performed during 1991 by CH2M Hill on the off-site portions of the plant drainage system that had shown elevated levels of radioactive contamination in the Phase I walk-over survey. TLDs were placed along the creek beds of Little Bayou Creek, the off-site portion of the north/south diversion ditch, and the off-site portion of outfall ditch Kentucky Pollutant Discharge Elimination System (KPDES) 011. Big Bayou Creek and other plant outfall ditches were also surveyed during Phase I, but the results showed little evidence of elevated direct gamma radiation above background levels and were not included in this assessment.

The TLDs were placed in the field beginning on April 1, 1991, and remained for times ranging from 92 to 107 days. TLD sampling locations were designed to provide comprehensive coverage of the creek beds and to further characterize locations with elevated contamination levels. Stations were established at regular intervals of approximately 550 ft and, where possible, stations were alternated from one side of the creek to the other.

The average background dose rate of $6.7 \mu\text{R/h}$ was used for comparison with the field dose rate results from the sample locations. The highest dose rate ($28.0 \mu\text{R/h}$) was detected near the confluence of

Fig. 3.5. Thermoluminescent dosimeter locations at PGDP.

Fig. 3.6. Quality control thermoluminescent dosimeter locations at PGDP.

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Table 3.4. Maximum potential 1992 PGDP external gamma exposure rates

Point ^a	Location	Average	
		(μR/h)	(mrem/year)
EG1	Air sampler perimeter north (PN)	5.83	51.2
EG2	Air sampler perimeter east (PE)	27.6	242
EG3	Air sampler perimeter south (PS)	40.2	353
EG4	Air sampler perimeter west (PW)	19.1	168
EG5	Air sampler boundary north (BN)	6.28	55.2
EG6	Air sampler boundary east (BE)	4.24	37.2
EG7	Air sampler 1 mile north (1N)	5.09	44.7
EG8	Air sampler 1 mile east (1E)	4.95	43.5
EG9	Air sampler 1 mile south (1S)	6.82	59.9
EG10	Air sampler 1 mile southeast (1SE)	6.41	56.3
EG11	Air sampler 1 mile west (1W)	6.40	56.2
EG12	Air sampler in Grahamville	6.86	60.3
EG13	House in Magruder Village	5.41	47.5
EG14	House in Paducah near Noble Park	6.76	59.4
EG15	House south of Paducah on Oaks Road	6.20	54.5

^aSee Fig. 3.5.

Table 3.5. 1992 quality control data for PGDP external gamma exposure

Point ^a	Location and description	First quarter (μR/h)	Second quarter (μR/h)	Third quarter (μR/h)	Fourth quarter (μR/h)	Average (μR/h)
QC1	Office cycle, C-710	3.4	2.7	1.7	1.5	2.3
QC2	1/2 office cycle, C-710	1.5	3.0	2.5	0.5	1.9
						83% agreement
QC3	Freezer cycle, C-710	2.5	2.2	3.0	2.3	2.5
QC4	1/2 freezer cycle, C-710	1.5	3.0	3.3	0.5	2.1
						84% agreement
QC5	Oven cycle, C-710	0.8	6.1	5.5	4.0	4.1
QC6	1/2 oven cycle, C-710	0.7	5.5	5.8	2.5	3.6
						88% agreement
QC7	Light dependence, unwrapped	37.0	36.6	42.9	44.0	40.1
QC8	Light dependence, wrapped	45.9	44.4	50.1	44.4	46.2
						87% agreement
QC9	Light dependence, unwrapped spiked 100 mrem	61.9	87.5	76.6	89.7	78.9
QC10	Light dependence, wrapped spiked 100 mrem	78.3	80.1	80.4	70.4	77.3
						98% agreement

^aSee Fig. 3.6.

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Fig. 3.7. PGDP external gamma radiation, 1988–1992.

KPDES 011 and Little Bayou Creek. The area where the north/south diversion ditch extends away from the plant boundary was also elevated at approximately three times background. Dose rates on Little Bayou Creek ranged from background levels to a maximum level of approximately twice background.

3.5 Conclusions

During 1992, 2.11 mCi (1.42 kg) of uranium were released to the atmosphere from all activities at PGDP. Previous reports have included only measured emissions from the C-310 stack. However, because of the NESHAP regulation and the Federal Facilities Compliance Agreement between PGDP and the EPA, emission estimates from all sources are included in the 1992 report and will be included in subsequent reports. The methods used to estimate these emissions are approved by the EPA, are very conservative, and in all likelihood overestimate emissions from these unmonitored sources. Therefore, although the results indicate an increase in

emissions, this perceived increase is caused by the inclusion of emissions from all known PGDP sources. For example, emission estimates for the C-400 decontamination building indicate a uranium emission of 1.70 mCi (1.16 kg). This emission estimate was based on the EPA method contained in 40 CFR 61, Appendix D, in which a determination is made of the curies "used" at a facility, and an area specified emission factor is applied to this number to arrive at an estimated emission. This estimation method is very conservative and most probably indicates emissions higher than actually occur. A comparison can be drawn between PGDP's actual uranium emissions and the new limit (or standard) for DOE-owned facilities established by EPA under the NESHAP regulations. In December 1989 EPA established a standard of 10 mrem effective dose equivalent to the most affected off-site person. This means that PGDP must not expose the most affected off-site person to radionuclides from atmospheric releases that would result in an annual effective dose equivalent of 10 mrem or more. Air dispersion

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modeling performed for PGDP by ORNL indicates that the annual effective dose equivalent for the most affected resident from all sources at PGDP is 0.0045 mrem, which is 2,222 times less than the EPA standard of 10 mrem.

During 1992, 0.202 mCi (12.3 mg) of technetium were released from PGDP operations. The majority (98%) of the ^{99}Tc emissions were from the C-310 stack. Although no direct correlation has been established, ^{99}Tc emissions from the C-310 stack seem to increase with an increase in ambient temperature and also with fluctuations of fluoride levels in the cascade. There has been no new introduction of ^{99}Tc into the cascade and no increase of ^{99}Tc in product withdrawal.

Minute quantities of ^{230}Th and ^{237}Np were also released to the atmosphere from the C-310 stack in 1992. Thorium-230 is a product of uranium decay, and neptunium is a contaminant that remains in the enrichment cascade as a result of past use of reactor returns as feed material. This practice was discontinued in the 1970s. These radionuclides are present in the cascade in small amounts, but occasionally they migrate up the cascade and are emitted from the C-310 stack. Emissions are in such small amounts that daily or monthly sample analysis produces no detectable concentrations. Therefore, a composite sample is analyzed on a quarterly basis. Even on this infrequent schedule of composite sample analyses, emissions of thorium were above detection limits only during the first and fourth quarters of 1992. Neptunium was detected in the fourth quarter emissions. According to the sample analysis, 0.002 g of ^{237}Np and 0.0002 g of ^{230}Th were emitted during 1992. C-310 samples from the remainder of the year indicated no detectable emissions of ^{239}Pu .

Even though the mass amounts of ^{230}Th and ^{237}Np were minute compared to the uranium emissions (which were only 1.42 kg), the activity per mass quantity and the dose per activity level of these radionuclides resulted in the bulk of the C-310 off-site dose being attributed to these radionuclides. However, the total dose from the C-310 stack was only $9.4\text{E-}5$ mrem, which is 5 orders of magnitude less than the EPA limit of 10 mrem/year from DOE facilities.

Ambient air concentrations of gaseous fluorides were well below state ambient air standards.

The stack monitoring data, their characteristics, and the joint frequency distribution of wind speed, stability, and wind direction are needed to calculate the amount of exposure of the surrounding population to plant emissions. The wind roses shown in Figs. 3.3 and 3.4 summarize the wind-speed frequency distribution data for the 1992 dose model estimates (see Sect. 2).

3.6 References

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4. Surface Water

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4. Surface Water

Paducah Gaseous Diffusion Plant (PGDP) is located in the western part of the Ohio River basin. Surface drainage from the site is to two small tributaries of the Ohio River: Big Bayou Creek on the west and Little Bayou Creek on the east (see Fig. 4.1). These two streams join north of the site and discharge to the Ohio River at about river kilometer 1524 (river mile 945), which is about 56 km (35 miles) upstream from the confluence of the Ohio and Mississippi rivers. These creeks exhibit widely fluctuating discharge characteristics that are closely tied to local precipitation. Natural runoff makes up a small portion of the flow in Big Bayou and Little Bayou creeks during the dry periods. The PGDP site is not located in the Ohio River 100-year floodplain [elevation 101.6 m (333.3 ft)], nor would it be affected by the historical high-water elevation of 104.2 m (341.8 ft). Figures 4.1 and 4.2 show the local PGDP surface hydrology systems and the regional area primary surface hydrology.

The vast majority of liquid effluents at PGDP consist of once-through cooling water, although a variety of liquid effluents (uranium contaminated as well as noncontaminated) result from activities associated with uranium precipitation and facility-cleaning operations. Conventional liquid discharges such as domestic sewage, steam plant wastewaters, and coal-pile runoff also exist. Routine monitoring activities provide data to quantify total discharges to surface water; to demonstrate compliance with federal, state, and U.S. Department of Energy (DOE) requirements; and to assist in evaluating the effectiveness of effluent treatment and control programs.

4.1 Surface Water Monitoring

SW13, the north/south diversion ditch (see Fig. 4.3), is monitored weekly. This ditch receives coal-pile runoff and the C-400 decontamination solution filtrate. A continuous leak sampler was used for the 7-d composite until September 16, 1992, when grab samples were substituted for the composite because of silting of the ditch with fly ash. The composite and grab samples are analyzed for the weekly parameters listed in Table 4.1. Each week a 100-mL sample is poured into a yearly composite container. At the end of each year, the composite sample is analyzed for the annual parameters listed in Table 4.1. (Because these data are not used for comparison to regulatory limits, the fact that holding times are exceeded is not of concern.) Analysis of samples indicates elevated levels of uranium and alpha and beta activity. However, the north/south diversion ditch is on-site and flows into the C-616 liquid pollution abatement facility, full-flow lagoon before discharging through outfall 001, where monitoring occurs in accordance with the Kentucky Pollutant Discharge Elimination System (KPDES) permit.

Monthly sampling is conducted at upstream Big Bayou Creek (SW1), downstream Big Bayou (SW5), downstream Little Bayou (SW10), upstream Ohio River (SW29), and downstream Ohio River (SW30). Background water quality is sampled at Big Bayou Creek Location 1 (SW1). Tables 4.1 through 4.26 in Part 2 provide surface water monitoring data.

Data comparisons were made using a one-tail (upper) *t* test at 95% confidence level for radiological

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Fig. 4.1. PGDP site surface hydrology systems.

Fig. 4.2. Regional area primary surface hydrology systems.

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Table 4.1. Summary of collection and analysis frequencies of surface water samples in 1992

Station ^a	Parameter	Collection frequency	Sample type	Analysis frequency
<i>C-746-S and C-746-T landfill runoff</i>				
Location 1 (SW1), Location 2, Location 3	Chloride, sulfate, pH, Na, U, TOC, ^b TSS, ^c TDS, ^d total solids, specific conductivity, gross alpha and beta	Quarterly	Grab	Quarterly
<i>Surface water locations</i>				
SW29	NO ₃ -N, SO ₄ , chloride, Cr ⁶⁺ , pH, PO ₄ -P, U, F ⁻ , dissolved alpha and beta, suspended alpha and beta, ⁹⁹ Tc, ²³⁹ Pu, ²³⁷ Np, ²³⁵ U	Monthly	Grab	Monthly
SW30	NO ₃ -N, SO ₄ , chloride, Cr ⁶⁺ , pH, PO ₄ -P, U, F ⁻ , dissolved alpha and beta, 1,2-dichloroethane, ²³⁵ U, ²³⁷ Np, ²³⁹ Pu, ⁹⁹ Tc, suspended alpha and beta	Monthly	Grab	Monthly
SW13	NO ₃ -N, PO ₄ -P, chloride, Cr ⁶⁺ , pH, U, F ⁻ , dissolved alpha and beta, suspended alpha and beta, SO ₄ , ²³⁵ U, ⁹⁹ Tc, temperature	Weekly	Grab and 7-d composite	Weekly
SW13	U, Ni, Hg, Cd, As, Ba, Cu, Pb, Se, Ag, dissolved alpha and beta, suspended alpha and beta, ⁹⁹ Tc, ²³⁷ Np, ²³⁹ Pu, ²³⁰ Th, % ²³⁵ U, Cr, ICP ^e metals scan	Annually	Annual composite	Annually
SW1	NO ₃ -N, SO ₄ , chloride, Cr ⁶⁺ , pH, PO ₄ -P, U, F ⁻ , ⁹⁹ Tc, % ²³⁵ U, ²³⁷ Np, ²³⁹ Pu, gross alpha and beta, weekly temperature	Monthly	Grab	Monthly
SW5, SW10	Gross alpha and beta, ⁹⁹ Tc, % ²³⁵ U, ²³⁷ Np, ²³⁹ Pu	Monthly	Grab	Monthly

^aSee Fig. 4.3.

^bTotal organic carbon.

^cTotal suspended solids.

^dTotal dissolved solids.

^eInductively coupled plasma spectrometer.

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results comparing downstream Big Bayou (SW5) and Little Bayou (SW10) creeks to reference or background data taken at upstream Big Bayou Creek (SW1). The only exception was for assay or weight percent ^{235}U , which was made using a two-tailed t test at 95% confidence level. In all instances except ^{235}U , the critical determinant increases over natural background. Uranium-235 being present on the site at both enriched and depleted assays may impact the creeks by raising or lowering the background assay. The data show statistically significantly elevated levels of gross alpha activity, uranium, and ^{235}U at downstream location SW10. SW5 location was elevated only for gross beta. The results evaluated for gross alpha and beta were obtained by combining gross results to the sum of the dissolved and suspended measurements. The activity at SW10 is most likely related to the elevated uranium levels in Little Bayou Creek, which reflect plant discharges in effluents. Additional indications of plant influence can be found in the lower ^{235}U results, which indicate that the uranium in the creek is tails (lower than normal) assay material. Data results do not indicate a cause or source for the elevated beta in Big Bayou Creek (SW5). No other radiological analyses at either location were different from the reference location this year although in the past technetium has been elevated. No measurement for 1992 gross alpha or gross beta exceeded the 15 pCi/L alpha and 50 pCi/L beta safe drinking water limits nor did uranium exceed 4% of the DOE DCG.

Two locations on the Ohio River, SW29 and SW30, are monitored monthly for the parameters listed in Table 4.1. These data are presented in Tables 4.21 and 4.22 in Part 2. Samples tested for 1,2-dichloroethane, discharged by an upstream Ohio River industrial complex, were $<5\text{ }\mu\text{g/L}$.

The surface runoff from the C-746-S residential landfill and the C-746-T inert landfill is monitored quarterly. Sampling is performed to comply with Kentucky Division of Waste Management requirements for landfill operations. Data comparisons were made using a one-tail (upper) t test at 95% confidence level for nonradiological results comparing each landfill location (SW45 and SW46) to reference or background data taken at upstream Big Bayou Creek (SW1). The critical determinant increases over natural background. The data show significantly elevated levels of fluorides (F) at both

locations along with elevated sulfate (SO_4), dissolved solids, and uranium at SW45. Although elevated uranium levels should also elevate the alpha and beta levels, it should be understood that the analytical procedures are much more sensitive to uranium than alpha and beta activity. Moreover, particularly when solids are present, as the elevated dissolved solids indicate, shielding of radiation occurs, causing variability that would mask low uranium concentration effects.

4.2 Kentucky Pollutant Discharge Elimination System Monitoring

The Clean Water Act is administered for PGDP by the Kentucky Division of Water (KDOW) through the KPDES Wastewater Discharge Permitting Program. The earlier National Pollutant Discharge Elimination System (NPDES) permit (KY0004049) was issued by Region IV of the U.S. Environmental Protection Agency (EPA) and became effective February 15, 1975. The permit was revised February 4, 1977, and was to expire in 1980. Although PGDP had applied for a new permit at the time the old one expired, no system was in place at the KDOW to replace the old NPDES, and a new permit could not be issued. PGDP operated under the original 1975 permit until October 22, 1986, when the state of Kentucky issued the KPDES permit (KY0004049). On November 5, 1986, the state permit was adjudicated because the permit limits were not achievable. Monitoring then resumed under the old NPDES permit. As a part of the negotiations associated with the adjudication process, an Agreed Order was proposed that would include interim limits while a biological monitoring study (see Subsect. 4.4) was being carried out at PGDP. Table 4.1 in Part 2 shows interim limits, sampling frequency, and the type of sample required by the Agreed Order. The Agreed Order became effective October 12, 1987. Monitoring then resumed under the KPDES permit with the Agreed Order modifications. The KPDES permit expired in October 1991; however, monitoring continued under the KPDES Agreed Order. By submitting permit renewal documents in May 1991, PGDP complied with regulations that allow the continued discharge of wastewater under the auspices of the expired permit.

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Monitoring of 17 individual outfalls was conducted in accordance with the KPDES Agreed Order. Table 4.2 lists all outfalls and their contributing processes; Fig. 4.4 depicts the location of the outfalls. Table 4.1 in Part 2 cites the effluent limits set forth by the Agreed Order.

Tables 4.2 through 4.15 in Part 2 give the yearly minimum, maximum, and average for each outfall monitored. Because no flow occurred at outfall 003 in 1992, no monitoring data were obtained. Flow from the north/south diversion ditch is normally channeled through outfall 001 by way of a lift station that pumps the effluent through the C-616 full-flow lagoon; however, during a rainfall with flows greater than 10 year/24 h (i.e., a maximum daily average flow over a 10-year occurrence interval), the lift station overflows to outfall 003. This is the only time that outfall 003 discharges and is monitored. Outfall 005 is not monitored regularly because its effluent flows into the C-611 secondary lagoon. Outfall 006, the C-611 secondary lagoon, is monitored for the same parameters as those required by outfall 005. Outfall 007, a septic field for the C-611 water treatment plant, is not allowed to experience any discharge. Outfall 014 was monitored once in 1992. This U-shaped lagoon experiences flow only when the C-611 sludge lagoon is dredged (i.e., every 2 or 3 years) and the filter backwash is directed to outfall 014. Monitoring of outfall 014 occurs at this time.

During 1992, PGDP achieved a compliance rate on limit exceedances of 99.50%, out of 1984 analytical results, with KPDES Agreed Order limits. (The 1991 compliance rate was 99.5%.) A total of approximately 4800 analyses were performed; the additional analyses reflect "report only" requirements. The total number of noncompliances in 1992 was 16, with 10 coming from limit exceedances and 6 from other sources such as holding time exceedances. Table 4.3 indicates the noncompliances experienced under the Agreed Order. The noncompliances during 1992 were for total residual chlorine, trichloroethylene, pH, and total suspended solids. Six unpermitted discharges and administrative errors also occurred.

One total residual chlorine noncompliance occurred in 1992 for which no cause could be assigned. Two total suspended-solids noncompliances occurred because of rain resuspending sediment in

effluent waters. The KPDES permit, which became effective November 1, 1992, does not contain limits for total suspended solids from rainfall runoff outfalls. However, PGDP daily inspects each outfall area to ensure that no oil sheens or erosion problems occur. Remedial actions are taken if problems are identified.

Four pH noncompliances occurred. Two of the four exceedances were related to algal growth that was unrelated to PGDP. A fish kill in the C-611 lagoon related to a process upset in January 1992 contributed to one pH excursion. A malfunctioning pump used in sanitary water treatment processing caused excess soda ash, a water-softening agent, to be discharged to the C-611 lagoon. More than 800 small fish, mainly shad and sunfish, died. Biologists from Oak Ridge National Laboratory (ORNL) investigated the incident and estimated that less than 10% of the lagoon's sunfish population was affected. The lagoon contains a large population of sunfish in poor condition because of overcrowding (ORNL 1992). The other pH noncompliance occurred when a normally capped line was leaking water to outfall 014. The filter backwash water, which normally flows to outfall 006 had a pH of 9.5. The Agreed Order pH limit at outfall 014 was 9.0. The pH limit at outfall 006 was 10.4. Repairs were made to the leaking line.

During an April 1992 groundwater pump test, water containing trichloroethylene was released to outfall 008, causing three trichloroethylene noncompliances. The KPDES Agreed Order limit of 27 mg/L was exceeded, with the highest concentration being 87 mg/L. The KPDES permit, which became effective November 1, 1992, contains a limit of 81 mg/L for trichloroethylene. Measures have been taken to reduce the chances of this problem recurring.

One holding time was missed in February. The holding time for a turbidity sample collected at outfall 006 was exceeded. The KDOH was notified in the monthly discharge monitoring report of this occurrence. Five unpermitted discharges happened in 1992. One unpermitted discharge in February 1992 was a spill of recirculating cooling water containing chromium to outfall 013. In August 1992 chilled water containing sodium molybdate was discharged to outfall 008 as a result of a coil drain valve that was inadvertently opened. On September 21, 1992, more

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Table 4.2. Kentucky Pollutant Discharge Elimination System outfalls at PGDP

Location ^a	Drainage source	Contributing process
001	C-616, C-600, C-400, C-410, C-635, C-335, C-337, C-535, C-537, C-746-A, C-747-A, C-635-6	Recirculating cooling water blowdown treatment effluent, coal-pile runoff, once-through cooling water, surface runoff, roof and floor drains, treated uranium solutions, sink drains
002	C-360, C-637, C-337-A	Once-through cooling water, roof and floor drains, sink drains, extended aeration sewage treatment system
003	North edge of plant	Storm overflow of north/south diversion ditch discharges
004	C-615 sewage treatment plant, C-710, C-728, C-750, C-100, C-620, C-400	Domestic sewage, laboratory sink drains, motor cleaning, garage drains, laundry, machine coolant treatment filtrate, condensate blowdown, once-through cooling water
005	C-611 primary sludge lagoon	Water treatment plant sludge, sand filter backwash, laboratory sink drains
006	C-611 secondary lagoon	Water treatment plant sludge, sand filter backwash, laboratory sink drains from outfall 005
007	Outfall eliminated	
008	C-743, C-742, C-741, C-723, C-721, C-728, C-729, C-400, C-420, C-410, C-727, C-411, C-331, C-310, C-724, C-744, C-600, C-405, C-409, C-631, C-720	Surface drainage, roof and floor drains, once-through cooling water, paint shop discharge, condensate, instrument shop cleaning area, metal-cleaning rinse water, sink drains
009	C-810, C-811, C-331, C-333, C-310, C-100, C-102, C-101, C-212, C-200, C-300, C-320, C-302, C-750, C-710, C-720	Surface drainage, roof and floor drains, condensate, once-through cooling water, sink drains
010	C-531, C-331	Switchyard runoff, roof and floor drains, condensate, sink drains
011	C-340, C-533, C-532, C-315, C-333, C-331	Once-through cooling water, roof and floor drains, switchyard runoff, condensate, sink drains
012	C-633, C-533, C-333-A	Roof, floor, and sink drains runoff; condensate; surface runoff; extended aeration sewage treatment system
013	Southeast corner of plant	Surface runoff
014	C-611 U-shaped sludge lagoon	Sand filter backwash, sanitary water
015	West central plant areas	Surface runoff
016	Southwest corner of plant	Surface runoff
017	Extreme south area of plant	Surface runoff
018	Landfill at north of plant	Surface runoff

^aSee Fig. 4.4.

Fig. 4.4. KPDES outfall locations at PGDP.

than 2 in. of rain fell in approximately 40 minutes. Runoff from the coal pile flowed through outfalls 008 and 015. At the time, coal-pile runoff was allowed to flow only through outfall 001. The KPDES permit has been amended to allow coal-pile runoff to flow through outfalls 008 and 015. Fire-training water was inadvertently discharged through outfall 016 during October fire-training exercises. The KPDES permit was later amended to allow this activity.

In February 1992, a fish kill occurred in the C-616 full-flow lagoon. ORNL biologists investigated the kill at the request of PGDP. Although the number of dead fish exceeded 400, the event was not ecologically significant. Mortality probably affected less than 10% of the bluegill population in the lagoon. Based on both field sampling and laboratory examinations, the lagoon contains a very large, stunted, and starving population of bluegill that are in poor condition because of overcrowding. The exact cause of death

for the bluegill could not be determined. A toxicity test of the water conducted with fathead minnows and *Ceriodaphnia* revealed no toxic effects. This information suggests that the kill was not related to chemical discharges from PGDP operations. However, the field observations, population dynamics, condition factors, blood analyses, and pathological examinations suggest that starvation is the primary stressor in the lagoon (Ryon 1992).

During 1992 the Polychlorinated Biphenyl (PCB) Source Identification Project concluded. Details are included in Subsect. 8.2.4.

On November 1, 1992, a revised KPDES permit became effective. The permit, which provides for chemical and toxicity testing, contains difficult to meet metals, pH, temperature, biomonitoring, and phosphorous limits. The metal effluent limits contained in the PGDP permit were based on water quality criteria with a zero flow receiving stream. PGDP adjudicated the portions of the permit that

Table 4.3. Compliance experience^d under interim Kentucky Pollutant Discharge Elimination System (KPDES) limits for 1992

Permitted parameters	Interim limits ^b and number of violations ^c at each outfall															
	001	002	003	004	005	006	008	009	010	011	012	013	014	015	016	017
Flow (Mgd)	M ^d	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Cr, total recoverable	0.15	0.31	0.15				0.1	0.23	0.5	0.85	0.76					
Zn, total recoverable	0.93	0.17	0.93				0.34	1.15	0.26	0.16	0.4					
Cl, residual	0.019 ^e (1)	0.15	0.1				0.33	0.01	0.01	0.14	0.01					
Temp (°F)	93	89	93				89	89	89	95	90					
Fe, total recoverable	34.3	6.55	5.19				9.42	8.41	8.32	5.94	18.22					
Al, total recoverable	M	M	M				M	M	M	M	M					
Cu, total recoverable	0.17	M	0.17				M	M	M	M	M					
Ni, total recoverable	3.1	M	3.1				M	M	M	M	M					
TSS ^f	158	M	158	45	50	50	M	M	M	M	M	271	50	427(1)	45	45(1)
Trichloroethylene ^g	0.0807	M	0.027				0.027(3)	M	M	M	M					
Fluoride	4.0	5.0	4.0				5	5	5	5	5					
Dissolved oxygen	5.0	5	5				5	5	5	5	5					
Oil and grease	15	M	15				M	M	M	M	M					
pH (SU) ^h	6–10(1)	6–10	6–10	6–9	6–9	6–10.4(1)	6–9	6–10	6–9(1)	6–10	6–9	6–9	6–9(1)	6–9	6–9	6–9
Uranium	M	M	M				M	M	M	M	M					
Dissolved alpha (pCi/L)	M	M	M				M	M	M	M	M					
Suspended alpha (pCi/L)	M	M	M				M	M	M	M	M					
Dissolved beta (pCi/L)	M	M	M				M	M	M	M	M					
Suspended beta (pCi/L)	M	M	M				M	M	M	M	M					
PCB ^k	0.1	0.1	0.1				0.1	0.1	0.1	0.1	0.1			0.1	0.1	0.1
BOD _{5i}				45												
Fecal coliform (col./100 mL)				400	M	M										
Turbidity (NTU) ^j					M	M										
COD ^k					M	M						M				

^aNote: There were 10 violations in 1984 analyses related to permit limits (i.e., 99.50% compliance). Total noncompliances were 16, total analyses approximately 4800.

^bChemical limits are milligrams per liter unless otherwise indicated.

^c() = number of violations.

^dM indicates monitoring requirement only.

^eThe KPDES permit, issued November 1, 1992, was effective at the time of this noncompliance. All other noncompliances were with the KPDES Agreed Order.

^fTotal suspended solids.

^gStandard units.

^hPolychlorinated biphenyl.

ⁱBiological oxygen demand (5 d).

^jNephelometric turbidity units.

^kChemical oxygen demand.

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contained effluent limits that were not attainable and implemented those portions of the permit not under adjudication. KDOW granted a stay from the adjudicated limits while an Agreed Order is negotiated. PGDP, at the request of KDOW, prepared a draft Agreed Order and submitted it to KDOW. KDOW is reviewing and revising the draft and will provide PGDP with comments soon.

4.3 Radiological Monitoring of Effluents

4.3.1 DOE Order 5400.5, “Radiological Sampling”

Radiological liquid effluent monitoring was conducted periodically by random grab sampling and laboratory analyses. Although no specific effluent limits are indicated for radiological parameters in the KPDES permit, DOE Order 5400.5 sets guidelines for allowable concentrations of radiological species in various effluents and requires radiological monitoring to protect the public health.

In addition to sampling required by the KPDES permit, each continuous-flow sampling point with annual average radionuclide concentrations greater than 1% of the Derived Concentration Guide (DCG) for any radionuclide was sampled weekly. Uranium was the only radionuclide measured in PGDP effluents with concentrations greater than 1% of the DCG. Monitoring of outfalls 010 and 012 for uranium, historically done on a quarterly basis, was increased to weekly to generate a sufficient quantity of data to characterize these discharges.

Tables 4.25 and 4.26 in Part 2 give the yearly minimum, maximum, and average concentrations of uranium and technetium at each effluent-monitoring location. Each radionuclide is compared with the DCG and is presented as a percentage of that standard. The average concentrations were small percentages of the corresponding DCGs for both uranium and technetium at all locations.

Routine monitoring also provides data to estimate the total radionuclide discharge to surface waters. Because current monitoring provides only instantaneous measurements for both concentration of radionuclides and flow, a large uncertainty is associated with this estimation. During 1992, 66 kg of uranium were discharged to surface waters, a

decrease from the 1991 discharge of 108 kg. Technetium releases to surface waters remained relatively constant at 4.7 g in 1992. Table 4.27 in Part 2 shows monthly data for the major contributors to the total discharge during 1992.

4.3.2 Agreement In Principle Activities—Off-Site and Effluent Surface Water Sampling

A quarterly sampling event takes place in which the state of Kentucky Cabinet for Human Resources (CHR) travels to the PGDP area and obtains samples from off-site and on-site surface water locations. PGDP personnel accompany the CHR. Split samples are taken at all scheduled locations. Samples from selected locations are analyzed immediately although most samples are reserved as backups. CHR results are reviewed, and backups are analyzed if problems are detected. These sampling events are conducted because the state of Kentucky wants to have independent verification that public health is protected. This protection is achieved at PGDP by meeting the DOE Order 5400.5 DCGs of 100 mrem per year. Safe drinking water limits do not apply to PGDP surface water sampling because the effluent ditches, Big and Little Bayou creeks, are not drinking water sources for any residents. The KPDES Permit has no effluent limits for radiological analytes, only a requirement to report results of sampling events. DOE orders 5400.1 and 5400.5 define effluent and surveillance monitoring requirements to provide confidence that the DCGs are not exceeded.

For monitoring purposes, PGDP uses estimates of DCG levels to determine sampling frequencies. Effluent monitoring is based on two categories for continuous discharges, greater than 1% and less than 1% of the DCGs. Intermittent discharges (ditches that discharge only during rainfall) are also based on two categories, greater than 1% and less than 1% of the DCGs.

In 1992, there were no continuous points above 10% of the DCGs. KPDES continuous discharge points 001 and 011 were between 1 and 10%; points 008 and 009 were less than 1%. KPDES intermittent effluent discharge point 015 was greater than 10%; 010 and 018 were between 1 and 10%; and 002, 012, 013, 016, and 017 were less than 1%. Off-site or surveillance locations in 1992 indicated that Big Bayou Creek was less than 1% and that Little Bayou

Creek was greater than 1% of the DCGs. Although PGDP monitors for other radionuclides (neptunium-239, plutonium-239, and thorium-230) and screens with alpha and beta measurements, uranium and technetium-99 (^{99}Tc) are the primary effluent concerns. No ^{99}Tc averages measured in the past have even approached 1% of the DCGs. Therefore, all DCG-level monitoring is based on uranium concentrations, and all alpha and beta values are assumed to come from uranium with the beta corrected based on any ^{99}Tc information. The DCG levels from DOE Order 5400.5 are 600 pCi/L for total uranium and 100,000 pCi/L for ^{99}Tc .

The purpose of having corroborative sampling between PGDP and the CHR is to provide quality assurance on the activity for the state and for PGDP by showing that sampling and analytical techniques provide data leading to equivalent decisions. This assurance is difficult to provide because of the screening nature of the analytical tests performed by the state. The state uses gross alpha and gross beta activity, ^{99}Tc , and man-made radionuclide analyses to monitor PGDP activities. PGDP uses direct measurements for radionuclides of concern to characterize surface water into the previously mentioned categories along with screening techniques or less frequent sampling for specific radionuclides to verify that no other radionuclides are being discharged. The alpha and beta activities are highly variable and subject to difficulties in analysis and data interpretation because of the following:

- Solid interferences—The presence of solids in a sample can cause both negative and positive interferences in the analysis of alpha and beta activity. Results can be biased high because of the presence of natural uranium, ^{40}K , and radionuclides from fallout. Results can also be biased low because of shielding effects. Alpha and beta energy is absorbed by the solids, not allowing the energy to reach the detector, thus lowering the analyzed value. Results can also be biased either high or low because of spiking corrections. Spikes, or standard material, are added to sample portions to estimate recovery. Variability in solids between the spike water and the sample water can produce correction factors that can significantly change the final result.
- Background influences—Even though background is measured and the result corrected, there is potential for shifts in background during analytical runs that can cause significant differences in low-level analyses where background and sample counts are somewhat equivalent.

For these reasons, only relative comparisons of PGDP's direct DCG estimates with screening activity measurements are possible. State samples taken from runoff locations are from pooled areas; however, PGDP takes samples for DCG levels during flow periods. The state also takes samples from areas that PGDP does not monitor. These areas on Big and Little Bayou creeks, the KPDES ditches not requiring radiological monitoring, and the blocked-off 003 ditch are not included in evaluations.

Variations in comparative data are discussed in this report, either explaining the cause of the differences or pointing out the differences if the cause is unknown. Detailed results from the corroborative sampling for gross alpha and beta activity and ^{99}Tc along with data comparisons of state and PGDP maximum and minimum reported results are shown in Part 2, Table 4.28. Table 4.4 (Part 1) contains the comparative data for PGDP DCGs to state gross alpha measurements. Gross alpha was selected because of the effect of ^{99}Tc , a beta emitter, on gross beta analyses. KPDES points are listed in declining order by 1992 DCG estimations from Table 4.25 in Part 2. Off-site points are listed with upstream and downstream state data. Table 4.4 shows the state measurements decreasing, as expected, according to PGDP's 1992 DCG estimates. There are four differences, three of which are readily explainable. State results for outfalls 001, 011, and 010 are lower than PGDP results. The differences are attributable to differences in sampling frequencies. PGDP sampled outfalls 001 and 011 weekly during 1992 for a total of 52 analyses; however, outfall 010 was sampled only eight times. The state monitored quarterly for a total of four analyses. The range of PGDP's results for these outfalls (see Table 4.28 in Part 2) overlaps the state values, which indicates that discharges do occur at the measured state levels. Outfall 010 also receives water routed from outfall 011 during periods of maintenance on 011 facilities. PGDP takes samples weekly when this occurs. The

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Table 4.4. 1992 state surface water measurements

PGDP sampling location	State gross alpha measurement range (pCi/L)	
	Min	Max
<i>Effluent monitoring^a</i>		
KPDES ^b 015	25	129
KPDES 011	<1	8
KPDES 001	<4	8
KPDES 018	8	45
KPDES 010	<1	8
KPDES 012	4	8
KPDES 017	3	4
KPDES 002	<1	2
KPDES 016	1	11
KPDES 008	<1	2
KPDES 013	<2	3
KPDES 009		All <1
<i>Off-site monitoring</i>		
Little Bayou Creek, upstream (L-9)		All <1
Big Bayou Creek, upstream (L-1)		All <1
Little Bayou Creek, downstream (L-11)	1	6
Big Bayou Creek, downstream (L-4)	3	8

^aListed in declining order according to 1992 percent of Derived Concentration Guide estimates (see Table 4.25 in Part 2).

^bKentucky Pollutant Discharge Elimination System.

state did not take samples during this rerouting of effluents. PGDP has no definitive explanation for the higher than expected value of 11 pCi/L at outfall 016. This value is above the 1992 PGDP range listed in Table 4.28 of Part 2. PGDP believes this was caused by the state's practice of sampling from pooled areas at runoff locations, and outfall 016 is a runoff location. The off-site state results show higher measurements for Big Bayou Creek than for Little Bayou Creek, contrary to PGDP estimates. Again, this is attributed to increased sampling (13 measurements to 4) and therefore better estimations. The PGDP measurements listed in Tables 4.18 and 4.19 in Part 2 show average uranium concentrations in Big and Little Bayou creeks at <0.005 and 0.019 mg/L, respectively, and these values are used for DCG monitoring.

4.4 Biological Monitoring of Effluents and Receiving Waters

On September 24, 1987, the Commonwealth of Kentucky Natural Resources and Environmental Protection Cabinet issued an Agreed Order, which required the development of a Biological Monitoring Program (BMP) for PGDP. The PGDP BMP was implemented in 1987 by the University of Kentucky. Beginning in fall 1991, the Environmental Sciences Division at ORNL assumed responsibility for the PGDP BMP. The overall goals of the BMP are to (1) demonstrate that the effluent limitations established for PGDP protect and maintain the use of Little Bayou and Big Bayou creeks for growth and propagation of fish and other aquatic life, (2) characterize potential health and environmental

impacts, (3) document the effects on stream biota resulting from operation of pollution abatement facilities, and (4) make recommendations on any necessary improvements for effluent treatability. In September 1992, a renewed KPDES permit was issued to PGDP. As of this writing, many of the provisions of the permit have been stayed, and a new Agreed Order is in draft form. The renewed permit requires quarterly toxicity monitoring of continuous and intermittent outfalls. A BMP is not required in either the draft Agreed Order or the renewed permit. However, biological monitoring of the DOE facilities at PGDP is required in DOE Order 5400.1. Data collected under the BMP will also be used to support three studies proposed in the draft Agreed Order.

The BMP for PGDP consists of three major tasks: (1) effluent and ambient toxicity monitoring, (2) bioaccumulation studies, and (3) ecological surveys of stream communities (i.e., benthic macroinvertebrates and fish). This report includes Environmental Sciences Division/ORNL activities from December 1990 to November 1992. A detailed description of the program and results will be published in the first report of the PGDP BMP in the spring of 1993.

4.4.1 Study Area

PGDP is located in the western part of the Ohio River basin. Surface drainage from PGDP enters Big Bayou and Little Bayou creeks, which are two small tributaries to the Ohio River. Big Bayou Creek is a perennial stream with a drainage basin extending from about 4 km south of PGDP to the Ohio River. Part of the creek's 14.5-km course flows along the western boundary of the plant. Little Bayou Creek originates in the West Kentucky Wildlife Management Area and flows north for 10.5 km toward the Ohio River; its course includes part of the eastern boundary of the plant. Four continuously flowing outfalls (001, 006, 008, and 009) discharge to Big Bayou Creek. Outfalls 002, 010, 011, and 012 are combined at the C-617 lagoon and discharged via outfall 011 to Little Bayou Creek. Effluent from outfalls 013, 015, 016, 017, and 018 regularly discharges to Big Bayou and Little Bayou creeks during rainfall events.

Three sites on Big Bayou Creek located 12.5 km, 10.0 km, and 9.1 km (BBK 12.5, BBK 10.0, and BBK 9.1) from the mouth of the creek, one site on

Little Bayou Creek located 7.2 km (LUK 7.2) from the mouth of the creek, and one off-site reference station on Massac Creek located 13.8 km from the mouth of the creek (MAK 13.8) were routinely sampled to assess the ecological health of the stream and to evaluate ambient toxicity. Three additional sites (BBK 2.8, LUK 9.0, and LUK 4.3) were sampled as part of the bioaccumulation monitoring task. Toxicity monitoring and benthic macroinvertebrate sampling were conducted quarterly, and fish community sampling and bioaccumulation sampling were conducted twice annually in the spring and fall. KPDES effluents evaluated for toxicity included 001, 004, 006, 008, 009, 011, 013, 015, 016, 017, and 018.

4.4.2 Toxicity Monitoring

Ceriodaphnia and fathead minnow toxicity tests of effluents from the continuously flowing outfalls (001, 004, 006, 008, 009, and 011), the intermittently flowing outfalls (013, 015, 016, 017, and 018), and ambient sites (BBK 12.5, BBK 10.0, BBK 9.1, LUK 7.2, and MAK 13.8) were conducted quarterly beginning in October 1991. All of the ambient sites and outfalls except 016 were evaluated five times; outfall 016 was evaluated four times. Tests with *Ceriodaphnia* and fathead minnows were typically conducted concurrently. A no-observed-effect concentration (NOEC; that concentration causing no reduction in survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*) and a 25% inhibition concentration (IC25; that concentration causing a 25% reduction in fathead minnow growth or *Ceriodaphnia* survival compared to a control) were determined for each test. The NOEC was used as a compliance end point for tests conducted under the draft Agreed Order (prior to September 1992). The lower the NOEC, the more toxic an effluent. The chronic toxicity unit (TUc = 100/IC25) is required as a compliance end point in the renewed permit (September 1992 to the present). Because Little Bayou and Big Bayou creeks have been determined to have low flows of zero, an NOEC < 100% or a TUc > 1.2 would be considered a noncompliance and an indicator of potential for instream toxicity.

Effluent from the continuous outfalls was rarely toxic (NOEC < 100% or TUc > 1.2) to *Ceriodaphnia*, and effluent from the intermittent outfalls was never

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toxic to *Ceriodaphnia*. When toxicity was observed in the outfalls, no toxicity was observed in the ambient sites. Effluent from the continuous and intermittent outfalls was occasionally toxic ($\text{NOEC} < 100\%$ or $\text{TUc} > 1.2$) to fathead minnows. Effluent from all of the continuous outfalls except 001 was toxic in February 1992. However, during this same test period, fathead minnow survival was reduced only at BBK 12.5 (above PGDP) and LUK 7.2. It is hypothesized that a pathogenic organism is the cause of low fathead minnow survival at these sites because treatment with ultraviolet light eliminated the toxicity. Likewise, it was hypothesized that a natural pathogen was the cause of "toxicity" to fathead minnows at all sites during the October 1991 test. Toxicity observed in the effluent from outfalls 004, 006, 008, and 009 was not present at the ambient sites. Effluent from outfall 009 was also toxic to fathead minnows in October 1992, but no instream toxicity was observed at BBK 9.1. Toxicity of the intermittent outfalls may be caused by high suspended solids. Ambient toxicity tests were not conducted concurrently with the intermittent outfalls. Tests with filtered and nonfiltered effluent during 1993–1994 will provide additional insight into the toxicity of the intermittent outfalls.

4.4.3 Bioaccumulation

The objectives of the bioaccumulation monitoring were to (1) continue PCB tracking studies in fish from Big Bayou and Little Bayou creeks, (2) confirm elevated mercury concentrations in fish in Big Bayou Creek and establish appropriate reference site concentrations, and (3) conduct screening analyses to detect other contaminants that may be of concern to consumers in fish from these streams.

Longear sunfish were collected for PCB and mercury analysis from Big Bayou Creek, Little Bayou Creek, and Massac Creek during April 1992. Hinds Creek (Tennessee) served as a source of uncontaminated reference fish. PCB contamination was evident in longear sunfish collected from both Big Bayou and Little Bayou creeks. Mean PCB concentrations in sunfish from sites downstream of PGDP discharges exceeded those from the reference sites. The highest mean concentration occurred in fish from the site in Little Bayou Creek immediately downstream from outfall 011. In Big Bayou Creek,

the highest mean PCB concentration was found in fish from BBK 9.1, below outfall 001, but fish from BBK 10.0 also contained PCB contamination. For both creeks, there was a strong downstream gradient in PCB contamination in sunfish. Along with a close association between the degree of contamination and proximity to outfalls demonstrated to be PCB sources in the past, this suggests that the pattern of contamination is sustained by continuing low-level contamination of waters discharged to the creeks, rather than a result of residual PCB contamination in sediments of the creeks themselves. Continued regular monitoring of PCB concentrations in fish is needed to detect any consistent trend over time.

Mean concentrations of mercury in redbreast sunfish from the reference site in Tennessee (Hinds Creek) were less than 50% of those observed at any local reference site (Big Bayou Creek or Massac Creek). Mean mercury concentrations in Hinds Creek fish differed significantly from concentrations in fish from Big Bayou Creek and Massac Creek. Mercury concentrations in fish from sites in Big Bayou Creek below PGDP were similar and exceeded that in local reference site fish. The slightly elevated concentrations of mercury in fish from Big Bayou Creek below PGDP may be a result of mercury in PGDP effluents, but they may also be a consequence of differences in the biogeochemical processing of mercury downstream from the plant.

Concentrations of metals measured in fillets of longear sunfish from Big Bayou Creek and Little Bayou Creek are typical of those observed in previous monitoring and generally differ little (with several exceptions) from concentrations observed in fish from the Hinds Creek reference site.

Concentrations of arsenic, cadmium, copper, lead, selenium, and zinc were lower than the national geometric mean concentrations observed for whole body analyses of fish in the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program. Concentrations of antimony, cadmium, chromium, nickel, selenium, and silver were well below screening levels used in the EPA Integrated Risk Information System (IRIS). Beryllium and arsenic were not detected in PGDP fish (beryllium detection limit was at the IRIS screening level; arsenic detection limit was ten times the screening level). Those metals for which IRIS screening levels are not published (copper, lead, thallium, uranium,

and zinc) were found at concentrations similar to or lower than those that typically occur in foods such as marine fish or mammalian muscle. Detection of elevated concentrations of uranium in fish from Little Bayou Creek is consistent with the observed elevated concentrations of uranium in this creek.

4.4.4 Ecological Monitoring

Prior to ORNL's initiation of the Instream Monitoring Task, a site selection study was conducted in early December 1990. This study included visits to 24 potential reference stream sites outside the PGDP boundaries and 5 stream sites adjacent to PGDP. Based on the site visits, biota surveys, and previous work conducted by the University of Kentucky, five stream sites were included in the Instream Monitoring Task.

Beginning in September 1991, benthic macroinvertebrate samples were collected at quarterly intervals from five stream sites. The services of a subcontractor will be retained in mid-1993 to process invertebrate samples. Samples are being stored and maintained at a benthic invertebrate sample chain-of-custody facility at ORNL in Oak Ridge, Tennessee. Processing will involve (1) sorting the invertebrates from the debris in each sample, (2) identifying taxa to the lowest practical level (genus in most cases), and (3) enumerating the individuals within each taxon.

Fish population and community studies can be used to assess the ecological effects of changes in water quality and habitat. The initial objectives of the instream fish monitoring task were to (1) characterize spatial and temporal patterns in the distribution and abundance of fishes in Little Bayou and Big Bayou creeks and (2) document the effects of PGDP operations on fish community structure and function. Quantitative sampling of the fish populations at four sites in the Bayou watershed (BBK 12.5, BBK 10.0, BBK 9.1, and LUK 7.2) and at one site in a reference stream, Massac Creek (MAK 13.8), was conducted by electrofishing on September 22–25, 1991, and March 15–17, 1992. Data from these samples were used to estimate species richness, population size (numbers and biomass per unit area), length frequency, and condition factors. Qualitative fish sampling was conducted by electrofishing on March 17 and June 9, 1992. Data from these samples were used to determine the species richness and

number of specimens (relative abundance) based on sampling a known length of stream.

Data on the fish communities of Big Bayou and Little Bayou creeks downstream of PGDP were compared to data from reference sites on Big Bayou Creek above PGDP and on Massac Creek. These comparisons indicated a slight but noticeable degradation in the communities downstream of PGDP. The fish communities at BBK 10.0 and BBK 9.1 showed signs of impact. The fish community at BBK 10.0 had a low mean and total species richness compared to the reference site (MAK 13.8). At both sites, there were few sensitive species at low densities, and tolerant species were more common and abundant than at the reference site. The presence of hybrid sunfish at both sites indicates that the communities were under some reproductive stress. Finally, condition factors at each site were higher than at MAK 13.8. The high condition factor combined with a large population of central stonerollers at BBK 10.0 indicates that there is some nutrient enrichment at this site.

The fish community at LUK 7.2 was generally in poor condition compared to the BBK 12.5 reference site. The mean and total species richness values were low, and the community lacked any catostomide species. Sensitive species were absent, and several tolerant species were present at considerable densities. Because the site is on a smaller stream, some of these deficiencies might be expected; however, overall the community was poorer than at BBK 9.1 but not as affected as BBK 10.0. The poor conditions found at LUK 7.2 did not appear to continue at the downstream qualitative site, LUK 4.3. Species richness was comparable to MAK 13.8, particularly in terms of sensitive species. The community was well represented in all families, except perhaps catostomids, and significant absences in feeding guilds were not demonstrated. The relative abundance and catch-per-effort data were similar to quantitative data at MAK 13.8 and BBK 9.1.

The fish communities associated with PGDP streams indicate depressed conditions. The greatest impacts occurred at sites closest to the plant, which suggests that PGDP effluents may be the cause. The low species richness and few sensitive species can be caused by poor water quality (e.g., high temperatures or chlorine levels) or reflect degraded habitat conditions. Biomass and density respond quickly to

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improvements in degraded conditions and it will be important to follow changes in these parameters, particularly at the most stressed sites.

4.5 Conclusions

Compliance with KPDES Agreed Order limits has increased from 99.5% in 1991 to 99.8% in 1992. Figure 4.5 shows a comparison of 1992, 1991, and 1990 noncompliances. The Plant Effluent Chlorine and Temperature Control Project will continue to alleviate chlorine and temperature noncompliances. Continued emphasis on erosion control should cause total suspended solids noncompliances to decrease. Because occasional elevated pH levels are not causing biological harm to the receiving streams, an alternate pH range will be pursued during the KPDES permit renewal process.

Radiological monitoring of plant effluents indicates that uranium and technetium values are below the DCGs stated in DOE Order 5400.5.

Comparisons of radiological results from upstream Big Bayou Creek with downstream Big Bayou and Little Bayou creeks and landfill runoff locations indicate that Little Bayou Creek has elevated levels of U, ^{235}U , and alpha and beta activity. Big Bayou Creek has only elevated beta, whereas the two landfill runoff locations have elevated uranium levels. The alpha and beta results are probably caused by the release of small amounts of uranium and technetium in plant effluents.

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Fig. 4.5. Kentucky Pollutant Discharge Elimination System noncompliances: 1990–1992. (TRC = total residual chlorine; TSS = total suspended solids; F. Col. = fecal coliform; TCE = trichloroethylene.)

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5. Groundwater

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5. Groundwater

Monitoring and protection of groundwater resources at the Paducah Gaseous Diffusion Plant (PGDP) are required by federal and state regulations and by U.S. Department of Energy (DOE) orders. Monitoring efforts have been initiated at PGDP to reflect these requirements. Characterization activities have also been undertaken that will resolve the recognized deficiencies in understanding of the site geology and hydrogeology. These activities are intended to develop a thorough understanding of the subsurface environment to aid in developing technically effective monitoring strategies.

5.1 Geology of PGDP

PGDP, located in the Jackson Purchase region of western Kentucky, lies within the northern tip of the Mississippi Embayment portion of the Gulf Coastal Plain Province. The Mississippi Embayment is a large sedimentary trough oriented nearly north-south that received sediments during the Cretaceous and Tertiary geologic time periods.

In the PGDP area, bedrock is overlain by the Upper Cretaceous McNairy Formation, which consists of interbedded and interlensing sand, silt, and clay. Paleocene Porters Creek Clay occurs in the southern portions of the site above the McNairy Formation and predominately consists of dark gray to black clay. The Porters Creek Clay subcrops along a buried terrace slope that extends east-west across the site. Eocene sediments, consisting of interbedded and interlensing sand, silt, and clay, overlie the Porters Creek Clay in the extreme southern end of the DOE reservation. The Cretaceous through Eocene strata dip gently to the south-southwest toward the axis of the embayment.

A unit designated as the continental deposits was laid down in the region during the late Tertiary and

Quaternary periods, creating an angular unconformity with the underlying sediments. A basal gravel facies (lower continental deposits) and an upper, fine-grained clastic facies (upper continental deposits) are recognized in the continental deposits. The continental deposits are interpreted as originating from an alluvial fan that covered most of the Jackson Purchase region (Olive 1980).

In response to base-level changes during Pleistocene glaciations, stream systems eroded and later alluviated their valleys, reworking the continental deposits at different elevations. A thicker sequence of Pleistocene continental deposits, representing a valley fill, underlies most of PGDP and extends northward to the Ohio River. Figure 5.1 presents a schematic cross-section that illustrates regional stratigraphic relationships in the vicinity of PGDP.

5.2 Hydrogeology of PGDP

The local groundwater flow system at PGDP exists within the Cretaceous through Pleistocene sediments and Holocene alluvium. Four specific components have been identified as part of the groundwater flow system: the McNairy Flow System, the Terrace Gravels, the Regional Gravel Aquifer (RGA), and the Upper Continental Recharge System (UCRS).

The McNairy Flow System, formerly termed the deep groundwater system, consists of interbedded and interlensing sand, silt, and clay of the McNairy Formation. Sand facies account for 40 to 50% of the total formation thickness of approximately 225 ft. The Terrace Gravels consist of shallow Pliocene-aged gravel deposits in the southern portion of the plant site. These deposits usually lack sufficient thickness and saturation to constitute an aquifer.

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Fig. 5.1. Schematic north-south section showing regional stratigraphic relationships at PGDP (from Phase III Groundwater Investigation).

The RGA consists of the Quaternary sand and gravel facies of the lower continental deposits and Holocene alluvium found adjacent to the Ohio River, which are of sufficient thickness and saturation to constitute an aquifer. These deposits have an average thickness of 30 ft and range up to 50 ft along an axis that trends east-west through the plant site. The RGA is the primary aquifer used locally by private residences located north of PGDP for drinking water and other domestic uses, irrigation of gardens, and watering of livestock. The UCRS, formerly termed the shallow groundwater system, predominantly consists of clayey silt with interbedded sand and gravel of the upper continental deposits. Groundwater flow in the UCRS is predominately downward, to recharge the RGA.

Topographically controlled recharge and discharge areas to the south and north, respectively, bound the local groundwater flow system. One area of recharge occurs south of PGDP within the area underlain by the Eocene sands and has resulted in a groundwater divide. Flow originates south of PGDP within the Eocene sands and the Pliocene terrace gravels. Groundwater within the Pliocene gravels either discharges to local streams or recharges the RGA. From the plant site, groundwater flows northward in the RGA toward the Ohio River, which is the local base level for the system.

5.3 DOE Order 5400.1

DOE Order 5400.1 outlines requirements for groundwater monitoring at all DOE facilities and specifies the development of three documents relating to groundwater monitoring: a Groundwater Protection Program Plan, a Groundwater Monitoring Plan, and an Environmental Monitoring Plan. The Groundwater Protection Program Plan (Clausen et al. 1992a) and the Groundwater Monitoring Plan (Early, Sigmon, and Williams 1989) for the PGDP site have been completed.

The general objective of the Groundwater Protection Program Plan is to formalize and give structure to the PGDP Groundwater Protection Program by identifying specific responsibilities and assigning them to various entities within the plant who are matrixed to the program. Environmental Restoration and Environmental Management

initiatives are coordinated within the plan to the greatest extent possible.

The general objective of the Groundwater Monitoring Plan is to provide a comprehensive blueprint for DOE to follow at each facility that targets the environmental protection of groundwater, is consistent with DOE's commitment to operate its facilities in an environmentally safe manner, and complies with all applicable and relevant environmental laws. The Groundwater Monitoring Plan fulfills these objectives for PGDP by providing a monitoring plan that accomplishes the following:

- develops an appropriate level of understanding of site geology and groundwater hydrology and of flow pathways and rates of contaminant migration from existing waste disposal sites to the underlying aquifer;
- provides the framework within which an integrated strategy for long-term monitoring of existing disposal sites can be developed to aid evaluation of remedial action alternatives; and
- creates a data base and fundamental geotechnical understanding of the site to facilitate future waste disposal decisions.

An Environmental Monitoring Plan has also been developed for the PGDP site. This plan contains the rationale and design criteria for the site monitoring programs, the extent and frequency of monitoring and measurements, procedures for laboratory analyses, quality assurance requirements, program implementation procedures, and directions for the preparation and disposition of reports. The Environmental Monitoring Plan was approved by DOE in July 1992.

5.4 Technical Objectives

The primary objectives of groundwater monitoring at PGDP are to detect as early as possible any contamination resulting from past and present land disposal of wastes and to provide the basis for developing groundwater quality assessments if contamination is detected. Additional objectives outlined in DOE Order 5400.1 require that groundwater monitoring at all DOE facilities "determine and document the effects of operations on groundwater quality and quantity." The order

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specifically requires groundwater monitoring to be conducted on-site and in the vicinity of DOE facilities to accomplish the following:

- obtain data to determine baseline conditions of groundwater quality and quantity;
- demonstrate compliance with, and implementation of, all applicable regulations and DOE orders;
- provide data to permit early detection of groundwater pollution or contamination;
- provide a reporting mechanism for detected groundwater pollution or contamination;
- identify existing and potential groundwater contamination sources and maintain surveillance of these sources; and
- provide data for making decisions about land disposal practices and the management and protection of groundwater resources.

5.5 Program Description

The monitoring and protection of groundwater resources at PGDP are required by federal and state regulations, and by DOE orders. Federal groundwater regulations generally are promulgated and enforced by the U.S. Environmental Protection Agency (EPA). PGDP lies within EPA Region IV jurisdiction, which encompasses the southeastern United States. The EPA Region IV headquarters are located in Atlanta, Georgia.

Many state groundwater regulations are promulgated and enforced by the Kentucky Division of Waste Management (KDWM), located in Frankfort, Kentucky. A KDWM field office for western Kentucky is located in Paducah, Kentucky. Some interactions between PGDP and KDWM concerning groundwater involve the Hazardous Waste Branch of the KDWM in Frankfort.

Groundwater monitoring activities at PGDP are described as “effluent monitoring” or “environmental surveillance monitoring.” Effluent monitoring as applied to groundwater is monitoring to achieve compliance with one or more federal or state regulations, or permit conditions. Included under this heading are groundwater monitoring at either interim-status or permitted-status Resource Conservation and Recovery Act (RCRA) units;

monitoring of RCRA 3004 (u/v) facilities; monitoring in conjunction with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) actions (e.g., Remedial Investigation/Feasibility Studies); monitoring around landfills in compliance with permit regulations; and monitoring around underground storage tanks (USTs). In addition, groundwater monitoring in response to administrative orders or a memorandum of understanding (e.g., an Agreed Order between the facility and EPA) is included as effluent monitoring.

Environmental surveillance monitoring is defined as perimeter exit pathway monitoring and off-site water-well monitoring. Perimeter exit pathway monitoring is conducted to aid understanding of the effects of facility operations on the regional groundwater quality and quantity. In addition to verifying compliance with regulatory requirements at the DOE reservation boundary, perimeter exit pathway monitoring provides a means of detecting previously unidentified on-site groundwater quality problems. Off-site water-well monitoring is conducted to address public concerns about off-site groundwater contamination, especially of drinking water sources.

The general characteristics that differentiate groundwater effluent monitoring and surveillance monitoring are summarized in Table 5.1. Subsections 5.5.1 and 5.5.2 describe the existing effluent and environmental surveillance monitoring conducted by PGDP. For a more detailed description of the groundwater monitoring requirements prescribed by the applicable regulations and DOE orders, refer to the Groundwater Protection Program. Figures 5.2 through 5.10 show the locations of all wells sampled during PGDP’s 1992 groundwater monitoring activities. Analytical results from the sampling described in Subsects. 5.5.1 and 5.5.2 are included in Tables 5.1 through 5.11 in Part 2.

5.5.1 Effluent Monitoring

5.5.1.1 RCRA Interim Status and Permit Monitoring Programs

RCRA groundwater monitoring is required under two separate sections of the regulations, applying to units that are under interim status or are regulated (and therefore have a RCRA permit). The

5-6 Groundwater

Table 5.1. Comparison of general characteristics of groundwater effluent and groundwater surveillance monitoring

Groundwater effluent monitoring	Groundwater surveillance monitoring
Regulation-, permit-, or investigation-driven	DOE order-driven
Monitors individual units, facilities, or waste area groupings	Monitors entire plant
Monitoring locations are generally on site	Monitoring locations are at the plant perimeter and off-site
Short-, intermediate-, and/or long-term monitoring	Permanent monitoring
Constantly changes sites, adds and deletes wells, changes parameters, changes frequencies	Rarely changes after full implementation

Commonwealth of Kentucky is an authorized state and maintains the permitting and enforcement authority for the PGDP RCRA units.

At present, the only RCRA facility at PGDP that requires groundwater monitoring is the C-404 low-level radioactive waste burial ground. The C-404 burial ground operated until 1986, when routine testing programs indicated that the gold dissolver precipitate disposed of in early 1986 was hazardous, as determined by extraction procedure toxicity tests. The burial ground was covered with a RCRA clay cap and certified closed as a hazardous waste landfill in 1987.

In June 1989, a postclosure permit application was prepared and submitted to KDWM. Twelve detection monitoring wells were subsequently installed to monitor groundwater quality during the required postclosure care period (see Fig. 5.10 and Table 5.2). The detection wells were installed in the UCRS and the underlying regional gravel aquifer, which is considered to be the uppermost aquifer. A statistical evaluation of the indicator parameters was conducted using quarterly sample results from the initial year of monitoring. The evaluation indicated that monitoring well 88 (MW88) had significantly greater levels of contamination for trichloroethylene (TCE), technetium-99 (^{99}Tc), uranium, and arsenic than MW94, which was assumed to be upgradient. As a result, the Commonwealth of Kentucky determined that additional information was needed to support the postclosure permit application.

An assessment monitoring plan for C-404 was proposed to the state. The plan included further assessment of the plume, using the groundwater investigation: being conducted at PGDP pursuant to a CERCLA Administrative Order by Consent (ACO) between DOE and the EPA. Additionally, sampling for Appendix IX analytes was to be performed at C-404.

PGDP began preparation of an updated postclosure permit application in 1991, based on the results of the additional assessment and monitoring. The updated postclosure plan (permit modification application) was submitted to the KDWM in 1992. The additional quarterly groundwater monitoring results indicated that a release to the uppermost aquifer (RGA) had not occurred, so the permit modification application was prepared pursuant to detection monitoring requirements for permitted facilities.

Monitoring continues at this unit on a quarterly basis. Table 5.1 in Part 2 contains the quarterly sampling results for the C-404 wells during 1992.

5.5.1.2 UST Monitoring

In July 1989, petroleum hydrocarbons were discovered by Energy Systems in a plant monitoring well located approximately 500 ft northeast of the C-750 garage. Tank tightness tests were conducted on two underground fuel tanks, C-750-A and C-750-B, and results confirmed that the two USTs were

Fig. 5.2. Wells sampled by PGDP in 1992 (by sectors).

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Fig. 5.4. Northeastern sector—wells sampled by PGDP during 1992.

Fig. 5.5. Western sector—wells sampled by PGDP during 1992.

Fig. 5.6. Eastern sector—wells sampled by PGDP during 1992.

Fig. 5.7. Southwestern sector—wells sampled by PGDP during 1992.

Fig. 5.8. Southeastern sector—wells sampled by PGDP during 1992.

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Fig. 5.9. Plant site—wells sampled by PGDP during 1992.

Fig. 5.10. Approximate locations of groundwater sampling wells around the C-404 area.

Table 5.2. Resource Conservation and Recovery Act monitoring wells at the C-404 area

Well	Monitored zone
84	RGA ^a
85	UCRS ^b
86	RGA
87	RGA
88	UCRS
89	RGA
90	RGA
91	UCRS
92	RGA
93	RGA
94	UCRS
95	RGA

^aRegional gravel aquifer.

^bUpper Continental Recharge System.

leaking. Both tanks were immediately taken out of service, and the fuel remaining in them was removed.

In August 1989, a preliminary site characterization was initiated by CDM Federal Programs Corporation to define the level of contamination present in soil and groundwater in the area surrounding the two USTs. Results of the initial site characterization confirmed the presence of soil and groundwater contamination in the vicinity of the C-750 garage that may have been the result of releases from the USTs. In the spring of 1991, the two leaking USTs were removed and soil samples were collected from the walls and floor of the excavation areas. These samples were analyzed and also revealed the presence of contamination from petroleum hydrocarbon releases possibly originating from the USTs.

During 1991 and 1992, 13 new monitoring wells were installed in the UCRS under the UST program. The site investigation focused on the two USTs at the C-750 garage and three additional USTs in the general vicinity. In addition to the 13 monitoring wells, 4 background and 9 investigative soil borings were taken at various depths to assess the extent of the contamination from the known leaking tanks and to monitor for releases from 3 other tanks in the area. The locations of the UST monitoring wells are shown in Fig. 5.11.

Results of the site investigation indicate that groundwater contamination from leaking USTs is limited to the UCRS, which is not considered to be an aquifer and is not a source of drinking water in the PGDP area. A more detailed description of the results of the site investigation can be found in the final draft of the Site Investigation Report, which was submitted to the Commonwealth of Kentucky in September 1992.

5.5.1.3 CERCLA/ACO Monitoring

5.5.1.3.1 Off-Site Well Monitoring

With the discovery of contamination in the groundwater north of the plant in August 1988, DOE and the EPA entered into an ACO under CERCLA Sects. 104 and 106 to determine the nature and extent of off-site contamination. The EPA ACO, Docket No. 88-35-c, Part V, Sect. J, 2 and 3, requires monthly sampling of potentially affected wells and plant well MW66 for TCE, ⁹⁹Tc, and gross alpha and beta activity. Any levels exceeding the national interim primary drinking water standards for alpha activity (>15 pCi/L) and beta activity (>50 pCi/L) must be analyzed further to determine the cause. Extensive groundwater monitoring of residential and plant wells

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Fig. 5.11. UST investigation monitoring well locations (from CDM Federal Programs Corporation 1992).

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was initiated in 1988. More than 400 plant and off-site wells were sampled and analyzed for TCE and ^{99}Tc .

Based on the results of this initial sampling, PGDP established a sampling program that exceeds the EPA ACO requirements. This program includes

- monthly sampling for the wells already showing contamination,
- weekly sampling of wells with the highest potential for contamination,
- bimonthly sampling of wells with little chance of contamination,
- quarterly sampling of Tennessee Valley Authority (TVA) monitoring wells, and
- monthly sampling of uncontaminated residential wells because of their proximity to TVA monitoring wells showing contamination.

Table 5.3 lists the wells included within each category.

Ongoing sampling of residential wells performs two functions: detecting the spread of contamination to other wells and gaining additional information about those wells already contaminated. Each sample is analyzed for TCE and ^{99}Tc . Residents are notified of the result of each sample. The residences' well water is also sampled regularly for gross alpha and beta activity. Steps are taken to supply alternate water supplies if the action levels are exceeded. An off-site drinking water well is considered contaminated if any sample has levels above the DOE-PGDP action limits of 25 pCi/L for ^{99}Tc and 1 $\mu\text{g/L}$ for TCE. Residential wells sampled weekly and monthly are shown in Fig. 5.12. TVA monitoring wells sampled quarterly are shown in Fig. 5.13. Figure 5.14 shows the location of any residential or TVA well having TCE or ^{99}Tc contamination.

Table 5.3. Wells included in the CERCLA/ACO^a well monitoring program

Monthly (contaminated)	Weekly	Bimonthly	Annual and semiannual	Monthly (uncontaminated)
R2b	R10	R8	R90	R6
R4	R12	R9	R165	R21
R5	R13	R20	R156	R43
R17	R14	R22	R161	R72
R18	R19	R23	R162	R82
R113	R39	R24	R163	R83
W38 ^c	R40	R25	R165	R84
W41	R54	R26	R167	R302
W43	R294	R28	R170	
W44		R41	R173	
W66		R42	R174	
		R53	R183	
		R69	R381	
		R79		
		R88		
		R89		
		R112		
		R278		
		R293		
		R368		
		R386		

^aComprehensive Environmental Response, Compensation, and Liability Act/Administrative Consent Order.

^bR = residential wells or Tennessee Valley Authority monitoring wells.

^cW = PGDP monitoring wells.

Fig. 5.12. Wells sampled weekly and monthly.

Fig. 5.13. TVA wells sampled quarterly.

Fig. 5.14. Residential and TVA groundwater sampling locations where ⁹⁹Tc and/or TCE were detected.

Data generated by this sampling program (Tables 5.3 through 5.5 in Part 2) are used primarily to protect the health of affected residents by giving advance warning of increases in levels of contamination so that appropriate actions can be taken. These data, in combination with data from plant monitoring wells, are also used by plant personnel and consultants as qualitative indicators of the nature and extent of off-site groundwater contamination.

5.5.1.3.2 Site Investigation for Groundwater Contamination

In addition to extensive groundwater sampling, the ACO also required a site investigation to determine the nature and extent of off-site contamination and to assess remedial alternatives for possible on-site sources of contamination. DOE and Martin Marietta Energy Systems, Inc. (Energy Systems), contracted with CH2M Hill to develop and implement a work plan for the site investigation that would determine the nature and extent of off-site contamination in order to protect human health and the environment. Phase II of the two-part investigation was completed in 1991. A complete discussion of the site investigation and findings can be found in the final Phase II Report issued in April 1992 (CH2M Hill 1992).

The major findings of the CH2M Hill site investigation include the following:

- The contaminants in the on-site shallow groundwater system (UCRS) are primarily ^{99}Tc and TCE, with frequently detectable ^{234}U and ^{238}U , and occasionally detectable toluene. High concentrations of TCE may indicate the presence of dense nonaqueous phase liquids at two on-site locations.
- Contaminants were detected in the off-site shallow groundwater system (these results were not confirmed in split samples). TCE was detected in the immediate vicinity of the northwest corner of the plant. Low levels of TCE and ^{99}Tc were detected near the landfill north of the plant.
- The primary contaminants in the regional gravel aquifer off site are TCE and ^{99}Tc . The groundwater contamination is migrating toward the Ohio River.

- Both ^{234}U and ^{238}U were detected in several wells in the deep groundwater system at the detection limit during Phase I. Phase II sampling showed these parameters to be near reference background values. Additionally, no uranium was detected in the RGA or UCRS of these same well clusters.
- Potential sources of TCE and ^{99}Tc contamination were found on site.
- Of the 21 waste management units found to be contributing to off-site contamination, 9 were identified as contributing only to groundwater contamination, 9 were identified as contributing only to surface water contamination, and 3 were found to be contributing to groundwater, surface water, and sediment contamination.

5.5.1.3.3 Agreement in Principle Activities—Off-Site Residential Groundwater Sampling

A quarterly sampling event takes place in which the state of Kentucky Cabinet for Human Resources (CHR) travels to the PGDP area and obtains samples from residential wells. The state of Kentucky wanted to have independent verification that public health was protected, which is achieved by meeting the 15 pCi/L alpha and 50 pCi/L beta primary drinking water limits listed in the ACO or, if these are exceeded, identifying the specific radionuclide so health concerns may be evaluated. The purpose of having corroborative sampling between the PGDP and state CHR is to provide quality assurance on the activity for the state and PGDP by showing that sampling and analytical techniques provide data leading to equivalent decisions.

The only situations investigated are those in which either the state CHR or PGDP, but not both, show exceedances of alpha and beta limits after correction for specific radionuclide contribution. Minor variations in comparative data are discussed in this report, either explaining the cause(s) of the differences or pointing out those differences if the cause is unknown. Detailed results from the corroborative sampling along with data comparisons of state and PGDP maximum and minimum reported results are shown in Part 2, Table 5.11.

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An investigation would occur if any of the following criteria are met:

- The gross alpha minus the contribution of alpha from quantified radionuclides (uranium is most likely at PGDP) is greater than 15 pCi/L and is not corroborated by the other source's result.
- The gross beta minus the contribution of beta from quantified radionuclides (technetium is most likely at PGDP) is greater than 50 pCi/L and is not corroborated by the other source's result.
- The ^{99}Tc value reported is greater than 25 pCi/L by one but not the other; 25 pCi/L is the level at which PGDP provides water to area residents.
- The ^{99}Tc value reported is greater than 900 pCi/L by one but not the other; 900 pCi/L is the level above which drinking water limits are exceeded.

In 1992, one comparative result exceeded the preceding criteria; therefore, an investigation was initiated. Sample location R2 showed significant alpha differences and in two instances exceeded the 15 pCi/L limit although PGDP data were consistently below this level. The difference was attributed to a phenomenon known as crosstalk between the alpha and beta measurements. When simultaneous counting occurs in the detector, approximately 2% of the signal from either the alpha or beta is registered in the other area. This crosstalk is not constant and varies with changes in the mixture of the carrier gas. To correct for this, a known source or standard must be run along with the samples being quantified. When alpha and beta levels are approximately equal, the effect cancels out. In instances such as R2 where there is little alpha and elevated beta because of the ^{99}Tc present, corrections must be made. These results were discussed with the state CHR. The CHR confirmed that they do not make crosstalk corrections, attributed the difference to this phenomenon, and agreed that the 15 pCi/L limits had not been exceeded. Additionally, no questions have arisen from the state about the equivalency of these data used to verify PGDP's monitoring of off-site residential health effects.

5.5.1.4 State Solid Waste Disposal Regulations

Compliance monitoring requirements exist for facilities C-746-S (new sanitary landfill) and C-746-T (inert landfill), permitted by the KDWM. Sample frequency and analytes are dictated by the specific permit for each facility. Wells 16 through 19, 38 through 44, and 220 through 225 serve as monitoring stations for these facilities (see Fig. 5.10). These wells are sampled quarterly for the constituents in Table 5.4 and annually for the additional constituents in Table 5.5. Groundwater is analyzed for chloride during the first and third quarters of each year.

The C-746-T landfill was closed on June 29, 1992. However, closure has not yet been certified. The Environmental Restoration Division will assume responsibility for postclosure compliance monitoring once it is certified closed in accordance with the state permit requirements.

In the summer of 1992, six monitoring wells were installed in the RGA to provide active and postclosure monitoring for the C-746 landfill. These monitoring wells (MW220 through MW225) are intended to provide the quarterly sampling required for the permitting of a new landfill site (Cell 3 of the C-746-S landfill), scheduled to begin receiving waste in July 1993. They will also provide for postclosure groundwater monitoring for Cell 2, a closed cell at the C-746-S landfill.

5.5.1.5 RCRA 3004 (u/v)

Additional groundwater monitoring to be performed at PGDP relates to RCRA 3004 (u/v) and CERCLA requirements for characterizing contamination from all nonregulated sources [i.e., solid waste management units (SWMUs) not regulated under a RCRA permit or in interim status] at a facility that has had releases that may contaminate groundwater. Results of this monitoring will be used to determine and implement remedial actions as necessary to protect human health and the environment. Prescriptive regulations, such as those governing RCRA interim status and regulated units,

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Table 5.4. Quarterly analytical parameters for groundwater monitoring at PGDP

Parameters	Methods
Chromium	W-100
Copper	SC-ENV-4
Dissolved alpha	R-4
Dissolved beta	R-4
Fluoride	SA-F-5
Iron	SC-ENV-4
Lead	SC-ICAP-1
Nickel	SC-ICAP-1
Nitrate	W-50
Organic carbon, total	W-150
Organic halogens, total	SC-TOX-1 or SC-TOX-2
pH	Meter
Polychlorinated biphenyl	AL-OP-1
Sulfate	W-50
Suspended alpha	R-4
Suspended beta	R-4
Technetium-99	R-46
Temperature	Meter
Trichloroethylene	AL-OP-3 or AL-OP-4
Uranium	SA-U-8
Water color	SA-CLR-1
Water conductivity	SA-COND-1
Water depth	
Water turbidity	W-170
Zinc	SC-ICAP-1

Table 5.5. Annual analytical parameters for groundwater monitoring at PGDP

Parameters	Methods
Americium-241	R-52
Cadmium	SC-ENV-4
Calcium	SC-ENV-4
Chloride	W-50
Chromium, hexavalent	W-100
Cobalt-60	R-52
Dissolved solids	W-140
Magnesium	SC-ICAP-1
Manganese	SC-ICAP-1
Phosphate	W-50
Selenium	SC-ENV-1
Sodium	SC-ICAP-1
Water alkalinity	W-12

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do not exist for remedial action groundwater monitoring at this time.

Currently, over 180 SWMUs and areas of concern (AOCs) have been identified at PGDP. The SWMUs/AOCs have been categorized into two groups: SWMUs suspected of contributing to off-site contamination and SWMUs not suspected of contributing to off-site contamination. As part of the Phase II Site Investigation, 21 SWMUs were identified as sources of primary contaminants that are contributing to off-site contamination. These SWMUs were evaluated in a draft Public Health and Ecological Assessment that was completed in December 1991. A range of potential remedial alternatives that may be used to address the contamination at each of the 21 SWMUs was presented in a draft Alternatives Evaluation Report (SAIC 1991), which will be used to support the feasibility studies for these units.

SWMUs not suspected of contributing to off-site contamination have been grouped into RCRA waste area groups and are scheduled for RCRA facility investigation (RFI) work plan development pursuant to the Hazardous Solid Waste Amendments (HSWA) Corrective Action Program. Development of RFI work plans for the first three scheduled RFIs was initiated during 1992. The remaining SWMUs either are operative RCRA-regulated units that will be addressed according to RCRA regulations during closure or require no further action because contaminant concentrations are below RFI action levels. To date, no groundwater monitoring has been initiated at SWMUs pursuant to RCRA 3004 (u/v) and CERCLA requirements.

In 1992, a Site Management Plan (SMP) for the Environmental Restoration Program at PGDP was developed in preparation for the Federal Facilities Agreement. The SMP has been developed to serve as the primary strategy document for remediation activities at PGDP. The SMP will drive all schedules once the Federal Facilities Agreement is in place. The plan establishes remedial action priorities for the SWMUs/AOCs and also establishes schedules for the various regulatory documents to be generated during the remedial action process at PGDP. Those SWMUs suspected of presenting the greatest risk to public health or the environment are to be investigated first.

5.5.1.6 SWMU Monitoring

Groundwater monitoring is conducted at several SWMUs at PGDP. A total of 49 wells monitor SWMUs, including wells located at the active C-746-S and C-746-T landfills (Table 5.6). Well installation began at selected units in 1979 and continued through the mid-1980s. This monitoring effort was initially based in part on DOE orders that required monitoring at low-level radioactive waste sites.

SWMU monitoring wells are monitored quarterly for the constituents listed in Table 5.4 and annually for the additional constituents listed in Table 5.5, with the exception of wells 23 through 27 at the inactive C-746-K sanitary landfill. Wells 23 through 27 are sampled annually for the constituents listed in Table 5.5. As indicated earlier, many of these units are targeted for investigation under the HSWA permit. As characterization continues during these projects, monitoring at these facilities will be changed accordingly.

On January 30, 1992, leachate seeps were observed by PGDP personnel in a ditch on the southwest side of the C-746-K landfill, an inactive capped sanitary landfill. Sampling identified metals and volatile organics (TCE and its degradation by-products) in the leachate. Immediately upon discovering the seep, PGDP personnel installed a sandbag dam to prevent any further release of solids to an unnamed tributary of Big Bayou Creek. A new seep site located on the bank of the unnamed tributary was sampled on February 16, 1992. Results indicated a pH of 2.3 for the leachate. On the recommendation of the Kentucky Division of Water and the Kentucky Department for Environmental Protection, further actions were taken to contain the leachate-contaminated water, including the installation of a solid precipitate filter in the ditch. PGDP committed to submit an Interim Measures Work Plan to KDWM and the EPA in accordance with guidance from the HSWA permit. The landfill investigation was moved up in priority and will be conducted by the Environmental Restoration Division under the HSWA permit in the first scheduled RFI. Interim corrective measures taken while the RFI work plan awaits approval included repair of the landfill

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Table 5.6. Summary of solid waste management unit monitoring at PGDP

Unit	Description	Monitoring wells/ interval monitored
SWMU 2: C-749 uranium scrap burial ground	Used from the late 1950s to the mid-1970s for the disposal of uranium scrap, some of which was pyrophoric (i.e., easily ignitable in air). To stabilize the uranium, it was submerged in waste oil.	MW48/RGA ^a MW49/UCRS ^b MW50/RGA MW51/RGA MW57/UCRS MW67/RGA
SWMU 3: C-404 low-level radioactive waste burial ground	Used as a low-level waste burial ground until 1986. The waste was discovered to be hazardous in 1986. The unit was certified closed in 1987 as a hazardous waste landfill. A postclosure permit application, first submitted in 1989, was resubmitted in 1992.	MW46/RGA MW47/UCRS MW84/RGA ^c MW85/UCRS ^c MW86/RGA ^c MW87/RGA ^c MW88/UCRS ^c MW89/RGA ^c MW90/RGA ^c MW91/UCRS ^c MW92/RGA ^c MW93/RGA ^c MW94/UCRS ^c MW95/RGA ^c
SWMU 5: C-746-F classified burial yard	Used for the disposal of cascade equipment, paper, and electronic media (such as computer disks) that are classified or may reveal classified information.	MW52/RGA MW53/RGA MW54/RGA
SWMU 7: C-747-A burial ground	Used for the disposal of all types of waste material from plant operations.	MW22/RGA MW63/RGA MW64/UCRS MW65/RGA MW66/RGA
SWMU 8: C-746-K inactive sanitary landfill	Used for the disposal of fly ash from 1951 to 1982. Sanitary trash was also placed in this landfill until 1982. A 15.24-cm (6-in.) cap was placed on this landfill in 1982. Additional cap material was added in 1992 to repair grade.	MW23/PCC ^d MW24/PCC MW26/PCC MW27/PCC
SWMU 9: C-746-S new sanitary landfill	Used for the disposal of nonhazardous putrescible wastes such as paper, cardboard, and cafeteria wastes. C-746-S is permitted by the Kentucky Division for Waste Management.	MW16/UCRS MW17/RGA MW18/UCRS MW19/RGA MW38/RGA MW39/RGA MW40/RGA MW41/RGA MW42/RGA MW220/RGA MW221/RGA MW222/RGA MW223/RGA MW224/RGA MW225/RGA

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Table 5.6 (continued)

Unit	Description	Monitoring wells/ interval monitored
SWMU 12: C-747-A inactive burial area, uranium tetrafluoride (UF ₄) drum yard	Consists of a large waste pile of crushed UF ₄ drums.	MW22/RGA
SWMU 13: C-746-P scrap metal yard	Used to accumulate uncontaminated scrap metal for sale to reclaimers.	MW22/RGA MW63/RGA MW64/UCRS MW65/RGA MW66/RGA
SWMU 14: C-746-E contaminated scrap yard	Contains contaminated scrap metal generated during plant operations. Scrap material is separated by metal type. Most contamination is from depleted, natural, or slightly enriched uranium on the metal surfaces.	MW22/RGA
SWMU 15: C-746-C scrap yard	Contains scrap metal of all types. The contamination is mostly from depleted, natural, or slightly enriched uranium.	MW22/RGA
SWMU 17: C-616-E sludge lagoon	On-grade surface impoundment that receives sludge from the C-616 chromium reduction facility.	MW21/RGA
SWMU 18: C-616-F full-flow lagoon	On-grade surface impoundment that receives overflow from the C-616-E sludge lagoon and liquid effluent from the clarifiers at the C-616 chromate reduction facility. In addition, effluents from the C-400 cleaning and decontamination building and coal-pile runoff are piped to this impoundment.	MW22/RGA
SWMU 30: C-747-A burn area	Used for burning combustible wastes until approximately 1970. This unit is located in the vicinity of the C-747-A burial ground.	MW63/RGA MW64/UCRS MW65/RGA MW66/RGA

^aRegional gravel aquifer.

^bUpper Continental Recharge System.

^cResource Conservation and Recovery Act (RCRA) quality monitoring wells.

^dPorters Creek clay.

cap. Additional cap material was added during September and October 1992. Continued sampling of groundwater and surface water in the C-746-K area will determine if additional corrective actions should be taken in 1993 to address the seepage problem.

5.5.2 Environmental Surveillance Monitoring

Implementation of groundwater surveillance monitoring (as prescribed by DOE Order 5400.1 and

as previously defined) was initially scheduled to begin in 1991. The Groundwater Surveillance Plan describes in detail an expanded analytical program for 12 monitoring wells—4 existing wells and 8 proposed wells—for exit-pathway monitoring along the northern boundary of the DOE reservation. Environmental surveillance monitoring activities have been delayed until 1993. Environmental surveillance monitoring will be a continuation of some of the sampling activities that concluded with the completion of the ACO-driven site investigation.

The Groundwater Investigation Phase III, completed in 1992, included installation of monitoring wells to provide interim perimeter monitoring until the proposed environmental surveillance monitoring activities can be funded.

5.5.3 Groundwater Monitoring Results

Upon discovery of contamination in the groundwater north of PGDP in August 1988, DOE and the EPA entered into an ACO under CERCLA Sects. 104 and 106. The intent of the ACO was to determine the nature and extent of off-site contamination near PGDP. Subsequent investigations, including the Phase I and Phase II ACO Site Investigations by CH2M Hill (1990 and 1992) and the Phase III Groundwater Monitoring Study conducted by the Environmental Restoration Department's Hydrogeological Services Section (HSS) (1992), have led to the identification of several on-site and three off-site TCE and ^{99}Tc plumes of groundwater contamination. A brief discussion of the three off-site plumes in the RGA follows. A more detailed discussion of the plumes can be found in the Groundwater Investigation Phase III Report (Clausen et al. 1992b).

The Northwest Plume emanates from the northwest corner of PGDP and extends toward the Ohio River for approximately 3 miles, underlying an area of about 1.6 miles². Contamination within the Northwest Plume consists principally of TCE and ^{99}Tc , the apparent source of which is the C-747-A burial ground area. Contaminant levels range up to 6200 $\mu\text{g/L}$ TCE and 3670 pCi/L ^{99}Tc near the source of the plume. Analyses of TCE and ^{99}Tc levels over time in MW66 at PGDP indicate that wide fluctuations in concentration have occurred since 1988 (Figs. 5.15 and 5.16). However, the TCE concentration and ^{99}Tc activity show a general decreasing trend through mid-1992. The ratio of TCE concentration to ^{99}Tc activity appears to remain relatively constant (Fig. 5.17).

Another off-site plume, the Northeast TCE Plume, consists only of TCE contamination and extends off-site to the northeast of the plant. The boundaries of the Northeast Plume are not well defined, but the plume appears to underlie an area of approximately 1.2 miles². The plume trends oblique to the inferred groundwater flow path. At present, the difference in contaminant migration direction and the

apparent groundwater flow direction has not been resolved. Future investigations will address the cause of this apparent contradiction. The Northeast TCE Plume is believed to have multiple sources. Possible sources include the C-400 cleaning building, the C-745 Kellogg storage building, and the C-333 process building area. Undiscovered source areas of TCE could also be responsible for the plume.

An off-site ^{99}Tc plume has been identified in the area directly east of the Northwest Plume. RGA monitoring wells located east of the Northwest Plume (MW200 and MW98) have detectable levels of ^{99}Tc but not detectable TCE. The plume ranges in width from approximately 800 ft near the plant boundary to approximately 1600 ft at the Shawnee Steam Plant. Three possible sources have been postulated for the off-site ^{99}Tc plume: the C-616-F lagoon, a source near the northwest corner of the plant such as the C-746-E contaminated scrap yard, or a source farther to the south such as the C-749 or C-404 burial grounds.

A summary of the results of groundwater monitoring at SWMUs is presented in the following paragraphs. Table 5.7 lists the parameters analyzed, the recommended regulatory limits, and the wells that exceeded the reference limit at least once during 1992.

Groundwater at the C-746-K inactive sanitary landfill is monitored by four monitoring wells—MW23, MW24, MW26, and MW27 (see Fig. 5.5). All four wells had total zinc concentrations above the reference value (Table 5.7 in Part 2). This is believed to be the result of corrosion of the galvanized steel casing material. Total iron, total manganese, and fluoride were other analytes that commonly exceeded reference levels. A monitoring well installed for the Phase II Site Investigation, MW184, is also in the C-746-K area. MW184 had total manganese and total iron concentrations above reference levels.

Groundwater in the C-746-S and C-746-T areas is monitored by wells MW16 through MW19, MW38 through MW44, and MW220 through MW225 (see Fig. 5.6). TCE was detected above the reference level from the RGA wells MW41 and MW44 (Table 5.6 in Part 2). None of the wells monitored had ^{99}Tc activities above reference levels. Total iron was above the reference level in all wells except MW40

Fig. 5.15. Concentration of TCE from July 1988 to December 1992 in MW66.

Fig. 5.16. Concentration of ⁹⁹Tc from July 1988 to December 1992 in MW66.

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Fig. 5.17. Concentration of TCE and ⁹⁹Tc from July 1988 to December 1992 in MW66.

and MW43. Copper was found above the reference level in MW17.

Wells MW21 and MW22 are located near the C-616 lagoons and monitor the RGA. TCE levels in MW22 exceeded the reference level. MW21 had no detectable TCE. Neither well had ⁹⁹Tc above the reference level. MW21 and MW22 (see Fig. 5.5) had total iron levels above reference level. Sulfate concentrations in MW21 continued to remain above the reference level.

Monitoring wells MW63 through MW66 (see Fig. 5.9) are associated with the C-746-P scrap metal yards. TCE and ⁹⁹Tc were above the reference levels in RGA MW66.

Groundwater at the C-746-F burial area is monitored by RGA MW52 through MW54 (see Fig. 5.9). Total iron and total manganese were the only constituents detected above reference levels (Tables 5.7 and 5.9 in Part 2). MW52 and MW54 had detectable activities of ⁹⁹Tc, but the activity was below reference levels.

MW47, MW52, MW68, MW69, MW71, and MW96 (see Figs. 5.9 and 5.10) were monitored for petroleum products and other constituents during

1992 (Table 5.2 in Part 2). Only ethyl benzene was detected above reference levels (in MW96). A plot of total benzene, toluene, ethyl benzene, and xylene concentration in MW96 for the period August 1989 to July 1992 indicates a gradual downward trend (Fig. 5.18). TCE was present above reference levels in MW47, MW68, and MW71. Detectable levels of ⁹⁹Tc were found in MW68 and MW71.

MW84 through MW95 (see Fig. 5.10) are RCRA quality wells that monitor groundwater at the C-404 low-level radioactive waste burial ground. (Sampling results for these wells can be found in Table 5.1 in Part 2.) MW85, MW88, MW91, and MW94 monitor the UCRS. During 1992, TCE and ⁹⁹Tc levels were above the reference levels for MW88 and MW94. Monitoring well MW91 had TCE concentrations above the reference level and detectable levels of ⁹⁹Tc. Monitoring well MW85 had detectable levels of ⁹⁹Tc but no detectable TCE. MW84, MW86, MW87, MW89, MW90, MW92, MW93, and MW95 monitor the RGA. MW95 had TCE concentrations above reference level and elevated ⁹⁹Tc concentrations. MW84 had detectable ⁹⁹Tc concentrations (below the

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Table 5.7. Effluent monitoring at PGDP^a

Parameter	Applicable value	Reference	Wells exceeding reference value at least once during 1992
Arsenic, total	0.05 mg/L	1	None
Benzene	5 µg/L	1	None
Cadmium, total	0.005 mg/L	1	MW26
Chromium, total	0.1 mg/L	1	MW47, MW71
Copper, total	1.0 mg/L	2	MW17, MW47
Iron, total	0.30 mg/L	2	MW16–24, MW26, MW27, MW29, MW38, MW39, MW41, MW42, MW46–48, MW50–54, MW57, MW62–64, MW66, MW69, MW71, MW154, MW184, MW220–225
Manganese, total	0.05 mg/L	2	MW24, MW27, MW29, MW38–40, MW48, MW50–54, MW57, MW62, MW64, MW184
Nickel, total	None	<i>b</i>	<i>b</i>
Lead, total	0.05 mg/L	1	MW26, MW47
Zinc, total	5.0 mg/L	2	MW23, MW24, MW26, MW27
Arsenic, dissolved	None	<i>b</i>	<i>b</i>
Cadmium, dissolved	None	<i>b</i>	<i>b</i>
Lead, dissolved	None	<i>b</i>	<i>b</i>
Selenium dissolved	None	<i>b</i>	<i>b</i>
Chromium, hexavalent	None	<i>b</i>	<i>b</i>
Calcium	None	<i>b</i>	<i>b</i>
Magnesium	None	<i>b</i>	<i>b</i>
Sodium	None	<i>b</i>	<i>b</i>
pH	6.5–8.5 SU ^c	2	MW27, MW29 MW41–44, MW46–48, MW50–54, MW59–61, MW63, MW65–71, MW84–95, MW154, MW184, MW220–225
Temperature	None	<i>b</i>	<i>b</i>
Water turbidity	5 NTU ^d	1	MW16–20, MW23, MW24, MW26, MW27, MW39, MW41, MW46, MW50–52, MW54, MW57, MW62–64, MW66, MW68, MW69, MW154, MW184
Water color	15 units	2	MW18, MW19, MW21, MW23, MW24, MW26, MW27, MW39, MW46, MW47, MW50–52, MW54, MW64, MW69
Water conductivity	None	<i>b</i>	<i>b</i>
Water alkalinity (CaCO ₃)	None	<i>b</i>	<i>b</i>
Dissolved solids, total	500 mg/L	2	MW47, MW159
Chloride	250 mg/L	2	None
Fluoride	4.0 mg/L	1	MW26
Nitrate as nitrogen	10 mg/L	1	None
Phosphate as phosphorus	None	<i>b</i>	<i>b</i>
Sulfate	250 mg/L	2	MW21, MW47
Organic carbon, total	None	<i>b</i>	<i>b</i>
Organic halide, total	None	<i>b</i>	<i>b</i>
Trichloroethylene	5 µg/L	4	MW20, MW22, MW41, MW44, MW47, MW66, MW68, MW71, MW88, MW91, MW94, MW95, MW108, MW109, MW114, MW117, MW154, R2, R113

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Table 5.7 (continued)

Parameter	Applicable value	Reference	Wells exceeding reference value at least once during 1992
Polychlorinated biphenyl	None	<i>b</i>	<i>b</i>
Ethyl benzene	700 µg/L	1	MW96
Toluene	2,000 µg/L	1	None
Xylene	10,000 µg/L	1	None
Americium-241	1 pCi/L	3	None
Cobalt-60	200 pCi/L	3	None
Radon-222	300 pCi/L	3	R10, R12, R13, R14, R19, R29, R39, R40, R54, R93, R111, R139, R294, R297, R416, R417, R424
Technetium-99	4,000 pCi/L	3	None
Dissolved alpha	None	<i>b</i>	<i>b</i>
Suspended alpha	None	<i>b</i>	<i>b</i>
Dissolved beta	None	<i>b</i>	<i>b</i>
Suspended beta	None	<i>b</i>	<i>b</i>
Gross beta	50 pCi/L	1	MW66, R2, R17, R113

^aReferences:

1. 40 CFR 141. Safe Drinking Water Act—National Primary Drinking Water Regulations, as amended.
2. 40 CFR 143. Safe Drinking Water Act—National Secondary Drinking Water Regulations, as amended.
3. Four percent of Derived Concentration Guides (DCGs) for Air and Water, DOE Order 5400.5 (4 mrem/year).
4. U.S. Environmental Protection Agency, National Primary Drinking Water Regulations; Synthetic Organic Chemicals, *Fed. Regist.* 54(97) (May 22, 1989).

^bNot analyzed.

^cStandard units.

^dNephelometric turbidity units.

Fig. 5.18. Concentration of benzene, toluene, ethyl benzene, and xylene from August 1989 to November 1992 in MW96.

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drinking water standard of 900 pCi/L) but no detectable TCE.

One other monitoring well in the C-404 and C-749 areas, MW47, continued to have elevated TCE and ^{99}Tc levels (Table 5.6 in Part 2). Total chromium, total copper, total dissolved solids, total iron, and total lead levels also were above reference levels in MW47. MW46, MW48, MW50, MW51, and MW57 showed total iron and total manganese concentrations above reference levels (Tables 5.7 and 5.9 in Part 2).

5.6 Project Accomplishments

Work continues under the auspices of the Groundwater Protection Plan to address recognized deficiencies in the understanding of the site hydrogeology and geology (Early et al. 1989). Activities consist of specific projects performed and directed by the HSS and the coordination of related activities conducted by other organizations. These activities are designed to complement existing compliance and restoration initiatives. Information obtained from related activities is assimilated and analyzed to address global deficiencies identified in the Groundwater Monitoring Plan.

The next two subsections describe special projects conducted by the HSS during 1992 and related projects that have assisted in further characterization of the site.

5.6.1 Hydrogeologic Services Section (HSS)

The HSS has three main responsibilities: to oversee and maintain the PGDP Groundwater Protection Program, to provide technical oversight and input on Environmental Restoration projects, and to provide technical services as requested to line organizations within the plant. The first responsibility includes implementation of the Groundwater Management Plan, which identifies deficiencies in the understanding of the site groundwater flow system and prescribes activities to address these deficiencies. Toward this end, several activities designed to complement ongoing compliance and environmental restoration activities were conducted and/or completed during 1992.

5.6.2 Phase III Groundwater Monitoring Project

The primary objectives of the Phase III Groundwater Monitoring Project are to complement previous monitoring efforts and site investigations by addressing basic deficiencies in the current understanding of site geology and hydrogeology and to provide interim perimeter monitoring for the DOE reservation. Phase III Groundwater Monitoring field activities were conducted from fall 1991 through spring 1992. A final report detailing the activities and findings of the project was issued on November 25, 1992.

The Phase III Project supports development of the site conceptual model of groundwater flow and contaminant migration by providing field data that fill many of the significant data gaps remaining after completion of previous site-initiated studies. The project was designed to address the following data gaps:

- the potentiometric surface in areas of uncertainty;
- quantification of various hydraulic parameters of the RGA, particularly in an area of suspected high hydraulic conductivity located in the vicinity of the C-333 building; and
- the continuity of the shallowest aquifer over the buried terrace located near the southern boundary of PGDP.

The following field activities were performed as part of the Phase III Groundwater Investigation:

- Installation of groundwater surveillance monitoring wells in the RGA to provide interim perimeter monitoring for the DOE reservation.
- Installation of piezometers and monitoring wells in the RGA to provide potentiometric data where few or no data currently exist. Groundwater samples from the monitoring wells were analyzed for TCE and ^{99}Tc to assist in plume mapping and to aid in identifying sources of contamination.
- Installation of a background monitoring well cluster, with individual monitoring wells completed in the UCRS, the RGA, and the McNairy Formation. This cluster was located between PGDP and the old Kentucky Ordnance Works, near the base of the buried terrace slope.

- Installation of soil borings to provide detailed lithologic information (six soil borings were located approximately perpendicular to the buried terrace slope to assist in characterizing the feature).
- Installation of piezometers, pressure transducers, and a high-capacity pumping well for conducting an aquifer pump test in the RGA.

A number of conclusions regarding site geology and hydrogeology were reached as a result of information obtained during the Phase III Groundwater Monitoring Project. A few of the more important conclusions include the following:

- Interpretation of Phase III soil-boring data has provided additional support for the view that a buried river terrace exists near the southern boundary of the plant. The soil-boring logs have further characterized the location and slope of the terrace and have provided additional evidence of the discontinuity of the shallow sediments across the terrace slope. The RGA is either truncated or grades laterally into the Pliocene terrace gravels, resulting in restricted flow across the terrace, as evidenced by the steep hydraulic gradient observed there.
- Monitoring wells located downgradient and in areas peripheral to PGDP have provided contaminant measurements useful in defining the limits of groundwater contamination at PGDP. Recent data from on-site and off-site groundwater monitoring wells, including the Phase III wells, suggest that there are between five and nine distinct contaminant plumes resulting from PGDP activities. Three of these plumes extend off site. Hydraulic head measurements made during this project have provided additional information useful for further characterizing groundwater flow. These head measurements also have confirmed that the water table is very low under portions of the mid-plant area.
- Deep soil borings installed for the Phase III Project provided additional lithologic and hydrogeologic data concerning the McNairy Formation. The Phase III borings encountered very fine- to medium-grained, well-sorted sand with thin clay layers in the McNairy Formation. Further characterization of the McNairy, particularly the upper portion of the formation, is

considered a critical data need and will be addressed in a future investigation (the Phase IV Groundwater Investigation).

Additional conclusions based on the results of the Phase III aquifer testing are discussed in Subsect. 5.6.1.2.

In addition to summarizing the findings of the project, the Groundwater Investigation Phase III Report provides an overview of the hydrogeologic, geologic, and geochemical data obtained in past investigations. The report also presents the current conceptual model for groundwater flow and contaminant migration at PGDP.

5.6.3 Aquifer Testing

Aquifer testing was performed in 1992 as an integral part of the Phase III Groundwater Monitoring Project. Terran Corporation was contracted by Energy Systems to design and conduct the aquifer testing program west of the C-333 building. The field work was performed during March and April 1992, and a final report presenting the results of the testing was issued in June 1992.

The primary objective of the testing was to determine the hydraulic properties of the RGA in the area west of building C-333 at PGDP. These properties include the transmissivity and storativity of the RGA, leakage of the overlying confining unit into the RGA, the boundary effects of the buried terrace south of the C-333 area, and the anisotropic transmissivity tensor components of the RGA at the test site. Water levels were measured with seven 2-in.-diam piezometers and three buried pressure transducers located in the area surrounding the pumped well. A complete description of the testing program and an analysis of the data can be found in the final report. The major findings of the aquifer testing program were:

- Leakage through the clay aquitard above the RGA was calculated and found to be substantial under pumping conditions. This suggests that either the aquitard is relatively permeable or that high permeability “windows” exist in the aquitard in portions of the test area. Because the aquitard is acting more as a semiconfining unit than as a confining unit,

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the overlying UCRS can contribute flow to the RGA, particularly under pumping conditions.

- TCE concentrations in the 2000 µg/L range were encountered at the pumped well during the pump test. This may indicate an undiscovered source area of TCE existing either south or east of the C-333 building.
- The range of RGA hydraulic conductivity values (1000 to 1200 ft/d) is higher than previous field tests have encountered. The hydraulic conductivity values derived from the C-333 pumping test indicate that highly permeable zones exist within the RGA in the C-333 test area.

5.6.4 Groundwater Monitoring Phase IV

Preliminary work on the conceptual design of the Groundwater Monitoring Phase IV Project was begun in 1992. Phase IV will be designed specifically to address uncertainties concerning the hydraulic properties of the McNairy Formation and will consist of installing additional monitoring wells and piezometers. The project also may involve the abandonment of selected monitoring wells that have been determined to have questionable construction. The use of geophysical well logging in these monitoring wells prior to plugging and abandoning them is being explored as a potential method of improving lithologic and hydrogeologic characterization of the subsurface at each well site.

5.6.5 Sampling and Analysis Plan

A groundwater sampling and analysis plan for PGDP was written in 1992 and received final approval in early 1993. The plan specifies (1) which wells will be sampled, (2) frequency of sample collection, and (3) parameters in groundwater to be analyzed for from each sample event. Procedures for formal request and documentation of changes to sampling schedules are included in the plan.

5.6.6 HSS Special Studies

During 1992, HSS hydrogeologists have continued their efforts to remain up to date on research that may be applicable to PGDP site characterization and remediation selection activities. To this end, they have developed working relationships with several experts in groundwater

flow, contaminant transport and fate, and innovative remedial technologies. Researchers at the University of Waterloo have provided valuable information concerning their ongoing research into hydraulic containment reactive curtain technologies. Work will continue on evaluating the applicability of these technologies to the groundwater contamination problem at PGDP.

Among the other activities completed or initiated by the HSS during 1992 was a borehole flowmeter study. TVA was retained by Energy Systems to perform electromagnetic borehole flowmeter testing in the RGA. The flowmeter testing was performed at PGDP in August 1992, and a final report presenting the results will be issued in early 1993.

The primary objective of the borehole flowmeter testing was to more accurately characterize the spatial variability of hydraulic conductivity in the RGA. Measurements were made under both pumping and nonpumping conditions in two wells. The flow measurements obtained under ambient conditions were assumed to represent the natural vertical flow existing in each well. The flow measurements made under pumping conditions were used to characterize the vertical distribution of horizontal hydraulic conductivity in the RGA.

The results of the borehole flowmeter testing reveal that large vertical variations in hydraulic conductivity exist in the RGA. Testing under pumping conditions indicated the presence of a 2- to 3-ft-thick, highly permeable sand layer at the top of the RGA. This sand layer may be up to 10 times more permeable than the underlying gravel layers within the RGA. The data obtained from the flowmeter tests will provide information critical to defining the preferred pathways for contaminant movement at PGDP.

Two additional studies were directed by HSS during 1993, a groundwater modeling study performed by GeoTrans and the Northwest Plume study. These special studies are discussed in Subject. 8.2.1 and so are not addressed here.

5.6.7 Related Activities

Efforts are made to coordinate all related activities to ensure that maximum information is gained in order to achieve the overall technical and programmatic goals of the Groundwater Protection Program. This is accomplished by assigning a

hydrogeologist within the HSS to a particular related project. The HSS staff member tracks the project and provides technical input to ensure that the specific project objectives and the overall Groundwater Protection Program objectives are met to the extent possible. Discussion of specific projects follows.

5.6.7.1 Environmental Restoration Program (CERCLA, UST, HSWA)

A number of projects conducted or completed in 1992 by the Environmental Restoration Program affect the Groundwater Protection Program. These include the CERCLA/ACO Phase II Site Investigation, the C-750 UST Site Investigation, and investigations required under HSWA.

The Phase II Site Investigation was conducted by CH2M Hill in 1990 and 1991. A final report detailing the results of the investigation was submitted to the EPA in April 1992. On August 13, 1992, and October 2, 1992, PGDP received comments on the Final Phase II Site Investigation Report from EPA Region IV and the Commonwealth of Kentucky (Kentucky Department for Environmental Protection), respectively. The EPA has required that the Phase II Report be supplemented, in the form of Remedial Investigation Addenda to be developed on an operable unit basis. The final Phase II Report will be used for supporting the addenda documents.

During 1992, the HSS provided support for an investigation focused on five USTs located in the south-central portion of PGDP near the C-750 garage, the C-200 guard and fire headquarters, and the C-710 technical services building. CDM Federal Programs Corporation conducted the UST investigation. The final site investigation report was submitted to DOE and the KDWM on September 10, 1992. A draft corrective action plan, developed by Science Applications International Corporation, was submitted for regulatory review in December 1992.

Progress was made during 1992 in the scheduling of a HSWA investigation of SWMUs at PGDP. SWMUs have been segregated into waste area groups and scheduled for RFI work plan development pursuant to the HSWA Corrective Action Program.

Two or more waste area groups are to be addressed by each RFI. During 1992, contractors developed the first three draft RFI work plans. Two were submitted to the EPA and the Commonwealth of Kentucky for regulatory review.

5.7 References

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6. Biological Monitoring

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6. Biological Monitoring

6.1 Food Crops

The Paducah Gaseous Diffusion Plant (PGDP) staff sampled food crops during 1992 from the vicinity of the plant. Food crop samples collected included corn, squash, tomatoes, beans, peppers, carrots, and eggplant. Figure 6.1 shows the locations where samples were obtained. Locations were selected to correspond to the most prevalent wind directions. One additional location was used north of the plant in the direction of the groundwater contamination plume. Background locations were selected approximately 10 miles west of the plant for comparison to the indicator locations.

Each sample was analyzed for ^{239}Pu , ^{99}Tc , ^{230}Th , ^{237}Np , ^{235}U , ^{234}U , and ^{238}U . Table 6.1 shows the concentration of various radionuclides detected (by wet weight basis) in edible vegetation. Only the radionuclides that were present above the detection limit (at 99% confidence level) were included.

The radionuclides detected— ^{234}U , ^{238}U , and ^{230}Th —are all known to be naturally occurring in soil. Because the sampling method does not require washing of the vegetables prior to analysis, the percent contribution from the uptake of radionuclides into the plant could not be determined.

6.2 Deer Harvest

In August 1992 four deer were harvested in the West Kentucky Wildlife Management Area (WKWMA) to monitor the effects of PGDP on the ecology of the surrounding area. A new procedure for deer sampling was tested during 1992. Deer samples were collected by WKWMA personnel from deer taken by hunters in the area. This new procedure allowed the plant to sample deer in older age groups and deer that were outside the buffer areas surrounding PGDP. WKWMA and PGDP personnel

were reluctant to sample older deer, particularly bucks, in the special summer sampling events because these are considered the trophy animals that draw hunters to the area. Expanding outside the buffer areas was deemed acceptable for two reasons: (1) deer home range areas are encompassing both buffer and hunting areas, and (2) contaminants would have more time to bioaccumulate in older deer, thus increasing the likelihood of detection in this surveillance activity. Three deer obtained as background samples from the Land Between the Lakes in 1992 were used for reference. Liver and muscle samples were analyzed for radionuclides, metals, and polychlorinated biphenyls (PCBs). In addition, bone and thyroid samples were analyzed for radionuclides and fat samples for PCBs. The liver, muscle, and fat tissue are evaluated for radiological or chemical risks if analyses reveal detectable levels above background or reference deer. These types of tissues are considered consumable by hunters. Bone and thyroid are used as indicators of contamination only. The results for all detected analytes in muscle and liver samples are summarized in Tables 6.2 and 6.3.

The only radionuclide results that were statistically different from zero in edible portions of deer tissue were for uranium isotopes. The mean concentration of ^{234}U in edible portions of reservation deer was 0.29 (0.30 muscle, 0.28 liver) pCi/g. The data indicate no significant difference (at 95% confidence level) between the average concentrations of uranium isotopes in reservation deer and in background deer. Detectable concentrations of uranium isotopes and ^{90}Sr , a radionuclide present in the atmosphere from worldwide fallout, were found in most bone samples. No detectable levels of ^{99}Tc , reservation and background, were found in the thyroids of the deer.

Fig. 6.1. Food crop collection locations.

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Table 6.1. 1992 annual food crop sampling

Location ^a (sample)	²³⁷ Np (pCi/g)	²³⁹ Pu (pCi/g)	⁹⁹ Tc (pCi/g)	²³⁰ Th (pCi/g)	²³⁴ U (pCi/g)	²³⁵ U (pCi/g)	²³⁸ U (pCi/g)
1 Corn	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.027	<i>b</i>	<i>b</i>
2 Tomato	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.004	<i>b</i>	<i>b</i>
3 Squash	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
4 Corn	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.006	<i>b</i>	<i>b</i>
5 Tomato	<i>b</i>	<i>b</i>	<i>b</i>	0.010	0.010	<i>b</i>	<i>b</i>
6 Beans	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
7 Corn	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.007	<i>b</i>	<i>b</i>
8 Squash	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
9 Tomato	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.005	<i>b</i>	<i>b</i>
10 Tomato	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.007	<i>b</i>	0.004
11 Pepper	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
12 Beans	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
13 Tomato	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
14 Corn	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
15 Mixed	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
16 Squash	<i>b</i>	<i>b</i>	<i>b</i>	0.004	<i>b</i>	<i>b</i>	<i>b</i>
17 Carrot	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.007	<i>b</i>	0.005
18 Tomato	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	0.004	<i>b</i>	<i>b</i>
19 Corn	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>
20 Eggplant	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>b</i>

^aSee Fig. 6.1.

^bOnly radionuclides that are present above detection limits (at 99% confidence level) are included.

Table 6.2. 1992 annual deer harvest—muscle analysis

(Confidence that analytes are present in samples is 99%)

Deer	Al (μg/g)	Cd (μg/g)	Cr (μg/g)	Cu (μg/g)	Fe (μg/g)	Ni (μg/g)	Pb (μg/g)	Zn (μg/g)	²³⁴ U (pCi/g)	²³⁵ U (pCi/g)	²³⁸ U (pCi/g)
<i>Indicator</i>											
1	0.75	<i>a</i>	0.06	1.40	28	0.03	<i>a</i>	61	0.24	<i>a</i>	<i>a</i>
2	1.10	<i>a</i>	0.07	1.30	37	<i>a</i>	<i>a</i>	100	0.17	<i>a</i>	<i>a</i>
3	1.10	<i>a</i>	0.11	2.10	93	0.12	910.00 ^b	39	0.60	0.17	0.15
4	1.10	<i>a</i>	0.06	1.20	33	<i>a</i>	0.07	69	0.18	<i>a</i>	<i>a</i>
<i>Background</i>											
5	2.00	<i>a</i>	0.07	1.60	30	<i>a</i>	0.02	28	<i>a</i>	<i>a</i>	<i>a</i>
6	0.89	<i>a</i>	0.07	1.50	38	0.16	<i>a</i>	57	0.68	0.32	0.19
7	1.50	<i>a</i>	0.15	3.10	85	<i>a</i>	0.02	89	0.08	<i>a</i>	<i>a</i>

^aNot detected.

^bResults of analyses on recovered deer meat did not confirm this result.

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Table 6.3. 1992 annual deer harvest—liver analysis

(Confidence that analytes are present in samples is 99%)

Deer	Al (μg/g)	Cd (μg/g)	Cr (μg/g)	Cu (μg/g)	Fe (μg/g)	Ni (μg/g)	Pb (μg/g)	Zn (μg/g)	²³⁴ U (pCi/g)	²³⁵ U (pCi/g)	²³⁸ U (pCi/g)
<i>Indicator</i>											
1	0.72	<i>a</i>	0.05	0.92	300	<i>a</i>	<i>a</i>	33	0.17	<i>a</i>	<i>a</i>
2	5.80	0.15	0.13	61.00	68	0.23	0.60 ^b	30	0.19	<i>a</i>	<i>a</i>
3	<i>a</i>	0.36	0.13	34.00	75	0.18	0.56 ^b	29	0.68	<i>a</i>	<i>a</i>
4	<i>a</i>	<i>a</i>	0.03	0.74	250	0.20	0.05	29	0.09	<i>a</i>	<i>a</i>
<i>Background</i>											
5	<i>a</i>	<i>a</i>	0.06	0.85	440	<i>a</i>	<i>a</i>	23	0.12	<i>a</i>	<i>a</i>
6	<i>a</i>	0.21	0.07	57.00	140	<i>a</i>	0.04	37	1.08	0.30	0.22
7	0.09	<i>a</i>	0.08	0.80	330	<i>a</i>	0.03	25	0.22	<i>a</i>	<i>a</i>

^aNot detected.

^bAlthough these results could not be checked, they are questionable because of the information in footnote *a* in Table 6.2.

Analytical data on concentrations of PCBs and 27 metals were also evaluated. Because all PCB concentrations were below the reporting limits, no evaluation was made of potential PCB intake. Eight metals are listed in Tables 6.2 and 6.3 for muscle and liver tissue. These 8 were selected from the list of 27 metals because they are potentially dischargeable from PGDP and as such are listed on the Kentucky Pollutant Discharge Elimination System Permit. Detectable levels, significantly higher than background, were seen in the liver for aluminum, nickel, and lead and in muscle for lead. The presence of detectable aluminum and nickel resulted from improvements in analytical techniques rather than from increases in concentrations in the environment except for the deer No. 2 liver result for aluminum. Assessment of risk was not performed for aluminum because this level (5.8 mg/kg or μg/g), using the ingestion rate and frequency in Sect. 2, Table 2.4, would result in a yearly intake of aluminum from this source equivalent to three doses of over-the-counter antacid liquid or tablets. The quantification limit for pre-1992 data was higher than the detectable results reported in 1992. The lead results are above previous quantification levels and indicate bioaccumulation from some source or sources in the area. When results of preliminary risk assessments from Oak Ridge National Laboratory (ORNL) showing

potential health effects were received, PGDP became concerned and completed the following immediate actions, which did not confirm the originally reported levels. Reanalyses of the original two deer samples by ORNL confirmed the presence of lead, but subsequent analyses on unused meat and bone from both deer retrieved from the hunters by WKWMA and state wildlife personnel and analyzed by ORNL and a university laboratory used by the state did not confirm the presence of lead. The results of all analyses have been reported to the Department of Energy (DOE) and through DOE to the state. PGDP participated in a meeting with DOE, state wildlife personnel, and the Army Corps of Engineers to determine if any future actions were required to protect public health. Although it was decided that no immediate actions were required, PGDP will also participate in future studies to confirm the negative lead results. The Corps of Engineers is responsible for evaluating the Kentucky Ordnance Works site, which originally occupied the site of WKWMA and PGDP, for potential hazards and inclusion to the National Priority List for cleanup.

6.3 Vegetation

Vegetation (grass) samples are collected at 18 locations every 3 months. The samples are returned

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to the laboratory, air dried, and analyzed for fluorides. The primary objective of vegetation sampling is to determine the total fluorides in foliage for comparison with the fluoride-in-foliage section of the Kentucky air pollution control regulations. Figure 6.2 shows the locations of the grass-sampling points. These locations represent the perimeter fence, property boundary, and 1.6- and 8-km (1- and 5-mile)

distances as related to the primary emission point. Table 6.4 summarizes the analyses.

Samples collected outside the fenced area are compared with the Kentucky Ambient Air Quality Standard of 60 µg/g for a 2-month average. All samples were well below the 60-µg/g standard. Samples taken outside the fenced area range from less than 5.2 to 9.3% of the standard.

Table 6.4. PGDP fluoride in grass for 1992 (dry weight)

Growing season is April through September

Point ^a	Number of samples	Min (µg/g)	Max (µg/g)	Annual av (µg/g)	Av during growing season (µg/g)	Std ^b (µg/g)	% Std
G1	4	5.8	15.0	10.8	7.6	c	c
G2	4	7.5	12.0	8.8	7.6	c	c
G3	4	<3.0 ^d	6.0	<4.6	<3.9	c	c
G4	4	<3.0	5.2	<4.1	<3.1	c	c
G5	4	<3.0	8.1	<5.7	<5.6	60	<9.3
G6	4	4.6	5.1	4.8	4.9	60	<8.2
G7	4	<3.0	5.8	<4.0	<4.4	60	<7.3
G8	4	<3.0	8.1	<4.8	<5.6	60	<9.3
G9	4	<3.0	5.2	<4.5	<3.9	60	<6.5
G10	4	<3.0	7.2	<5.0	<4.0	60	<6.7
G11	4	<3.0	4.2	<3.3	<3.1	60	<5.2
G12	4	<3.0	9.0	<5.3	<3.7	60	<6.2
G13	4	<3.0	3.9	<3.5	<3.6	60	<6.0
G14	4	<3.0	3.9	<3.3	<3.2	60	<5.3
G15	4	<3.0	14.6	<6.8	<3.8	60	<6.3
G16	4	<3.0	5.4	<3.9	<4.2	60	<7.0
G17	4	<3.0	5.0	<4.3	<4.0	60	<6.7
G18	4	<3.0	8.0	<5.2	<3.7	60	<6.2

^aSee Fig. 6.2.

^bKentucky Ambient Air Quality Standards (401 KAR 53:010): Fluoride measured on forage is not to exceed an average of 40 µg/g over the growing season, 60 µg/g for a 2-month average, or 80 µg/g for a 1-month average (dry weight).

^cSampling locations are on government property inside the plant security fence.

^dLower limit of detection is 3 µg F⁻/g.

Fig. 6.2. Grass-sampling locations.

7. Soil and Sediment Monitoring

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7. Soil and Sediment Monitoring

Soil and sediment data are collected at Paducah Gaseous Diffusion Plant (PGDP) to show the accumulation of any airborne or waterborne pollutants. Although sampling procedures are designed to minimize the well-known variability found in soils and sediments, the significance of individual units of data is small. If trends exist, data collected over a period of years may reveal them.

7.1 Soil

Soil samples are taken annually at 10 locations—north, south, east, and west at the property boundary and at distances of 8 km (5 miles) beyond the property boundary (Fig. 7.1). Remote (background) samples are taken at two locations 13 to 15 km (8.08 to 9.32 miles) from PGDP. Each sampling site was selected because the soil appeared or was known to have been undisturbed for a number of years. Two 1-m² (11-ft²) areas are measured out, 3 m (10 ft) apart. The vegetation to a height of 10 to 20 mm (0.4 to 0.8 in.) above the soil is removed. Soil samples to a depth of 5 cm (2 in.) are taken from the center and from each corner of the 1-m² area. The plugs of soil are composited into a labeled plastic bag. Table 7.1 lists sampling locations and parameters for analysis.

Table 7.2 lists the concentrations of uranium in soil samples from 1987 through 1992. Although other analyses are performed and results summarized, only uranium is presented in a tabular form because it is considered to be the element of concern in PGDP air emissions. The 1992 uranium concentrations show no apparent differences from past data and are within the range for concentration and assay expected for naturally occurring uranium. The range of soil analyses during 1992 was from a low of 1.5 µg/g at

the north boundary to a high of 4.0 µg/g at the site 8 km north of the plant. There were no significant differences, at the 95% confidence level, between upwind (S3, S4, S7, S8, S9, S10) and downwind (S1, S2, S5, S6) locations. Radionuclide analyses were also performed for ⁹⁹Tc, ²³⁰Th, ²³⁷Np, and ²³⁹Pu. No detectable concentrations of these radionuclides were seen at any of the sampling sites.

In addition to radiochemical analyses, each soil sample was analyzed for 35 metals and polychlorinated biphenyl (PCB). Detectable concentrations of PCB were again found in two property boundary samples, S3 and S4. Concentrations above reference locations of Ag, Be, Cr, Fe, K, Na, and P were detected in the S5 sample. Concentrations of Na, Pb, and Th were detected in the S5 sample. Concentrations of silver were elevated in the S8 sample. No other apparent differences were noted between samples from at or near the property boundary and the remote locations.

7.2 Stream Sediment

The stream bottom is a very important constituent of the aquatic environment. If a pollutant is a suspended solid or attached to suspended sediment, it can settle to the bottom (thus creating the need for sediment sampling), it can be filtered by certain organisms, or it can become attached to plant surfaces. Pollutants in solution can adsorb on suspended organic and inorganic solids or be assimilated by plants and animals. The suspended solids, dead biota, or excreta settle to the bottom and become part of the organic substrate that supports the bottom-dwelling community of organisms. Figure 7.2 shows possible exposure routes of trace metals

Fig. 7.1. PGDP soil- and sediment-sampling locations.

7-4 Site and Sediment Monitoring

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Table 7.1. Summary of collection and analysis frequencies of soil and sediment samples in 1992

Station	Parameter	Collection frequency	Sample type	Analysis frequency
<i>Soil^a</i>				
S1, S2, S3, S4, S5, S6, S7, S8, S9, S10	U, ²³⁹ Pu, ²³⁷ Np, ¹³⁷ Cs, ²³⁵ U, ²³⁰ Th, ⁹⁹ Tc, ⁴⁰ K, PCB, ^b Ag, Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Ru, Sb, Si, Sn, Sr, Ta, Th, Ti, Tl, V, W, Zn, Zr, As	Annually	Grab	Annually
<i>Sediment^a</i>				
SS1, SS2, SS20, SS21, SS27, SS28	¹³⁷ Cs, ⁴⁰ K, ²³⁷ Np, ²³⁹ Pu, ⁹⁹ Tc, ²³⁰ Th, U, ²³⁵ U, PCB, Ag, Al, Ba, Be, Bi, Cd, Ca, Co, Cr, Cu, Fe, K, I, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Ru, Sb, Si, Sn, Sr, Ta, Th, Ti, Tl, V, W, Zn, Zr, As	Annually	Grab	Annually

^aSee Fig. 7.1.

^bPolychlorinated biphenyls.

Table 7.2. Concentrations of uranium in soil at PGDP, 1987–1992^a
(μg/g)

Location	1987	1988	1989	1990	1991	1992
<i>Property boundary</i>						
S1 (north)	4.8	4.9	2.2	5.0	4.3	1.5
S2 (east)	3.4	4.6	2.4	3.9	4.1	3.5
S3 (south)	5.5	4.3	5.6	7.1	4.3	3.4
S4 (west)	2.5	2.2	1.4	3.3	2.9	2.6
<i>8 km from plant</i>						
S5 (north)	3.9	4.2	2.2	4.3	4.2	4.0
S6 (east)	2.6	2.3	1.1	2.5	3.0	2.5
S7 (south)	2.7	2.5	1.2	2.8	2.9	2.6
S8 (west)	2.8	3.4	1.2	2.9	3.3	3.1
<i>13 to 15 km from plant</i>						
S9 (south)	2.4	2.5	0.8	2.2	2.8	2.0
S10 (west)	2.9	2.1	0.7	2.7	2.9	2.4

^aSee Fig. 7.1.

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Fig. 7.2. Routes of trace metals in an aquatic ecosystem. Source: Jinks and Eisenbud 1972.

(including uranium) in an aquatic ecosystem (Jinks and Eisenbud 1972).

Sediments play a significant role in aquatic ecology by serving as a repository for radioactive or

chemical substances that pass via the bottom-feeding biota to the higher trophic levels. Soluble pollutants introduced into a body of water reach the bottom sediment primarily by adsorption on suspended solids that later deposit on the bottom. The deposited remains of biota that have absorbed pollutants may also be an important source of radioactive and chemical pollutants that enter the food chain.

Sediment samples were taken from six locations. Figure 7.1 shows the location of each sampling point. At each location a clean sampling scoop is used to obtain a sample from the bottom of the stream or lagoon, taking as few rocks as possible. Approximately 2 kg (4.5 lb) of sediment is placed in a new plastic bag. The samples are dried and delivered to the analytical laboratory. Table 7.1 lists a summary of the frequencies of collection and analyses.

Table 7.3 shows the 1992 PCB and radionuclide data. The locations have been changed from 1991 and past reports because of the initiation of portions of the PGDP Environmental Monitoring Plan. None of the locations contained levels of ^{99}Tc , ^{237}Np , ^{239}Pu , or ^{230}Th above analytical lower reporting limits. Levels of uranium at SS2, downstream Little Bayou Creek, are 36 times higher than at SS21, upstream Little

Table 7.3. 1992 PGDP sediment data

Location ^a	Technetium-99 (pCi/g)	Neptunium-237 (pCi/g)	Plutonium-239 (pCi/g)	Thorium-230 (pCi/g)	Uranium-235 (wt %)	Uranium (μg/g)	PCB ^b (μg/g)
SS1 downstream Big Bayou	<17	<0.5	<0.5	<3	0.53	4.6	<0.1
SS2 downstream Little Bayou	<17	<0.5	<0.5	<3	0.20	107.0	0.7
SS20 upstream Big Bayou (L-1)	<17	<0.5	<0.5	<3	0.70	1.3	<0.1
SS21 upstream Little Bayou	<17	<0.5	<0.5	<3	0.61	2.8	<0.1
SS27 below north/south diversion ditch in Little Bayou	<17	<0.5	<0.5	<3	0.29	11.6	<0.1
SS28 Massac Creek at Hwy 62	<17	<0.5	<0.5	<3	0.63	0.9	<0.1

^aSee Fig. 7.1.

^bPolychlorinated biphenyl.

7-6 Site and Sediment Monitoring

Bayou Creek. Downstream Big Bayou Creek, SS1, contained 3.5 times the concentration of uranium in the sediment at SS20, upstream Big Bayou Creek. These elevated levels can be attributed to plant operations because the assay is lower than normal uranium. The effects of these concentrations are discussed in Part 1, Sect. 2.4, and in Table 2.1. PCB was detected at SS2, downstream Little Bayou Creek. This result confirms past studies in which both PCB and uranium had been detected and resulted in the posting of Little Bayou Creek to make the public aware that prolonged exposure could result in a dose above background and to warn of PCB contamination. Big and Little Bayou creeks and the Kentucky Pollutant Discharge Elimination System--permitted discharge ditches have been investigated during administrative consent order (ACO) activities.

Remedial alternatives have been drafted (Science Applications International Corporation 1991) and are being reviewed by the U.S. Environmental Protection Agency and the Kentucky Department for Environmental Protection. When finalized, the document will become the Record of Decision under the Comprehensive Response, Compensation, and Liability Act in response to the ACO.

7.3 References

- Jinks, S. M., and M. Eisenbud. 1972. "Concentration Factors in the Aquatic Environment," *Radia. Data Rep.* **13**, 243.
- Science Applications International Corporation (SAIC). December 1991. *Summary of Phase II (Stage C) Activities*, draft, Oak Ridge, Tenn.

8. Unusual Occurrences and Special Studies

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8. Unusual Occurrences and Special Studies

Paducah Gaseous Diffusion Plant (PGDP) had a total of 573 spills or releases of various types of materials during CY 1992. A record of each incident is kept by the PGDP shift superintendent's office. All generated cleanup debris is handled in accordance with PGDP standard operating procedures. The PGDP shift superintendent's office reports all spills or releases to various levels of PGDP management and to federal and state officials as is appropriate. Occurrences are categorized and notifications to the Department of Energy (DOE) are made in accordance with Standard Practice Procedure, P-GP-43, *Occurrence Reporting System*.

Many of the spills during CY 1992 (a total of 311 incidents) were from leaking ventilation duct gaskets containing polychlorinated biphenyl (PCB) oils (Fig. 8.1). All gasket leaks were inside buildings. Troughs were installed beneath leaking gaskets immediately upon discovery.

Highlights of significant incidents are given in Sect. 8.1.

8.1 Unusual Occurrences

8.1.1 PGDP Spill Report

8.1.1.1 Release of Sodium Bicarbonate: C-611 Water Treatment Facility

On January 7, 1992, during routine outfall sampling, the pH at Kentucky Pollutant Discharge Elimination System (KPDES) outfall 006 was determined to be 10.7, which exceeded the permit limit of 10.4. Approximately 20 dead or dying fish were observed in the sludge lagoon upstream of the outfall. Other fish were showing signs of stress. The increase in lagoon pH was caused by an overflow of

dilute soda ash from its mixing tank, which was caused by feed pump failure. The dilute soda ash entered the floor trench, which drained to the C-611-V sludge lagoon. The release was immediately reported to DOE and the Kentucky Department for Environmental Protection (KDEP). The lagoon effluent to outfall 006 was restricted by use of a Vetter plug and was later treated with sulfuric acid to lower the pH. An undetermined number of fish died because of the incident. A full investigation of the occurrence was conducted by PGDP personnel with guidance from individuals at Oak Ridge National Laboratory.

8.1.1.2 Release of Leachate: C-746-K Inactive Landfill

On January 30, 1992, during an inspection of the closed sanitary landfill, leachate was found entering a drainage ditch and tributary of Big Bayou Creek. The material had settled in the ditch and in low places in the creek. Booms were placed in the creek, and a temporary sandbag dam was constructed in the ditch near the source of discharge. The KDEP was notified of the discovery. Sampling activities were initiated to determine the hazards of the substance. Since the landfill has been inactive since 1982, the situation has been turned over to the Environmental Restoration Department for remediation.

8.1.1.3 Chromate Water Release: C-633-5 South Blending Cooling Tower

On February 5, 1992, an employee reported a spill in progress at the C-633-5 cooling tower. Approximately 25,000 gal of recirculating cooling water (RCW) containing 8–9 ppm of hexavalent chromium (Cr^{6+}) spilled as a result of a 4-in. fiberglass distribution lateral pipe becoming

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Fig. 8.1. Spills or releases at PGDP in 1992.

disconnected from the main 20-in. header. This allowed cooling water to damage the tower wall and splash out onto the surrounding ground. Response personnel arrived at the scene and valved out the supply riser to stop further spillage. The material was contained at several key locations; the nearby storm sewer was covered with plastic and sandbags; the downstream flow weir was damned with plywood and sandbags; a Vetter's plug was placed in a downstream drainage pipe; and beavers had constructed a dam near the influent of Little Bayou Creek. The amount of chromium released was calculated to be approximately 1.8 lb, which is less than the reportable quantity. Notification was made to the Kentucky Division of Water (KDOW) and to the KDEP. The majority of the spill material was recovered by Chemical Operations personnel by use of the King Vac truck.

8.1.1.4 Elevated Opacity: C-600 Steam Plant

On February 7, 1992, the No. 2 north coal mill was removed from service because of obstruction in the classifier section. During the mill outage, firing of fuel oil resulted in elevated stack opacity. The duration of the mill outage was approximately 45 min. Average opacity readings were noted as 19% using U.S. Environmental Protection Agency (EPA) method 9. The Paducah Office of the Kentucky Division for Air Quality was notified of emission.

8.1.1.5 Uranium Hexafluoride (UF₆) Leak: Cylinder Valve

On April 2, 1992, while moving a full UF₆ product cylinder to the C-310 purge and product

building cylinder yard, an operator detected an odor that he suspected was hydrogen fluoride (HF). The operator investigated and found a small leak of UF₆/HF smoke coming from around the valve cap on the cylinder (PK1373). The cylinder had been filled on March 31, 1992, and contained UF₆ at an assay of 1.90% ²³⁵U. After notifying supervision, operators wearing anti-contamination clothing and respirators stopped the leak by tightening the cylinder valve packing nut and the valve cap and torquing the valve seat. Health physics personnel monitored for contamination, and precautionary urine samples were submitted by those involved.

8.1.1.6 Chromate Water Release: C-331 Process Building

On August 7, 1992, a leak was discovered on the B-loop RCW return header at the northwest corner of the C-331 process building. The source of the leak was determined to be in an underground vault. The RCW had filled the vault and was overflowing onto the surface above. The leak was isolated and contained to the surrounding area by use of sandbags. No water entered the plant drainage system. Upon recovery of the RCW from the vault, it was determined that a 1-in. pipe supporting an air relief valve had deteriorated and failed. The failure resulted in the spilling of approximately 200 gal of 8.4 ppm Cr⁶⁺ water. Calculations based on this concentration indicated the amount of Cr⁶⁺ to be 0.014 lb, which is less than the reportable quantity. Notifications were made to DOE and the KDEP.

8.1.1.7 Diesel Fuel Release: C-751 Fuel Dispensing Facility

On August 8, 1992, fuel was observed coming from the plant fuel truck. Investigations revealed that the fill nozzle to the diesel fuel tank had been stowed in the open position. The valve between the diesel tank and the hose was closed. Approximately 1 gal of diesel fuel spilled to the ground and was entering the plant drainage system to KPDES outfall 009. The drain was immediately plugged, and oil absorbent booms and pads were placed in the outfall, upstream of the oil control dam. Migration of the oil sheen was controlled at this point. The KDEP was notified of the occurrence.

8.1.1.8 Chilled Water Release: C-600 Steam Plant

On August 31, 1992, approximately 2000 gal of water was lost from the plant chilled water system during a 14-h period. The release was caused when a coil drain valve on the plant chill water unit was inadvertently opened. The water from the unit flowed to a drain and to KPDES outfall 008. The chill water system contained 280 ppm sodium molybdate and 0.2 ppm chromate. As soon as the open valve was identified, it was closed and "caution tagged." Sampling activities were initiated in the plant drainage system and at outfall 008. Approximately 4.7 lb of sodium molybdate, which is not listed or allowed to be discharged by the KPDES permit, was released to the outfall. The KDEP was notified of the occurrence.

8.1.1.9 Spill of PCB-Contaminated Fluid: C-722 Acid Neutralization Pit

On March 17, 1992, during pumping and cleaning operations at the C-722 acid neutralization pit, some of the contents spilled into the diked area and onto transfer equipment and surrounding gravel. Approximately 8 oz reached the gravel area. Sample results indicated the material contained greater than 50 ppm PCBs resulting in an improper disposal violation of 40 CFR 761.135 (Title 40, Code of Federal Regulations, Part 761.135). The gravel was cleaned up, and the occurrence was reported to the KDEP.

8.1.1.10 Failure of PCB Static Capacitors: C-537 and C-533 Switchyards

On May 8, 1992, PCB-filled static capacitor 33 failed in the C-537 switchyard, bank 7H on C-phase. The bottom of the capacitor ruptured, allowing approximately 3 to 4 gal of PCB fluid to spill onto adjacent capacitors, the diked area beneath the capacitor bank, and on nearby rock and concrete decking. On May 9, 1992, during a routine inspection, capacitor 45B in the C-533 switchyard capacitor bank 3E was found to be leaking. Approximately 1 quart (3 to 4 lb) had leaked into the diked area beneath the capacitor bank and onto adjacent capacitors. The capacitor banks were

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de-energized for cleanup and repairs. EPA Region 4 and the National Response Center were notified of each occurrence.

8.1.1.11 PCB Oil Spill: C-537 Switchyard

On July 21, 1992, during operations to drain oil from an electrical insulating bushing removed from C-537 switchyard transformer No. 69, approximately 2 gal of PCB oil spilled. The oil spilled when the drain plug was being removed and internal pressure in the bushing caused the oil to spray out. The oil sprayed on two employees' skin and clothing, an adjacent equipment cart, and an area of soil approximately 10 ft in diam. The employees were instructed to shower and bag their clothing. The area was flagged off for cleanup activities. Laboratory analysis of the oil indicated it contained 41 ppm PCB.

8.1.2 Radionuclide Releases

In 1992, 13 incident reports were generated as a result of the release of radioactive materials. Ten of the incidents consisted of the release of UF₆ puffs resulting from connecting and disconnecting of cylinder pigtails or leakage from cylinder valves. All puffs except one were controlled by high-efficiency particulate air filter systems. The released amounts were often so minute that they were undetectable. The remaining three occurrences consisted of: (1) the discovery of a small deposit of uranium oxide on the outside of a purge and evacuation pump seal, (2) a slight amount of uranium sludge that leaked to the outside of two storage drums and a wooden pallet, and (3) less than 1 oz of uranium-bearing compound on the exterior surface of seal piping. None of the remaining three incidents were categorized as immediately reportable to the KDEP or other outside agencies.

8.2 Special Studies

8.2.1 Special Studies—Hydrogeological Services Section (HSS)

Several special studies were conducted under the direction of the HSS during 1992. These studies were designed to resolve some data deficiencies and uncertainties in site hydrogeology. The studies have

also defined areas where additional focused investigations should be considered.

8.2.1.1 Groundwater Flow Modeling

During 1992, GeoTrans, Incorporated, was retained to perform numerical modeling of the groundwater flow system beneath PGDP. One of the primary objectives of the modeling was to update a regional three-dimensional groundwater flow model developed by GeoTrans in 1990 using the additional field data obtained in the two years since that model was developed. The field data consist primarily of soil-boring information, monthly water level measurements from monitoring wells, slug tests, and aquifer pump tests. The updated model would be used to provide an increased understanding of groundwater flow pathways and rates of contamination migration at the site. A second objective of the groundwater modeling study was to use the updated model to evaluate a proposed hydraulic containment action for a contaminant plume that extends off-site northwest of the plant. The model would be designed to optimize the selection of the number and location of the recovery wells and to calculate the appropriate pump rates for each well.

A three-phased approach was used to perform the groundwater modeling study. Phase I, completed in March 1992, consisted of a review of the current conceptual models of groundwater flow at the site and a presentation of the new field data. Phase II, completed in August 1992, involved developing a revised three-dimensional groundwater flow model using the new field data. Calibration, particle tracking, and sensitivity analysis were also performed. Phase III evaluated the effectiveness of the proposed hydraulic containment plan using the Phase II calibrated model and a pumpage optimization module developed by GeoTrans. A final report (GeoTrans, Inc. 1992) summarizing the results of all three phases was issued in December 1992.

The first objective of the modeling project, to update the conceptual hydrogeologic model of PGDP, was met and resulted in the following revisions to the 1990 regional groundwater flow model:

- The 1990 model included a consideration of preferential flow pathways, or paleochannels, in the regional gravel aquifer (RGA) and concluded that

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paleochannels do not play a significant role in transport migration. The presence of the hypothesized paleochannels in the RGA was not verified by the new field data, so they were removed entirely from consideration in the updated model.

- The 1990 model assumed hydraulic connection in the RGA across the erosional terrace located near the southern edge of the plant. The revised model does not allow any flow across the terrace face. This scenario provides a lower bound to the estimate of average hydraulic conductivity of the RGA.
- A small percentage of the water movement in the RGA was determined to be downward into the McNairy Formation. For the modeled area, mass balance calculations indicated that less than 4% of the total water in the RGA flows downward into the McNairy.
- Particle tracking was used to model the pathways and rates of movement of conservative solutes, excluding dispersion effects. It was concluded that a particle introduced to the water table on-site would take from 10 to 28 years to travel downward to the RGA. Once reaching the RGA, the particle would move horizontally north-northeast to the Ohio River, reaching it within 25 to 58 years.
- Changes were made in the modeled hydraulic conductivity values for the Upper Continental Recharge System (UCRS) and RGA. In the UCRS, a zone of higher hydraulic conductivity was assigned to the alluvium than to the rest of the UCRS. A zone of reduced hydraulic conductivity in the RGA was assigned at the Ohio River to account for the steep hydraulic gradient observed there.

The approach used to evaluate the hydraulic containment plan for the Northwest Plume involved evaluating two scenarios, a narrow plume containment and a wide plume containment. For the narrow plume scenario, optimal containment, designed to contain a plume 600 ft in width, was obtained with five wells positioned in a broad U-shaped configuration and pumping a total of 183 gpm. For the wide plume scenario, optimal containment for the 2400-ft-wide plume was achieved with 16 wells spaced 150 ft apart in a similar U-shaped configuration and pumping a total of 464 gpm. A number of other configurations were also

generated, and it was concluded that the number of wells could drop as low as nine for the wide-plume scenario without significantly increasing the total pumping rate. GeoTrans is involved in modeling a new scenario and will have the results of this study by March 1993.

The final modeling report (GeoTrans, Inc. 1992) includes a number of recommendations concerning the types of information needed to further characterize the site hydrogeology. The major recommendations are as follows:

- Further characterization of the degree of connection between the McNairy Formation and the RGA is needed to assess the potential for downward migration of contaminants. This need will be addressed in the Phase IV Groundwater Investigation planned for 1993.
- Additional information concerning the erosional terrace at the southern edge of the plant should be gathered. The investigation should focus on the amount of groundwater flow across the terrace face in the RGA and the UCRS.
- Reducing areas of uncertainty regarding recharge is critical. Additional information obtained from continued monitoring of Ohio River stage, precipitation, and groundwater levels should assist in more accurately determining recharge conditions.
- Investigations may be warranted to determine the cause of the discrepancy between modeled and observed water levels in the UCRS at the northwest portion of the site. At present, the cause of groundwater mounding observed in this area cannot be determined.

8.2.1.2 Northwest Plume Study

A field study of the contaminant plume that extends off-site in the northwest corner of the plant was conducted in 1992 by the HSS. The Northwest Plume is a contaminant plume, underlying approximately 1.6 miles², containing both trichloroethylene (TCE) and technetium-99 (⁹⁹Tc). The study involved the use of a driven discrete-depth sampler developed at Oak Ridge National Laboratory to obtain groundwater samples from 15 separate locations. The focus of the investigation was to further characterize the hydrogeology and extent of contamination in the area.

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A description of the field method and results of the study will be presented in a final report, scheduled to be completed in March 1993. Results of the study will assist in planning future drilling activities and selecting remedial actions in the area. The Northwest Plume Study will also assist in the design of the hydraulic containment plan for the Northwest Plume, scheduled to be initiated during 1993.

8.2.1.3 CFC-114 Replacement

Recent studies and investigations have determined that certain compounds, particularly chlorofluorocarbons (CFCs), deplete the stratospheric ozone layer and allow a greater amount of damaging ultraviolet light to reach the earth, which in turn causes harmful environmental and health effects.

CFCs are widely used as refrigerants and degreasing solutions. The CFCs leak or are released from these operations and travel to the stratosphere, where they chemically react with the stratospheric ozone layer to deplete it. Because of this stratospheric ozone depletion determination, the EPA has mandated a phaseout of production of class I ozone-depleting compounds, which include CFC-114. PGDP uses CFC-114 as coolant in the gaseous diffusion cascade. The cessation of production as a result of the EPA mandate and a presidential executive order is due on or before January 31, 1995. PGDP has initiated a project to identify a suitable replacement for CFC-114. A CFC-114 Replacement Program manager has been named for PGDP and Portsmouth Gaseous Diffusion Plant. Non-ozone-depleting replacement candidates have been identified, and testing has begun at PGDP to determine if the candidates are suitable replacements for CFC-114. When a suitable replacement is identified, the CFC-114 will be replaced on an as-needed basis.

8.2.1.4 Chromium Corrosion Inhibitor Replacement

PGDP uses a binary system for dissipating the heat generated by the gaseous diffusion cascade. First, the heat of compression of the UF_6 is transferred to CFC-114 by vaporization of this compound. Then, the heat is transferred to the RCW system. The heat is finally transferred from the RCW

to the atmosphere via four cooling tower complexes. A chromium compound is added to the RCW to prevent corrosion of the RCW piping system. The chromium compound is released to the atmosphere through the cooling tower complexes. In anticipation of regulations to be promulgated under Title III (Hazardous Air Pollutants), PGDP has initiated a project to replace the chromium-based corrosion inhibitor with a phosphate-based corrosion inhibitor. One tower complex has been converted to the new corrosion inhibitor, and it is expected that the other three will be converted by September 1993. It is also expected that PGDP will be in compliance with the new regulation affecting industrial cooling towers when it is promulgated.

8.2.2 Environmental Advisory Committee

The PGDP Environmental Advisory Committee is composed of seven individuals (two of which were added in the past year) who represent a cross section of scientists, educators, health professionals, and local businessmen. The committee was established in 1986 and has been chartered with the following responsibilities:

- to review the sources of environmental pollutants, the control systems, and the surveillance activities associated with operation of PGDP;
- to evaluate plans for remedial activities and studies to correct, enlarge, or close waste management facilities and to provide recommendations for appropriate changes in strategy or direction;
- to assess the long-term fate and health effects of trace quantities of uranium, other radionuclides, and other pollutants of concern in PGDP environs;
- to advise the PGDP plant manager or the director of the Office of Environment, Safety, and Health, Martin Marietta Energy Systems, Inc. (Energy Systems), on environmental and health issues of concern to both scientists and the community; and
- to advise on appropriate methods and forms of reporting environmental and health data to the public.

It is anticipated that the PGDP Environmental Advisory Committee will continue until current needs are assessed and remedial action problems are

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resolved. In 1992 two additional members (university instructors) were added to the committee to increase the committee's expertise in hydrogeological and physical science disciplines.

During 1992 the PGDP Environmental Advisory Committee continued to participate in reviewing PGDP environmental programs and activities. Two meetings were conducted at the site—one in July and one in September. The committee meetings were attended by many upper- and middle-management and staff personnel from the DOE Oak Ridge Operations and from Energy Systems. Topics of discussion included

- the Resource Conservation and Recovery Act/Mixed Waste Federal Facility Compliance Agreement;
- the Natural Resource Damage Assessment Rule;
- the PCB Federal Facility Compliance Agreement;
- the National Emission Standards for Hazardous Air Pollutants (NESHAP) Federal Facility Compliance Agreement;
- environmental restoration activities: water policy, the C-746-K landfill, interim corrective measures, and the northwest groundwater plume study;
- KPDES permitting activities;
- the CFC-114 Replacement Program;
- the Cooling Tower Phosphate Changeover Program; and
- environmental noncompliance reporting.

8.2.3 Neighborhood Council

The PGDP Neighborhood Council was formed in September 1992 with eight members, all residents of the general vicinity of the plant. The goal was regular and direct communication between the plant and a group of neighbors to provide information and broaden residents' understanding of PGDP operations. To achieve that goal, the council was given these objectives:

- to hear unclassified presentations on a variety of topics of public interest, including those related to the environment;

- to ask questions and request information from PGDP representatives, who respond as thoroughly as possible at meetings or by mail, telephone, or home visits;
- to evaluate the clarity and adequacy of selected public communications by DOE or Energy Systems on behalf of the plant; and
- to recommend actions the plant can take to improve public understanding or help the community.

The council was chartered to meet at least quarterly and to have from 5 to 12 members serving from six months to two years. Monthly meetings were held from September through December 1992. The members' prevailing interest was environmental issues. Topics of discussion included

- groundwater and surface water contamination and related environmental restoration projects;
- air quality and monitoring;
- the PGDP Water Policy (providing municipal water to residents whose wells contain or may someday contain groundwater contamination);
- a tour of the plant laboratories and an explanation of water sampling analyses;
- the basics of radiation; and
- an overview of the *Paducah Gaseous Diffusion Plant Environmental Report for 1991* (PGDP 1992).

8.2.4 Waste Minimization Program

The Waste Minimization Program at PGDP has existed since 1987. Objectives of the program include identification of opportunities, goal setting, prioritization of efforts, initiation of projects, identification of responsibilities and resource requirements, and the tracking of project results for waste minimization and waste reduction. This subsection discusses some of the activities of the Waste Minimization Program during 1992.

8.2.4.1 Aerosol Can Use Reduction

The use of aerosol cans for all applications in the plant is being phased out as suitable non-aerosol products become available. Emphasis is on using

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refillable spray bottles and brush-applied paints and eliminating personal aerosol products. The amount of aerosol can wastes generated in 1992 was 20% less than that generated in 1991.

8.2.4.2 Cooling Tower and RCW System Waste Oil Minimization

A performance improvement process team investigated ways to reduce the generation of waste oil from the cooling towers and recirculating cooling water systems. Several options were available including reuse of pump motor lubricating oil for pumpshaft bearing lubrication, extending lubrication frequencies, and oil quality testing. Waste oil generation will be totally eliminated from each pumphouse and will be greatly reduced from cooling tower fan gearboxes.

8.2.4.3 Diesel Fuel/Oil Blending

A filtration system was ordered in 1992 to recycle used motor oil from diesel engines. The system filters engine crankcase oil and blends the oil with diesel fuel, which is used as fuel for the plant's fleet. The plant benefits by reducing waste oil quantities and diesel fuel consumption.

8.2.4.4 Floor-Sweep Use Reduction

Floor-sweep compound is used in the plant to aide the efficient removal of dust while sweeping plant buildings. Waste floor-sweep was reduced by increasing intervals between sweeping, using less sweeping compound, and avoiding the use of premixed sweeping compounds. In 1992 floor-sweep wastes were reduced 97% from 1991.

8.2.4.5 Garage Oil-Filter Crusher

A filter-crushing unit was installed to reduce the volume of automotive-type oil filters.

8.2.4.6 Packaging Material Waste Reduction

Many items are shipped to the plant in boxes containing large amounts of packing material. If this material is allowed inside the plant, it becomes contaminated suspect waste and cannot be shipped off-site or be reused. This material is usually sent to

the landfill. The Receiving Department now unboxes and removes packing material before boxes are taken into the plant.

8.2.4.7 Paint Shop Lacquer Thinner and Mineral Spirits Recovery

Material was ordered to set up a paint thinner and mineral spirits recovery system at the paint shop. This system consists of settling drums for recovery of clean fluids. Other Energy Systems plants have had great results in this area.

8.2.4.8 Process Lube Oil Leak Repairs

Major amounts of waste oil and oil-absorbing material are generated each year because of leaks from gaskets and joints in the process lube oil systems. A program was initiated in 1992 to systematically repair these leaks.

8.2.4.9 Process Lube Oil Recovery

Waste oil was generated in the past during routine maintenance activities on process equipment. A system is now in place to collect this oil and return it to the process lube oil system from which it was drained. Major reductions in the amount of waste lube oil is expected.

8.2.4.10 Seal Shop Lapping Oil Recovery

A settling system is now in place to recycle used lapping oil from the seal shop. Large reductions in waste oil generation from this area are anticipated.

8.2.4.11 TCE/Trichloroethane (TCA) Use Reduction

TCE and TCA were used in the plant for years as degreasers and were common as solvents in many products. Use of these products is being eliminated through product substitution.

8.2.4.12 Waste Machine Coolant Recycling

During 1992, a machine coolant recycling unit was purchased to minimize the generation of waste oil from the machine shop. Waste machine coolant

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was identified as a major source of storage problems because of the corrosion of metal chips that caused drum overpressure. The coolant recycling unit will enable the machine shop to filter impurities from dirty machine tool coolant and reuse the clean fluid.

8.2.4.13 Wood Pallet Waste Reduction

Wood pallets are used in many areas of the plant for equipment storage and material handling. Broken pallets are potentially contaminated and present disposal problems. Metal pallets are being substituted on a trial basis in the C-720 fabrication, machine, and equipment repair shops. Metal pallets will survive multiple uses better than wood pallets, can be decontaminated if necessary, and contribute to less waste generation.

8.2.5 PCB Source Identification Project

The PCB Source Identification Project was completed to identify potential sources of PCB contamination in effluents to Big Bayou and Little Bayou creeks. Additionally, this study was in response to a Notice of Violation issued by the KDOW on August 31, 1990. PGDP was alleged to have violated the water quality standard for PCBs contained in 401 Kentucky Administrative Regulations (KAR) 5:031. Performed by the Nashville District Corps of Engineers, the study began in August 1991 and continued through April 1992.

Two sampling programs were used, the Outfall Program and the Storm Sewer Program. Sampling was conducted twice monthly, once under dry conditions and once during or immediately following a runoff-producing rainfall event. Some sampling sites were sampled only under wet conditions. Laboratory analysis was limited to PCBs identified by specific aroclor and total suspended solids (TSS). The Outfall Program included the collection of water grab samples from 30 discrete locations, which included the KPDES sampling points. Twenty-five storm sewer locations composed the Storm Sewer Program. Sample collection points were adjusted during the study based on field observations and laboratory data.

The purpose of this investigation was to establish data trends indicating the location of PCB sources and the correlation of PCB and TSS concentrations.

However, it was determined that low-level PCB concentrations occurred on an erratic basis at a number of different sample locations. In addition, no well-defined relationship between PCB and TSS values was observed. Of the 643 samples collected, 19 had a PCB concentration greater than or equal to 0.1 µg/L, the lowest concentration reported. Nine positive results were from a wet sampling event, and ten were from a dry sampling event. Of the 17 locations that exhibited at least 1 positive result, 8 were from the Outfall Program, and 9 were from the Storm Sewer Program.

PGDP is conducting several related activities to reduce and clean up PCBs. Specifically related to PCB reduction and cleanup are the Toxic Substances Control Act Federal Facilities Compliance Agreement, collection and treatment of PCB-contaminated water, and Environmental Restoration Program activities. In an effort to further characterize the extent of PCB contamination of sediment in Big Bayou and Little Bayou creeks, sediment sampling, in addition to that already conducted by PGDP and the Environmental Restoration Program, will be conducted by the Corps of Engineers. The results of this investigation will be provided to the KDOW.

PGDP has submitted the final report and related information to the KDOW. This information has been prepared as PGDP's response to the Notice of Violation for PCB discharges. PGDP has requested KDOW's concurrence that the report and the information are satisfactory resolutions to the Notice of Violation. A response has not yet been received.

8.2.6 C-310 Purge and Product Building Stack Effluent Sampling Project

In February 1992, a stack sampling project was performed on the C-310 stack. The C-310 stack exhausts minute quantities of radionuclides and lightweight molecular gases that have migrated up the gaseous diffusion cascade. The project was required by the EPA in accordance with the NESHAP Federal Facilities Compliance Agreement to determine whether radionuclide particulates are present in the cascade effluent at the location of the existing sampling point. EPA methods require isokinetic sampling for particulates. According to PGDP radiochemistry personnel, the chemical and physical properties associated with the gaseous

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diffusion process preclude particulate formation in the C-310 stack. The existing C-310 sampler does not provide isokinetic extraction because of the contention that the effluent at the point of sampling is a gas. Effluent gases do not require isokinetic sampling. The project was performed by a subcontractor experienced in stack sampling. Results of the project indicated that there was no particulate activity. Therefore, no isokinetic sampling system is required.

Stack effluent sampling was also performed on other exhausts with the potential to emit cascade gases. In November 1991 and February 1992, personnel from the Oak Ridge K-25 Site sampled the effluent from the C-360 toll transfer and sampling building, pigtail exhaust stack, the C-337 process building wet air/seal exhaust stack (a common stack), the C-331 process building seal exhaust stack, and the C-331 wet air stack. Results of this sampling project will indicate emissions from other similar cascade effluents in other buildings. Results of this project indicated detectable but minute quantities of uranium in the C-331 wet air exhaust and plutonium in the C-337 wet air/seal exhaust stacks. Air dispersion modeling of these emissions resulted in an annual dose of only $2.8\text{E-}5$ mrem. All other emissions in this study were not distinguishable from zero. These stacks are scheduled to be resampled in 1997.

8.2.7 Clean Air Act Amendments of 1990 Activities

The Clean Air Act Amendments of 1990 (the act) resulted in sweeping changes to the existing air pollution regulation. In general, the act is divided into eight titles, three of which have significant impact on PGDP activities.

8.2.7.1 Title III: Hazardous Air Pollutants

This section of the act lists 189 pollutants as hazardous air pollutants (HAPs) and requires the EPA to promulgate a list of source categories that emit these pollutants. The EPA is also required to establish an emission standard for each of the source categories that results in a maximum degree of reduction in emissions of the respective HAP. The following list contains the primary source categories

and the scheduled promulgation dates of implementing regulations that could affect operations at PGDP.

Source category	Scheduled date
Industrial boilers	11/15/2000
Stationary internal combustion engines	11/15/1997
Flat wood paneling (surface coating)	11/15/2000
Large appliance (surface coating)	11/15/2000
Metal coil (surface coating)	11/15/2000
Miscellaneous metal parts and products (surface coating)	11/15/2000
Plastic parts and products (surface coating)	11/15/2000
Printing/publishing (surface coating)	11/15/1994
Municipal landfills	11/15/1997
Site remediation	11/15/2000
Solid waste treatment, storage, and disposal facilities	11/15/1994
UF ₆ production	11/15/2000
Halogenated solvent cleaners	11/15/1994
Industrial process cooling towers	11/15/1994
Paint stripper users	11/15/2000
Wood treatment	11/15/1997
Asbestos processing	11/15/1994

In response to Title III, the PGDP Air and Water Policy Department has issued a 3-year plan for the reduction of HAP releases from PGDP. This plan outlines HAP emission reduction at PGDP primarily from the elimination of the degreasing agents TCE and methyl chloroform (1,1,1-TCA) and from the elimination of the chromium-based corrosion inhibitor used in the gaseous diffusion RCW system. PGDP expects to discontinue use of these HAPs by the end of CY 1994.

8.2.7.2 Title V: Permits

This section of the act establishes a federal permitting program. Prior to the passage of the amendments, states had the option of establishing a permitting program. The Commonwealth of Kentucky, through the Kentucky Division for Air Quality, established a permitting program and issued an operating permit to PGDP in 1985. This section of the act requires the EPA to establish the minimum requirements for a permitting program. Each state must establish a program that contains the minimum requirements stated in the act. For any state that does not have an EPA-approved permitting program, the EPA is required to establish and enforce a permitting

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program for that state. This section also requires the states, as part of the permitting program, to establish emission fees of not less than \$25.00 per ton of regulated pollutant per year, unless the EPA determines that a lesser amount is adequate to operate the state's permitting program. To ensure compliance with Title V of the act, PGDP has completed a stack/vent survey that identified all emission points. Future regulations specific to the emission points will determine permit applicability for each point. Emission estimates have been calculated to help determine future budgetary requirements for the emission fees.

8.2.7.3 Title VI: Stratospheric Ozone Protection

This section of the act requires the EPA to promulgate regulations to protect the stratospheric ozone. Recent studies have indicated that the release of certain ozone-depleting substances (ODSs) such as CFCs, hydrochlorofluorocarbons, halons, carbon tetrachloride, and methyl chloroform (1,1,1-TCA) destroy stratospheric ozone. This stratospheric ozone layer protects the environment from harmful ultraviolet rays that may cause an increase in skin cancer, cataracts, and other harmful effects. In the act, the EPA is required to mandate phasing out the manufacture of class I ODSs by 2000. However, a presidential executive order accelerated this phaseout to 1995. Furthermore, the EPA is required to promulgate regulations that prohibit the intentional venting of ODSs during maintenance activities and that require warning labels on substances containing and/or manufactured with ODSs. In response to proposed rules that would implement the requirements of the act, PGDP has established a CFC-114 replacement program manager whose primary responsibility is to identify a replacement for the CFC-114 that is used as heat transfer media in the gaseous diffusion cascade. One replacement candidate, C₄F₁₀, has been tested in a cascade cell

with promising results. PGDP Air and Water Policy personnel also met with EPA Headquarters personnel in February 1993, to discuss compliance problems relating to the prohibition of intentional venting, which is inherent with the gaseous diffusion process. The EPA was receptive to the PGDP issues and indicated that it would consider PGDP's compliance difficulties when issuing the final rule. PGDP has also contacted EPA personnel in charge of regulation development and enforcement to determine the applicability of the labeling requirements to activities at PGDP. The PGDP garage has purchased an ODSs recovery unit for motor vehicle air conditioners, and mechanics have been certified as required in maintenance activities performed on motor vehicle air conditioners. Refrigeration maintenance is complying with the requirements of the act by using ODSs recovery equipment on refrigeration systems at PGDP.

8.3 References

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9. Solid Waste Management Program

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9. Solid Waste Management Program

9.1 Description

9.1.1 Purpose

The Solid Waste Management Program at the Paducah Gaseous Diffusion Plant (PGDP) is designed to protect the environment, the public, and on-site personnel through the proper management of solid wastes generated by plant operations and eventually to dispose of the wastes in an environmentally acceptable manner. A “cradle-to-grave” system provides management services for all types of waste from the point of generation through ultimate disposal. The system ensures that wastes are managed in accordance with state and federal regulations; U.S. Department of Energy (DOE) Orders 5480.3, 5400.3, 5820.2A, and 5480.1B; and accepted industry practices. In addition to waste disposal, the program includes efforts to minimize the quantities of wastes generated and to treat wastes to reduce volume and toxicity.

In addition to the day-to-day waste management activities, the Solid Waste Management Program must anticipate future needs in both the technical and regulatory areas. Staff members provide technology development and regulatory review services to ensure that the program remains in compliance, that future waste management needs are anticipated, and that proper planning in response to these needs occurs. These efforts are coordinated with personnel at the other DOE Oak Ridge Operations Office sites to facilitate the consolidation of work and the enhancement of communication among sites.

9.1.2 Regulatory Review

The Resource Conservation and Recovery Act (RCRA) regulates the generation, storage, transportation, treatment, and disposal of hazardous

wastes; air emissions of organic sources from permitted units, including piping, process vents, and so forth; and facilities involved in these activities. The state of Kentucky has been authorized by the U.S. Environmental Protection Agency (EPA) to administer specific sections of RCRA in lieu of the federal program. This authorization has resulted in the promulgation of regulations in the Kentucky Administrative Regulations (KAR). The state also administers the disposal of sanitary and inert wastes through regulations published in the KAR. PGDP is subject to most of the requirements of these regulations; however, radioactive wastes such as source, special nuclear, and by-product materials are exempt from RCRA regulation by the Atomic Energy Act of 1954. The hazardous components of mixed waste (i.e., hazardous wastes containing radionuclides) are regulated by RCRA.

Wastes containing polychlorinated biphenyls (PCBs) are regulated by the Toxic Substances Control Act (TSCA). As in the case of mixed wastes, PCB wastes containing radionuclides are also managed under TSCA. PCB wastes containing hazardous wastes are managed in accordance with RCRA and TSCA by application of the more stringent regulation.

The Clean Water Act (CWA) and the Clean Air Act do not directly affect solid waste management activities; however, the operation of waste management facilities must not adversely affect the ability of PGDP to comply with these regulations. Such compliance is also planned for in accordance with the National Environmental Policy Act requirements, one of which is that the environmental impacts of plant projects be considered during the project planning process.

DOE has issued orders establishing policies in waste management areas. DOE Order 5632.1A

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prescribes requirements for the physical protection of classified wastes. DOE Order 5400.3 addresses the management of hazardous and mixed wastes at DOE facilities and directs that such wastes will be managed in an environmentally acceptable manner. Low-level radioactive wastes (LLW) without hazardous or toxic constituents are regulated under the federal Atomic Energy Act. These wastes are managed under DOE Order 5820.2A, which was issued in September 1988. This order establishes handling and disposal policies and a waste classification system to be implemented throughout DOE.

9.1.3 Compliance Activities

Hazardous waste facilities at PGDP are operated under permitted status granted by the state of Kentucky (facility EPA ID KY8890008982). The Part B permit has been issued for the 5 storage and 15 treatment units on the plant site.

9.1.4 Program Strategy

Proper identification, characterization, and classification of waste materials is essential for ensuring that waste management activities are performed safely, efficiently, and in compliance with regulations and policies. This is an ongoing process that must react to changes within the plant and to changes in regulations and policies beyond the control of plant management. A system of administrative controls assigns responsibilities for waste handling activities and specifies criteria that must be met before a waste is accepted by the Waste Management Operations Department. These controls include plantwide standard practice procedures; job-specific standard operating procedures; waste sampling, analysis, and handling requirements of the facility Part B Permit; and other requirements. For wastes not handled through the Waste Management Operations Department (such as process wastes discharged directly from a treatment unit), a system of administrative controls and, in some cases, physical controls (e.g., valve lockouts, etc.) are used to ensure that the waste is properly characterized prior to discharge. The primary control in these instances is the Kentucky Pollutant Discharge Elimination System permit under the CWA. RCRA characterizations are performed periodically on these

wastes at the point of generation and, where necessary, following treatment.

To facilitate waste management activities, a new Generator Waste Management Program was developed. The program, implemented in 1990, focuses on the proper identification, segregation, and packaging of wastes at the point of generation. Following completion of a successful pilot program in the C-720 maintenance and stores building area, a plantwide waste generator tracking program has been implemented, and training of PGDP personnel was completed in September 1991. A less rigorous training course will be given to generators on an annual update basis.

PGDP operates a program to minimize the amount of waste being generated. Under the direction of the Plant Waste Minimization Program manager, a team of waste management, technical, operations, and maintenance personnel is charged with identifying opportunities and strategies for waste minimization and coordinating efforts to accomplish these strategies. Where possible, avoiding or minimizing waste is to be accomplished through process changes that eliminate the waste stream or recycle it back into use. Given the nature of the processes at PGDP, however, opportunities for waste elimination and recycling at the source are limited.

Other options include reducing waste stream toxicity and hazard through the use of less toxic or hazardous raw materials, or limiting the use of toxic and hazardous materials. For example, limiting the use of trichloroethylene (TCE) to large degreasing units and using less toxic solvents in the field has reduced the quantity of hazardous waste requiring disposal. Installing new treatment processes or modifying existing processes can also reduce waste stream toxicity and volume. Segregating waste materials to reduce the volume of hazardous or radionuclide-contaminated materials requiring special handling and disposal is a common practice.

Several options are available for waste disposal. Some wastes are treated and disposed of directly (e.g., the neutralization of waste acids). Sanitary and inert wastes are also disposed of on-site. Some types of hazardous and PCB liquid wastes are capable of being incinerated at the K-1435 TSCA incinerator located at Oak Ridge, Tennessee. All off-site disposal facilities must meet RCRA and TSCA regulatory requirements. Some wastes (such as mixed and

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low-level radioactive wastes) must be placed in on-site, long-term storage until treatment or disposal technology is developed and demonstrated.

PGDP has prepared a plan including projects and budget requirements for waste management activities needed to ensure regulatory compliance. As part of the overall DOE effort (PGDP February 1990), this plan (discussed in Subsect. 4.4.2) is to be used as a program strategy document. Projects for waste minimization and new storage, treatment, and disposal facilities are part of the plan. PGDP also generates, or has generated in the past, several wastes that cannot be treated or disposed of at this time. For the next several years, PGDP will continue identifying and evaluating technologies for treatment and disposal of these wastes.

9.2 Waste Generation

9.2.1 Types of Waste Generated

Residential. This waste category includes office, cafeteria, and similar wastes.

Inert (Industrial). Fly ash from coal-fired boilers and construction spoils make up the bulk of this category.

Hazardous. This class of wastes is defined by RCRA regulations. Hazardous wastes at PGDP include waste acids such as sulfuric and nitric acids, solutions containing metals such as chromium, and ignitable wastes such as paint solvents. Other hazardous wastes include TCE and various laboratory chemicals.

Mixed. These wastes consist of RCRA hazardous wastes contaminated with radionuclides. Uranium is the most common contaminant.

PCBs. All wastes containing more than 50 parts per million (ppm) of PCBs by weight and wastes resulting from PCB spill cleanup operations are handled as PCB wastes. Waste containing detectable (i.e., >1 ppm in soil, >0.5 ppb in water, and >2 ppm in oil) PCBs are disposed of as PCB wastes but are not classified as such.

PCB/radioactive. This category consists of PCB wastes (as defined in the preceding paragraph) that are contaminated with >50 ppm depleted U and/or detectable Np, Pu, Th, and/or Tc.

Transuranic. These wastes contain more than 100 nCi/g of transuranic radionuclides. The most

common radionuclides are ²³⁹Pu and ²³⁷Np. A small quantity of this type of waste is stored at PGDP. This waste is not currently produced at the plant.

Low-level radioactive. This category consists of any nonhazardous, non-PCB or PCB-contaminated waste that contains radioactivity and is not classified as high-level waste, transuranic waste, spent nuclear fuel, or 11e(2) by-product material as defined by DOE Order 5820.2A, "Radioactive Waste Management."

Asbestos. This waste, classified as either "clean" or "contaminated," depending on the absence or presence of uranium, consists of friable asbestos generated by plant maintenance operations.

Scrap metal. This stream, also classified as either "clean" or "regulated," consists of scrap metal generated by maintenance operations and machine shop work.

Nonhazardous. This category consists of miscellaneous wastes not fitting into one of the preceding RCRA categories. An example of this would be nonhazardous liquids not suitable for on-site disposal.

Classified. Wastes considered to contain sensitive security information are accorded special handling. Wastes in any of the preceding categories may also be considered classified.

9.2.2 Waste-Generating Activities

Utilities operations. Wastes produced during operation of plant auxiliary systems include fly ash produced by generation of steam from coal-fired boilers, sludge produced by treatment of sewage, and sludges produced by lime-soda ash softening of water from the Ohio River for process use. Sewage treatment sludges contain PCBs and uranium. The sewage sludge is drummed and stored. Another plant waste stream is blowdown from the recirculating cooling water system. The blowdown, which contains about 8 ppm chromium, is hazardous and is treated to remove chromium. PGDP is changing the recirculating cooling water system blowdown from chromium to a nonhazardous phosphate-based inhibitor. The changeover would be completed in CY 1993.

Chemical operations. The majority of the low-level radioactive waste produced at PGDP is produced by the Chemical Operations Department. The major contaminant is uranium; trace quantities of

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^{99}Tc , ^{237}Np , ^{230}Th , and ^{239}Pu are also present. The largest low-level waste stream is filter cake produced by lime precipitation treatment of spent decontamination, cylinder wash, and laboratory waste solutions. Smaller amounts of other low-level wastes include contaminated floor sweep, articles of clothing, small parts, and supplies.

Some hazardous wastes are also produced by the Chemical Operations Department. These include spent TCE used in degreasing, and waste from a small-parts nickel-deplating process. The lime precipitation process waste is occasionally a mixed waste.

Fabrication and maintenance. Maintenance activity is generally divided into two types—shop and field. Shop activities include major equipment repair, rebuilding and construction, metal machining, forming and welding, instrument repair, carpentry, and painting. Scrap metal, both clean and contaminated, is produced by shop activity. A variety of machining fluids (usually oils), lubricating oils, and cutting fluids are used. Most wastes produced from these materials are nonhazardous. Small amounts of spent chlorinated solvents, including TCE and 1,1,1-trichloroethane, are produced by degreasing operations. Other hazardous wastes include painting wastes, which are hazardous because of their ignitability. Most other wastes, such as scrap wood, boxes, and other containers, are classified as nonhazardous sanitary or industrial waste.

Waste lubricating oil forms a large-volume waste stream produced by field maintenance activities. The oil is classified as hazardous, nonhazardous, or contaminated, depending on the chlorinated solvent or radionuclide content. Clean and contaminated asbestos wastes result from repair of systems such as steam-heating systems that were insulated during plant construction. Clean and contaminated scrap metal, nonhazardous construction debris, PCBs and PCB-contaminated wastes, and waste oils also are produced at PGDP through maintenance activity.

Laboratory operations. Small quantities of hazardous, nonhazardous, low-level radioactive, and PCB wastes are generated by laboratory operations. The bulk of the wastes are residues or leftovers from analytical work. Uranium-salvage solutions are mixed waste. Waste oils, solvents, and other organic materials are also hazardous wastes, as are discarded laboratory chemicals.

Environmental restoration activities. PGDP has begun an extensive Environmental Restoration Program designed to investigate the present groundwater contamination problem and on-site waste management units and spill sites. Drill tailings, grout, equipment wash water, and water from sampling activities are being generated along with personal protective equipment and are managed in accordance with regulations and plant procedures.

9.2.3 Waste Generation Summary

Table 9.1 summarizes the waste generated on-site during 1992. The types of waste are described in Sect. 9.2.1. The quantities are indicated in the table.

The most significant change in waste generation rates occurred in the LLW, hazardous, and mixed waste areas. The increase in the hazardous and mixed waste categories stored on-site was primarily a result of the off-site shipment moratorium imposed by DOE in the spring of 1991. Most waste streams within PGDP have the potential to be considered LLW because lower limits have not been established. Until a lower limit for LLW is established, all RCRA, TSCA, and LLWs will continue to be stored on-site. Waste characterization procedures are being developed to identify radioactive contamination in RCRA and TSCA waste streams at PGDP.

9.3 Waste Management Activities

9.3.1 Waste Management System

Containerized wastes and wastes requiring off-site disposal are managed by the Waste Management Operations Department. All wastes are required to have a request-for-disposal form completed before they can be moved. This form functions as an internal manifest. If information on the form is insufficient, the waste is sampled and characterized before being disposed of or stored. Characterization is routinely performed on several waste streams in accordance with the Waste Analysis Plan in the facility Part B permit; off-site disposal facility requirements; general RCRA, TSCA, and CWA requirements; and other criteria set forth by DOE and internal procedures.

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Table 9.1. 1992 PGDP waste generation summary

Waste type	Volume (ft ³) ^a	Mass (lb)
Low-level radioactive	17,657	857,143
Polychlorinated biphenyl/mixed ^b	8,730	366,720
Hazardous/mixed	5,728	241,237
PCB/hazardous/mixed ^b	1,056	46,132
Residential	37,661	<i>d</i>
Inert ^c	10,567	<i>d</i>
Scrap metal	15,876	<i>d</i>

^aIncludes only characterized wastes. Wastes in accumulation areas and wastes that have not been characterized are not included.

^bPCB contribution to waste type is based on preliminary data and is subject to change.

^cOpen only 6 months of 1992.

^dNot applicable.

Once a waste has been properly identified and characterized, it is packaged for shipment or placed in storage. U.S. Department of Transportation (DOT) criteria are used to select containers such as drums. Small quantities of chemicals are lab-packed by either PGDP personnel or off-site disposal facility personnel.

Wastes are managed at several on-site facilities. Residential and industrial waste, clean scrap metal, clean asbestos, and treated medical wastes are disposed of at the on-site landfill. Some hazardous wastes are treated to render them nonhazardous prior to disposal. Some low-level radioactive wastes are treated to reduce their volume. Clean (i.e., without technetium, uranium, or transuranic contamination) PCB and hazardous wastes are disposed of off-site at inspected and permitted incinerators. Off-site landfills are used only under special circumstances. Some wastes, such as mixed and PCB/radioactive wastes, cannot be disposed of and are placed in indefinite storage. Medical wastes are treated by autoclaving. They are then packaged in containers appropriate for the type of waste and are disposed of in the residential landfill.

All waste management units are operated in accordance with appropriate regulations. Hazardous, mixed, PCB, PCB/mixed, and low-level wastes are tracked and accounted for using a computerized inventory system. Each container is assigned a unique identification number that is entered into a computer data base. Bulk liquids are inventoried at the time they are placed in tanks. Quantities of other wastes are estimated.

Wastes not managed by the Waste Management Operations Department are discharged directly from treatment units or activity areas. Such wastes are routinely characterized to ensure that they are being properly handled.

9.3.2 Waste Management Facilities

A number of waste management units are located on the PGDP site. Each unit handles a limited number of types of waste. Units are grouped according to three general types—storage, treatment, and disposal. Table 9.2 shows the 1992 waste treatment data; Table 9.3 shows the 1992 on-site disposal information. The PGDP waste management units are listed in the following subsection.

9.3.2.1 RCRA Hazardous and Mixed Waste Facilities

9.3.2.1.1 RCRA-permitted units

C-733 hazardous waste storage area. A diked, roofed storage area for container and tank storage. PGDP stores ignitable wastes in this building. Capacity is approximately 160,860 L (42,500 gal).

C-746-Q hazardous waste storage and treatment area. A diked, totally enclosed area for container storage and treatment of fluorescent and incandescent lamps. No ignitable wastes are to be stored in the area. Capacity is approximately 934,000 L (246,800 gal).

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Table 9.2. 1992 PGDP waste treatment

Waste type	Quantity (ft ³)	Treatment
Uranium salvage (hazardous mixed)	88.8	Neutralization/ precipitation
Machine coolant (nonhazardous)	0.0	Coagulation/ filtration

Table 9.3. 1992 PGDP on-site waste disposal

Waste type	Disposal method	Quantity (ft ³)
Residential	Landfill	37,661
Inert ^a	Landfill	10,567

^aOpen only 6 months of 1992.

C-746-R waste solvent storage area. A diked area used for the temporary storage of drummed waste oils during sampling activities. Some mixed, hazardous, and PCB residues are also stored in tanks and at C-746-A.

C-746-A hazardous waste storage and treatment area. A diked, totally enclosed area for container storage and treatment of fluorescent and incandescent lamps. This building is also used to store PCB wastes.

C-400-B waste solution storage tank. A 18,900-L (5000-gal) stainless steel storage tank. The tank is contained in a concrete, stainless steel-lined containment area. To date, the tank has never been used.

C-400-C nickel stripper evaporation unit. A hazardous waste treatment unit. Nickel stripper solutions are evaporated in a 454-L (120-gal) stainless steel steam-heated tank.

C-400-D lime precipitation tank. A 16,250-L (4300-gal) stainless steel tank used for neutralization and metals precipitation.

C-409 hazardous waste pilot plant. Used for technology development work and limited treatment and disposal of small quantities of hazardous wastes.

recirculating cooling water blowdown. This is a RCRA "permit-by-rule" facility.

C-403 neutralization pit. An inground pit used as a holding basin for wastewater from the C-400 building. It has limited use as a permit-by-rule elementary neutralization unit.

C-410-C hydrofluoric neutralization building pit. An inground pit used for the neutralization of spent battery acids and fluorine cell electrolytes. This is a permit-by-rule elementary neutralization unit.

9.3.2.2 PCBs and PCB/Mixed Waste Facilities

C-746-A storage area. A storage area located in the C-746-A warehouse. The area is diked and has a capacity of approximately 7440 drums. PCB and PCB/mixed wastes are stored here. The area also contains hazardous wastes.

C-746-B south warehouse and C-337 and C-333 process building waste storage areas. Container storage areas located in the C-746-B warehouse and the C-337 and C-333 process buildings. These areas are lined and diked with a synthetic material meeting EPA requirements. Approximately 12,000 drums can be stored in these areas.

9.3.2.3 Nonhazardous Waste Management Areas

C-746-S new sanitary landfill. Used for the disposal of sanitary trash. The residential landfill comprises three cells. One cell has been closed and capped, the second cell is nearing its capacity, and the third cell has been fully constructed. PGDP is awaiting final authorization from the Kentucky Division of Waste Management to begin operation of the third cell.

C-746-T inert landfill. Used for disposal of fly ash, clean asbestos, and construction debris. This landfill ceased operations on June 30, 1992, in accordance with state landfill regulations and has been closed and capped. PGDP will now begin to conduct post-closure care of the unit.

9.3.2.1.2 Permit-by-rule facilities

C-616 chromium reduction facility. A wastewater treatment unit used to remove chromium from the

9.3.2.4 Scrap Metal Facilities

C-746-P1 west clean scrap metal yard. Used for accumulation of clean scrap metal for resale.

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C-746-P east regulated scrap yards. Used for storage of scrap metal containing nontransferable radioactive contamination.

9.3.2.5 Low-Level Radioactive Waste Facilities

C-333 LLW storage area. Located within the C-333 process building, which is enclosed. Approximately 5500 drums may be stored here.

C-746-M waste uranium chip storage facility. A diked, totally enclosed drum storage area with a capacity of approximately 60 drums. The area currently contains drums of nonhazardous waste.

C-745-K storage area. A graveled area adjacent to the UF₆ cylinder yards. Over 900 steel 55-gal drums of LLW are stored here. In addition, a portion of this area is a concrete pad for storing redwood from cooling tower construction.

C-335 criticality storage area. Restricted storage requirements limit this area to a storage capacity of 147 drums.

C-746-B south warehouse LLW storage area. This area has a capacity for 870 drums.

C-301 LLW storage area. This area has a capacity for 2000 drums.

9.3.3 Off-Site Waste Disposal Activities

Incineration is the preferred method for off-site treatment/disposal of waste. Landfills and other types of disposal are used only on a limited basis under special circumstances. All commercial sites are visited and approved annually by Martin Marietta Energy Systems, Inc., personnel prior to use. These

visits are used to inspect the facilities and to review management, permit, and insurance information. No radioactive wastes are shipped off-site except to DOE facilities. In September 1992, PGDP made the first shipment of LLW from Energy Systems to the DOE Hanford Site for disposal. A second shipment is scheduled for 1993.

Off-site treatment/disposal is arranged for by the Waste Management and Purchasing departments. Unless special circumstances warrant other arrangements, all such disposals are awarded to the qualified contractor with the lowest bid. Commercial transporters or transportation provided by the waste management firm are used to move the waste from the PGDP site. Table 9.4 shows the off-site waste treatment/disposal quantities for 1992.

All containers of waste must meet DOT shipping requirements. Packages are inspected and inventoried prior to shipment.

9.3.4 Waste Placed in Storage

In some cases wastes are accumulated to provide for cost-effective off-site disposal. These wastes are placed in storage. In some cases waste generated in 1992 will be retained on-site in storage until suitable disposal options are available. Several waste streams, including hazardous/mixed and PCB/mixed wastes, cannot now be disposed of by any means. These wastes are covered by Federal Facility Compliance Agreements (FFCAs) with EPA Region IV. Both FFCAs contain provisions for development and deployment of appropriate treatment and disposal technologies. These wastes are placed in long-term storage on-site.

Table 9.4. 1992 PGDP off-site waste disposal

Waste type	Disposal method	Quantity (lb)
PCB/mixed ^a	Incineration	51,100
PCB transformers	Resource recovery	0
Hazardous	Incineration	0
PCB/hazardous/mixed	Incineration	20,840
Hazardous/mixed	Incineration	21,660

^aPolychlorinated biphenyl.

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9.3.5 Special Activities

9.3.5.1 Waste Generation Program

To improve regulatory compliance and reduce costs associated with waste management activities, a waste generation program was developed and implemented plant wide. The program established waste identification, segregation, packaging, and management standards for waste generators. The program has reduced the presence of unidentified waste containers, improved waste segregation practices, and prevented buildup of wastes in generation areas. All PGDP personnel have received

waste generator training, including new employees and subcontractors. Waste generator handbooks, which are easy reference guides for handling waste, were issued to all personnel.

9.4 Reference

Paducah Gaseous Diffusion Plant (PGDP). February 14, 1990. *Environmental Restoration and Waste Management Site-Specific Plan for Oak Ridge Operations Office, Paducah Gaseous Diffusion Plant* (final draft), KY/H-104, Paducah, Ky.

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10. Quality Assurance

Quality assurance (QA) planning is integrated into every step of the environmental surveillance and monitoring effort at Paducah Gaseous Diffusion Plant (PGDP). Contributors are totally responsible for the quality of their contributions. Developed and evolved over many years of such activity and careful study of appropriate regulatory guidance, the surveillance and monitoring programs can be roughly divided into three major efforts: sampling of the environment, analysis of the samples, and treatment or interpretation of the results.

The Analytical Laboratory Department and the Quality Support Section of the Technical Services Division, in cooperation with the Environmental Sampling Section of the Environmental Services Department, implemented two quality control programs to monitor the quality of analyses of surface water and groundwater samples. These programs use purchased certified standard materials prepared by the Quality Support Section that are submitted according to regulatory guidance to the laboratory groups performing the analyses. Program results are used to assess laboratory performance and to provide more immediate feedback to analysts and customers involved in the programs. The following paragraphs highlight the significant additions to the programs in each section that affect the quality of data or PGDP's overall capacity to provide additional information on environmental activities.

The Technical Services Division has employed two procedure writers matrixed from the Procedures Management Department to coordinate and assist in the development and revision of QA and quality control (QC) procedures so that they comply with plant procedures and policies.

The Quality Support Section provides surface water monitoring controls and groundwater monitoring controls and routinely issues summary

reports to inform lab supervisors and managers of the data quality measurements in the Technical Services Division. The section has upgraded their computer equipment and enlisted the efforts of a statistician to improve computer programming for the evaluation of the data packages. Control charts and trend analysis evaluations complete the statistical evaluations of data.

A project begun in 1991 was completed, and implementation began to incorporate requirements from U.S. Department of Energy (DOE) orders 5400.1 and 5400.5 and DOE/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, as they relate to the Environmental Monitoring Plan (EMP) at PGDP. The EMP was drafted over several years and was approved by DOE in July 1992. Also considered in this project were the Tiger Team findings on air, groundwater, QA, and radiation monitoring. The specific purpose of the project was to analyze the functional responsibilities being coordinated among the Environmental Compliance, Monitoring, and Restoration departments to expedite implementation of the EMP at PGDP. The following benefits were expected from the project:

- better use of the timetable being imposed by Martin Marietta Energy Systems, Inc., Environmental, Safety, and Health Central Staff;
- improved program management and better defined oversight responsibilities;
- enhanced communication among departments in meeting objectives;
- increased efficiency of data review for technical interpretation and reporting; and
- better allocation of available resources for the EMP and the Agreement In Principle with the state of Kentucky.

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The recommendations of this project resulted in the formation of the Environmental Monitoring Department (EMD) in the Environmental, Safety, and Health Division (now the Environmental Management Division). The Environmental Services Department from the Technical Services Division and personnel in the compliance organization were transferred to the monitoring organization where responsibilities were related to DOE order implementation. General responsibilities of the EMD are

- EMP programs (sampling, QA, data management),
- environmental monitoring plans,
- Agreement In Principle coordination for monitoring,
- Annual Environmental Report,
- Environmental Information Management System,
- Internal reporting of environmental data,
- dose assessments,
- input to Sampling and Analysis Plan development, and
- technical support.

Sixty-seven positions were identified in the final project report. The actual number requested was 43 based on known budget restraints. The project team decided that a staff of 43 was adequate to begin implementation. The ideal personnel projection of 67 provided guidance on how to use personnel as funds became available. Because of the reduced levels of staffing, several roles would either not be filled or be partially filled. Surveillance and screening activities would not be increased. Special projects and increased work loads were not planned. Projections for data validation activities were extended into the future. Oversight of external laboratories would not be included.

The resulting organization was aligned according to pathway-related programs in the EMP. Figure 10.1 shows the current organization and responsibilities for the 34 persons and 9 vacancies in the department. From January 1992 to May 1993, there were 16 new hires and 4 transfers added to the 14 existing personnel. The department manager is responsible for financial, technical, and staffing direction and is supported by a secretary responsible for coordinating required reading, Lockout/Tagout training, general training tracking, and Department of Transportation documentation along with normal secretarial duties. Six program managers support the department head

in major areas. All of the program managers or coordinators have staff reporting to them.

The department acquired three trailers to store and organize sample containers. The number of persons having direct access to sample containers was reduced. A Total Quality Management/Cycle Time Reduction study was performed on the Polychlorinated Biphenyls Cleanup Verification Program. This led to defining "TSCA [Toxic Substances Control Act] Good Faith Effort" deadlines for cleanup verification sampling. All deadlines are being met. Additional personnel in all programs attended 40-h Hazardous Material Training and certification, enhancing the health protection and utility of department personnel. Fireproof cabinets were purchased to protect environmental documentation such as field notebooks and chain-of-custody information.

The department also received two mobile laboratories in CY 1992. These self-propelled laboratories will be used as staging areas for major sampling events as well as for certain routine activities. The mobile labs also provide a controlled environment for employees to recover from environmental exposure during adverse weather conditions in remote sampling locations. In addition, laboratory and office space for the staging of groundwater and surface water monitoring activities were acquired during the year. This additional space was required to house the increased staff and to provide additional fixed laboratory space for field monitoring activities.

Although several of the new functions and activities previously noted are not fully implemented, EMD has made substantial progress during this year of change. FY 1993 promises to build on these accomplishments and enhance the effectiveness of the organization.

10.1 Field Sampling and Monitoring

10.1.1 Basic Concepts and Practices

From the point of conception of any sampling program, QA plays an important role. Each monitoring or sampling organization plans a project, sets objectives, identifies responsibilities, and selects sampling methods and the appropriate sampling

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Fig. 10.1. Environmental Monitoring Department organization chart.

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instruments or devices according to use and cleaning practices recommended by the American Society for Testing and Materials, the U.S. Environmental Protection Agency (EPA), or other established authorities. The number of samples, location of sampling sites, sampling methods, sampling schedule, and coordination of sampling and analytical resources to meet critical completion times must all be decided. The rationale for these and other decisions is mainly the responsibility of the sampling organization, receiving input from compliance and analytical organizations. Sampling plans and field documentation are prepared as needed.

Chain-of-custody documentation is maintained from the point of sampling, and samples are properly protected until they are placed into the custody of analytical laboratory control programs. In the laboratory, chain-of-custody procedures are followed until the sample is analyzed. For hazardous waste samples, chain-of-custody procedures are maintained to the point of sample disposal. The performance of all field analytical procedures is documented using EPA-approved methods when available. These procedures are listed in Table 10.7 in Part 2.

10.1.2 External Gamma Monitoring

Monitoring for gamma radiation is mandated by U.S. Department of Energy (DOE) Orders 5400.1 and 5400.5 along with other published guidelines (DOE 1991). Guidance for procedures has also been published (ANSI 1975). The calibration, preparation, and analysis of PGDP thermoluminescent dosimeters is performed by Oak Ridge National Laboratory (ORNL).

10.1.3 Air Monitoring

The design of the ambient air samplers is based on an internal study that determined the efficiency of potassium-carbonate-impregnated filter paper for collecting gaseous fluorides. The procedure requires that flow be measured using a calibrated flow meter. If the flow drops by more than 40% of the initial reading, the sample is not used. This procedure helps to ensure that reported data accurately reflect plant emissions. Air filter sampling data are recorded in the field logs and in the chain-of-custody logs, and they are entered into the computer system. Analytical

procedures are listed in Table 10.1 in Part 2. (See Tables 10.21 and 10.22 in Part 2 for QC data.)

10.1.4 Water Monitoring

Water sampling is conducted both for PGDP's information and to meet regulatory requirements. Procedures have been written for surveillance sampling and for Kentucky Pollutant Discharge Elimination System (KPDES) permit sampling. Guidance for developing these procedures has been codified (40 CFR 136.3) and may also be found in other applicable sources. Records are kept in the field logs and in the chain-of-custody logs and are entered into the computer system. The chain-of-custody logs also record the subsampling (i.e., a procedure by which aliquots of a sample are divided for specific analysis) and preservation of each sample. The chain-of-custody logs are stored in the Environmental Sampling office. The analytical procedures for these samples are listed Tables 10.2, 10.3, and 10.7 in Part 2. (See Tables 10.8 through 10.21 in Part 2 for QC data.)

10.1.5 Groundwater Monitoring

Water samples from plant wells are collected according to written procedures based on published guidelines (EPA 1987). Field measurements used for reporting analytical data are taken using calibrated instruments to ensure accurate data. Records for wells are kept in the field logbook and in the chain-of-custody logs and are entered into the computer system. The chain-of-custody logs also record subsampling and preservation for each sample. The analytical procedures for these samples are listed in Tables 10.2, 10.3, 10.6, and 10.7 in Part 2. (See Tables 10.8 through 10.21 in Part 2 for QC data.)

10.1.6 Biological Monitoring

Biological monitoring consists of quarterly grass sampling from the surrounding area to determine levels of fluoride concentrations and annual sampling of wildlife, vegetation, and food crops for radioactive analytes. Analytical procedures for these samples are listed in Table 10.4 in Part 2.

10-6 Quality Assurance

10.1.7 Soil and Sediment Sampling

Samples of soil and sediment are collected according to published procedures (Jett 1992; Watson 1989). No field measurements are taken in these sampling procedures. Background soil and sediment samples are used to establish the baseline from which the plant's contribution of contaminants can be calculated. As a QC check on the accuracy of the data, ^{40}K in the samples is analyzed. Because ^{40}K levels are not affected by plant operations and are analyzed by the same method as the other parameters, any deviation from expected values indicates procedural problems. Records are kept in the field logs and the chain-of-custody logs and are entered into the computer system. The analytical procedures for these samples are listed in Table 10.5 in Part 2.

10.1.8 Solid Waste Monitoring, Site Characterizations, and Spill Cleanup

Solid waste sampling and characterizations are conducted to ensure that storage and disposal of solid wastes is in accordance with the Toxic Substances Control Act (TSCA), the Resource Conservation and Recovery Act (RCRA), and DOE Order 5820.2A. Sampling at spill sites is conducted to quantify the magnitude of the spill and to verify cleanup in accordance with applicable regulations. Site characterizations and surveys are performed to ascertain the regulatory status or continuing status of specific areas and to ensure that any wastes resulting from activities in these areas are properly managed.

Requests for both routine and special sampling and characterizations are issued by environmental management and waste management personnel. Specific activities include sampling and characterization of containerized wastes, lagoons, certain waste streams at the point of generation, and construction sites. QA/QC in support of these efforts includes the use of precleaned sample containers, collection of equipment field blanks and field duplicates, and the use of statistically based sampling plans, where possible.

Guidance for sampling and characterization is obtained from EPA documents (EPA 1987) and from other applicable regulations. Records are maintained in field logs, laboratory notebooks, chain-of-custody notebooks, and the AnaLIS data management computer system. Results from RCRA evaluations of

waste streams and special RCRA evaluations are summarized in quarterly, semiannual, and annual reports.

10.2 Analytical Quality Assurance

The analytical laboratories of PGDP continue a long tradition of QA. Such terms as sound methodology, safe practices, analytical recovery, and QC are well defined. Also well established is the use of statistical methods to establish precision, accuracy, lowest concentration reported (LCR), and minimum detection level (MDL). Since the beginning of operations at PGDP, the laboratories have been involved in the handling and analysis of hazardous materials, materials for which strict accountability is required, and materials of high purity. QA is, therefore, a daily responsibility.

After receiving the samples from the sampling group or the sample transporter, the laboratory custodian assumes responsibility for proper protection and handling of the samples. Using guidance from the EPA, the laboratories document the steps in handling, analysis, and approval of results. The performance of all analytical procedures is documented using EPA-approved methods when they are available. These procedures for air, water, soil, sediment, biota, and groundwater (with traceability to EPA methods) are listed in Tables 10.1 through 10.6 in Part 2.

A key feature in analytical QA is QC. PGDP participates in programs that are internal to the laboratory (i.e., internal controls), internal to PGDP but external to the laboratory (i.e., external controls), and external to the plant (i.e., independent controls).

10.2.1 Internal Quality Control

All analytical activities are supported by the use of standard materials or reference materials. The compositions of these materials are well known and are used in calibration of instruments, method standardization, spike additions for recovery testing, and other practices. Certified standards from the National Institute of Standards and Technology, the EPA, or other DOE laboratories are often used in such work.

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These internal programs are the mainstay of analytical QC. They are the basis for ensuring reliable results on a daily basis and between batches. The total effort in these programs is at least 10% of the total laboratory effort (in accordance with EPA expectations) and probably reaches 20% in some activities.

The internal QA and QC programs have become major factors in the environmental analysis procedures because of the low levels of pollutants measured and the relationships of these measured values to regulatory limits. These QC programs also provide for laboratory analyst training and qualification in the many procedures involved. The daily QC data are stored in a retrievable manner so they can be related to the analytical results they support. Examples of some of these programs are listed in Tables 10.8 and 10.9 in Part 2.

10.2.2 External Quality Control

The Technical Services Division has a Quality Support Section (QSS) that is functionally independent of the laboratory. QSS administers external quality control programs at the request of the analytical laboratories and their customers. Through these programs, the QSS generates QC samples of known composition and periodically submits these to the laboratory as known controls of unknown value (blind). Many of these programs include computer-generated notices for immediate feedback of performance. Formal reports summarizing statistical evaluation of data, control charts, and results of trend analyses are issued regularly. Results that exceed the 3-sigma alarm limits are investigated and documented in accordance with formal procedures.

10.2.3 Independent Quality Control

PGDP is directed by DOE and by the EPA regulators to participate in external quality control programs. PGDP also participates in voluntary external programs to provide for improved analytical QC. These programs generate data that are readily recognizable as objective measures, allowing the participating laboratories and government agencies a periodic review of performance. Although participation is mandated, the degree of participation is voluntary, so that each laboratory can select

parameters that are of particular interest to that plant. The sources of these programs are EPA, DOE, and commercial-sector laboratories. Examples are given in Tables 10.10 through 10.23 in Part 2 for both radiological and nonradiological areas. The QSS coordinates and evaluates the results of the independent QC programs discussed in the following subsections.

10.2.3.1 Environmental Protection Agency Discharge Monitoring Report Quality Assurance Program

The EPA conducts a national QA program in support of the National Pollutant Discharge Elimination System (NPDES) program. All holders of major NPDES permits are required to participate. The EPA furnishes the QC samples annually and evaluates the results. The state of Kentucky monitors PGDP's performance in this program. PGDP is required to analyze those parameters on its permit that are included in the Discharge Monitoring Report (DMR) QA Program. Other parameters may be analyzed on a voluntary basis for documentation or method checking. Table 10.10 in Part 2 shows all 12 analyses within acceptable limits.

10.2.3.2 Proficiency Environmental Testing Program

PGDP participates in the Proficiency Environmental Testing (PET) Program, a voluntary external measurement control program using samples purchased from Analytical Products Group, Inc. (APG), a commercial supplier. Samples at two concentration levels are analyzed bimonthly and reported to APG. An evaluation report is received in approximately 3 weeks. Most samples are evaluated by comparing (in standard deviations) the reported value to the mean of the reporting laboratories. Samples for dissolved and suspended solids are compared with average percent of recovery in the same way. The performance evaluation in the tables is derived using the same criteria as those in the EPA DMR QA program. The QSS maintains control charts on these analyses. Tables 10.11 through 10.16 in Part 2 present the results of the 1992 PET testing.

Measurements that have unacceptable recoveries of more than 2.58 standard deviations from the mean

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are investigated to determine the cause. Of 622 measurements, 16 were deemed not acceptable.

10.2.3.3 Proficiency Analytical Testing Program

PGDP participates in the Proficiency Analytical Testing (PAT) Program, an external measurement control program from the National Institute for Occupational Safety and Health (NIOSH). This program targets industrial hygiene analyses but also has application to environmental factors because the concerns in both fields overlap. Of 64 measurements, 1 was an outlier (Tables 10.17 through 10.20 in Part 2). The performance evaluations for these tables are provided by NIOSH. The laboratory maintained a "proficient" rating for all analyses during 1992.

10.2.3.4 DOE Environmental Measurements Laboratory Quality Assessment Program

PGDP participated in the Environmental Measurements Laboratory (EML) measurements control program as required by DOE Order 5400.1. The results are given in Tables 10.21 and 10.22 in Part 2. The performance evaluation is determined by using the three ratio ranges given in the EML report to determine "acceptable," "marginal," or "not acceptable" results. There were 3 "not acceptable" results out of the 42 results reported.

10.3 Quality Incidents

10.3.1 Environmental Protection Agency Discharge Monitoring Report Quality Assurance Program

No results exceeded the acceptable limits for this program in 1992. Program information may be found in Part 1, Sect. 10.2.3.1; data are in Part 2, Table 10.10.

10.3.2 Proficiency Environmental Testing Program

The January 1992 round of testing had one result rated "not acceptable." One control for high-level total hardness as CaCO_3 was outside the lower acceptance limit. No problems were apparent in the

internal QC for the day. After receiving an exception report, laboratory personnel reanalyzed the solution and determined the result to be 41 mg/L, which was within acceptable limits. The previous result appeared to be a duplicate analysis of the low-level solution. No change in procedure was made at that time.

The March 1992 round had five results rated "unacceptable." The ammonia as N (level 2) result was outside the control limits. Upon investigation, the vial containing the level-2 solution was found unopened. The flask from which the result was analyzed contained the ammonia solution from the previous round. That solution had been analyzed and reported in error. All technicians have been notified to make note of the date of preparation on the flask before analyzing future samples. The hardness as CaCO_3 (level 2) result was outside the high control limit for the solution. Investigation of the result indicated that calcium hardness had been analyzed on the solution instead of total hardness. Total hardness was analyzed after the error was discovered with a result of 54 mg/L, which was within acceptable limits. Three metal analyses (aluminum, arsenic, and selenium) were above acceptable limits. Reanalysis of the original aluminum solution confirmed the reported result. All QC data from the original analysis batch were acceptable. The original data also showed that results from another dilution of the original PET solution would have yielded results within acceptable limits. Isolated contamination is considered the cause of the error. Glassware cleaning has been inspected, and no system-wide problem can be identified. The problem appears to be an isolated incident. Investigation of the arsenic and selenium results indicated that the solution was analyzed on an instrument with insufficient modifier. The instrument modifier has been corrected accordingly.

The May 1992 round had no unacceptable results.

The July 1992 round had one unacceptable result. The mercury (level 1) result was above the control limits for the solution. Originally, several dilutions of the original solution were prepared. The result for the first dilution was within acceptable limits, but instrument problems negated the analysis run. Apparently, contamination from pipetting entered the original vial upon the second dilution, yielding high results for all subsequent dilutions and analysis of this solution. Pipetting methods and washing

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techniques will be reviewed to prevent recurrence of this problem.

The September 1992 round had four unacceptable results. Calculation errors accounted for three of the four errors (mercury, levels 1 and 2, and beryllium, level 2). All three results were reported without correcting for dilutions made. The data-checking system is being reviewed to determine a more efficient method. The arsenic (level 1) sample was above control limits for the sample. Investigation showed that all QA/QC criteria were acceptable for the analysis run. However, analysts noticed that although the QC data were acceptable, the value was in the high range of acceptable results, which probably accounted for the slightly higher reading reported. The acceptable range of the QC will be reevaluated to ensure better control.

The November 1992 round had six unacceptable results. Both alkalinity results were reported beyond their control limits. Upon investigation of the error, the samples were reanalyzed and found to be within acceptable limits. Apparently the results for the two solutions were switched. In addition, both calcium results were reported beyond their control limits. Investigation revealed that the solutions had been analyzed for calcium hardness instead of total hardness. The solutions were analyzed for total hardness, and the results were within acceptable limits. The nitrate (level 1) result was above the acceptable limit. During the investigation the calculations were checked and the solutions reanalyzed. The nitrate value on the original solution should have been reported as <1 , the lowest concentration reportable for this method. The high-level aluminum result was also beyond the acceptable limit for the solution. The investigation suggested that a contamination problem may be the cause for the error. In the future, all glassware will be acid washed prior to sample dilution.

In addition to the independent PET program, an external program was used in 1992 to monitor environmental results. Standard material from the PET program is submitted along with routine KPDES and groundwater samples to provide quick feedback to the analytical labs. Program information may be found in Part 1, Sect. 10.2.3.2; data are in Part 2, Tables 10.11 through 10.16.

10.3.3 Proficiency Analytical Testing Program

The January, April, and July rounds had no unacceptable results.

The October 1992 round had one cadmium result outside acceptable limits. A calculation error was found in the original data. When corrected, the result was within acceptable limits. Program information may be found in Part 1, Sect. 10.2.3.8; data are in Part 2, Tables 10.17 through 10.20.

10.3.4 Environmental Measurements Laboratory Program

The March 1992 round had one uranium result rated as unacceptable. The result was reported in incorrect units. When corrected to proper units for reporting, the result was acceptable.

The September 1992 round had two results rated as unacceptable. Both the ^{134}Cs and ^{137}Cs reported results were low. Upon investigation, laboratory personnel discovered that the cesium had plated out of solution on the beaker used for evaporating the original solution during preparation of the solution for analysis. The preparation procedure has been revised to eliminate evaporation to dryness, and glassware will be checked routinely for residuals in the preparation of solutions. Program information may be found in Part 1, Sect. 10.2.3.4; data are in Tables 10.21 and 10.22.

10.3.5 Environmental Measurements Systems Laboratory—Las Vegas Program

The October round had one result listed as an outlier (^{133}Ba in water). A transcription error was made in transferring the result from the raw data to the computer entry. The results in the raw data were within the acceptable range. All other results were within acceptable ranges. Data may be found in Part 2, Table 10.23.

10.4 Documentation Quality Assurance

At the request of the project coordinator, the Energy Systems Publications Division assists each Energy Systems site by coordinating the compilation,

editing, and reproduction of its data. This volume is part of a four-volume set designed to fulfill the DOE 5400.1 annual environmental data reporting requirement for all Energy Systems sites.

The Publications Division appoints a team of editors and electronic publishers to produce the documents. Draft volumes are produced in the spring for internal review and for comment by DOE, and then a final copy is printed for delivery before the June 1 deadline. For each draft and for the final copy, the editors are responsible for ensuring the quality of the document and that all submitted materials are included and accurately reflect the text and data as submitted. The quality and technical accuracy of submissions are the responsibility of the site coordinator.

The editors follow procedures that address recording the submissions of entries (including text, figures, and tables) and the status of submissions (in production, being proofread, etc.). The record-keeping measures are based on the submissions required for the previous year's report (determined from the table of contents) plus any alterations agreed upon by the project coordinator and site coordinators. Tracking sheets for data tables and figures are also kept.

All text, tables, and figures are edited, and questions are directed to the site or project coordinator. All final copy is proofread for accuracy and fidelity to copy. Draft copies of the entire volume are submitted to the site coordinator for technical review and approval.

10.5 References

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PART 2: Data Presentation

1. Introduction

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All data for this section are presented in Part 1.

2. Potential Radiation Dose to the Public

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Table 2.1. 1992 annual dose estimation—worst-case ingestion of groundwater

Radionuclide	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/L)	Ingestion rate (L/d)	Exposure frequency (d/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^{c,d} (mrem/year)
⁹⁹ Tc	25.000	2.0	365	18,250.00	1.30E-06	0.024

^aExposure values from U.S. Environmental Protection Agency 600/8-89-043, "Exposure Factors Handbook," July 1989.

^bDose factors from U.S. Department of Energy/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.

^cCommitted effective dose equivalent as committed (50-year) dose from 1 year of exposure (mrem/year).

^dDose rounded to two significant figures based on ingestion rate.

Table 2.2. 1992 annual dose estimation—worst-case incidental ingestion of sediment in Little Bayou Creek

Radionuclide	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/g)	Ingestion rate (g/d)	Exposure frequency (d/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^c (mrem/year)
<i>Downstream</i>						
²³⁴ U	10.02	0.8	213	1707.41	2.60E-04	0.44
²³⁵ U	0.46	0.8	213	78.38	2.50E-04	0.02
²³⁸ U	35.88	0.8	213	6113.95	2.30E-04	1.141
Total						1.87
<i>Upstream</i>						
²³⁴ U	0.79	0.8	213	134.62	2.60E-04	0.04
²³⁵ U	0.04	0.8	213	6.82	2.50E-04	0.00
²³⁸ U	0.94	0.8	213	160.18	2.30E-04	0.04
Total						0.08
Total dose above background ^d						2

^aExposure values from U.S. Environmental Protection Agency 600/8-89-043, "Exposure Factors Handbook," July 1989.

^bDose factors from U.S. Department of Energy/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1988.

^cCommitted effective dose equivalent as committed (50-year) dose from 1 year of exposure (mrem/year).

^dDose rounded to one significant figure based on ingestion rate estimate.

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Table 2.3. 1992 annual dose estimation—worst-case ingestion of deer tissue

Radionuclide ^c	Intake (exposure) values ^a				Dose values ^b	
	Concentration (pCi/g)	Ingestion rate (g/d)	Exposure frequency (d/year)	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^d (mrem/year)
<i>Indicator</i>						
²³⁴ U	0.68	226.8	178	27,451.87	2.6E-04	7.14
²³⁵ U	0.18	226.8	178	7,266.67	2.5E-04	1.82
²³⁸ U	0.15	226.8	178	6,055.56	2.3E-04	1.39
Total						10.4
<i>Background</i>						
²³⁴ U	1.08	226.8	178	43,600.03	2.6E-04	11.34
²³⁵ U	0.32	226.8	178	12,918.53	2.5E-04	3.23
²³⁸ U	0.22	226.8	178	8,881.49	2.3E-04	2.04
Total						16.6
Total dose compared to background ^e						-6.3

^aExposure values as per C. Logsdon. Personal communication with M. G. Guhy, November 27, 1990.

^bDose factors from U.S. Department of Energy/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1989.

^cOnly radionuclides present above detection limits (99% confidence level) are included.

^dCommitted effective dose equivalent as committed (50-year) dose from 1 year of exposure.

^eDose rounded to two significant figures based on dose conversion factor.

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Table 2.4. 1992 annual dose estimation—worst-case ingestion of food crops

Type	Radionuclide ^c	Intake (exposure) values ^a					Dose values ^b	
		Concentration (pCi/g)	Ingestion rate (g/d)	Exposure frequency (d/year)	Fraction homegrown	Total intake (pCi/year)	Ingestion dose conversion factor (mrem/pCi)	Annual CEDE ^d (mrem/year)
<i>Indicator</i>								
Corn Tomato	²³⁴ U	0.027	213	366	0.4	839.65	2.6E-04	0.22
	²³⁴ U	0.010	123	366	0.4	179.58	2.6E-04	0.05
	²³⁸ U	0.004	123	366	0.4	71.83	2.3E-04	0.02
Squash	²³⁰ Th	0.010	123	366	0.4	179.58	5.3E-04	0.10
	²³⁰ Th	0.004	143	366	0.4	83.51	5.3E-04	0.04
								Total
<i>Background</i>								
Carrot	²³⁴ U	0.007	51	366	0.4	52.12	2.6E-04	0.01
	²³⁸ U	0.005	51	366	0.4	37.23	2.3E-04	0.01
Tomato	²³⁴ U	0.004	123	366	0.4	71.83	2.6E-04	0.02
							Total	0.04
Total dose above background ^e								0.4

^aExposure values from U.S. Environmental Protection Agency 600/8-89-043, "Exposure Factors Handbook," July 1989.

^bDose factors from U.S. Department of Energy/EH0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," July 1989.

^cOnly radionuclides present above detection limits (99% confidence level) are included.

^dCommitted effective dose equivalent as committed (50-year) dose from 1 year of exposure (mrem/year).

^eDose rounded to one significant figure based on fraction homegrown.

Table 2.5. 1992 annual dose estimation—worst-case direct radiation in K011 effluent ditch^a

Location	Dose rate (mR/h)	Quality factor ^b (mrem/mR)	Exposure rate (h/trip)	Frequency ^c (trip/year)	Estimated dose (mrem/year)
Indicator	0.028	1	0.5	213	2.98
Background	0.0067	1	0.5	213	0.71
Total dose above background ^d					2

^aBackground dose calculated using the same assumptions is 0.71 mrem/year.

^bQuality factor for converting gamma radiation from milliroentgen to millirem.

^cExposure frequency as per C. Logsdon. Personal communication with M. G. Guhy, May 10, 1991.

^dDose rounded to one significant figure based on quality factor.

3. Airborne Discharges, Ambient Air Monitoring, Meteorological Monitoring, and External Gamma Radiation

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Table 3.1. Permitted air sources at PGDP^a

Source number	Location	Control equipment
1	C-600 number 2 boiler	Electrostatic precipitators and low-sulfur coal
2	C-600 number 3 boiler	Electrostatic precipitators and low-sulfur coal
4	C-405 incinerator (north) ^b	Venturi scrubber
5	C-405 incinerator (south) ^b	Venturi scrubber
7	C-310 purge vent	Chemical traps, high-speed centrifuge
8	C-410 fluorine production	Cold condensers ^c
15	C-400 UF ₄ pulverizer ^b	Filters
26	C-746 reverberatory furnace ^b	
27	C-746 aluminum sweat furnace ^b	
29	C-400 gold recovery ^b	
31	C-724 paint spray booth	Water wash scrubber
32	C-725 paint spray booth	Water wash scrubber
33	C-746-A rotary calciner ^b	CaCO ₃ traps
34(a)	Smelter—central dust collector ^b	Filters
35	C-600 number 1 boiler	
36	Smelter—induction furnace ^b	Torit filters
37	C-600 coal handling equipment	Water sprays
38	C-400 Detrex open-top vapor degreaser	Covered systems and condensing coils
39	C-400 Blakeslee open-top vapor degreaser	Covered systems and condensing coils
40	C-720 Branson open-top vapor degreaser (trichloroethylene)	
41	C-720 cold cleaning degreaser ^b	
42	Chemical unloading	Wet cyclone scrubber
43	C-340 uranium alloy remelting operation ^b	Filters

^aPermit No. 0-85-110 issued on September 30, 1985.

^bShut down with no plans to restart.

^cUnused as a result of low production.

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Table 3.2. 1992 PGDP monthly stack effluent pollutant emissions^a

	January	February	March	April	May	June	July	August	September	October	November	December
Uranium C-310 purge vent stack (g)	b	0.1	0.08	0.24	0.69	3.28	2.63	0.65	0.78	3.16	4.47	11.14
Technetium C-310 purge vent stack (mg)	b	1	2	b	b	1	b	b	b	3	3	2
C-310 purge vent stack (μCi)	b	17	34	b	b	17	b	b	b	51	51	34
Fluoride C-310 purge vent stack (lb)	891	1,075	1,275	1,391	1,196	1,395	1,599	1,244	1,260	1,508	995	632
Nitrogen oxide ^c C-600 stack (kg)	27,193	22,263	23,524	21,889	22,089	22,175	10,242	17,640	17,977	25,481	22,728	25,490
Sulfur dioxide ^c C-600 stack (kg)	41,184	32,721	35,925	33,432	33,732	33,441	12,473	25,270	26,388	39,475	35,210	39,389
Sulfur dioxide ^c C-600 stack (lb/M Btu) ^d	1.24	1.13	1.28	1.28	1.28	1.22	0.56	1.01	1.06	1.19	1.19	1.19
Particulates ^c C-600 stack (lb/M Btu) ^{e,f}	0.03	0.08	0.09	0.09	0.09	0.09	0.04	0.05	0.06	0.07	0.07	0.05
Particulates ^c C-600 stack (kg)	1,138	2,250	2,605	2,424	2,446	2,389	807	1,315	1,399	2,174	1,939	1,662
Carbon monoxide ^c (kg)	815	734	679	631	638	674	681	611	590	728	649	733

^aSee discussion in Subsect. 3.1.

^bNone detected.

^cBased on emission calculations from U.S. Environmental Protection Agency guidance document AP-42, *Compilation of Air Pollution Emission Factors*.

^dKentucky Division for Air Quality (KDAQ) permit limit = 3.1 lb/M Btu (boilers number 2 and 3) and 0.8 lb/M Btu (boiler number 1).

^eKDAQ permit limit = 0.242 lb/M Btu (boilers number 2 and 3) and 0.1 lb/M Btu (boiler number 1).

^fThe lb/M Btu values are a composite of all three boilers. There were no exceedances of the permit limits.

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Table 3.3. 1992 PGDP annual stack effluent pollutant emissions^a

	1992 Total	1991 Total	1990 Total	1989 Total	1988 Total	1987 Total	1986 Total
Uranium ^b							
C-310 purge vent stack (g)	27.22	5.32	31.8	205	16	34	46
Technetium ^b							
C-310 purge vent stack (mg)	12	182	23	211	221	56	520
C-310 purge vent stack (μCi)	202	3,074	386	3,566	3,732	890	8,956
Fluoride							
C-310 purge vent stack (lb)	14,421	12,554	12,679	14,996	15,091		
Nitrogen oxide ^c							
C-600 stack (kg)	258,696	256,234	278,613	282,380	256,800	252,900	262,900
Sulfur dioxide ^c							
C-600 stack (kg)	388,648	317,922	276,380	292,309	188,000	178,700	176,400
Particulates ^c							
C-600 stack (kg)	22,550	11,451	11,284	11,272			
Carbon monoxide ^c (kg)	8,164	9,117	9,091	8,179			

^aSee discussion in Subsect. 3.1.

^bIncludes only those emissions at or above the lower limit of detection.

^cBased on emission calculations from U.S. Environmental Protection Agency guidance document AP-42, *Compilation of Air Pollution Emission Factors*.

Table 3.4. Comparison of selected actual emissions and limits/standards

Source	Pollutant	Emission	Limit/standard
C-310 stack	Uranium	27.22 g/year	7.41×10^6 g/year ^a
	Technetium-99	0.012 g/year	1.7×10^4 g/year ^a
	Fluorides	19.75 lb/12 h ^b	50 lb/12 h
C-600 stack	Sulfur dioxide	0.81 lb/M Btu ^c	0.8 lb/M Btu ^d 3.1 lb/M Btu ^e
	Particulates	0.96 lb/M Btu ^c	0.1 lb/M Btu ^d
			0.24 lb/M Btu ^e

^aBased on emissions required to exceed the 10 mrem National Emissions Standards for Hazardous Air Pollutants (NESHAP) limit and 1992 meteorological data.

^bAnnual average.

^cAnnual average of all boilers combined.

^dBoiler number 1.

^eBoilers number 2 and 3.

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Table 4.1. Interim limitations for Agreed Order—Paducah Gaseous Diffusion Plant

Parameters	Monthly average	Daily maximum	Sample frequency	Sample type ^a
<i>Outfall 001</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.15 mg/L	1/week	Composite
Zinc, total recoverable		0.93 mg/L	1/week	Composite
Chlorine, total residual		0.1 mg/L	1/week	Grab
Temperature		93°F	1/week	Grab
Iron, total recoverable		34.3 mg/L	2/month	Composite
Aluminum, total recoverable			2/month	Composite
Copper, total recoverable		0.17 mg/L	2/month	Composite
Nickel, total recoverable	2.36 mg/L	3.1 mg/L	2/month	Composite
Suspended solids, total		158 mg/L	2/month	Composite
Trichloroethylene		0.0807 mg/L	2/month	Composite
Fluoride	3.5 mg/L	4.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease	10 mg/L	15 mg/L	2/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 002</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.31 mg/L	1/week	Composite
Zinc, total recoverable		0.17 mg/L	1/week	Composite
Chlorine, total residual		0.15 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Iron, total recoverable		6.55 mg/L	2/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 003</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.15 mg/L	1/week	Composite
Zinc, total recoverable		0.93 mg/L	1/week	Composite
Chlorine, total residual		0.1 mg/L	1/week	Grab
Temperature		93°F	1/week	Grab
Iron, total recoverable		5.19 mg/L	2/month	Composite

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Table 4.1 (continued)

Parameters	Monthly average	Daily maximum	Sample frequency	Sample type ^a
Aluminum, total recoverable			2/month	Composite
Copper, total recoverable		0.17 mg/L	2/month	Composite
Nickel, total recoverable	0.26 mg/L	3.1 mg/L	2/month	Composite
Suspended solids, total		158 mg/L	2/month	Composite
Trichloroethylene		0.027 mg/L	2/month	Composite
Fluoride	3.5 mg/L	4.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease	10 mg/L	15 mg/L	2/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 004</i>				
Flow			2/month	Instantaneous
BOD _{5b}	30 mg/L	45 mg/L	2/month	Composite
Suspended solids, total	30 mg/L	45 mg/L	2/month	Composite
Fecal coliform	200	400	2/month	Grab
pH	6.0 (min)	9.0	2/month	Grab
<i>Outfall 005</i>				
Flow			1/week	Instantaneous
Suspended solids, total	30 mg/L	50 mg/L	1/week	Composite
Chemical oxygen demand			1/week	Grab
Turbidity			1/week	Grab
pH	6.0 (min)	9.0	1/week	Grab
<i>Outfall 006</i>				
Flow			1/week	Instantaneous
Suspended solids, total	30 mg/L	50 mg/L	1/week	Grab
Chemical oxygen demand			1/week	Grab
Turbidity			1/week	Grab
pH	6.0 (min)	10.4	1/week	Grab
<i>Outfall 008</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.1 mg/L	1/week	Composite
Zinc, total recoverable		0.34 mg/L	1/week	Composite
Chlorine, total residual		0.33 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Iron, total recoverable		9.42 mg/L	2/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total			1/month	Composite
Trichloroethylene		0.027 mg/L	1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab

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Table 4.1 (continued)

Parameters	Monthly average	Daily maximum	Sample frequency	Sample type ^a
pH	6.0 (min)	9.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 009</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.23 mg/L	1/week	Composite
Zinc, total recoverable		1.15 mg/L	1/week	Composite
Chlorine, total residual		0.01 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Iron, total recoverable		8.41 mg/L	2/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5.0 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 010</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.5 mg/L	1/week	Composite
Zinc, total recoverable		0.26 mg/L	1/week	Composite
Chlorine, total residual		0.01 mg/L	1/week	Grab
Temperature		89°F	1/week	Grab
Iron, total recoverable		8.32 mg/L	2/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab

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Table 4.1 (continued)

Parameters	Monthly average	Daily maximum	Sample frequency	Sample type ^a
<i>Outfall 011</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.85 mg/L	1/week	Composite
Zinc, total recoverable		0.16 mg/L	1/week	Composite
Chlorine, total residual		0.14 mg/L	1/week	Grab
Temperature		95°F	1/week	Grab
Iron, total recoverable		5.94 mg/L	2/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	10.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 012</i>				
Flow			1/week	Instantaneous
Chromium, total recoverable		0.76 mg/L	1/week	Composite
Zinc, total recoverable		0.40 mg/L	1/week	Composite
Chlorine, total residual		0.01 mg/L	1/week	Grab
Temperature		90°F	1/week	Grab
Iron, total recoverable		18.22 mg/L	2/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total			1/month	Composite
Trichloroethylene			1/month	Composite
Fluoride	3.5 mg/L	5.0 mg/L	2/month	Composite
Dissolved oxygen	5 mg/L (min)		2/month	Grab
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/week	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 013</i>				
Flow			1/month	Instantaneous
Iron, total recoverable			1/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite

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Table 4.1 (continued)

Parameters	Monthly average	Daily maximum	Sample frequency	Sample type ^a
Suspended solids, total		271 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 014</i>				
Flow			1/week	Instantaneous
Suspended solids, total	30 mg/L	50 mg/L	1/week	Grab
Chemical oxygen demand			1/week	Grab
Turbidity			1/week	Grab
pH	6.0 (min)	9.0	1/week	Grab
<i>Outfall 015</i>				
Flow			1/month	Instantaneous
Iron, total recoverable			1/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total		427 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab
<i>Outfall 016</i>				
Flow			1/month	Instantaneous
Iron, total recoverable			1/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total		45 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab

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Table 4.1 (continued)

Parameters	Monthly average	Daily maximum	Sample frequency	Sample type ^a
<i>Outfall 017</i>				
Flow			1/month	Instantaneous
Iron, total recoverable			1/month	Composite
Aluminum, total recoverable			1/month	Composite
Copper, total recoverable			1/month	Composite
Nickel, total recoverable			1/month	Composite
Suspended solids, total		45 mg/L	1/month	Composite
Fluoride			1/month	Composite
Oil and grease			1/month	Grab
pH	6.0 (min)	9.0	1/month	Grab
Uranium			1/quarter	Grab
Dissolved alpha			1/quarter	Grab
Suspended alpha			1/quarter	Grab
Dissolved beta			1/quarter	Grab
Suspended beta			1/quarter	Grab
Polychlorinated biphenyl		0.1 mg/L	1/quarter	Grab

^aComposite samples are 24-h samples.

^bBOD₅ = biochemical oxygen demand, 5 d.

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Table 4.2. 1992 annual data summary for sampling location K001^a

Process, cooling, and storm

Parameters	Max	Min	Av	Number of samples
Acetone (mg/L)	<5.000	<1.000	<1.191	21
Aluminum (mg/L)	2.290	0.212	0.686	25
Arsenic (mg/L)	<0.005	<0.005	<0.005	1
Assay % uranium-235 (wt %)	1.214	0.253	0.561	42
Cadmium (mg/L)	<0.010	<0.005	<0.008	6
Chlorine, total residual (mg/L)	0.040	<0.010	<0.011	53
Chromium, total recoverable (mg/L)	0.089	<0.050	<0.051	44
Copper, total recoverable (mg/L)	0.036	<0.010	<0.011	25
Dissolved alpha (pCi/L)	112.600	-14.800 ^b	10.977	52
Dissolved beta (pCi/L)	116.000	-17.000 ^b	43.717	52
Dissolved oxygen (mg/L)	10.900	6.700	8.743	21
Fecal coliform (colonies/100 mL)	115.000	6.000	48.500	4
Flow (Mgd)	3.430	0.384	1.661	52
Fluoride (mg/L)	0.850	0.250	0.512	21
Gross alpha (pCi/L)	8.100	-0.600 ^b	3.750	2
Gross beta (pCi/L)	57.000	39.000	48.000	2
Hardness as CaCO ₃ (mg/L CaC)	1009.000	194.000	419.429	14
Hexavalent chromium (mg/L)	0.020	<0.010	<0.012	6
Iron, total recoverable (mg/L)	2.120	0.098	0.447	25
Isopropanol (mg/L)	<5.000	<1.000	<1.191	21
Lead (mg/L)	<0.200	<0.030	<0.108	6
Neptunium-237 (pCi/L)	0.100	-0.300 ^b	-0.050 ^b	4
Nickel, total recoverable (mg/L)	<0.050	<0.050	<5.000	25
Oil and grease (mg/L)	<5.000	<5.000	<5.000	31
pH (standard units)	10.100	6.900		53
Phosphate as phosphorus (mg/L)	0.300	0.080	0.161	8
Plutonium-239 (pCi/L)	0.130	0.100	0.108	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	14
Suspended alpha (pCi/L)	9.200	-4.500 ^b	-0.375 ^b	52
Suspended beta (pCi/L)	24.000	-15.000 ^b	1.698 ^b	52
Suspended solids (mg/L)	42.000	4.000	16.700	30
Technetium-99 (pCi/L)	77.000	0.000	22.748	54
Temperature (°F)	92.000	44.000	68.500	52
Total phosphorus (mg/L)	0.240	0.120	0.165	11
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	22
Uranium (mg/L)	0.170	0.001	0.022	52
Zinc, total residual (mg/L)	0.082	<0.005	<0.014	47

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.3. 1992 annual data summary for sampling location K002^a

Process, cooling, and storm

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	2.840	0.655	1.574	9
Assay % uranium-235 (wt %)	0.731	0.590	0.661	2
Cadmium (mg/L)	<0.010	<0.005	<0.008	3
Chlorine, total residual (mg/L)	<0.010	<0.010	<0.010	10
Chromium, total recoverable (mg/L)	0.094	<0.050	<0.055	9
Copper, total recoverable (mg/L)	0.014	<0.010	<0.011	9
Dissolved alpha (pCi/L)	9.300	-1.900 ^b	3.575	4
Dissolved beta (pCi/L)	32.000	1.000	10.250	4
Dissolved oxygen (mg/L)	11.200	6.000	8.425	8
Flow (Mgd)	2.570	0.019	0.688	10
Fluoride (mg/L)	0.470	0.130	0.224	8
Hardness as CaCO ₃ (mg/L CaC)	77.000	72.000	74.500	2
Hexavalent chromium (mg/L)	0.050	0.050	0.050	1
Iron, total recoverable (mg/L)	2.810	0.515	1.479	9
Lead (mg/L)	<0.200	<0.070	<0.113	3
Neptunium-237 (pCi/L)	0.200	-0.400 ^b	-0.033 ^b	3
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	9
Oil and grease (mg/L)	<5.000	<5.000	<5.000	9
pH (standard units)	8.000	6.500		10
Phosphate as phosphorus (mg/L)	0.230	0.230	0.230	1
Plutonium-239 (pCi/L)	0.100	0.000	0.033	3
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	8
Suspended alpha (pCi/L)	2.300	-2.300 ^b	-0.175 ^b	4
Suspended beta (pCi/L)	4.000	-3.200 ^b	0.450	4
Suspended solids (mg/L)	75.000	11.000	34.222	9
Technetium-99 (pCi/L)	8.000	8.000	8.000	1
Temperature (°F)	78.000	43.000	62.700	10
Total phosphorus (mg/L)	0.230	0.090	0.160	2
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	9
Uranium (mg/L)	0.006	0.003	0.004	4
Zinc, total residual (mg/L)	0.075	0.020	0.052	9

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.4. 1992 annual data summary for sampling location K004^a
Sanitary wastewater

Parameters	Max	Min	Av	Number of samples
Biochemical oxygen demand (mg/L)	16.000	5.000	10.375	24
Fecal coliform (colonies/100 mL)	38.000	<1.000	<5.560	25
Flow (Mgd)	0.505	0.288	0.336	24
Hardness as CaCO ₃ (mg/L CaC)	120.000	120.000	120.000	1
pH (standard units)	8.400	6.700		25
Suspended solids (mg/L)	14.000	<4.000	<6.476	21

^aSee Fig. 4.4 in Part 1.

Table 4.5. 1992 annual data summary for sampling location K006^a
Water Treatment Plant sludge lagoon 2

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	1.040	0.197	0.539	4
Cadmium (mg/L)	<0.010	<0.005	<0.008	6
Chemical oxygen demand (mg/L)	25.000	<5.000	<12.326	43
Chlorine, total residual (mg/L)	<0.020	<0.010	<0.012	10
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	4
Copper, total recoverable (mg/L)	0.018	<0.010	<0.012	4
Dissolved oxygen (mg/L)	14.900	14.900	14.900	1
Flow (Mgd)	2.860	0.014	1.356	82
Hardness as CaCO ₃ (mg/L CaC)	133.000	48.000	73.071	14
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	2
Iron, total recoverable (mg/L)	2.020	0.242	0.817	4
Lead (mg/L)	<0.200	<0.030	<0.102	6
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	4
Oil and grease (mg/L)	<5.000	<5.000	<5.000	9
pH (standard units)	10.700	7.500		88
Phosphate as phosphorus (mg/L)	0.140	0.084	0.109	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	12
Specific conductance (µmhos/cm)	316.000	192.000	258.297	37
Suspended solids (mg/L)	47.000	<4.000	<12.789	52
Total phosphorus (mg/L)	0.140	0.080	0.100	11
Turbidity (nephelometric turbidity units)	49.000	1.700	8.071	42
Zinc, total residual (mg/L)	0.030	<0.005	<0.013	4

^aSee Fig. 4.4 in Part 1.

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Table 4.6. 1992 annual data summary for sampling location K008^a

Process, cooling, and storm

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	0.567	<0.100	<0.212	25
Assay % uranium-235 (wt %)	0.749	0.578	0.653	4
Cadmium (mg/L)	<0.010	<0.005	<0.008	6
Chlorine, total residual (mg/L)	0.150	<0.010	<0.013	56
Chromium, total recoverable (mg/L)	0.075	<0.050	<0.051	63
Copper, total recoverable (mg/L)	0.024	<0.010	<0.011	25
Dissolved alpha (pCi/L)	6.200	-5.200 ^b	1.450	12
Dissolved beta (pCi/L)	27.000	0.000	13.500	12
Dissolved oxygen (mg/L)	11.200	5.300	7.955	29
Flow (Mgd)	1.190	0.257	0.754	60
Fluoride (mg/L)	0.240	0.110	0.169	29
Hexavalent chromium (mg/L)	0.010	<0.010	<0.010	3
Iron, total recoverable (mg/L)	0.952	<0.010	<0.288	34
Gross alpha (pCi/L)	0.200	0.200	0.200	1
Gross beta (pCi/L)	1.000	1.000	1.000	1
Hardness as CaCO ₃ (mg/L CaC)	127.000	35.000	67.429	14
Lead (mg/L)	<0.200	<0.030	<0.107	6
Molybdenum (mg/L)	<0.050	<0.050	<0.050	1
Neptunium-237 (pCi/L)	0.300	-0.400 ^b	-0.140 ^b	5
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	25
Oil and grease (mg/L)	<5.000	<5.000	<5.000	29
pH (standard units)	9.000	6.500		61
Phosphate as phosphorus (mg/L)	0.640	0.510	0.590	4
Plutonium-239 (pCi/L)	0.490	0.000	0.118	5
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	18
Suspended alpha (pCi/L)	2.000	-3.600 ^b	-0.525 ^b	12
Suspended beta (pCi/L)	15.000	-4.500 ^b	1.875	12
Suspended solids (mg/L)	21.000	<4.000	<7.759	29
Technetium-99 (pCi/L)	25.000	0.000	14.077	13
Temperature (°F)	86.000	49.000	69.536	56
Total phosphorus (mg/L)	0.740	0.510	0.612	11
Trichloroethylene (mg/L)	0.087	<0.001	<0.013	20
Uranium (mg/L)	0.005	<0.001	<0.002	15
Zinc, total residual (mg/L)	0.124	<0.005	<0.025	57

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.7. 1992 annual data summary for sampling location K009^a

Process, cooling, and storm

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	2.180	0.325	0.742	15
Assay % uranium-235 (wt %)	0.823	0.630	0.750	3
Cadmium (mg/L)	<0.010	<0.003	<0.008	6
Chlorine, total residual (mg/L)	<0.020	<0.010	<0.010	52
Chromium, total recoverable (mg/L)	0.079	<0.050	<0.051	47
Copper, total recoverable (mg/L)	0.031	<0.010	<0.011	15
Dissolved alpha (pCi/L)	5.800	0.900	2.800	4
Dissolved beta (pCi/L)	15.000	3.000	8.250	4
Dissolved oxygen (mg/L)	14.100	5.000	8.795	21
Flow (Mgd)	1.180	0.057	0.204	52
Fluoride (mg/L)	0.180	<0.100	<0.145	21
Hardness as CaCO ₃ (mg/L CaC)	132.000	19.000	70.357	14
Hexavalent chromium (mg/L)	0.020	<0.010	<0.015	2
Iron, total recoverable (mg/L)	1.640	0.295	0.749	25
Lead (mg/L)	<0.200	<0.030	<0.123	7
Mercury (mg/L)	<0.000	<0.000	<0.000	1
Molybdenum (mg/L)	<0.050	<0.050	<0.050	1
Neptunium-237 (pCi/L)	0.000	-0.400 ^b	-0.125 ^b	4
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	15
Oil and grease (mg/L)	<5.000	<5.000	<5.000	20
pH (standard units)	9.700	6.200		52
Phosphate as phosphorus (mg/L)	0.230	0.110	0.173	4
Plutonium-239 (pCi/L)	0.400	-0.300 ^b	0.025	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	13
Suspended alpha (pCi/L)	2.300	-3.400 ^b	0.075	4
Suspended beta (pCi/L)	5.000	-2.000 ^b	0.500	4
Suspended solids (mg/L)	29.000	<4.000	<13.150	20
Technetium-99 (pCi/L)	12.000	0.000	8.250	4
Temperature (°F)	84.000	41.000	63.077	52
Total phosphorus (mg/L)	0.240	0.110	0.180	11
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	12
Uranium (mg/L)	0.003	<0.001	<0.002	6
Zinc, total residual (mg/L)	0.152	<0.005	<0.047	47

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.8. 1992 annual data summary for sampling location K010^a
Process, cooling, and storm

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	3.000	0.586	1.663	9
Assay % uranium-235 (wt %)	0.713	0.240	0.384	9
Cadmium (mg/L)	<0.010	<0.005	<0.008	3
Chlorine, total residual (mg/L)	0.010	<0.010	<0.010	12
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	9
Copper, total recoverable (mg/L)	0.028	<0.010	<0.012	9
Dissolved alpha (pCi/L)	19.000	0.500	8.100	9
Dissolved beta (pCi/L)	65.000	-14.000 ^b	21.444	9
Dissolved oxygen (mg/L)	11.300	5.200	7.738	8
Flow (Mgd)	1.490	0.001	0.527	10
Fluoride (mg/L)	0.420	0.120	0.284	8
Hardness as CaCO ₃ (mg/L CaC)	96.000	63.000	79.500	2
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	1
Iron, total recoverable (mg/L)	2.680	<0.010	<1.396	9
Lead (mg/L)	<0.200	<0.070	<0.113	3
Neptunium-237 (pCi/L)	0.500	-0.300 ^b	0.025	4
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	9
Oil and grease (mg/L)	<5.000	5.000	<5.000	9
pH (standard units)	9.800	6.800		9
Phosphate as phosphorus (mg/L)	0.170	0.170	0.170	1
Plutonium-239 (pCi/L)	0.000	0.000	0.000	4
Polychlorinated biphenyl (μg/L)	<0.100	<0.100	<0.100	8
Suspended alpha (pCi/L)	3.800	-0.560 ^b	1.816	9
Suspended beta (pCi/L)	18.000	-2.000 ^b	4.111	9
Suspended solids (mg/L)	45.000	10.000	26.000	9
Technetium-99 (pCi/L)	93.000	13.000	40.500	4
Temperature (°F)	77.000	48.000	67.000	9
Total phosphorus (mg/L)	0.220	0.170	0.195	2
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	9
Uranium (mg/L)	0.027	0.006	0.018	8
Zinc, total residual (mg/L)	0.073	<0.005	<0.038	9

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.9. 1992 annual data summary for sampling location K011^a

Process, cooling, and storm

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	0.550	0.161	0.328	15
Assay % uranium-235 (wt %)	0.546	0.200	0.287	50
Cadmium (mg/L)	0.020	<0.005	<0.010	6
Chlorine, total residual (mg/L)	0.020	<0.010	<0.011	52
Chromium, total recoverable (mg/L)	0.156	<0.006	<0.054	47
Copper, total recoverable (mg/L)	0.010	<0.005	<0.010	15
Dissolved alpha (pCi/L)	30.300	-8.100 ^b	8.861	51
Dissolved beta (pCi/L)	36.000	-3.000 ^b	10.569	51
Dissolved oxygen (mg/L)	10.600	6.600	8.715	20
Fecal coliform (colonies/100 mL)	144.000	<1.000	<58.667	3
Flow (Mgd)	1.110	0.127	0.408	50
Fluoride (mg/L)	0.210	0.100	0.142	20
Gross alpha (pCi/L)	18.000	6.800	12.400	2
Gross beta (pCi/L)	31.000	8.000	19.500	2
Hardness as CaCO ₃ (mg/L CaC)	128.000	44.000	65.643	14
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	2
Iron, total recoverable (mg/L)	0.834	<0.010	<0.305	24
Lead (mg/L)	0.200	<0.030	<0.105	6
Nickel, total recoverable (mg/L)	0.050	<0.020	<0.048	15
Oil and grease (mg/L)	<5.000	<5.000	<5.000	18
pH (standard units)	9.400	6.500		51
Phosphate as phosphorus (mg/L)	0.330	0.204	0.284	4
Plutonium-239 (pCi/L)	0.200	0.000	0.075	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	12
Suspended alpha (pCi/L)	17.700	-5.500 ^b	0.122	51
Suspended beta (pCi/L)	40.000	-13.000 ^b	0.316	51
Suspended solids (mg/L)	38.000	<4.000	<10.421	19
Technetium-99 (pCi/L)	37.000	-7.000 ^b	7.721	53
Temperature (°F)	93.000	48.000	72.098	51
Total phosphorus (mg/L)	0.380	0.190	0.298	11
Trichloroethylene (mg/L)	0.004	<0.001	<0.002	11
Uranium (mg/L)	0.063	0.002	0.025	52
Zinc, total residual (mg/L)	0.107	<0.002	<0.022	46

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.10. 1992 annual data summary for sampling location K012^a
Storm water runoff

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	1.710	0.408	1.041	8
Assay % uranium-235 (wt %)	0.607	0.290	0.442	8
Cadmium (mg/L)	<0.010	<0.005	<0.008	3
Chlorine, total residual (mg/L)	<0.010	<0.010	<0.010	11
Chromium, total recoverable (mg/L)	0.086	<0.050	<0.054	9
Copper, total recoverable (mg/L)	0.012	<0.010	<0.010	8
Dissolved alpha (pCi/L)	8.100	-2.100 ^b	2.500	9
Dissolved beta (pCi/L)	21.000	-2.800 ^b	8.911	9
Dissolved oxygen (mg/L)	11.300	6.300	8.257	7
Fluoride (mg/L)	0.530	0.290	0.407	7
Iron, total recoverable (mg/L)	1.700	0.262	0.987	8
Flow (Mgd)	2.860	0.022	0.832	10
Hardness as CaCO ₃ (mg/L CaC)	116.000	73.000	94.500	2
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	1
Lead (mg/L)	<0.200	<0.070	<0.113	3
Neptunium-237 (pCi/L)	0.100	-0.400 ^b	-0.100 ^b	3
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	8
Oil and grease (mg/L)	<5.000	<5.000	<5.000	8
pH (standard units)	8.000	6.300		9
Phosphate as phosphorus (mg/L)	0.260	0.260	0.260	1
Plutonium-239 (pCi/L)	0.100	0.000	0.033	3
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	7
Suspended alpha (pCi/L)	3.300	-2.000 ^b	1.300	9
Suspended beta (pCi/L)	23.000	-3.000 ^b	2.000	9
Suspended solids (mg/L)	71.000	8.000	27.375	8
Technetium-99 (pCi/L)	14.000	0.000	5.667	3
Temperature (°F)	85.000	50.000	68.111	9
Total phosphorus (mg/L)	0.260	0.180	0.220	2
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	8
Uranium (mg/L)	0.016	<0.001	<0.007	8
Zinc, total residual (mg/L)	0.079	0.016	0.046	9

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.11. 1992 annual data summary for sampling location K013^a

Storm water runoff

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	3.880	0.208	1.770	12
Assay % uranium-235 (wt %)	0.660	0.520	0.583	3
Cadmium (mg/L)	0.026	<0.005	<0.012	5
Chromium, total recoverable (mg/L)	6.960	<0.050	<2.652	5
Copper, total recoverable (mg/L)	<0.010	<0.010	<0.010	12
Dissolved alpha (pCi/L)	3.500	-2.500 ^b	1.700	4
Dissolved beta (pCi/L)	54.000	-24.000 ^b	15.500	4
Flow (Mgd)	3.830	0.022	0.714	13
Fluoride (mg/L)	1.100	0.260	0.582	10
Hardness as CaCO ₃ (mg/L CaC)	158.000	60.000	109.000	2
Hexavalent chromium (mg/L)	7.880	<0.010	<4.930	3
Iron, total recoverable (mg/L)	3.980	0.128	1.642	12
Lead (mg/L)	0.200	<0.030	<0.140	5
Neptunium-237 (pCi/L)	0.300	-0.400 ^b	-0.075 ^b	4
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	12
Oil and grease (mg/L)	<5.000	<5.000	<5.000	12
pH (standard units)	7.800	6.900		12
Plutonium-239 (pCi/L)	0.100	0.000	0.040	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	12
Suspended alpha (pCi/L)	0.000	-4.900 ^b	-2.150 ^b	4
Suspended beta (pCi/L)	8.000	-6.000 ^b	-0.500 ^b	4
Suspended solids (mg/L)	81.000	<4.000	<31.083	12
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	2
Uranium (mg/L)	0.005	<0.001	<0.002	4
Zinc, total residual (mg/L)	0.021	0.016	0.019	2

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 4.12. 1992 annual data summary for sampling location K014^a

Filter backwash

Parameters	Max	Min	Av	Number of samples
Chemical oxygen demand (mg/L)	7.000	7.000	7.000	1
Chlorine, total residual (mg/L)	<0.010	<0.010	<0.010	1
Flow (Mgd)	0.005	0.005	0.005	1
pH (standard units)	9.500	9.500		1
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	1
Suspended solids (mg/L)	9.000	9.000	9.000	1
Turbidity (nephelometric turbidity units)	1.400	1.400	1.400	1

^aSee Fig. 4.4 in Part 1.

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Table 4.13. 1992 annual data summary for sampling location K015^a
Storm water runoff

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	7.620	0.276	2.774	12
Assay % uranium-235 (wt %)	0.633	0.280	0.425	4
Cadmium (mg/L)	0.026	<0.005	<0.014	4
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	3
Copper, total recoverable (mg/L)	0.016	<0.010	<0.011	12
Dissolved alpha (pCi/L)	111.000	4.200	45.625	4
Dissolved beta (pCi/L)	218.000	0.000	71.250	4
Flow (Mgd)	4.630	<0.001	<1.138	11
Fluoride (mg/L)	0.580	0.340	0.467	9
Hardness as CaCO ₃ (mg/L CaC)	69.000	58.000	63.500	2
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	1
Iron, total recoverable (mg/L)	6.270	0.083	2.270	12
Lead (mg/L)	<0.200	<0.030	<0.158	4
Neptunium-237 (pCi/L)	0.000	-1.000 ^b	-0.375 ^b	4
Nickel, total recoverable (mg/L)	0.162	<0.050	<0.059	12
Oil and grease (mg/L)	<5.000	<5.000	<5.000	11
pH (standard units)	8.100	6.900		12
Plutonium-239 (pCi/L)	0.100	0.040	0.085	4
Polychlorinated biphenyl (µg/L)	0.100	<0.100	<0.100	10
Suspended alpha (pCi/L)	1.600	-4.900 ^b	-0.425 ^b	4
Suspended beta (pCi/L)	26.000	-0.700 ^b	11.575	4
Suspended solids (mg/L)	698.000	<4.000	<103.250	12
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	2
Uranium (mg/L)	0.340	0.011	0.158	4
Zinc, total residual (mg/L)	0.021	<0.005	<0.013	3

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.14. 1992 annual data summary for sampling location K016^a

Storm water runoff

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	1.280	0.202	0.531	10
Assay % uranium-235 (wt %)	0.630	0.540	0.585	2
Cadmium (mg/L)	<0.010	<0.005	<0.008	2
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	2
Copper, total recoverable (mg/L)	<0.010	<0.010	<0.010	10
Dissolved alpha (pCi/L)	2.300	-3.800 ^b	0.600	4
Dissolved beta (pCi/L)	43.000	-30.000 ^b	9.000	4
Flow (Mgd)	1.010	<0.001	<0.165	10
Fluoride (mg/L)	0.250	0.180	0.206	8
Hardness as CaCO ₃ (mg/L CaC)	226.000	62.000	144.000	2
Iron, total recoverable (mg/L)	1.050	0.090	0.431	10
Lead (mg/L)	<0.200	<0.030	<0.115	2
Neptunium-237 (pCi/L)	0.600	-0.600 ^b	0.113	4
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	10
Oil and grease (mg/L)	<5.000	<5.000	<5.000	10
pH (standard units)	8.500	6.900		10
Plutonium-239 (pCi/L)	0.230	0.000	0.108	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	10
Suspended alpha (pCi/L)	2.300	-2.500 ^b	-0.250 ^b	4
Suspended beta (pCi/L)	6.000	-7.000 ^b	-1.000 ^b	4
Suspended solids (mg/L)	19.000	<4.000	<10.600	10
Technetium-99 (pCi/L)	12.000	12.000	12.000	1
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	2
Uranium (mg/L)	0.008	<0.001	<0.004	4
Zinc, total residual (mg/L)	0.014	0.011	0.013	2

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.15. 1992 annual data summary for sampling location K017^a

Storm water runoff

Parameters	Max	Min	Av	Number of samples
Assay % uranium-235 (wt %)	0.684	0.470	0.545	3
Aluminum (mg/L)	14.600	0.232	1.833	12
Cadmium (mg/L)	0.026	<0.005	<0.016	5
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	2
Copper, total recoverable (mg/L)	0.030	<0.010	<0.012	12
Dissolved alpha (pCi/L)	5.100	-0.500 ^b	2.800	4
Dissolved beta (pCi/L)	17.000	-6.000 ^b	3.150	4
Flow (Mgd)	1.580	<0.001	<0.253	12
Fluoride (mg/L)	0.630	0.360	0.472	10
Hardness as CaCO ₃ (mg/L CaC)	186.000	91.000	138.500	2
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	1
Iron, total recoverable (mg/L)	21.500	0.162	2.388	12
Lead (mg/L)	<0.200	<0.030	<0.140	5
Neptunium-237 (pCi/L)	0.100	-0.700 ^b	-0.250 ^b	4
Nickel, total recoverable (mg/L)	0.135	<0.050	<0.057	12
Oil and grease (mg/L)	<5.000	<5.000	<5.000	12
pH (standard units)	8.200	7.100		12
Plutonium-239 (pCi/L)	0.100	0.000	0.050	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	12
Suspended alpha (pCi/L)	1.100	-2.700 ^b	-0.725 ^b	4
Suspended beta (pCi/L)	10.000	-1.000 ^b	3.250	4
Suspended solids (mg/L)	1930.000	4.000	182.167	12
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	2
Uranium (mg/L)	0.012	0.001	0.006	4
Zinc, total residual (mg/L)	0.022	0.008	0.015	2

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.16. 1992 annual data summary for sampling location K018^a

Landfill runoff

Parameters	Max	Min	Av	Number of samples
Aluminum (mg/L)	119.000	0.408	20.780	11
Assay % uranium-235 (wt %)	0.700	0.530	0.615	2
Cadmium (mg/L)	0.031	<0.005	<0.015	4
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	2
Copper, total recoverable (mg/L)	0.141	<0.010	<0.028	11
Dissolved alpha (pCi/L)	24.200	0.000	9.050	4
Dissolved beta (pCi/L)	45.000	7.000	29.250	4
Flow (Mgd)	10.200	<0.001	<1.599	11
Fluoride (mg/L)	0.720	0.330	0.488	9
Hardness as CaCO ₃ (mg/L CaC)	118.000	89.000	103.500	2
Hexavalent chromium (mg/L)	<0.010	<0.010	<0.010	1
Iron, total recoverable (mg/L)	163.000	0.134	24.532	11
Lead (mg/L)	<0.200	<0.030	<0.158	4
Neptunium-237 (pCi/L)	0.600	-0.300 ^b	0.125	4
Nickel, total recoverable (mg/L)	0.125	<0.050	<0.057	11
Oil and grease (mg/L)	8.500	<5.000	<5.318	11
pH (standard units)	8.200	7.200		11
Plutonium-239 (pCi/L)	0.200	0.000	0.100	4
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	11
Suspended alpha (pCi/L)	4.100	-1.400 ^b	1.100	4
Suspended beta (pCi/L)	29.000	4.000	12.500	4
Suspended solids (mg/L)	2980.000	<4.000	<369.182	11
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	2
Uranium (mg/L)	0.065	0.002	0.020	4
Zinc, total residual (mg/L)	0.050	0.016	0.033	2

^aSee Fig. 4.4 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.17. 1992 annual data summary for sampling location SW1^a
Upstream Big Bayou Creek and landfill runoff location 1, background

Parameters	Max	Min	Av	Number of samples
Antimony (mg/L)	0.060	<0.060	<0.060	1
Arsenic (mg/L)	<0.005	<0.005	<0.005	1
Assay % uranium-235 (wt %)	1.080	0.650	0.769	6
Barium (mg/L)	0.021	0.021	0.021	1
Beryllium (mg/L)	<0.005	<0.005	<0.005	1
Cadmium (mg/L)	<0.010	<0.010	<0.010	1
Chloride (mg/L)	18.000	5.000	12.813	16
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	1
Cobalt (mg/L)	<0.050	<0.050	<0.050	1
Copper, total recoverable (mg/L)	<0.010	<0.010	<0.010	1
Dissolved alpha (pCi/L)	4.200	-4.800 ^b	-0.308 ^b	12
Dissolved beta (pCi/L)	19.000	-3.000 ^b	6.308	12
Dissolved solids (mg/L)	138.000	99.000	117.250	4
Fluoride (mg/L)	0.240	0.110	0.157	13
Gross alpha (pCi/L)	13.500	-1.200 ^b	4.600	5
Gross beta (pCi/L)	27.000	-2.000 ^b	10.200	5
Hexavalent chromium (mg/L)	0.020	<0.010	<0.011	12
Iron, total recoverable (mg/L)	26.000	0.997	8.427	4
Lead (mg/L)	<0.200	<0.200	<0.200	1
Mercury (mg/L)	<0.000	<0.000	<0.000	1
Neptunium-237 (pCi/L)	1.000	-0.500 ^b	0.083	12
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	1
Nitrate as nitrogen (mg/L)	2.600	<1.000	<1.150	12
pH (standard units)	8.300	6.400		16
Phosphate as phosphorus (mg/L)	<2.000	<2.000	<2.000	12
Plutonium-239 (pCi/L)	0.100	0.000	0.065	12
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	1
Selenium (mg/L)	<0.005	<0.005	<0.005	1
Silver (mg/L)	<0.030	<0.030	<0.030	1
Sodium (mg/L)	13.300	2.720	7.623	4
Specific conductance (µmhos/cm)	248.000	54.700	165.567	3
Sulfate (mg/L)	54.000	8.000	31.125	16
Suspended alpha (pCi/L)	2.000	-2.500 ^b	0.225	12
Suspended beta (pCi/L)	21.000	-14.000 ^b	-1.167 ^b	12
Suspended solids (mg/L)	1638.000	6.000	459.500	4
Technetium-99 (pCi/L)	16.000	-7.000 ^b	4.023	13
Temperature (°F)	80.000	37.000	57.258	62
Thallium (mg/L)	<0.090	<0.090	<0.090	1
Tin (mg/L)	<0.050	<0.050	<0.050	1
Total organic carbon (mg/L)	11.000	5.000	8.250	4
Total solids (mg/L)	1740.000	144.000	576.750	4
Uranium (mg/L)*	0.014	<0.001	<0.002	17
Vanadium (mg/L)	<0.050	<0.050	<0.050	1
Zinc, total residual (mg/L)	<0.005	<0.005	<0.005	1

^aSee Fig. 4.3 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.18. 1992 annual data summary for sampling location SW5^a
Downstream Big Bayou Creek

Parameters	Max	Min	Av	Number of samples
Assay % uranium-235 (wt %)	0.880	0.451	0.619	10
Dissolved alpha (pCi/L)	13.100	-11.700 ^b	1.617	12
Dissolved beta (pCi/L)	30.000	5.000	14.150	12
Gross alpha (pCi/L)	4.100	4.100	4.100	1
Gross beta (pCi/L)	6.000	6.000	6.000	1
Neptunium-237 (pCi/L)	0.300	-0.700 ^b	0.000	13
pH (standard units)	8.600	7.400		2
Plutonium-239 (pCi/L)	0.200	0.000	0.065	13
Suspended alpha (pCi/L)	4.500	-6.500 ^b	-0.150 ^b	12
Suspended beta (pCi/L)	15.000	-4.000 ^b	0.358	12
Technetium-99 (pCi/L)	16.000	-9.000 ^b	6.154	13
Thorium-230 (pCi/L)	0.000	0.000	0.000	1
Uranium (mg/L)	0.017	<0.001	<0.005	13

^aSee Fig. 4.3 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 4.19. 1992 annual data summary for sampling location SW10^a
Downstream Little Bayou Creek

Parameters	Max	Min	Av	Number of samples
Assay % uranium-235 (wt %)	0.603	0.196	0.310	13
Chromium, total recoverable (mg/L)	<0.050	<0.050	<0.050	3
Dissolved alpha (pCi/L)	19.000	-3.300 ^b	7.325	12
Dissolved beta (pCi/L)	25.000	-28.000 ^b	8.958	12
Gross alpha (pCi/L)	6.100	6.100	6.100	1
Gross beta (pCi/L)	8.000	8.000	8.000	1
Neptunium-237 (pCi/L)	0.600	-0.500 ^b	0.000	13
pH (standard units)	7.800	7.600		2
Plutonium-239 (pCi/L)	0.100	0.000	0.049	13
Suspended alpha (pCi/L)	2.100	-2.700 ^b	-0.475 ^b	12
Suspended beta (pCi/L)	21.000	-11.000 ^b	-0.067 ^b	12
Technetium-99 (pCi/L)	14.000	-10.000 ^b	3.377	13
Thorium-230 (pCi/L)	0.000	0.000	0.000	1
Uranium (mg/L)	0.028	0.007	0.019	13

^aSee Fig. 4.3 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.20. 1992 annual data summary for sampling location SW13^a

North/south diversion ditch

Parameters	Max	Min	Av	Number of samples
Assay % uranium-235 (wt %)	1.280	0.560	0.690	38
Chloride (mg/L)	945.000	14.000	111.596	52
Dissolved alpha (pCi/L)	27.800	-36.000 ^b	4.944	52
Dissolved beta (pCi/L)	130.000	-2.000 ^b	19.462	52
Fluoride (mg/L)	0.940	<0.100	<0.261	51
Flow (Mgd)	1.690	0.077	0.609	52
Hexavalent chromium (mg/L)	0.050	<0.010	<0.013	51
Nitrate as nitrogen (mg/L)	3.000	<1.000	<1.275	51
pH (standard units)	10.000	6.500		52
Phosphate as phosphorus (mg/L)	2.500	<2.000	<2.010	52
Sulfate (mg/L)	217.000	31.000	81.039	52
Suspended alpha (pCi/L)	5.400	-5.600 ^b	0.035	52
Suspended beta (pCi/L)	18.000	-12.000 ^b	0.156	52
Technetium-99 (pCi/L)	139.400	-5.000 ^b	15.539	52
Temperature (°F)	90.000	60.000	74.596	52
Uranium (mg/L)	0.120	0.001	0.020	52

^aSee Fig. 4.3 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.21. 1992 annual data summary for sampling location SW29^a
Upstream Ohio River

Parameters	Max	Min	Av	Number of samples
Assay % uranium-235 (wt %)	0.860	0.620	0.763	7
Aluminum (mg/L)	1.950	1.950	1.950	1
Cadmium (mg/L)	<0.010	<0.010	<0.010	1
Chloride (mg/L)	14.000	7.600	9.833	12
Copper, total recoverable (mg/L)	<0.010	<0.010	<0.010	1
Dissolved alpha (pCi/L)	14.600	-6.800 ^b	1.015	13
Dissolved beta (pCi/L)	29.000	-39.000 ^b	3.885	13
1,2-Dichloroethane (µg/L)	2.000	<1.000	<1.667	3
Fluoride (mg/L)	0.130	<0.100	<0.107	12
Hardness as CaCO ₃ (mg/L CaC)	150.000	150.000	150.000	1
Hexavalent chromium (mg/L)	0.050	<0.010	<0.017	13
Iron, total recoverable (mg/L)	2.590	2.590	2.590	1
Lead (mg/L)	<0.080	<0.080	<0.080	1
Neptunium-237 (pCi/L)	0.900	-0.600 ^b	-0.100 ^b	12
Nickel, total recoverable (mg/L)	<0.050	<0.050	<0.050	1
Nitrate as nitrogen (mg/L)	1.800	<1.000	<1.075	12
Oil and grease (mg/L)	<5.000	<5.000	<5.000	1
pH (standard units)	8.300	7.300		13
Phosphate as phosphorus (mg/L)	<2.000	<2.000	<2.000	12
Plutonium-239 (pCi/L)	0.440	0.000	0.108	12
Polychlorinated biphenyl (µg/L)	<0.100	<0.100	<0.100	1
Sulfate (mg/L)	48.000	13.000	22.417	12
Suspended alpha (pCi/L)	4.400	-6.200 ^b	-1.000 ^b	13
Suspended beta (pCi/L)	17.000	-15.000 ^b	0.385	13
Suspended solids (mg/L)	45.000	45.000	45.000	1
Technetium-99 (pCi/L)	13.000	-5.000 ^b	3.250	12
Total phosphorus (mg/L)	0.120	0.120	0.120	1
Trichloroethylene (mg/L)	<0.001	<0.001	<0.001	1
Uranium (mg/L)	<0.001	<0.001	<0.001	13
Zinc, total residual (mg/L)	0.009	0.009	0.009	1

^aSee Fig. 4.3 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

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Table 4.22. 1992 annual data summary for sampling location SW30^a
Downstream Ohio River

Parameters	Max	Min	Av	Number of samples
Assay % uranium-235 (wt %)	0.990	0.658	0.773	5
Chloride (mg/L)	15.000	7.000	11.000	11
1,2-Dichloroethane (µg/L)	<5.000	<1.000	<3.667	9
Dissolved alpha (pCi/L)	5.900	-4.000 ^b	-0.646 ^b	11
Dissolved beta (pCi/L)	25.000	-5.000 ^b	4.482	11
Fluoride (mg/L)	0.140	<0.100	<0.108	11
Hexavalent chromium (mg/L)	0.030	<0.010	<0.013	11
Neptunium-237 (pCi/L)	0.600	-0.300 ^b	0.036	11
Nitrate as nitrogen (mg/L)	1.700	<1.000	<1.091	11
pH (standard units)	8.400	7.400		11
Phosphate as phosphorus (mg/L)	<2.000	<2.000	<2.000	11
Plutonium-239 (pCi/L)	0.200	0.000	0.055	11
Sulfate (mg/L)	53.000	16.000	28.273	11
Suspended alpha (pCi/L)	4.500	-7.900 ^b	-0.655 ^b	11
Suspended beta (pCi/L)	25.000	-11.000 ^b	5.909	11
Technetium-99 (pCi/L)	12.000	-15.000 ^b	2.000	11
Uranium (mg/L)	<0.001	<0.001	<0.001	11

^aSee Fig. 4.3 in Part 1.

^bNegative numbers indicate that analytical result minus background was less than zero.

Table 4.23. 1992 annual data summary for sampling location SW45^a
Landfill runoff location 2

Parameters	Max	Min	Av	Number of samples
Chloride (mg/L)	29.000	6.000	13.500	4
Dissolved solids (mg/L)	385.000	160.000	246.000	4
Fluoride (mg/L)	0.790	0.790	0.790	1
Gross alpha (pCi/L)	8.400	0.500	4.425	4
Gross beta (pCi/L)	23.000	13.000	17.500	4
Iron, total recoverable (mg/L)	7.950	2.500	5.528	4
Nitrogen (mg/L)	18.230	6.660	10.695	4
pH (standard units)	8.000	7.200		4
Sodium (mg/L)	18.230	6.660	10.695	4
Specific conductance (µmhos/cm)	552.000	144.000	321.667	3
Sulfate (mg/L)	89.000	29.000	51.750	4
Suspended solids (mg/L)	1254.000	180.000	672.750	4
Total organic carbon (mg/L)	20.000	9.000	12.750	4
Total solids (mg/L)	1454.000	419.000	918.750	4
Uranium (mg/L)	0.009	0.002	0.005	4

^aSee Fig. 4.3 in Part 1.

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Table 4.24. 1992 annual data summary for sampling location SW46^a
Landfill runoff location 3

Parameters	Max	Min	Av	Number of samples
Chloride (mg/L)	29.000	6.000	15.500	4
Dissolved solids (mg/L)	603.000	206.000	355.750	4
Fluoride (mg/L)	0.780	0.780	0.780	1
Gross alpha (pCi/L)	12.700	3.000	7.700	4
Gross beta (pCi/L)	31.000	2.000	14.000	4
Iron, total recoverable (mg/L)	13.300	4.030	10.358	4
pH (standard units)	7.900	6.800		4
Sodium (mg/L)	24.700	9.760	15.090	4
Specific conductance (µmhos/cm)	790.000	139.000	407.000	3
Sulfate (mg/L)	238.000	50.000	128.500	4
Suspended solids (mg/L)	649.000	200.000	342.250	4
Total organic carbon (mg/L)	37.000	9.000	17.000	4
Total solids (mg/L)	1029.000	452.000	697.000	4
Uranium (mg/L)	0.010	0.001	0.005	4

^aSee Fig. 4.3 in Part 1.

Table 4.25. 1992 radionuclide concentrations in effluents

Uranium

Location ^a	Number of samples	Concentration (mg/L)			²³⁵ U average	Percent of Derived Concentration Guide ^b
		Max	Min	Av		
K001	52	0.170	0.001	0.022	0.56	1.91
K002	4	0.006	0.003	0.004	0.66	0.45
K008	15	0.005	<0.001	<0.002	0.65	0.22
K009	6	0.003	<0.001	<0.002	0.75	0.21
K010	8	0.027	0.006	0.018	0.38	1.05
K011	52	0.063	0.002	0.025	0.29	1.13
K012	8	0.016	<0.001	<0.007	0.44	0.49
K013	4	0.005	<0.001	<0.002	0.58	0.18
K015	4	0.340	0.011	0.158	0.43	10.50
K016	4	0.008	<0.001	<0.004	0.59	0.35
K017	4	0.012	0.001	0.006	0.55	0.50
K018	4	0.065	0.002	0.020	0.62	1.94

^aSee Fig. 4.4 in Part 1.

^bDerived Concentration Guide for total uranium is 600 pCi/L.

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Table 4.26. 1992 radionuclide concentrations in water

Technetium-99

Location ^a	Number of samples	Concentration (pCi/L)			Percent of Derived Concentration Guide ^b
		Max	Min	Av	
K001	54	77.00	0.00	22.75	0.02
K002	1	8.00	8.00	8.00	0.01
K008	13	25.00	0.00	14.08	0.01
K009	4	12.00	0.00	8.25	0.01
K010	4	93.00	13.00	40.50	0.04
K011	53	37.00	-7.00	7.72	0.01
K012	3	14.00	0.00	5.67	0.01
K016	1	12.00	12.00	12.00	0.01

^aSee Fig. 4.4 in Part 1.

^bDerived Concentration Guide for technetium-99 is 100,000 pCi/L.

Table 4.27. 1992 Paducah Gaseous Diffusion Plant major discharges to surface waters

Month	Uranium (kg)			Technetium (mCi)		
	KPDES ^a 001	KPDES 008	KPDES 011	KPDES 001	KPDES 008	KPDES 011
January	12.0	0.21	1.60	5.14	0.62	0.42
February	4.0	<i>b</i>	2.83	2.53	<i>b</i>	0.47
March	4.96	<i>b</i>	1.72	3.53	<i>b</i>	0.11
April	2.84	0.16	0.76	2.91	1.36	0.13
May	0.51	<i>b</i>	0.76	2.77	<i>b</i>	0.54
June	0.59	<i>b</i>	0.44	2.83	<i>b</i>	0.16
July	2.93	0.27	0.97	5.93	2.19	0.75
August	2.11	<i>b</i>	1.22	9.29	<i>b</i>	0.02
September	3.15	<i>b</i>	1.46	4.75	<i>b</i>	0.22
October	0.75	0.16	1.13	2.82	2.82	0.50
November	5.60	<i>b</i>	2.14	6.08	<i>b</i>	0.61
December	9.66	<i>b</i>	1.36	5.52	<i>b</i>	0.21
Total	49.10	2.4	14.39	54.1	20.97	4.14

^aSee Fig. 4.4 in Part 1.

^bQuarterly average assumed to be representative of each month's contribution.

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Table 4.28. 1992 Paducah Gaseous Diffusion Plant (PGDP) state Cabinet of Human Resources (CHR) radiochemical data comparison for surface water

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
Upstream Big Bayou at L-1							
4397-92	2-11-92	Backup ^a	<1	Backup	3±1	Backup	NR ^b
4930-92	5-12-92	Backup	<1	Backup	4±1	Backup	NR
5488-92	8-19-92	-0.9	<1	-2	<3	1	NR
6142-92	11-11-92	Backup	<1	Backup	4±1	Backup	NR
Annual maximum ^c		13.5	<1	40	4±1	16	
Annual minimum ^c		-7.3		-11	<3	-7	
Upstream Little Bayou above K013 at L-9							
4398-92	2-11-92	2.8	<1	10	4±1	13	NR
4931-92	5-12-92	Backup	<1	Backup	5±1	Backup	NR
5489-92	8-19-92	Backup	<1	Backup	4±1	Backup	NR
6143-92	11-11-92	Backup	<1	Backup	7±1	Backup	NR
Annual maximum		2.8 ^d	<1	10 ^d	7±1	13 ^d	
Annual minimum					4±1		
Downstream Little Bayou at Iron Bridge, L-11							
4399-92	2-11-92	Backup	4±1	Backup	8±1	Backup	<9
4932-92	5-12-92	0.4	6±2	-0.4	8±1	14	<9
5490-92	8-19-92	Backup	1±1	Backup	<3	Backup	NR
6144-92	11-11-92	Backup	2±1	Backup	7±1	Backup	NR
Annual maximum		0.4 ^d	6±2	-0.4 ^d	8±1	14 ^d	<9
Annual minimum			1±1		<3		
Downstream Little Bayou below TVA at L-12							
4400-92	2-11-92	Backup	1±1	Backup	9±1	Backup	10±8
4933-92	5-12-92	Backup	4±2	Backup	9±1	Backup	<9
5491-92	8-19-92	Backup	<1	Backup	8±1	Backup	<8
6145-92	11-11-92	Backup	<1	Backup	7±1	Backup	NR
Annual maximum			4±2		9±1		10±8
Annual minimum			<1		7±1		<8
Downstream Big Bayou at 3/4 Bridge, L-7							
4401-92	2-11-92	Backup	<2	Backup	11±2	Backup	<9
4934-92	5-12-92	Backup	<1	Backup	8±1	Backup	<9
5492-92	8-19-92	Backup	<2	Backup	11±2	Backup	11±8
6146-92	11-11-92	Backup	<1	Backup	13±2	Backup	9±4
Annual maximum			<2		13±2		11±8
Annual minimum			<1		8±1		<9
Downstream Big Bayou at Rossington, L-6							
4402-92	2-11-92	3.2	<2	43	16±2	15	<9
4935-92	5-12-92	-2.8	3±2	6	7±1	11	NR
5493-92	8-19-92	Backup	2±2	Backup	14±2	Backup	11±8
6147-92	11-11-92	Backup	7±2	Backup	16±2	Backup	14±4
Annual maximum		3.2	7±2	43	16±2	15	14±4
Annual minimum		-2.8	<2	6	7±1	11	<9

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Table 4.28 (continued)

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
Downstream Big Bayou at Iron Bridge, L-4							
4403-92	2-12-92	Backup	3±2	Backup	13±2	Backup	<9
4936-92	5-13-92	Backup	3±2	Backup	11±2	Backup	<9
5494-92	8-18-92	Backup	3±2	Backup	15±2	Backup	12±8
6148-92	11-10-92	Backup	8±3	Backup	16±2	Backup	11±4
Annual maximum			8±3		16±2		12±8
Annual minimum			3±2		11±2		<9
KPDES ^e 001 at normal sampling location, K001							
4404-92	2-11-92	8.1	<4	39	17±4	4	<9
4937-92	5-12-92	Backup	<4	Backup	20±3	Backup	<9
5495-92	8-19-92	-0.6	8±4	57	28±4	42	33±8
6149-92	11-11-92	Backup	8±4	Backup	32±4	Backup	27±4
Annual maximum		112.4	8±4	124	32±4	77	33±8
Annual minimum		-15.5	<4	-13	17±4	0	<9
KPDES 004 at normal location, L-23							
4405-92	2-11-92	Backup	2±1	Backup	9±1	Backup	12±8
4938-92	5-12-92	Backup	2±1	Backup	8±1	Backup	<9
5496-92	8-19-92	Backup	<1	Backup	5±1	Backup	NR
6150-92	11-11-92	Backup	<1	Backup	10±1	Backup	<9
Annual maximum			2±1		10±1		12±8
Annual minimum			<1		5±1		<9
KPDES 006 at L-27							
4406-92	2-11-92	Backup	<1	Backup	3±1	Backup	NR
4939-92	5-12-92	Backup	<1	Backup	3±1	Backup	NR
5497-92	8-19-92	Backup	<1	Backup	<3	Backup	NR
6151-92	11-11-92	Backup	<1	Backup	3±1	Backup	NR
Annual maximum			<1		3±1		
Annual minimum					<3		
KPDES 008 at K008 or L-20							
4407-92	2-11-92	Backup	<1	Backup	5±1	Backup	NR
4940-92	5-12-92	Backup	<1	Backup	5±1	Backup	NR
5498-92	8-19-92	0.2	<1	1	<3	7	NR
6152-92	11-11-92	Backup	2±1	Backup	12±1	Backup	13±4
Annual maximum		5.5	2±1	41	12±1	25	13±4
Annual minimum		-3.2	<1	1	<3	0	
KPDES 009 at L-19							
4408-92	2-11-92	Backup	<1	Backup	<2	Backup	NR
4941-92	5-12-92	Backup	<1	Backup	3±1	Backup	NR
5499-92	8-19-92	Backup	<1	Backup	<3	Backup	NR
6153-92	11-11-92	Backup	<1	Backup	4±1	Backup	NR
Annual maximum		8.1	<1	13	4±1	12	
Annual minimum		-1.5		4	<2	0	

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Table 4.28 (continued)

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
KPDES 011 at K011 or L-17							
4409-92	2-11-92	18	3±1	31	4±1	15	NR
4942-92	5-12-92	6.8	4±1	8	7±1	10	<9
5500-92	8-19-92	Backup	<1	Backup	<3	Backup	NR
6154-92	11-11-92	Backup	8±1	Backup	8±1	Backup	NR
Annual maximum		41.7	8±1	76	8±1	37	<9
Annual minimum		-12.3	<1	-7	<3	-7	
KPDES 002 at L-15							
4410-92	2-11-92	Backup	2±1	Backup	6±1	Backup	NR
4943-92	5-12-92	Backup	2±1	Backup	5±1	Backup	NR
5501-92	8-19-92	Backup	<1	Backup	<3	Backup	NR
6155-92	11-11-92	Backup	2±1	Backup	6±1	Backup	NR
Annual maximum		11.6	2±1	36	6±1	8 ^d	
Annual minimum		-4.2	<1	-2.2	<3		
KPDES 003 at L-14							
4411-92	2-11-92	Backup	32±3	Backup	104±3	Backup	96±9
4944-92	5-12-92	Backup	11±2	Backup	25±2	Backup	25±8
5502-92	8-19-92	Backup	13±2	Backup	17±2	Backup	13±8
6156-92	11-11-92	Backup	6±2	Backup	17±1	Backup	23±4
Annual maximum			32±3		104±3		96±9
Annual minimum			6±2		17±1		13±4
KPDES 010 at L-16							
4412-92	2-11-92	Backup	4±1	Backup	8±1	Backup	NR
4945-92	5-12-92	Backup	8±2	Backup	10±1	Backup	<9
5503-92	8-19-92	Backup	<1	Backup	<3	Backup	NR
6157-92	11-11-92	Backup	4±1	Backup	8±1	Backup	<9
Annual maximum		18.44	8±1	67	10±1	93	<9
Annual minimum		1.2	<1	-9	<3	13	
KPDES 012 at L-18							
4413-92	2-11-92	Backup	4±2	Backup	5±1	Backup	NR
4946-92	5-12-92	28	8±3	19	7±1	5	NR
5504-92	8-19-92	Backup	5±2	Backup	<3	Backup	NR
6158-92	11-11-92	Backup	5±1	Backup	6±1	Backup	NR
Annual maximum		28	8±3	32	7±1	14	
Annual minimum		-1.1	4±2	-2	<3	0	
KPDES 013 at L-60							
4414-92	2-11-92	Backup	3±2	Backup	5±1	Backup	NR
4947-92	5-12-92	Backup	<2	Backup	5±1	Backup	NR
5505-92	8-19-92	Dry					
6159-92	11-11-92	Backup	2±1	Backup	3±1	Backup	NR
Annual maximum		2.9	3±2	62	5±1		
Annual minimum		-3.4	<2	-30	3±1		

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Table 4.28 (continued)

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
KPDES 015 at L-34							
4415-92	2-11-92	Backup	25±4	Backup	35±2	Backup	12±8
4948-92	5-12-92	Backup	129±9	Backup	110±4	Backup	33±8
5506-92	8-19-92	Backup	66±5	Backup	45±2	Backup	21±8
6160-92	11-11-92	Backup	45±5	Backup	48±3	Backup	32±4
Annual maximum		112.6	129±9	244	110±4		33±8
Annual minimum		5.5	25±4	-0.7	35±2		12±8
KPDES 016 at L-57							
4416-92	2-11-92	Backup	11±2	Backup	6±1	Backup	NR
4949-92	5-12-92	Dry					
5507-92	8-19-92	Dry					
6161-92	11-11-92	Backup	1±1	Backup	7±1	Backup	NR
Annual maximum		4.6	11±2	36	7±1	12 ^d	
Annual minimum		-2.4	1±1	-36	6±1		
KPDES 017 at L-58							
4417-92	2-11-92	Backup	4±2	Backup	7±2	Backup	<9
4950-92	5-12-92	Backup	3±2	Backup	5±1	Backup	NR
5508-92	8-19-92	Dry					
6162-92	11-11-92	Backup	3±1	Backup	5±1	Backup	NR
Annual maximum		4.1	4±2	16	7±2	-4	<9
Annual minimum		-1.4	3±1	51	5±1	31	
KPDES 018 at L-59							
4418-92	2-11-92	Backup	45±4	Backup	43±2	Backup	30±8
4951-92	5-12-92	Backup	27±4	Backup	38±2	Backup	13±8
5509-92	8-19-92	Dry					
6163-92	11-11-92	Backup	8±2	Backup	23±2	Backup	25±4
Annual maximum		22.8	45±4	51	43±2		30±8
Annual minimum		3.7	8±2	31	23±2		25±8
Landfill C-746K at the source, point 3 and point 3A							
4419-92 (source)	2-11-92	1.0	<9	22	<18	0	<9
4952-92 (point 3)	5-12-92	-1.4	<1	8	4±1	18	NR
5510-92 (point 3A)	8-19-92	Backup	<3	Backup	<8	Backup	NR
6164-92 (point 3A)	11-11-92	3.5	<1	9	4±1	12	NR
Annual maximum							
Annual minimum							

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Table 4.28 (continued)

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
<i>Landfill C-746K at point 1 upstream</i>							
	2-11-92 ^f		<1		3±1		NR
4953-92	5-12-92	Backup	2±1	Backup	3±1	Backup	NR
5511-92	8-19-92	Backup	<1	Backup	3±1	Backup	NR
6165-92	11-11-92	4.3	<1	1	4±1	4	NR
Annual maximum		4.3	2±1	1	4±1	6	
Annual minimum		-2.1	<1	-1	3±1	4	

^aSamples designated as backup were collected by PGDP at the same time the CHR samples were collected. These samples were not analyzed by PGDP unless the corresponding CHR samples were damaged, lost, or yielded questionable results.

^bNot run.

^cThe annual maximum and annual minimum values reported by PGDP are the maximum and minimum values that resulted from all samples taken by PGDP at the specified location in 1992. The total number of samples taken in 1992 differed among sampling locations (e.g., a single sample was collected and analyzed from L-9 in 1992, while approximately 54 samples were collected and analyzed from K001 in 1992). A maximum of one sample per location was taken per quarter by the CHR; therefore, the annual maximum and minimum values reported by the CHR are the maximum and minimum of the CHR results reported in this table.

^dA single sample was collected and analyzed for this constituent by PGDP at the specified location in 1992.

^eKentucky Pollutant Discharge Elimination System.

^fThis sample was taken at the discretion of the CHR after arriving at the site and was not required by the Quarterly Sampling Plan. PGDP did not split this additional sample.

5. Groundwater

Table 5.1. Results of 1992 quarterly C-404 Resource Conservation and Recovery Act effluent monitoring

Date	pH (unit)	Cond. ^a (µmhos/cm)	Temp (°F)	⁹⁹ Tc ^b (pCi/L)	TCE ^c (µg/L)	TOC ^d (mg/L)	TOX ^e (µg/L)	As ^f (mg/L)	Diss. As ^g (mg/L)	Cd ^h (mg/L)	Pb ⁱ (mg/L)	Se ^j (mg/L)	Diss. Se ^k (mg/L)	U ^l (mg/L)
MW84														
3/23	6.2	211	59	170	<1	<1	<5	<0.005	NA ^m	<0.1	<0.2	<0.005	NA	<0.001
6/25	NA	205	60	179	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
					<1	<1	<5							
					<1	<1	<5							
					<1	<1	<5							
					<1	1	<5							
9/25	5.9	215	60	100	<1	1	6	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
					2	8	8							
					1	1	<5							
					1	17								
MW85														
3/27	6.4	514	60	274	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
6/23	6.7	562	62	300	<1	<1	8	<0.005	NA	<0.01	<0.2	<0.005	NA	0.001
					<1	<1	6							
					<1	<1	<5							
					<1	<1	<5							
					<1	1	<5							
9/25	6.8	593	60	304	<1	1	7	<0.005	NA	<0.01	<0.2	<0.005	NA	0.001
					3	1	<5							
					2		<5							
					2		<5							
							<5							
MW86														
3/24	6.3	235	59	8	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	0.001
6/23	6.1	233	61	-19	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	0.002
					<1	<1	<5							
					<1	<1	<5							
					<1	<1	5.2							
					<1	<1	<5							

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Table 5.1 (continued)

Date	pH (unit)	Cond. ^a (umhos/cm)	Temp (°F)	⁹⁰ Tc ^b (pCi/L)	TCE ^c (µg/L)	TOC ^d (mg/L)	TOX ^e (µg/L)	As ^f (mg/L)	Diss. As ^g (mg/L)	Cd ^h (mg/L)	Pb ⁱ (mg/L)	Se ^j (mg/L)	Diss. Se ^k (mg/L)	U ^l (mg/L)
9/25	5.9	234	59	4	<1	<1	<5	<0.05	NA	<0.01	<0.2	<0.005		0.002
MW87														
3/26	6.4	247	59	2	<1	<1	6.6	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
6/25		227	61	2	<1	<1	<5	<0.005		<0.01	<0.2	<0.005	NA	<0.001
MW88														
9/23	6.2	235	60	0	<1	<1	<5	<0.005		<0.01	<0.2	<0.005	NA	<0.001
MW89														
3/26	6.4	538	60	1224	310	1	218	0.010	<0.005	<0.01	<0.2	<0.005	NA	<0.001
MW90														
6/22	6.1	539	60	913	470	<1	225	0.005	<0.005	<0.01	<0.2	<0.005	NA	<0.001
MW91														
9/24	6.0	537	60	855	480	<1	238	0.006	<0.005	<0.01	<0.2	<0.005	NA	<0.001
MW92														
3/26	6.3	226	60	19	<1	1	249	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
MW93														
						<1	266							
						1	310							
						1	253							
						<1	241							
						2	434							
						1	436							
						2	474							
						2	448							

Table 5.1 (continued)

Date	pH (unit)	Cond. ^a (µmhos/cm)	Temp (°F)	⁹⁹ Tc ^b (pCi/L)	TCE ^c (µg/L)	TOC ^d (mg/L)	TOX ^e (µg/L)	As ^f (mg/L)	Diss. As ^g (mg/L)	Cd ^h (mg/L)	Pb ⁱ (mg/L)	Se ^j (mg/L)	Diss. Se ^k (mg/L)	U ^l (mg/L)
6/23	6.7	224	60	-19	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						<1	<5							
						<1	<5							
9/23	6.3	235	60	0	<1	<1	5	0.01	<0.005	<0.01	<0.2	<0.005	NA	<0.001
						<1	6							
						<1	7							
						1	<5							
						1	<5							
MW90														
3/26	6.1	203	60	19	<1	<1	8.7	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						<1	<5							
						<1	<5							
6/24	6.2	196	61	6	<1	<1	8.6	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						<1	<5							
						<1	<5							
9/23	6.3	200	61	0	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						1	<5							
						<1	9							
						1	<5							
MW91														
3/26	6.1	377	60	43	25	<1	21	<0.005	NA	<0.01	<0.2	<0.005	NA	0.001
						<1	25							
						1	31							
6/24	6.4	401	63	41	18	<1	23	<0.005	NA	<0.01	<0.2	<0.005	NA	0.001
						<1	19							
						<1	21							
						<1	25							
						1	38							
9/23	7.3	374	61	18	<15	2	21	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						2	17							
						<1	24							
						1	13							

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Table 5.1 (continued)

Date	pH (unit)	Cond. ^a (µmhos/cm)	Temp (°F)	⁹⁹ Tc ^b (pCi/L)	TCE ^c (µg/L)	TOC ^d (mg/L)	TOX ^e (µg/L)	As ^f (mg/L)	Diss. As ^g (mg/L)	Cd ^h (mg/L)	Pb ⁱ (mg/L)	Sd ^j (mg/L)	Diss. Se ^k (mg/L)	U ^l (mg/L)
MW92														
3/24	6.0	152	59	7	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						NA	<5							
						<1	<5							
6/24	6.0	149	60	5	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						1	<5							
						1	<5							
						<1	<5							
9/22	5.7	152	61	0	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						<1	<5							
						<1	<5							
						<1	<5							
						1	<5							
MW93														
3/27	6.3	209	59	7	<1	<1	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						1	<5							
						<1	<5							
6/25	NA	201	60	9	<1	2	<5	<0.005	NA	<0.01	<0.2	<0.005	NA	<0.001
						<1	5							
						2	<5							
						<1	6							
9/29	6.0	212	59	3	<1	<1	<5	<0.005		<0.01	<0.2	<0.005		<0.001
						<1	<5							
						<1	<5							
						<1	<5							
						<1	<5							
MW94														
3/27	5.8	1225	60	1268	58	5	92	<0.005	NA	<0.01	<0.2	<0.005	NA	0.001
						5	96							
						5	79							
						5	98							
6/26	6.3	1194	60	885	54	4	66	0.007	<0.005	<0.01	<0.2	<0.005		<0.001
						5	91							
						4	95							
						5	82							

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Table 5.2. Results of 1992 effluent monitoring at underground storage tanks

Date	Benzene (µg/L)	Ethyl benzene (µg/L)	Toluene (µg/L)	Petroleum hydrocarbon (mg/L)	Xylene (µg/L)
<i>MW47</i>					
2/19	<5	<5	<5	0.2	<10
4/23	<5	<5	<5	0.4	<10
6/26	<5	<5	<5	0.9	<10
12/11	<5	<5	<5	0.3	<10
<i>MW48</i>					
2/19	<5	<5	<5	0.1	<10
4/23	<5	<5	<5	0.2	<10
5/27	<5	<5	<5	0.2	<10
12/11	<5	<5	<5	0.2	<10
<i>MW52</i>					
2/19	<5	<5	<5	0.2	<10
4/03	<5	<5	<5	<0.1	<10
8/06	<5	<5	<5	0.2	<10
10/13	<5	<5	<5	0.1	<10
12/08	<5	<5	<5	0.2	<10
<i>MW53</i>					
2/19	<5	<5	<5	0.1	<10
4/08	<5	<5	<5	<0.1	<10
8/06	<5	<5	<5	0.2	<10
10/13	<5	<5	<5	0.1	<10
12/08	<5	<5	<5	0.2	<10
<i>MW54</i>					
2/19	<5	<5	<5	0.1	<10
4/10	<5	<5	<5	<0.1	<10
8/06	<5	<5	<5	0.2	<10
10/07	<5	<5	<5	0.1	<10
12/08	<5	<5	<5	0.2	<10
<i>MW68</i>					
1/22	<5	<5	<5	<0.1	<10
5/15	<5	<5	<5	0.1	<10
7/21	<5	<5	<5	0.2	<10
10/29	<5	<5	<5	0.2	<10
<i>MW69</i>					
1/23	<100	650	<100	1.1	290
5/15	<100	480	<100	2.1	98
7/30	<50	340	<50	1.2	<50

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Table 5.2 (continued)

Date	Benzene (µg/L)	Ethyl benzene (µg/L)	Toluene (µg/L)	Petroleum hydrocarbon (mg/L)	Xylene (µg/L)
<i>MW70</i>					
1/23	<5	<5	<5	0.5	<10
5/15	<50	<50	<50	0.2	<100
7/16	<50	<50	<50	0.2	<100
11/19	<5	<5	<5	0.5	<10
<i>MW71</i>					
1/22	<5	<5	<5	<0.1	<10
5/15	<5	<5	<5	0.2	<10
7/22	<5	<5	<5	0.1	<10
10/29	<5	<5	<5	0.2	<10
<i>MW96</i>					
5/15	<500	2000	<500	4.5	6400
7/16	<500	1800	<500	7.1	5100
11/19	<500	1600	<500	10.2	4900

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Table 5.3 (continued)

Date	TCE ^a (μg/L)	⁹⁹ Tc ^b (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^c (pCi/L)
<i>R424</i>					
3/09	11	<25			363
3/10	10				
5/28	8				
9/04	3	<25			
9/04	<1	<25			
9/04	<1	<25			
9/04	<1	<25			
<i>R432</i>					
7/13	6	<25			
9/04	<1	<25			
9/04	5	<25			
9/04	<1	<25			
<i>R433</i>					
7/24	<1	<25			90
<i>R434</i>					
7/27	<1	<25			161
<i>R435</i>					
7/27	<1				
<i>R438</i>					
8/31	<1	<25			103
<i>R442</i>					
9/04	<1	<25			

^aTrichloroethylene.

^bTechnetium-99.

^cRadon-222.

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Table 5.4. Results of 1992 weekly, monthly, bimonthly, semiannual, and annual ACO/CERCLA^a off-site effluent monitoring

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R2</i>					
2/12	690	611	-4.8	56	
3/27	850	515	-2.6	329	
4/29	700	442	1.6	166	
5/13	710	545	6.5	330	
6/25	790	632	-1.4	360	
7/29	1040	784	-8.1	525	
8/18	1100	911	9.8	535	
9/30	1300	1007	-1.3	509	
10/21	1200	921	-5.9	577	
11/10	1400	1102	2.6	698	
12/08	1300	992	0.2	500	
<i>R5</i>					
1/13	<1	<25	2.0	-2	
2/12	<1	<25	2.5	4	
3/27	<1	<25	-2.0	2	
4/24	1	<25	0	0.5	
5/13	<1	<25	1.5	1	
6/23	1	<25	2.3	2	
7/23	3	<25	3.7	2	
8/18	1	<25	1.5	-3	
9/11	1	<25	-5.4	-1	
10/20	1	<25	-3.4	-6	
11/10	1	<25	0.6	-3	
12/10	<1	<25	1.3	4	
<i>R6</i>					
1/08	<1	<25	4.1	17	
2/12	<1	<25	3.7	8	
3/05	<1	<25	10.4	8	
4/03	<1	<25	0.1	4	
5/13	<1	<25	6.0	6	
6/05	<1	<25	0.8	2	
6/10	<1	<25	-2.1	10	
7/10	<1	<25	1.1	5	
8/18	<1	<25	2.0	-2	
9/03	<1	<25	1.1	-1	
10/08	<1	<25	0.5	-4	
11/10	<1	<25	3.7	5	
12/01	<1 ^e	<25	2.9	8	
<i>R8</i>					
1/07	<1	<25			
3/06	<1	<25			
5/06	<1	<25			
7/16	<1	<25			
9/03	<1	<25			
11/03	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R9</i>					
2/05	<1	<25			
4/07	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
12/03	<1 ^e	<25			
<i>R10</i>					
1/06	<1	<25	2.3	2	555
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	3.2	13	727
2/12	<1	<25	2.8	5	
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	3.2	2	703
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	1.1	2	705
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	-1.1	2	NA ^f
5/13	<1	<25	2.4	3	627
5/18	<1	<25			
5/26	<1	<25			
6/01	<1	<25	-1.3	-1	593
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	-0.6	-1	
7/13	<1	<25			593
7/20	<1	<25			
7/27	<1	<25			
8/03	<1	<25	0.8	-4	567
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-1.9	-3	705
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-5.2	-5	727
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	2.3	0	698
11/10	<1	<25	-2.0	-3	
11/16	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (μg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25	1.5	2	604
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			
			R12		
1/06	<1	<25	1.0	-6	296
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	1.8	5	308
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	5	5	366
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	0.4	2	657
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	0.2	0.3	NA 742
5/11	<1	<25			
5/18	<1	<25			
5/26	<1	<25			
6/01	<1 ^g	<25	7.1	-1	359
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	0.7	-1	
7/13	<1	<25			303
7/20	<1	<25			
7/28	<1	<25			
8/03	<1	<25	-0.2	-3	276
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-2.3	-1	347
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-2.7	-3	351
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	1.0	1	364
11/09	<1	<25			
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
12/07	<1	<25	3.2	2	352
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			
<i>R13</i>					
1/06	<1	<25	2.0	-2	255
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	3.3	7	342
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	-12.6	-8	365
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	6.2	7	384
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	0.8	0.1	NA
5/13	<1	<25	3.5	3	335
5/18	<1	<25			
5/26	<1	<25			
6/01	<1 ^g	<25	0.7	9	318
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	0.8	1	
7/13	<1	<25			310
7/20	<1	<25			
7/28	<1	<25			
8/03	<1	<25	-2.5	0	304
8/10	<1	<25			
8/18	<1	<25	2	-0.2	
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	1.0	-2	355
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-2.5	11	358
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	1.3	2	372
11/10	<1	<25	-1	-0.8	
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25	4.9	7	310
12/14	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
12/21	<1	<25			
12/28	<1	<25			
<i>R14</i>					
1/06	<1	<25	1.8	2	1169
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	0.9	3	1469
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	4.7	12	1575
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	5.3	6	1548
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	1.9	2	NA
5/11	<1	<25			1427
5/18	<1	<25			
5/26	<1	<25			
6/01	<1 ^g	<25	3.8	-5	1380
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	0.4	0.1	
7/13	<1	<25			1203
7/20	<1	<25			
7/28	<1	<25			
8/03	<1	<25	-0.8	-2	1275
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-1.5	-3	1585
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-4.0	-2	1457
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	2	2.7	1565
11/09	<1	<25			
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25	1.0	5	1467
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (μg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R17</i>					
1/13	160	158	2.7	124	
2/12	130	161	5.1	121	
3/27	260	171	-2.8	157	
4/24	290	239	-1.0	149	
5/13	340	243	-0.4	160	
6/23	340	244	0.4	183	
7/23	250	287	0.6	136	
8/18	270	202	2.9	127	
9/11	220	199	5.4	127	
10/20	210	174	-2.7	181	
11/10	220	215	3.0	119	
12/10	160	191	0	135	
<i>R18</i>					
1/13	<1	<25	2.3	-3	
<i>R19</i>					
1/06	<1	<25	7.0	5	341
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	1.4	7	485
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	-0.3	9	530
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	-1.6	3	516
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	-3.1	0.1	NA
5/11	<1	<25			467
5/18	<1	<25			
5/26	<1	<25			
6/01	<1 ^g	<25	1.4	-1	495
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	-1.4	-2	
7/13	<1	<25			387
7/20	<1	<25			
7/28	<1	<25			
8/03	<1	<25	-2.3	-3	441
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
9/08	<1	<25	-1.4	-2	575
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-4.0	-3	498
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	2.3	4	527
11/09	<1	<25			
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25	3.5	3	593
12/07	<1	<25	3.1	2	397
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			
<i>R20</i>					
6/12	<1	<25			
8/20	<1	<25			
<i>R21</i>					
1/08	<1	<25	0.6	6	
2/12	<1	<25	1.0	13	
3/16	<1	<25	-0.3	2	
4/10	<1	<25	0.6	-1	
5/13	<1	<25	-0.8	0.8	
6/05	<1	<25	-1.1	0.1	
7/10	<1	<25	-4.2	-1	
8/18	<1	<25	0.3	-2	
9/03	<1	<25	0.6	-5	
10/08	<1	<25	-7.9	-7	
11/10	<1	<25	-2.8	1	
12/01	<1	<25	0	5	
<i>R22</i>					
2/06	<1	<25			
4/03	<1	<25			
6/10	<1	<25			
8/07	<1	<25			
10/06	<1	<25			
12/03	<1	<25			
<i>R23</i>					
1/07	<1	<25			
3/06	<1	<25			
5/06	<1	<25			
7/16	<1	<25			
9/03	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R24</i>					
2/06	<1	<25			
4/03	<1	<25			
6/10	<1	<25			
8/07	<1	<25			
10/06	<1	<25			
12/03	<1	<25			
<i>R25</i>					
1/07	<1	<25			
3/05	<1	<25			
5/04	<1	<25			
7/16	<1	<25			
7/20	<1	<25			
9/14	<1	<25			
11/03	<1	<25			
<i>R26</i>					
2/12	<1	<25	0.5	3	
4/03	<1	<25			
6/10	<1	<25			
8/07	<1	<25			
10/06	<1	<25			
12/03	<1	<25			
<i>R28</i>					
1/07	<1	<25			
3/05	<1	<25			
5/04	<1	<25			
7/16	<1	<25			
7/20	<1	<25			
9/14	<1	<25			
11/03	<1	<25			
<i>R39</i>					
1/06	<1	<25	4.2	3	453
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	0.3	5	447
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	0.8	5	695
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	1.5	2	846
4/13	<1	<25			
4/20	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (μg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
4/28	<1	<25	1.8	10	NA 284
5/04	<1	<25			
5/11	<1	<25			
5/18	<1	<25	3.4	6	662
5/26	<1	<25			
6/01	<1 ^g	<25			
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25	-1.7	1	471
6/29	<1	<25			
7/06	<1	<25			
7/13	<1	<25	1.4	-3	408
7/20	<1	<25			
7/27	<1	<25			
8/03	<1	<25			
8/10	<1	<25			
8/17	<1	<25	-2.0	-4	593
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-4.5	-6	659
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25			
10/12	<1	<25	1.0	4	668
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25			
11/09	<1	<25			
11/16	<1	<25	2.7	1	837
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25			
12/14	<1	<25			
12/21	<1	<25	<i>R40</i>	-2	248
12/28	<1	<25			
1/06	<1	<25			
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25			316
2/12	<1	<25			
2/18	<1	<25		3	
2/24	<1	<25			
3/02	<1	<25		1	309
3/09	<1	<25			
3/16	<1	<25		4	308
3/23	<1	<25			
3/30	<1	<25		-0.1	
4/06	<1	<25			
4/13	<1	<25		4.5	281
4/20	<1	<25			
4/28	<1	<25		10	
5/04	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
5/13	<1	<25	0.9	1	
5/18	<1	<25			
5/26	<1	<25			
6/01	<1	<25	-2.3	-3	286
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	0.5	1	
7/13	<1	<25			246
7/20	<1	<25			
7/27	<1	<25			
8/03	<1	<25	1.0	-4	252
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-0.8	-4	315
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-3.0	-3	319
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	0.2	1	312
11/10	<1	<25	0	1	
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25	1.7	3	330
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			
<i>R42</i>					
1/07	<1	<25			
3/06	<1	<25			
5/06	<1	<25			
7/16	<1	<25			
9/03	<1	<25			
11/03	<1	<25			
<i>R43</i>					
1/08	<1	<25	0.8	18	
2/13	<1	<25	4.9	-3	
3/12	<1	<25	12.1	24	
4/14	<1	<25	-0.2	-1	
5/18	<1	<25	1.5	-3	
6/17	<1	<25	3.3	-0.1	
7/16	<1	<25	-1.0	-4	
8/13	<1	<25	-2.3	-4	
9/16	<1	<25	-4.5	-5	
11/19	<1	<25	-1.1	5	

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R53</i>					
2/06	<1	<25			
4/03	<1	<25			
6/10	<1	<25			
8/07	<1	<25			
10/06	<1	<25			
12/03	<1	<25			
<i>R54</i>					
1/06	<1	<25	6.1	1	294
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	3.0	8	344
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	4.5	4	403
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	1.2	4	404
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	0	1	NA
5/11	<1	<25			362
5/18	<1	<25			
5/26	<1	<25			
6/01	<1	<25	3.8	1	323
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	1.8	1	
7/13	<1	<25			348
7/20	<1	<25			
7/27	<1	<25			
8/03	<1	<25	1.2	-3	325
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-0.6	-4	415
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	2.3	1	463
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	0.5	1	383
11/09	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (μg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			
12/07	<1	<25	4.5	3	418
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			
<i>R69</i>					
1/07	<1	<25			
3/05	<1	<25			
5/04	<1	<25			
7/16	<1	<25			
9/14	<1	<25			
11/03	<1	<25			
<i>R72</i>					
1/08	<1	<25	3.5	-5	
2/13	<1	<25	3.8	5	
3/16	<1	<25	2.3	2	
4/10	<1	<25	1.2	1	
5/12	<1	<25	0.4	2	
6/05	<1	<25	-0.8	-1	
7/10	<1	<25	-0.3	3	
8/12	<1	<25	-1.1	-2	
9/03	<1	<25	-2.9	-6	
10/08	<1	<25	-1.8	-4	
11/09	<1	<25	0.9	5	
12/01	<1	<25	-2.5	0	
<i>R79</i>					
2/05	<1	<25			
4/07	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
10/06	<1	<25			
12/03	<1	<25			
<i>R82</i>					
1/08	<5	<25	11.8	25	
2/13	<5	<25	0	3	
3/16	<5	<25	-1.9	4	
4/09	<5	<25	1.1	9	
5/12	<5	<25	-0.9	2	
6/05	<1	<25	-2.0	-1.5	
7/10	<5	<25	-0.3	3	
8/12	<5	<25	-1.4	-5	
9/03	<5	<25	-0.8	-9	
10/08	<5	<25	-9.8	7	
11/05	<5	<25	1.6	5	
12/01	<5	<25	-0.6	5	

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R83</i>					
1/08	<1	<25	-2.7	-1	
2/13	<1	<25	11.3	18	
3/16	<1	<25	2.8	10	
4/10	<1	<25	-5.0	0.1	
5/12	<1	<25	-0.4	2	
6/05	<1	<25	-1.0	-0.1	
7/10	<1	<25	-1.1	-1	
8/12	<1	<25	0	-4	
9/03	<1	<25	-3.3	-8	
10/08	<1	<25	-3.3	4	
11/05	<1	<25	8.4	11	
12/01	<1	<25	1.1	4	
<i>R84</i>					
1/08	<1	<25	-1.7	-14	
2/13	<1	<25	3.2	2	
3/16	<1	<25	-6.4	0.3	
4/10	<1	<25	5.9	-1	
5/12	<1	<25	0.4	3	
6/05	<1	<25	0	1.2	
7/10	<1	<25	-2.3	-1	
8/12	<1	<25	4.8	-4	
9/03	<1	<25	-2.3	-7	
10/08	<1	<25	-5.1	-4	
11/05	<1	<25	7.1	7	
12/01	<1	<25	1.0	6	
<i>R88</i>					
2/05	<1	<25			
4/07	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
<i>R89</i>					
6/12	<1	<25			
8/20	<1	<25			
<i>R90</i>					
6/12	<1	<25			
12/03	<1	<25			
<i>R112</i>					
2/05	<1	<25			
4/07	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
10/06	<1	<25			
12/03	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R113</i>					
1/30	500	243	9.9	234	
2/20	650	339	2.0	244	
3/31	710	273	-2.5	243	
4/29	1100	429	-3.3	273	
5/15	1200	440	-2.4	586	
6/25	1100	717	-1.0	291	
7/29	1080	427	-3.4	260	
8/28	890	405	-0.2	298	
9/30	820	345	-2.4	199	
10/21	1100	345	-1.8	237	
11/20	980	410	0.3	248	
12/08	1000	404	2.3	237	
<i>R78</i>					
2/05	<1	<25			
4/14	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
10/07	<1	<25			
12/03	<1	<25			
<i>R293</i>					
1/07	<1	<25			
3/06	<1	<25			
5/06	<1	<25			
7/16	<1	<25			
9/03	<1	<25			
11/03	<1	<25			
<i>R294</i>					
1/07	<1	<25	0	-31	307
1/13	<1	<25			
1/20	<1	<25			
1/27	<1	<25			
2/03	<1	<25	2.3	5	298
2/10	<1	<25			
2/18	<1	<25			
2/24	<1	<25			
3/02	<1	<25	-3.6	9	330
3/09	<1	<25			
3/16	<1	<25			
3/23	<1	<25			
3/30	<1	<25			
4/06	<1	<25	2.4	6	362
4/13	<1	<25			
4/20	<1	<25			
4/28	<1	<25			
5/04	<1	<25	-2.8	1	193
5/11	<1	<25			
5/18	<1	<25			
5/26	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (μg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
6/01	<1 ^g	<25	-2.3	4	219
6/08	<1	<25			
6/15	<1	<25			
6/22	<1	<25			
6/29	<1	<25			
7/06	<1	<25	0.6	0.5	233
7/13	<1	<25			
7/20	<1	<25			
7/27	<1	<25			
8/03	<1	<25	-2.7	2	226
8/10	<1	<25			
8/17	<1	<25			
8/24	<1	<25			
8/31	<1	<25			
9/08	<1	<25	-0.6	-2	269
9/14	<1	<25			
9/21	<1	<25			
9/28	<1	<25			
10/05	<1	<25	-5.3	2	294
10/12	<1	<25			
10/19	<1	<25			
10/26	<1	<25			
11/02	<1	<25	0.7	3	292
11/09	<1	<25			
11/16	<1	<25			
11/23	<1	<25			
11/30	<1	<25			
12/14	<1	<25			
12/21	<1	<25			
12/28	<1	<25			
<i>R302</i>					
1/08	<1	<25	8.0	26	
2/13	<1	<25	3.0	4	
3/16	<1	<25	7.2	5	
4/10	<1	<25	3.4	1	
5/12	<1	<25	0	3	
6/05	<1	<25	0.3	-1	
7/10	<1	<25	1.7	3	
8/12	<1	<25	-1.1	-7	
9/03	<1	<25	-3.8	-9	
10/08	<1	<25	-2.9	-4	
11/05	<1	<25	11.3	9	
12/01	<1	<25	-1.1	3	
<i>R368</i>					
2/05	<1	<25			
4/14	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
10/07	<1	<25			
12/03	<1	<25			

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Table 5.4 (continued)

Date	TCE ^b (μg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>R381</i>					
6/12	<1	<25			
12/03	<1	<25			
<i>R386</i>					
2/05	<1	<25			
6/12	<1	<25			
8/20	<1	<25			
10/07	<1	<25			
12/03	<1	<25			
<i>TVAD-3 (R156)</i>					
6/16	1	-6			
<i>TVAD-5 (R155)</i>					
6/16	<1	-3			
<i>TVAD-7 (R166)</i>					
6/16	<1	-2			
<i>TVAD-8 (R167)</i>					
6/16	<1	3			
<i>TVAD-9 (R163)</i>					
6/16	<1	-4			
<i>TVAD-13 (R161)</i>					
6/16	<1	-14			
<i>TVAD-15 (R183)</i>					
6/16	<1	2			
<i>TVAD-24 (R165)</i>					
6/16	<1	-2			
<i>TVAD-25 (R170)</i>					
6/16	<1	9			
<i>TVAD-27 (R173)</i>					
6/16	<1	209			
<i>TVAD-28 (R174)</i>					
6/16	<1	6			

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
<i>TVAD-30 (R162)</i>					
6/16	<1	-6			
<i>MW38</i>					
2/18	4	40			
4/22	3	8	-0.3	11	
5/08	4	22			
7/22	4	11	-1.4	13	
8/20	4	20			
10/22	4	24			
11/17	3	44	1.6	18	
12/09	3	14	2.9	16	
<i>MW41</i>					
2/19	19	21			
4/22	20	0	3.1	5	
5/19	24	18			
7/22	23	-0.6	0	4	
8/21	20	0			
10/22	21	0			
11/17	18	20	0.2	4	
12/09	12	1	1.9	8	
12/09	1	2	3.3	4	
<i>MW43</i>					
2/19	1	23			
4/22	1	0	-0.2	3	
5/12	1	13			
7/22	2	3.7	0.3	1	
8/26	2	0			
10/22	2	8			
11/17	2	22	0	3	
<i>MW44</i>					
2/20	30	0			
4/22	31	0	-0.6	4	
5/11	35	5			
7/22	35	1	-1.8	1	
8/26	31	5			
10/27	29	12			
11/17	28	31	3.8	9	
12/09	25	1	4.8	15	
<i>MW66</i>					
1/24	1800	1033			
2/20	2500	1076	3.2	714	
3/31	1600				
3/31	610				
3/31	1100				
3/31	1900				

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Table 5.4 (continued)

Date	TCE ^b (µg/L)	⁹⁹ Tc ^c (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	²²² Rn ^d (pCi/L)
3/31	2100				
3/31	2600				
3/31	2700	1500	-13.9	919	
4/29	4600	2397			
5/15	4600	2063	0	3356	
7/22	830	698			
11/19	4200	1677			
12/08	4600	1948	2.0	922	

^aAdministrative Consent Order/Comprehensive Environmental Response, Compensation, and Liability Act.

^bTrichloroethylene.

^cTechnetium-99.

^dRadon-222.

^eThese data are conditional because of the presence of a 1-cm-diam bubble in each of the sample vials.

^fNot analyzed.

^gThis value is believed to be correct. However, the surrogate for the sample for 1,2-dichloroethane-d4 was out of limits (122/121).

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Table 5.5. Results of 1992 quarterly, semiannual, and annual effluent monitoring at solid waste management units

Date	pH (units)	Conductivity (μ mhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
<i>MW16</i>						
2/06	6.0	441	55	6.2	12	17.81
2/06	6.2	447				
2/06	6.2	441				
2/06	6.3	443				
5/06	6.6	476	55	1.5	10	18.25
5/06	6.6	462				
5/06	6.6	461				
5/06	6.6	463				
8/27	6.2	470	66	3.3	8	20.58
8/27	6.3	471				
8/27	6.3	472				
8/27	6.4	474				
10/21	6.6	469	61	3.5	9	18.12
10/21	6.9	467				
10/21	6.7	468				
10/21	6.7	472				
<i>MW17</i>						
2/06	6.8	1143	16.5	19.5	11	51.15
2/06	6.7	1135				
2/06	6.7	1125				
2/06	6.7	1137				
5/06	6.8	1285	62	11	14	54.58
5/06	6.7	1272				
5/06	6.8	1280				
5/06	6.8	1273				
8/18	7.2	1420	76	19	10	51.50
8/18	7.4	1430				
8/18	7.4	1420				
8/18	7.4	1420				
10/20	7.0	1224	57	20	9	52.33
10/20	7.0	1288				
10/20	7.0	1294				
10/20	7.0	1390				
<i>MW18</i>						
2/05	7.1	1271	62	44	34	33.10
2/05	7.1	1269				
2/05	7.1	1278				
2/05	7.1	1293				
5/05	7.1	1370	61	46	30	33.28
5/05	7.1	1380				
5/05	7.1	1380				
5/05	7.2	1380				
8/18	6.8	1400	61	34	23	34.23
8/18	6.9	1400				
8/18	7.1	1400				
8/18	7.2	1410				
10/20	7.2	1279	61	66	17	35.10
10/20	7.3	1270				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μ mhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
10/20	7.3	1265				
10/20	7.3	1268				
<i>MW19</i>						
2/06	7.2	223	60	9.0	22	40.15
2/07	6.6	225				
2/07	6.8	225				
2/07	6.7	225				
5/07	7.2	212	70	4.4	11	32.29
5/07	7.2	211				
5/07	7.3	211				
5/07	7.3	214				
8/20	6.6	239	69	27	12	40.40
8/20	6.8	230				
8/20	7.0	228				
8/20	7.0	225				
10/21	7.1	226	65	18	7	41.24
10/21	7.3	227				
10/21	7.4	222				
10/21	7.5	221				
11/10	7.6		51			41.28
<i>MW20</i>						
2/12	6.6	322	55	110	7	
2/12	6.4	324				
2/12	6.4	325				
2/12	6.4	325				
5/13	6.5	324	63	33	12	NA ^b
5/13	6.4	324				
5/13	6.4	324				
5/13	6.4	323				
8/17	6.2	330	63	23	10	
8/17	6.1	331				
8/17	6.1	331				
8/17	6.1	331				
<i>MW21</i>						
3/17	6.3	1550	61	4.7	16	46.52
3/17	6.4	1540				
3/17	6.5	NA				
3/17	6.5	1550				
6/04	6.6	1440	64	0.6	25	45.18
6/04	6.7	1450				
6/04	6.7	1460				
6/04	6.7	1450				
9/02	6.4	1560	73	1.5	9	46.83
9/02	6.5	1560				
9/02	6.4	1560				
9/02	6.5	1560				
12/01	6.7	1590	57	1.6	4	47.27
12/01	6.8	1590				
12/01	6.6	1590				
12/01	6.6	1600				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μ mhos/cm)	Temp (°F)	Turbidity (NTU) ^d	Color (units)	Depth to water (ft)
<i>MW21</i>						
3/17	6.2	331	62	1.4	8	44.48
3/17	6.1	327				
3/17	6.1	327				
3/17	6.1	333				
6/02	6.0	343	68	0.2	14	43.37
6/02	6.1	342				
6/02	6.1	343				
6/02	6.1	341				
9/03	6.1	338	77	1.4	7	44.95
9/03	6.1	336				
9/03	6.1	336				
9/03	6.1	339				
10/21	6.2		63			45.63
12/01	6.4	348	56	1.7	7	45.34
12/01	6.4	349				
12/01	6.4	349				
12/01	6.4	347				
<i>MW23</i>						
2/01	6.4	372	55	7.5	21	16.70
8/17	6.7	329	66	3.4	18	16.70
8/17	6.4	542				
8/17	5.5	566				
8/17	5.6	572				
<i>MW24</i>						
2/01	6.1	219	55	14	17	11.20
8/11	7.0	206	69	23	27	10.30
8/11	6.4	220				
8/11	6.4	207				
8/11	6.4	203				
<i>MW26</i>						
2/01	7.4	0.16	56	95	65	28.87
8/11	NA					
8/11	7.3	275	73	108	180	32.59
8/11	NA					
8/11	NA					
<i>MW27</i>						
2/01	6.6	0.14	56	15	37	19.25
8/11	6.3	431	74	42	16	19.07
8/11	6.3	462				
8/11	6.4	454				
8/11	6.5	445				
<i>MW29</i>						
1/31	4.2	502	49	2.3	12	7.31

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
<i>MW38</i>						
2/18	6.2	441	59	3.7	9	59.72
2/18	6.3	438				
2/18	6.3	437				
2/18	6.3	438				
5/08	6.3	446	59	2.7	13	58.49
5/08	6.3	430				
5/08	6.3	438				
5/08	6.3	424				
8/20	6.6	443	60	1.7	11	59.88
8/20	6.6	443				
8/20	6.6	444				
8/20	6.6	440				
8/20	6.5	721				
10/22	6.4	439	59	3.2	10	60.97
10/22	6.4	437				
10/22	6.4	442				
10/22	6.4	443				
<i>MW39</i>						
2/18	6.5	711	59	16	12	56.58
2/18	6.5	719				
2/18	6.5	720				
2/18	6.5	719				
5/08	6.5	661	59	6.6	16	55.53
5/08	6.5	665				
5/08	6.5	678				
5/08	6.6	670				
8/20	6.5	714	60	16	9	56.95
8/20	6.5	715				
8/20	6.5	718				
10/22	6.5	710	59	17	13	57.97
10/22	6.5	717				
10/22	6.5	718				
10/22	6.5	720				
<i>MW40</i>						
2/18	6.4	335	59	0.6	3	57.14
2/18	6.3	331				
2/18	6.3	330				
2/18	6.3	329				
5/12	6.2	333	59	0.4	7	55.78
5/12	6.2	329				
5/12	6.2	330				
5/12	6.2	329				
8/21	6.2	336	59	0.8	12	57.50
8/21	6.2	331				
8/21	6.2	335				
8/21	6.2	330				
10/23	6.3	324	59	1.3	13	58.34
10/23	6.3	323				
10/23	6.3	323				
10/23	6.3	323				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (µmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
<i>MW41</i>						
2/19	6.1	353	59	3.7	2	54.21
2/19	6.1	352				
2/19	6.1	351				
2/19	6.1	354				
5/19	6.4	352	59	3.6	13	52.90
5/19	6.5	352				
5/19	6.5	354				
5/19	6.5	353				
8/21	6.2	362	60	6.8	10	54.27
8/21	6.2	363				
8/21	6.2	363				
8/21	6.2	366				
10/22	6.2	353	60	10	11	59.09
10/22	6.2	352				
10/22	6.2	353				
10/22	6.2	354				
<i>MW42</i>						
2/20	6.2	676	60	4.3	7	38.73
2/20	6.2	696				
2/20	6.2	699				
2/20	6.2	705				
5/19	6.5	687	60	1.6	13	37.26
5/19	6.5	707				
5/19	6.5	705				
5/19	6.4	702				
8/26	6.6	688	60	5.0	9	38.69
8/26	6.4	710				
8/26	6.4	709				
8/26	6.4	707				
10/22	6.7	671	60	4.7	10	39.43
10/22	6.4	684				
10/22	6.4	690				
10/22	6.4	699				
<i>MW43</i>						
2/19	6.2	303	57	0.7	5	49.23
2/19	6.2	302				
2/19	6.2	302				
2/19	6.2	302				
5/12	6.3	310	58	0.7	9	47.54
5/12	6.2	310				
5/12	6.2	311				
5/12	6.3	310				
8/26	6.5	309	58	2.3	9	49.26
8/26	6.4	308				
8/26	6.4	308				
10/22	6.2	308	58	1.6	5	50.00
10/22	6.4	308				
10/22	6.2	308				
10/22	6.3	309				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
<i>MW44</i>						
2/20	6.0	373	59	1.3	6	78.81
2/20	6.1	372				
2/20	6.1	370				
2/20	6.1	371				
5/11	6.1	375	59	1.1	9	77.09
5/11	6.2	373				
5/11	6.2	370				
5/11	6.2	369				
8/26	6.6	380	60	0.6	7	78.51
8/26	6.5	381				
8/26	6.5	380				
8/26	6.5	381				
10/27	5.9	376	59	0.7	7	78.86
10/27	5.9	375				
10/27	5.9	375				
10/27	5.9	375				
<i>MW46</i>						
3/04	6.4	213	60	17.0	16	51.25
3/04	6.4	216				
3/04	6.4	218				
3/04	6.4	209				
5/27	6.3	240	60	4.5	10	50.00
5/27	6.4	238				
5/27	6.3	228				
5/27	6.3	228				
9/09	6.3	237	61	15	26	51.52
9/09	6.3	235				
9/09	6.3	235				
9/09	6.3	233				
12/11	6.1	239	59	7.2	17	52.00
12/11	6.1	237				
12/11	6.2	236				
12/11	6.1	235				
<i>MW47</i>						
3/20	7.8	NA	60	2400	47	10.00
6/26	7.8	1630	69	600	18	NA
9/11	5.4	1710	65	27	19	16.86
12/11	7.1	1510	57	130	6	14.72
<i>MW48</i>						
3/04	6.6	196	59	1.7	6	52.20
3/04	6.5	195				
3/04	6.4	195				
3/04	6.4	196				
5/27	6.3	205	59	2.5	11	51.16
5/27	6.3	205				
5/27	6.3	204				
5/27	6.3	204				
9/09	6.1	208	60	1.2	14	52.36

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Table 5.5 (continued)

Date	pH (units)	Conductivity (µmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
9/09	6.1	204				
9/09	6.1	204				
9/09	6.1	203				
12/11	6.1	205	58	2.0	7	52.87
12/11	6.1	202				
12/11	6.0	200				
12/11	6.1	200				
<i>MW50</i>						
1/29	6.3	167	59	25.5	3	49.29
1/29	6.3	166				
1/29	6.2	165				
1/29	6.2	164				
4/03	6.1	149	59	6.0	22	48.21
4/03	6.1	152				
4/03	6.1	151				
4/03	6.1	152				
7/28	6.6	168	60	15	26	48.35
7/28	6.5	163				
7/28	6.4	163				
7/29	6.4	166				
10/07	5.9	163	59	18	9	49.30
10/07	5.9	161				
10/07	5.9	160				
10/07	5.9	160				
<i>MW51</i>						
1/29	6.1	184	59	15.5	2	48.79
1/29	6.1	180				
1/29	6.0	178				
1/29	6.0	177				
4/07	6.1	173	60	6.1	21	47.75
4/07	6.1	173				
4/07	6.1	171				
4/07	6.1	171				
7/23	6.4	173	61	5.2	17	47.86
7/23	6.4	170				
7/23	6.3	168				
7/23	6.3	170				
10/07	6.1	186	60	13	6	49.00
10/07	6.0	181				
10/07	6.0	179				
10/07	6.0	177				
<i>MW52</i>						
1/24	6.2	198	60	14	6	47.65
1/24	6.2	196				
1/24	6.2	184				
1/24	6.2	185				
4/03	6.3	182	60	8.0	15	46.62
4/03	6.3	184				
4/03	6.3	183				
4/03	6.3	184				
7/23	5.8	177	61	1.5	6	49.70

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μmhos/cm)	Temp (°F)	Turbidity (NTU) ^d	Color (units)	Depth to water (ft)
7/23	6.7	184	61	7.0	22	46.81
7/23	6.6	180				
7/23	6.5	179				
7/23	6.4	182				
10/13	6.1	188	60	10	17	47.71
10/13	6.1	185				
10/13	6.1	186				
10/13	6.1	185				
<i>MW53</i>						
1/24	6.0	178	59	1.5	2	50.53
1/24	6.0	171				
1/24	6.0	170				
1/24	6.0	170				
4/08	6.2	173	60	2.0	15	49.30
4/08	6.2	170				
4/08	6.2	166				
4/08	6.1	169				
7/23	5.8	169				
7/23	5.8	168				
7/23	5.8	169				
10/13	6.3	188	60	1.5	9	50.56
10/13	6.2	185				
10/13	6.2	184				
10/13	6.2	184				
<i>MW54</i>						
1/29	6.6	256	60	30	7	49.29
1/29	6.5	251				
1/29	6.4	254				
1/29	6.4	258				
4/10	6.6	251	61	20	26	48.50
4/10	6.6	243				
4/10	6.6	241				
4/10	6.5	241				
7/23	6.6	276	62	30	12	48.78
7/23	6.5	246				
7/23	6.3	247				
7/23	6.3	242				
10/07	6.5	244	62	8.9	6	49.35
10/07	6.6	236				
10/07	6.5	235				
10/07	6.5	234				
<i>MW57</i>						
1/30	6.9	383	59	90	160	21.44
1/30	6.9	453				
1/30	6.9	422				
1/30	6.7	423				
4/30	7.1	430	64	62	27	21.53
4/30	7.1	434				
4/30	7.0	420				
4/30	7.0	401				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μ mhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
7/28	6.7	434	64	48	25	21.60
7/28	7.1	435				
7/28	7.1	417				
7/28	6.9	415				
11/18	7.4	362	75	32	12	21.74
11/18	7.3	452				
11/18	7.2	449				
11/18	7.2	451				
<i>MW59</i>						
10/28	6.0	230	58	1.8	6	
10/28	6.0	229				
10/28	6.0	229				
10/28	6.1	230				
<i>MW60</i>						
10/28	6.2	488	64	1.0	8	
10/28	6.3	485				
10/28	6.4	484				
10/28	6.3	486				
<i>MW61</i>						
10/28	6.0	380	59	1.6	5	
10/28	6.1	378				
10/28	6.1	378				
10/28	6.1	376				
<i>MW62</i>						
10/28	7.2	302	60	NA	10	
10/28	7.2	301				
10/28	7.2	300				
10/28	7.2	301				
11/06	6.9					
<i>MW63</i>						
1/09	6.3	258	58	12	11	48.03
1/09	6.5	247				
1/09	6.3	247				
1/09	6.3	246				
4/09	6.1	251	60	19	12	46.91
4/09	6.1	248				
4/09	6.1	243				
4/09	6.1	246				
7/08	6.7	272	61	7.7	6	47.00
7/08	6.6	266				
7/08	6.6	265				
7/08	6.5	264				
11/03	6.2	255	60	14	8	48.26
11/03	6.3	251				
11/03	6.3	249				
11/03	6.3	249				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μ mhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
<i>MW64</i>						
4/24	6.9	630	61	4.9	12	9.70
4/24	7.2	633				
4/24	7.2	624				
4/24	7.3	623				
7/22	6.5	606	61	3.3	12	9.52
7/22	6.8	601				
7/22	6.7	620				
7/22	6.9	645				
11/04	7.1	641	59	5.5	21	9.62
11/04	7.2	621				
11/04	7.2	620				
11/04	7.2	617				
<i>MW65</i>						
1/09	5.9	186	58	2	2	48.03
1/09	5.9	187				
1/09	6.1	189				
1/09	6.0	187				
4/21	6.0	192	59	0.3	7	46.43
4/21	6.1	195				
4/21	6.1	196				
4/21	6.0	196				
7/08	6.4	195	61	1.0	5	47.07
7/08	6.5	195				
7/08	6.5	195				
7/08	6.4	195				
11/03	6.8	199	60	0.5	8	48.25
11/03	6.8	200				
11/03	6.8	199				
11/03	6.8	199				
<i>MW66</i>						
1/24	6.1	304	58	2.3	4	46.38
1/24	6.1	318				
1/24	6.1	320				
1/24	6.1	325				
4/29	6.6	335	59	1.4	7	44.89
4/29	6.4	330				
4/29	6.2	335				
4/29	6.2	336				
7/22	6.7	274	61	0.9	10	45.65
7/22	6.4	292				
7/22	6.5	287				
7/22	NA	218				
11/19	6.6	352	59	7.8	6	47.01
11/19	6.3	357				
11/19	6.3	358				
11/19	6.3	360				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
<i>MW67</i>						
1/14	5.9	179	58	0.6	4	49.72
1/14	6.0	180				
1/14	6.0	181				
4/28	6.3	162	60	1.2	8	48.72
4/28	6.4	168				
4/28	6.4	174				
4/28	6.3	173				
7/21	6.1	180	62	2.5	10	49.07
7/21	6.1	178				
7/21	6.1	177				
7/21	6.1	177				
11/04	6.9	175	60	1.2	8	50.20
11/04	6.8	174				
11/04	6.8	173				
11/04	6.8	174				
<i>MW68</i>						
1/22	5.7	402	59	0.5	3	53.88
1/22	5.9	366				
1/22	5.9	384				
1/22	5.9	389				
4/23	6.8	415	62	5.4	3	73.21
4/23	6.8	413				
4/23	6.5	412				
4/23	6.5	412				
7/21	6.4	408	62	0.7	11	53.43
7/21	6.3	388				
7/21	6.3	398				
7/21	6.3	397				
10/29	6.1	401	60	2.1	4	54.58
10/29	6.2	398				
10/29	6.2	396				
10/29	6.1	398				
<i>MW69</i>						
1/23	6.3	746	52	38	220	38.33
1/23	6.5	719				
1/23	6.5	718				
4/28	6.7	732	59	89	23	38.53
4/28	6.7	733				
4/28	6.9	732				
4/28	6.9	730				
7/30	6.4	714	76	47	17	38.64
7/30	6.4	750				
7/30	6.7	770				
7/30	6.5	778				
11/23						38.40
<i>MW71</i>						
1/22	5.8	561	60	3.3	8	53.82
1/22	5.8	555				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
1/22	5.8	545				
1/22	5.8	547				
4/28	6.5	547	61	2.7	6	53.27
4/28	6.4	551				
4/28	6.3	550				
4/28	6.3	554				
7/22	6.6	565	62	1.9	13	53.37
7/22	6.3	537				
7/22	6.2	535				
10/29	6.3	555	61	2.0	8	54.59
10/29	6.3	550				
10/29	6.2	549				
10/29	6.3	551				
<i>MW154</i>						
3/18	6.3	513	59	7.9	2	8.05
3/18	6.3	510				
3/18	6.3	490				
3/18	6.3	495				
6/19	6.0	543	62	19	13	10.28
6/19	6.3	513				
6/19	6.3	482				
6/19	6.4	499				
9/08	6.5	557	66	2.5	8	10.24
9/08	6.7	521				
9/08	6.3	516				
9/08	6.3	520				
12/03	6.9	542	45	3.4	8	12.00
12/03	6.9	539				
12/03	6.8	540				
12/03	6.8	541				
<i>MW184</i>						
1/31	6.4			152		
3/30	6.3	1230	52			13.82
10/19	NA		61			13.90
<i>MW220</i>						
7/09	6.6	384	61			56.35
7/09	6.6	381	61			NA
11/16	6.7	420	59			57.80
11/16	6.8	418				
11/16	6.8	430				
11/16	6.8	416				
<i>MW221</i>						
7/09	6.5	426	61			66.03
11/16	6.4	403	59			67.52
11/16	6.4	402				
11/16	6.4	404				
11/16	6.3	404				
11/16	6.3	406	59			67.52
11/16	6.3	396				

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Table 5.5 (continued)

Date	pH (units)	Conductivity (μmhos/cm)	Temp (°F)	Turbidity (NTU) ^a	Color (units)	Depth to water (ft)
11/16	6.3	407				
11/16	6.3	424				
<i>MW222</i>						
11/16	6.4	273	59			68.60
11/16	6.4	283				
11/16	6.5	287				
11/16	6.4	291				
<i>MW223</i>						
11/16	6.2	402	59			70.62
11/16	6.3	399				
11/16	6.3	397				
11/16	6.3	394				
<i>MW224</i>						
11/16	6.3	487	59			71.84
11/16	6.3	481				
11/16	6.3	478				
11/16	6.3	480				
<i>MW225</i>						
11/16	6.3	361	59			61.92
11/16	6.3	361				
11/16	6.3	359				
11/16	6.3	359				

^aNephelometric turbidity units.

^bNot analyzed.

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Table 5.6. Results of 1992 quarterly, semiannual, and annual effluent monitoring of organic and inorganic parameters at solid waste management units

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
<i>MW16</i>									
2/06	13	31	2	0.38	1 2 1 <1	<5 15 7 8	<1	13	<0.1
5/06	13	30	2.0	0.39	2 1 <1 2	<5 <5 6 <5	<1	22	<0.1
8/27	13	29	1.9	0.38	1 1 <1 1	5 8 6 <5	<1	14	<0.1
10/21	14	30	2.0	0.37	2 2 2 2	5 13 7 8	<1	14	<0.1
<i>MW17</i>									
2/06	18	185	<1	0.51	3 3 3 3	41 39 39 38	<1	7	<0.1
5/06	18	218	<1	0.63	3 4 3 4	43 52 45 51	<1	9	<0.1
8/18	25	207	<1	0.56	3 4 3 3	32 38 36 39	<1	0	<0.1
10/20	25	217	<1	0.48	4 3 3 3	22 21 18 21	<1	12	<0.1
<i>MW18</i>									
2/05	15	145	<1	0.89	8 8 9 8	31 83 50 78	<1	4	<0.1
5/05	14	143	<1	0.90	8 9 9 9	22 32 42 53	<1	11	<0.1
8/18	16	119	<1	0.91	9 8 8 8	18 25 17 11	<1	6.7	<0.1
10/20	16	105	<1	0.89	8 6 8 7	22 20 33 16	<1	19	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
<i>MW19</i>									
2/06	3	23	3.8	0.29	1 1 <1 <1	8 5 <5 <5	<10	0	<0.1
5/07	<5	15	2.4	0.30	2 1 <1 <1	7 <5 <5 <5	<1	8	<0.1
8/20	6	16	1.6	0.29	<1 1 <1 1	5 7 <5 <5	<1	20	<0.1
10/21	5	14	2.8	0.27	1 2 2 2	<5 ^j <5 ^j <5 ^j <5 ^j	<1	5	<0.1
						28.0 23.1 13.9 190			
<i>MW20</i>									
2/12	35	11	<1	0.13	2 1 <1 <1	95 102 87 91	110	48	<0.1
4/24 5/13		9	<1	0.12	<1 <1 <1 <1	106 97 84 <5	87 66	26 51	<0.1
8/17		13	<1	0.16	<1 <1 <1 <1	59 68 60 54	92	54.8	<0.1
12/10							65	65	
<i>MW21</i>									
3/17	176	421	<1	0.23	2 2 1 2	46 54 46 60	<1	1	<0.1
6/04		370	<1	0.26	3 2 <1 3	65 66 54 48	NA ^k	-7	
9/02		6	<1	0.22	<1 2 2 1	23 28 18 17	<1	3	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
12/01		NA	<1	0.23	2 2 2 2	25.5 835 30.7 38	<1	23	<0.1
MW22									
3/17	47	12	<1	0.11	<1 <1 <1 <1	49.6 ^j 48 ^j 48.9 ^j 33.8 ^j	64	61	<0.1
6/02		13	<1	0.12	<1 <1 <1 <1	67 61 57 63	66	60	<0.1
9/03		17	<1	0.12	<1 <1 <1 <1	40 43 39 45	64	36	<0.1
10/21							64	57	
12/01		15	1.1	0.10	1 <1 <1 <1	72.4 67.4 64.5 82.2	77	82	<0.1
MW23									
2/01	6	93	<1	0.16				1.0	
8/17	8	182	<1	0.18	<1 <1 <1 <1	<5 <5 <5 <5	<1	6.4	
MW24									
2/01	15	10	<1	0.13				4	
8/11	16	8	<1	0.16	<1 <1 <1 <1	<5 <5 <5 <5	<1	16	<0.1
MW26									
2/01	6	24	<1	395				17.0	
8/11	7	12	1.1	0.22	16	NA	<1	3	<0.1
MW27									
2/01	78	13	<1	468				1.0	
8/11	86	14	<1	0.14	2 1 1 <1	8 27 24 32	<1	4	<0.1
MW29									
1/31	5	234	<1	0.22				4	

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (µg/L)	TCE ^g (µg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (µg/L)
<i>MW38</i>									
2/18	50	9	3.0	0.25	<1 <1 1 <1	6 10 <5 <5	4	40	<0.1
4/22 5/08	39	10	1.8	0.26	1 <1 <1 1	15 10 9 8	3 4	8 22	<0.1
7/22 8/20	39	11	1.8	0.24	<1 <1 <1 <1 1	<5 <5 <5 <5 11	4 4	11 20	<0.1
10/22	41	11	1.9	0.24	1 1 1 1	16 15 14 14	4	24	<0.1
11/17 12/09							3 3	44 14	
<i>MW39</i>									
2/18	42	59	2.2	0.29	1 <1 1 1 1	17 7 15 13	<1	13	<0.1
5/08	37	51	1.4	0.28	1 1 1 1 1	13 <5 14 16	1	9	<0.1
8/20	38	48	1.4	0.28	1 1 2 2 2 2	9.0 9.0 11 9 8 13 22	<1	-8	<0.1
10/22	39	51	1.4	0.26	2 2 2 2	9 8 13 22	<1	15	<0.1
<i>MW40</i>									
2/18	46	14	2.5	0.16	<1 <1 <1 <1	10 16 13 10	<1	9	<0.1
5/12	34	12	1.5	0.16	1 <1 <1 <1 <1	11 <5 22 11	1	7	<0.1
8/21	41	13	1.3	0.15	<1 <1 <1 <1	<5 <5 <5 <5	1	4	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
10/23	33	14	1.6	0.15	1 1 1 <1	6 10 <5 10	1	2	<0.1
<i>MW41</i>									
2/19	44	10	1.9	0.15	<1 <1 <1 <1	16 11 21 15	19	21	<0.1
4/22							20	0	
5/19	44	11	1.1	0.16	1 <1 <1 <1	26.5 ^j 25.4 ^j NA NA	24	18	<0.1
7/22							23	-0.6	
8/21	32	14	1.6	0.15	NA <1 <1 <1	11 15 15 17	20	0	<0.1
10/22	42	12	1.3	0.15	1 1 1 1	11 21 17 18	21	0	<0.1
11/17							18	20	
12/09							12	1	
12/09							1	2	
<i>MW42</i>									
2/20	43	187	1.3	0.16	1 2 2 2	8 9 13 9	<1	13	<0.1
5/19	35	192	<1	0.16	<1 <1 <1 <1	NA NA 19 ^j 25 ^j	<1	25	<0.1
8/26	37	173	<1	0.16	<1 <1 <1 <1	6 7 13 <5	<1	33	<0.1
10/22	38	176	1.0	0.16	1 1 1 1	6 5 <5 8	<1	44	<0.1
<i>MW43</i>									
2/19	30	9	1.4	0.15	<1 <1 <1 <1	<5 <5 <5 <5	1	23	<0.1
4/22							1	0	

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
5/12	31	9	NA	0.15	<1 <1 <1 <1	7 <5 7 <5	1	13	<0.1
7/22 8/26	31	11	1.0	0.15	<1 <1	22 5	2 2	3.7 0	<0.1
10/22	32	11	1.1	0.15	1 1 1 1	12 15 8 7	2	8	<0.1
11/17							2	22	
<i>MW44</i>									
2/20	50	18	1.5	0.17	<1 <1 <1 1	30 47 34 36	30	0	<0.1
4/22 5/11		16	<1	0.18	1 <1 <1 <1	24 23 26 24	31 35	0 5	<0.1
7/22 8/26		17	1.1	0.17	<1 <1 <1 <1	17 24 27 25	35 31	1 5	<0.1
10/27	46	17	1.1	0.17	<1 <1 <1 <1	32 27 25 27	29	12	<0.1
11/17 12/09							28 25	31 1	
<i>MW46</i>									
3/04	14	7	<1	0.10	<1 NA <1 <1	<5 <5 <5 <5	<1	2	<0.1
5/27		8	<1	0.11	<1 <1 <1 <1	<5 <5 <5 13	<1	11	<0.1
9/09		11	<1	0.11	<1 <1 <1 <1	<5 <5 <5 <5	<1	6	<0.1
12/11		11	<1	0.11	<1 <1 <1 <1	<5 <5 <5 46	<1	0	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
<i>MW47</i>									
3/20	128	367	1.2	0.11			51	53	
6/26		228	<1	0.11	10	30 ^j	33	102	
9/11		313	<1	0.10	9	87	39	317	<0.1
12/11		354	<1	<0.10	9	120	46	13	<0.1
<i>MW48</i>									
3/04	11	9	<1	0.10	<1	<5	<1	3	<0.1
					<1	5			
					<1	<5			
5/27		9	<1	0.10	<1	<5	<1	11	<0.1
					<1	8			
					<1	<5			
					<1	<5			
9/09		11	<1	0.10	<1	<5	<1	7	<0.1
					<1	8			
					<1	<5			
					<1	<5			
12/11		12	<1	<0.10	<1	<5	<1	0	<0.1
					<1	<5			
					<1	<5			
					<1	<5			
<i>MW50</i>									
1/29	9	<5	<1	<0.1	<1	<5	3	12	<0.1
					<1	<5			
					<1	<5			
4/03		<5	<1	<0.1	<1	<5	2	14	<0.1
					<1	<5			
					<1	<5			
7/28		<5	<1	<0.1	<1	31 ^j	3	33.6	<0.1
					<1	10 ^j			
					<1	20 ^j			
					<1	11 ^j			
10/07		9	<1	<0.1	<1	<5	3	36	<0.1
					<1	6			
					<1	<5			
					<1	6			
<i>MW51</i>									
1/29	10	5	<1	<0.1	<1	14	1	29	<0.1
					<1	12			
					<1	14			
					1	10			
4/07		5	<1	<0.1	<1	8.7	<1 ^l	36	<0.1
					<1	<5			
					<1	5			
					<1	5			

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
7/23		5	<1	<0.1	<1 <1 <1 <1	<5 <5 <5 <5	2	53.2	<0.1
10/07		8	<1	<0.1	<1 <1 <1 <1	10 7 7 7	1	44	<0.1
MW52									
1/24	11	6	<1	<0.1	<1 <1 <1 <1	11 20 <5 7	<1	0	<0.1
4/03		6	<1	<0.1	<1 <1 <1 <1	<5 25 <5 5	<1	8	<0.1
7/23		8	<1	<0.1	1	NA	<1	10.4	<0.1
7/23		6	<1	<0.1	<1 1 <1 1	<5 <5 <5 <5	<1	21.6	<0.1
10/23		9	<1	<0.1	<1 <1 <1 <1	<5 <5 <5 <5	<1	7	<0.1
MW53									
1/24	8	8	<1	<0.1	<1 <1 <1 <1	<5 <5 <5 <5	<1	0	<0.1
4/08		8	<1	<0.1	<1 <1 <1 <1 <1 <1 <1	<5 <5 <5 <5 <5 <5 <5	<1	0	<0.1
10/13		11	<1	<0.1	<1 <1 <1 <1	<5 <5 <5 <5	<1	1	<0.1
MW54									
1/29	8	6	<1	0.14	<1 <1 <1 <1	<5 <5 <5 <5	1	4	<0.1
4/10		6	<1	0.13	<1 <1 <1 <1	<5 <5 <5 <5	1	0	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
7/23		<5	<1	0.12	<1 <1 <1 <1	<5 ^j <5 ^j <5 ^j <5 ^j	1	10.7	<0.1
10/07		9	<1	0.13	<1 <1 <1 <1	<5 <5 <5 <5	2	7	<0.1
<i>MW57</i>									
1/30	7	77	<1	0.10	4 3 2 2	8 <5 <5 <5	4	288	<0.1
4/30		80	<1	0.12	2 1 2 1	10 13 11 16	5	414	<0.1
7/28		55	<1	0.12	3 1 <1 1	<5 ^j 9 ^j 13 ^j 12 ^j	2	736.5	NA
11/18		59	<1	<0.1	3 2 2 2	7.2 6.4 7.5 7.3	2	102	<0.1
<i>MW59</i>									
10/28	13	6	3.8	<0.1	<1 1 3 1	<5 <5 <5 <5	<1	<25	<0.1
<i>MW60</i>									
7/27							<1		
10/28	41	58	3.3	0.11	1 1 2 1	21 35 38 35	<1	<25	<0.1
<i>MW61</i>									
10/28	46	9	2.8	0.16	1 1 <1 1	<5 <5 <5 <5	<1	<25	<0.1
<i>MW62</i>									
10/28	NA	NA	NA	0.20	1 1 1 1	<5 <5 <5 <5	<1	<25	<0.1
11/06	6	7	<1						

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (µg/L)	TCE ^g (µg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (µg/L)
<i>MW63</i>									
1/09	15	11	<1	0.14	<1 <1 <1 <1	<5 6 <5 6	<1	0	<0.1
4/09		10	<1	0.12	<1 <1 <1 <1	<5 <5 5.6 <5	<1	0	<0.1
7/08		11	<1	0.14	<1 <1 <1 <1	20 <5 <5 <5	<1	9	<0.1
11/03		13	<1	0.14	1 <1 <1 <1	5 <5 6 <5	<1	9	<0.1
<i>MW64</i>									
4/24		22	2.2	0.30	1 1 1 1	13 11 9.0 8.0	<1	0	<0.1
7/22		15	2.6	0.29	1 1 1 1	17 <5 12 <5	<1	-21	<0.1
11/04		18	2.2	0.31	2 1 1 1	5 8 1 6	<1	19	<0.1
<i>MW65</i>									
1/09	12	9	<1	0.11	<1 <1 <1 <1	8.5 7.2 9.9 1.5	<1	0	<0.1
4/21		9	<1	0.11	<1 <1 <1 <1	<5 <5 <5 <5	<1	0	<0.1
7/08		9	<1	0.11	<1 <1 <1 <1	<5 <5 <5 8	<1	6	<0.1
11/03		11	<1	0.11	<1 <1 <1 <1	<5 <5 <5 <5	<1	19	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
<i>MW66</i>									
1/24	20	11	3.5	0.11	<1 <1 <1 <1	1514 2358 1747 2031	1800	1033	
2/20							2500	1076	
3/31							1600		
3/31							610		
3/31							1100		
3/31							1900		
3/31							2100		
3/31							2600		
3/31							2700	1500	
4/29		11	6	<0.1	<1 <1 <1 <1	1564 1478 1012 1872	4600	2397	<0.1
5/15							4600	2063	
7/22		11	1.9	0.12	<1 <1 <1 <1	612 1916 1070 721	830	698	<0.1
11/19		13	4.7	<0.1	<1 <1 <1 <1	2320 2630 2350 2830	4200	1677	<0.1
12/08							4600	1948	
<i>MW67</i>									
1/14	11	9	<1	0.14	<1 <1 <1 <1	8 ^j 14 ^j 11 ^j 7	<1	0	<0.1
4/28		9	<1	0.12	<1 <1 <1 <1	7 <5 <5 1	<1	0	<0.1
7/21		9	<1	0.12	1 <1 1 1	13 <5 <5 13	<1	-6	<0.1
11/04		11	<1	0.11	<1 <1 <1 <1	<5 <5 <5 <5	<1	15	<0.1
<i>MW68</i>									
1/22	59	13	1.6	0.13	<1 <1 <1 <1	55 57 56 41	40	130	NA
4/23		13	1.5	0.14	1 1 <1 <1	39 34 40 29	44	129	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
7/21		13	1.6	0.14	<1 <1 <1 <1	35 31 36 38	42	118	<0.1
10/29		14	1.6	0.14	2 1 <1 <1	49 47 51 14	33	111	<0.1
<i>MW69</i>									
1/23	91	<5	<1	0.20	5 5 5	50 51 46	<20	0	<0.1
4/28		<5	<1	0.20	6 5 6 5	33 28 33 34	<20	2	<0.1
7/30		<5	<1	0.22	4 4 4 4	22 ^j 30 ^j <5 ^j NA	<10	<25	<0.1
<i>MW71</i>									
1/22	72	7	<1	0.11	2 2 1 2	81 60 89 81	27	2	<0.1
4/28		8	<1	0.11	2 1 1 1	27 33 34 28	3	13	<0.1
7/22		8	<1	0.11	1 1 1 1	26 26 30 24	1	9	<0.1
10/29		10	<1	0.11	1 2 2 2	24 24 29 26	2	17	<0.1
<i>MW154</i>									
3/18	5	124	1.1	0.11	2 1 1 1	NA	22	687	<0.1
6/19		130	<1	0.11	1 2 1 1	23 29 27 30	13	734	<0.1
9/08		128	1	0.11	1 1 1 <1	17 24 18 15	18	624	<0.1

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
12/03		135	1	0.11	1 2 2 1	18.8 17.9 19.7 17.3	8	706	<0.1
<i>MW184</i>									
1/31 3/30 10/19	14	132	<1				<1	3	
<i>MW220</i>									
7/09 7/09 7/09 11/16					<1 <1 <1 1 1 1 1	<5 <5 6.6 5 <5 <5 <5		10 19 16	
<i>MW221</i>									
7/09 11/16 11/16 11/16 11/16 11/16 11/16			1.9		<1 <1 <1 <1 <1 <1 1 1 1 1	6 <5 <5 7.7 <5 <5 8.9 6.8 5.8 NA		13 4	
<i>MW222</i>									
11/16			0.6		<1 <1 <1 <1	<5 <5 <5 <5			
<i>MW223</i>									
11/16			2.3		<1 <1 <1 <1	5.6 6.4 <5 <5			
<i>MW224</i>									
11/16			0.7		1 1 1 1	10.5 11.4 10.5 11.8			

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Table 5.6 (continued)

Date	Cl ^{-a} (mg/L)	SO ₄ ^b (mg/L)	NO ₃ -N ^c (mg/L)	F ^{-d} (mg/L)	TOC ^e (mg/L)	TOX ^f (μg/L)	TCE ^g (μg/L)	⁹⁹ Tc ^h (pCi/L)	PCB ⁱ (μg/L)
<i>MW225</i>									
11/16			2.2		1 <1 2 1	13 5 7.2 <5		9	

^aChloride.

^bSulfate.

^cNitrate as nitrogen.

^dFluoride.

^eTotal organic carbon.

^fTotal organic halogen.

^gTrichloroethylene.

^hTechnetium-99.

ⁱPolychlorinated biphenyls.

^jThis sample was held beyond the holding time limit of 7 d.

^kNot analyzed.

^lThe surrogate for the sample for 1,2-dichloroethane-d4 was out of limits.

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**Table 5.7. Results of 1992 quarterly, semiannual, and annual effluent monitoring of metals
at solid waste management units**

Date	Chromium (mg/L)	Chromium ⁶⁺ (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<i>MW16</i>							
2/06	<0.05	0.02	0.121	0.098	<0.2	<0.05	0.102
5/06	<0.05		0.371	0.062	<0.2	<0.05	0.297
8/27	<0.05		0.319	0.210	<0.2	<0.05	0.367
10/21	<0.05		0.171	0.936	<0.05	<0.05	0.213
<i>MW17</i>							
2/06	<0.05	<0.01	0.307	2.39	<0.2	<0.05	0.299
5/06	<0.05		0.546	1.32	<0.2	0.056	0.502
8/18	<0.05		0.723	1.15	<0.2	0.083	1.07
10/20	<0.05		2.26	1.9	<0.05	0.074	1.09
<i>MW18</i>							
2/05	<0.05	<0.01	<0.01	7.71	<0.2	<0.05	<0.005
5/05	<0.05		<0.01	8.01	<0.2	<0.05	<0.005
8/18	<0.05		<0.01	8.26	<0.2	<0.05	0.014
10/20	<0.05		0.111	9.72	<0.05	<0.05	0.094
<i>MW19</i>							
2/06	<0.05	<0.01	0.908	0.796	<0.2	0.137	1.99
5/07	<0.05		0.603	0.194	<0.2	0.124	1.56
8/20	<0.01		0.7	1.63	<0.2	0.07	1.19
10/21	<0.05		0.593	1.42	<0.05	0.086	1.62
<i>MW20</i>							
2/12	<0.05	0.01	0.205	41.2	<0.2	<0.05	0.144
5/13	<0.05		0.08	17.5	<0.2	<0.05	0.134
8/17	<0.05		0.027	5.68	<0.2	<0.05	0.073
<i>MW21</i>							
3/17	<0.05	<0.01	<0.01	1.65	<0.2	<0.05	0.024
6/04	<0.05		<0.01	2.25	<0.2	<0.05	0.034
9/02	<0.05		0.011	1.68	<0.2	0.07	0.044
12/01	<0.05		<0.01	1.36	<0.03	<0.05	0.023
<i>MW22</i>							
3/17	<0.05	<0.01	<0.01	5.59	<0.2	<0.05	<0.005
6/02	0.054		<0.01	7.03	<0.2	<0.05	0.097
9/03	<0.05		<0.01	5.1	<0.2	<0.05	<0.005
12/01	<0.05		<0.01	3.98	<0.03	<0.05	<0.005
<i>MW23</i>							
2/01	<0.05		<0.01	2.39	<0.2	<0.05	31.7
8/17	<0.05	<0.01	<0.01	11.7	<0.2	<0.05	27.1

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Table 5.7 (continued)

Date	Chromium (mg/L)	Chromium ⁶⁺ (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<i>MW24</i>							
2/01	<0.05		<0.01	5.24	<0.2	<0.05	34.7
8/11	<0.05	<0.01	<0.01	9.05	<0.2	<0.05	19.3
<i>MW26</i>							
2/01	<0.05		0.016	3.52	0.236	<0.05	31.3
8/11	<0.05	0.06	0.031	4.34	0.251	<0.05	26.1
<i>MW27</i>							
2/01	<0.05		<0.01	8.42	<0.2	<0.05	53.0
8/11	<0.05	<0.01	<0.01	10.2	<0.2	<0.05	53.4
<i>MW29</i>							
1/31	<0.05		<0.01	0.327	<0.2	<0.05	0.104
<i>MW38</i>							
2/18	<0.05	0.01	<0.01	0.242	<0.2	<0.05	0.005
5/08	<0.05		<0.01	0.131	<0.2	<0.05	<0.005
8/20	<0.05		0.022	0.189	<0.2	<0.05	0.039
10/22	<0.05		<0.01	0.348	<0.05	<0.05	0.007
<i>MW39</i>							
2/18	<0.05	<0.01	<0.01	2.24	<0.2	<0.05	<0.005
5/08	<0.05		<0.01	1.37	<0.2	<0.05	<0.005
8/20	<0.05		<0.01	1.8	<0.2	<0.05	<0.034
10/22	<0.05		<0.01	1.32	<0.05	<0.05	0.008
<i>MW40</i>							
2/18	<0.05	<0.01	<0.01	0.133	<0.2	<0.05	<0.005
5/12	<0.05		<0.01	0.204	<0.2	<0.05	0.045
8/21	<0.05		<0.01	0.046	<0.2	<0.05	0.007
10/23	<0.05		<0.01	0.201	<0.05	<0.05	0.016
<i>MW41</i>							
2/19	<0.05	<0.01	<0.01	0.454	<0.2	<0.05	<0.005
5/19	<0.05		<0.01	0.246	<0.2	<0.05	0.036
8/21	<0.05		<0.01	0.708	<0.2	<0.05	0.028
10/22	<0.05		<0.01	1.85	<0.05	<0.05	0.009
<i>MW42</i>							
2/20	<0.05	<0.01	<0.01	0.752	<0.2	<0.05	0.015
5/19	<0.05		<0.01	0.314	<0.2	<0.05	0.022
8/26	<0.05		0.015	0.491	<0.2	<0.05	0.044
10/22	<0.05		<0.01	0.65	<0.05	<0.05	0.006

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Table 5.7 (continued)

Date	Chromium (mg/L)	Chromium ⁶⁺ (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<i>MW43</i>							
2/19	<0.05	<0.01	<0.01	0.06	<0.2	<0.05	<0.005
5/12	<0.05		<0.01	0.159	<0.2	<0.05	<0.005
8/26	<0.05		<0.01	0.135	<0.2	<0.05	0.022
10/22	<0.05		<0.01	0.12	<0.05	<0.05	0.005
<i>MW44</i>							
2/20	<0.05	<0.01	<0.01	0.107	<0.2	<0.05	<0.008
5/11	<0.05		<0.01	0.076	<0.2	<0.05	0.01
8/26	<0.05		<0.01	0.138	<0.2	<0.05	0.011
10/22	<0.05		<0.01	0.057	<0.05	<0.05	0.006
<i>MW46</i>							
3/04	<0.05	<0.01	<0.01	11.2	<0.2	<0.05	0.015
5/27	<0.05		<0.01	10.8	<0.2	<0.05	0.020
9/09	<0.05		<0.01	10.4	<0.2	<0.05	0.006
12/11	<0.05		<0.01	13.3	<0.2	<0.05	0.026
<i>MW47</i>							
3/20		<0.01					
6/26	0.142		0.073	265.0	8.43	0.064	0.306
9/11	<0.05		0.106	23.9	<0.2	<0.05	0.179
12/11	0.39		1.95	537.0	<0.2	0.15	0.655
<i>MW48</i>							
3/04	<0.05	<0.01	<0.01	5.57	<0.2	<0.05	<0.005
5/27	<0.05		0.014	6.76	<0.08	<0.05	0.044
9/09	<0.05		0.016	5.96	<0.2	<0.05	0.030
12/11	<0.05		<0.01	7.18	<0.2	<0.05	0.018
<i>MW50</i>							
1/29	<0.05	<0.01	<0.01	8.08	<0.2	<0.05	<0.021
4/03	<0.05		<0.01	7.3	<0.2	<0.05	0.013
7/28	<0.05		<0.01	7.5	<0.2	<0.05	0.014
10/07	<0.05		<0.01	5.72	<0.2	<0.05	<0.005
<i>MW51</i>							
1/29	<0.05	<0.01	<0.01	10.3	<0.2	<0.05	0.011
4/07	<0.05		<0.01	12.6	<0.2	<0.05	0.042
7/23	<0.05		<0.01	9.64	<0.2	<0.05	0.013
10/07	<0.05		<0.01	14.8	<0.2	<0.05	0.008
<i>MW52</i>							
1/24	<0.05	<0.01	<0.01	6.31	<0.2	<0.05	<0.005
4/03	<0.05		<0.01	5.49	<0.2	<0.05	0.012
7/23	<0.05		<0.01	2.12	<0.2	<0.05	0.006
7/23	<0.05		<0.01	5.16	<0.2	<0.05	<0.005
10/13	<0.05		<0.01	4.85	<0.2	<0.05	<0.005

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Table 5.7 (continued)

Date	Chromium (mg/L)	Chromium ⁶⁺ (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<i>MW53</i>							
1/24	<0.05	<0.01	<0.01	2.4	<0.2	<0.05	0.008
4/08	<0.05		<0.01	2.84	<0.2	<0.05	0.011
10/13	<0.05		<0.01	2.02	<0.2	<0.05	<0.005
<i>MW54</i>							
1/29	<0.05	<0.01	<0.01	5.33	<0.2	<0.05	0.010
4/10	<0.05		<0.01	4.48	<0.2	<0.05	0.012
7/23	<0.01		<0.01	12.9	<0.2	<0.05	0.006
10/07	<0.05		<0.01	3.03	<0.2	<0.05	<0.005
<i>MW57</i>							
1/30	<0.05	0.01	<0.01	17.4	<0.2	<0.05	0.016
4/30	<0.05		<0.01	16.5	<0.2	<0.05	0.014
7/28	<0.05		<0.01	14.7	<0.2	<0.05	0.009
11/18	<0.05		<0.01	85.4	<0.04	<0.05	0.092
<i>MW59</i>							
10/28	<0.05	NA ^a	0.104	0.058	<0.2	<0.05	0.112
<i>MW60</i>							
10/28	<0.05	<0.01	0.01	0.042	<0.2	<0.05	1.03
<i>MW61</i>							
10/28	<0.05	<0.01 ^b	<0.01	0.077	<0.2	<0.05	<0.01
<i>MW62</i>							
10/28	<0.05	NA	<0.01	6.31	<0.2	<0.05	0.017
11/06		<0.01					
<i>MW63</i>							
1/09	<0.05	<0.01	<0.01	0.955	<0.2	0.227	0.024
4/09	<0.05		<0.01	1.25	<0.2	0.172	0.010
7/08	<0.05		<0.01	0.681	<0.2	0.273	0.006
11/03	0.064		<0.01	1.01	<0.2	0.264	<0.005
<i>MW64</i>							
4/24	0.051		<0.01	1.11	<0.2	0.051	0.023
7/23	<0.05		<0.01	0.394	<0.2	0.203	<0.005
11/04	<0.05		<0.01	0.872	<0.2	0.246	<0.005
<i>MW65</i>							
1/09	<0.05	<0.01	<0.01	<0.01	<0.2	<0.05	<0.005
4/21	<0.05		<0.01	0.011	<0.2	<0.05	0.017
7/08	<0.05		<0.01	0.032	<0.2	<0.05	<0.005
11/03	<0.05		<0.01	0.048	<0.2	<0.05	<0.005

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Table 5.7 (continued)

Date	Chromium (mg/L)	Chromium ⁶⁺ (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<i>MW66</i>							
1/24	<0.05	<0.01	<0.01	0.23	<0.2	0.065	<0.005
4/29	<0.05		<0.01	0.136	<0.2	0.067	<0.005
7/22	<0.05		<0.01	0.160	<0.2	0.08	<0.005
11/19	<0.01		<0.01	2.87	<0.04	0.377	0.012
<i>MW67</i>							
1/14	<0.05	<0.01	<0.01	0.272	<0.2	0.106	0.008
4/28	<0.05		<0.01	0.24	<0.2	0.093	<0.005
7/21	<0.05		<0.01	0.234	<0.2	0.077	<0.005
11/04	<0.05		<0.01	0.13	<0.2	0.087	0.050
<i>MW68</i>							
1/22	<0.05	<0.01	<0.01	0.081	<0.2	0.086	<0.005
4/23	<0.05		<0.01	0.076	<0.2	0.093	0.023
7/21	<0.05		<0.01	0.046	<0.2	0.116	<0.005
10/29	<0.05		<0.01	0.139	<0.2	0.129	0.012
<i>MW69</i>							
1/23	<0.05	<0.01	<0.01	26.3	<0.2	<0.05	<0.005
4/28	<0.05		<0.01	28.3	<0.2	<0.05	0.007
7/30	<0.05		<0.01	32.0	<0.2	<0.05	0.005
<i>MW71</i>							
1/22	0.055	<0.01	<0.01	0.523	<0.2	0.055	0.014
4/28	<0.05		<0.01	0.361	<0.2	0.067	0.007
7/22	0.526		<0.01	2.02	<0.2	0.106	0.006
10/29	0.113		<0.01	0.601	<0.2	0.098	0.016
<i>MW154</i>							
3/18	<0.05	<0.01	<0.01	0.77	<0.2	<0.05	<0.005
6/19	<0.05		0.013	0.271	<0.2	<0.05	0.067
9/08	<0.05		<0.01	0.124	<0.2	<0.05	<0.005
12/03	<0.05		<0.01	0.319	<0.03	<0.05	0.008
<i>MW184</i>							
1/31				77.6	<0.2	<0.05	0.005
3/30	<0.05		<0.01	76.0	<0.2	<0.05	
10/19	<0.05		<0.01 ^b	66.5	<0.2	<0.05	0.015
<i>MW220</i>							
7/09	<0.05			2.29	<0.01		
7/09	<0.05			2.06	<0.01		
11/16	<0.05			1.18	<0.05		

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Table 5.7 (continued)

Date	Chromium (mg/L)	Chromium ⁶⁺ (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<i>MW221</i>							
7/09	<0.05			0.82	<0.01		
11/16	<0.05			0.297	<0.05		
11/16	<0.05			2.34	<0.05		
<i>MW222</i>							
11/16	<0.05			0.818	<0.05		
<i>MW223</i>							
11/16	<0.05			0.337	<0.05		
<i>MW224</i>							
11/16	<0.05			0.476	<0.05		
<i>MW225</i>							
11/16	<0.05			2.18	<0.05		

^aNot analyzed.

^bHolding time exceeded for this sample.

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Table 5.8. Results of 1992 quarterly, semiannual, and annual effluent monitoring of radionuclides at solid waste management units

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
<i>MW16</i>					
2/06	<0.001	7.0	-3.4	22	-6
5/06	<0.001	1.9	-0.2	15	-2
8/27	<0.001	-0.6	0.2	44	3
10/21	<0.001	19.4	2.5	35	3
<i>MW17</i>					
2/06	0.01	3.8	-2.3	-4	-5
5/06	0.010	13.5	0.3	12	6
8/18	0.010	-1.0	-2.3	3	0
10/20	0.010	12	-0.2	-39	-22
<i>MW18</i>					
2/05	0.002	-16.9	0.2	-4	3
5/05	0.002	13.5	2.3	7	8
8/18	0.003	-8.1	1.4	9	4
10/20	0.003	11.3	-5.4	-29	-19
<i>MW19</i>					
2/06	<0.001	-6.6	-4.3	10	6
5/07	<0.001	-1.0	0.7	7	19
8/20	<0.001	0	1.4	1	-7
10/21	<0.001	-2.0	-3.6	-2	1
<i>MW20</i>					
2/12	<0.001	0.3	3.8	27	8
5/13	<0.001	-2.3	-3.4	5	-16
8/17	<0.001	-3.2	-1.6	17	-6
<i>MW21</i>					
3/17	<0.001	-6	-2.3	1	1
6/04	<0.001	-5.6	3.9	4	18
9/02	<0.001	-5.6	0.9	2	5
12/01	<0.001	0.9	-1.1	-3	-3
<i>MW22</i>					
3/17	<0.001	2.7	-5.2	62	3
6/02	<0.001	0	1.4	26	14
9/03	<0.001	3.7	-3.2	44	-11
12/01	<0.001	2	0.3	55	-5
<i>MW23</i>					
2/01	<0.001				
8/17	<0.001	-2.30	-2.00	-8.0	-9.0

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Table 5.8 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
<i>MW24</i>					
2/01	<0.001				
8/11	<0.001	-5.0	-3.60	5.0	-6.0
<i>MW26</i>					
2/01	0.016				
8/11	0.008	2.50	-2.00	21.0	1.0
<i>MW27</i>					
2/01	<0.001				
8/11	<0.001	-0.7	-3.60	7.0	-8.0
<i>MW29</i>					
1/31	0.001				
<i>MW38</i>					
2/18	<0.001	5.3	-1.8	15	10
5/08	<0.001	3.8	0.2	15	-0.3
8/20	<0.001	-5.0	-2.3	6	-3
10/22	<0.001	8.1	1.1	22	-7
<i>MW39</i>					
2/18	<0.001	4.5	-0.9	11	7
5/08	<0.001	5.6	-0.6	4.9	-0.2
8/20	<0.001	1.5	-2.0	0	-4
10/22	<0.001	11.5	2.3	17	-8
<i>MW40</i>					
2/18	<0.001	1	0	6	-11
5/12	<0.001	-1.9	-1.01	7	0
8/21	<0.001	-2.7	-2.7	1	-5
10/23	<0.001	8.2	2.5	26	-4
<i>MW41</i>					
2/19	<0.001	-2.1	-0.2	5	-8
5/19	<0.001	-3.1	-5.6	-4	-7
8/21	<0.001	1.4	-3.8	1	-4
10/22	<0.001	-1.9	-2.5	-2	-4
<i>MW42</i>					
2/20	<0.001	-7.0	-2.0	9.0	-9.0
5/19	<0.001	-1.3	-5.0	10	-4
8/26	<0.001	1.4	-0.2	39	-13
10/22	<0.001	2.7	-2.0	30	-5

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Table 5.8 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
<i>MW43</i>					
2/19	<0.001	-7.0	-3.0	-11.0	-10.0
5/12	<0.001	-1.3	1.1	8	4
8/26	<0.001	3.5	-3.2	6	-15
10/22	<0.001	5.5	-1.6	1	-3
<i>MW44</i>					
2/20	<0.001	-0.4	1	-11	5
5/11	<0.001	0	1.1	3	3
8/26	<0.001	5.1	-1.4	7	-9
10/27	<0.001	-1.8	-0.7	9	1
<i>MW46</i>					
3/04	<0.001	0.3	2.0	8	10
5/27	<0.001	-5.3	-4.5	0	7
9/09	<0.001	2.6	0.9	2	-1
12/11	<0.001	0.3	-2.9	-4	-6
<i>MW47</i>					
3/20	0.035	6.6	1.7	9	8
6/26	0.008	27.0	1.4	176	3
9/11	0.116	103.6	-1.8	380	-14
12/11	0.021	30.4	-1.1	295	-3
<i>MW48</i>					
3/04	<0.001	2.0	8.8	14	16
5/27	<0.001	-2.8	-5.3	6	-0.8
9/09	<0.001	0.6	0.9	-1	-5
12/11	<0.001	-2.9	3.6	-12	-8
<i>MW50</i>					
1/29	<0.001	2.9	-2.5	26	-7
4/03	<0.001	-1.6	0.6	12	2.0
7/28	<0.001	-1.2	-4.5	6	-4
10/07	<0.001	4.7	-1.4	11	-1
<i>MW51</i>					
1/29	<0.001	-8.7	-5.0	3	-11
4/07	<0.001	1.1	-1.8	5.4	-6
7/23	<0.001	-1.9	-3.4	22	-3
10/07	<0.001	0.4	-1.4	14	1
<i>MW52</i>					
1/24	<0.001	3.5	-2.0	23	-9
4/03	<0.001	-1.2	3.2	5	6
7/23	<0.001	2.8	-5.0	6	-4
7/23	<0.001	0.2	-1.4	-1	-2
10/13	<0.001	1.5	-1.1	14	3

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Table 5.8 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
<i>MW53</i>					
1/24	<0.001	-5.9	-1.4	-12	-2
4/08	<0.001	-1.3	-1.7	2.4	-1
10/13	<0.001	1.2	3.3	3	0.8
<i>MW54</i>					
1/29	<0.001	0.2	0	10	6
4/10	<0.001	1.6	2.5	4.7	-2
7/23	<0.001	-1.5	-1.4	1	4
10/07	<0.001	1.6	-1.4	6	-2
<i>MW57</i>					
1/30	0.022	6.5	7.0	47	296
4/30	0.010	-4.1	0	185	4
7/28	0.016	8.0	-0.7	139	33
11/18	0.007	7.1	0	92	7
<i>MW59</i>					
10/28	<0.001	1.1	0.7	2	-5
<i>MW60</i>					
10/28	<0.001	-0.4	1.8	1	-7
<i>MW61</i>					
10/28	<0.001	3.4	-0.7	16	-4
<i>MW62</i>					
10/28	<0.001	2.5	-1.1	8	-4
<i>MW63</i>					
1/09	<0.001	2.5	-2.7	-6	0
4/09	<0.001	-1.1	-1.8	-2	-6
7/08	<0.001	5.1	-3.6	2	3
11/03	<0.001	3.9	-0.5	5	2
<i>MW64</i>					
4/24	0.001	-4.1	-0.9	6	-6
7/22	0.001	-0.2	-3.4	-0.7	-6
11/04	0.002	9.0	0	5	-5
<i>MW65</i>					
1/09	<0.001	1.7	-5.6	8	2
4/21	<0.001	-6.1	0.3	8	-7
7/08	<0.001	-6.4	-3.0	3	3
11/03	<0.001	4.8	0.9	4	-1

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Table 5.8 (continued)

Date	Uranium (mg/L)	Dissolved alpha (pCi/L)	Suspended alpha (pCi/L)	Dissolved beta (pCi/L)	Suspended beta (pCi/L)
<i>MW66</i>					
1/24	<0.001	-10.3	-4.7	831	-6
4/29	<0.001	3.2	0.8	2595	22
7/22	<0.001	-3.5	-4.3	333	-2
11/19	<0.001	14.5	-0.8	777	6
<i>MW67</i>					
1/14	<0.001	14.2	-1.4	32	2
4/28	<0.001	5.8	-1.0	-4	-5
7/21	<0.001	-2.4	0.9	-1	-4
11/04	<0.001	-1.1	-1.1	5	0
<i>MW68</i>					
1/22	<0.001	2.9	-3.2	98	-4
4/23	<0.001	0.3	-0.6	87	-8
7/21	<0.001	-2.9	-0.5	63	-5
10/29	<0.001	0	-1.4	82	1
<i>MW69</i>					
1/23	<0.001	-12.0	-4.7	0	-11
4/28	<0.001	3.0	-0.8	-18	-6
7/30	<0.001	-1.8	-4.5	4	-3
<i>MW71</i>					
1/22	<0.001	3.2	-3.6	11	0
4/28	<0.001	0	-0.9	14	-4
7/22	<0.001	0.9	-3.6	9	-8
10/29	<0.001	2.1	-1.0	9	-3
<i>MW154</i>					
3/18	0.013	-5.9	-5.6	370	-5
6/19	0.014	-10.0	-0.2	466	5
9/08	0.012	15.8	-0.9	410	-7
12/03	0.012	1.5	3.6	483	4
<i>MW184</i>					
1/31	<0.001				
10/19	<0.001				

Table 5.9. Results of 1992 quarterly, semiannual, and annual effluent monitoring at solid waste management units

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cu ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW26														
2/01	7.4	230	168	54.5	23.1	0.696	6	<0.01	<0.05	0.06	<0.005	<2	0	0.6
8/11	7.3	224	156	54.1	15.7	2.32	7	0.014	0.06	0.064	<0.005	<2	0	0.6
8/11	NA ^m													
8/11	NA													
8/11	NA													
MW27														
2/01	6.6	236	91	16.1	7.14	32.3	78	<0.01	<0.05	0.03	<0.005	<2	-0.9	0.8
8/11	6.3	253	88	14.2	6.91	30.6	86	<0.01	<0.01	0.269	<0.005	<2		
8/11	6.3													
8/11	6.4													
8/11	6.5													
MW29														
1/31	4.2	423	<4	30.8	18.4	5.1	5	<0.01	<0.05	4.72	<0.005	<2	0	0
MW38														
2/18	6.2	262	139	27.6	11.5	43.7	50	<0.01	0.01	0.141	<0.005	<2	0	0
2/18	6.3													
2/18	6.3													
2/18	6.3					41.4	39		<0.05					
5/08	6.3													
5/08	6.3													
5/08	6.3													
5/08	6.3					46.2	39		<0.05					
8/20	6.6													
8/20	6.6													
8/20	6.6													
8/20	6.6													
8/20	6.5													
10/22	6.4					42.8	41		<0.05					
10/22	6.4													
10/22	6.4													
10/22	6.4

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Table 5.9 (continued)

Date	pH (units)	TDS ^c (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
<i>MW39</i>														
2/18	6.5	444	267	52.7	23.9	60.8	42	<0.01	<0.01	0.062	<0.005	<2	0	1
2/18	6.5													
2/18	6.5													
2/18	6.5													
5/08	6.5					58.5	37		<0.05					
5/08	6.5													
5/08	6.5													
5/08	6.5													
8/20	6.6					65.2	38		<0.05					
8/20	6.5													
8/20	6.5													
10/22	6.5					56.2	39		<0.05					
10/22	6.5													
10/22	6.5													
10/22	6.5													
<i>MW40</i>														
2/18	6.4	186	93	21.1	9.1	29.1	46	<0.01	<0.01	0.1	<0.005	<2	0	0
2/18	6.3													
2/18	6.3													
2/18	6.3													
5/12	6.2					29.1	34		<0.05					
5/12	6.2													
5/12	6.2													
5/12	6.2													
8/21	6.2					30.3	41		<0.05					
8/21	6.2													
8/21	6.2													
8/21	6.2													
10/23	6.3					28.9	33		<0.05					
10/23	6.3													
10/23	6.3													
10/23	6.3													

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Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW41														
2/19	6.1	218	95	21.6	9.5	32.6	44	<0.01	<0.01	0.006	<0.005	<2	0	0
2/19	6.1													
2/19	6.1													
2/19	6.1						44		<0.05					
5/19	6.4					34.7								
5/19	6.5													
5/19	6.5													
5/19	6.5													
5/19	6.5					34.5	32		<0.05					
8/21	6.2													
8/21	6.2													
8/21	6.2					33.2	42		<0.05					
10/22	6.2													
10/22	6.2													
10/22	6.2													
MW42														
2/20	6.2	404	117	52.3	19.8	56.7	43	<0.01	<0.01	0.009	<0.005	<2	0	0
2/20	6.2													
2/20	6.2													
2/20	6.2					58.2	35		<0.05					
5/19	6.5													
5/19	6.5													
5/19	6.5													
5/19	6.4					51.6	37		<0.05					
8/26	6.6													
8/26	6.4													
8/26	6.4													
8/26	6.4					54.0	38		<0.05					
10/22	6.7													
10/22	6.4													
10/22	6.4													
10/22	6.4													

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cu ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW43														
2/19	6.2	146	85	20.5	8.77	26.7	30	<0.01	<0.01	<0.005	<0.005	<2	0	0
2/19	6.2													
2/19	6.2													
2/19	6.2					27.7	31		<0.05					
5/12	6.3													
5/12	6.2													
5/12	6.2													
5/12	6.3													
8/26	6.5					28.5	31		<0.05					
8/26	6.4													
8/26	6.4													
10/22	6.2					26.9	32		<0.05					
10/22	6.4													
10/22	6.2													
10/22	6.3													
MW44														
2/20	6.0	160	97	25.6	10.7	30.4	50	<0.01	<0.01	<0.005	<0.005	<2	0	0
2/20	6.1													
2/20	6.1													
2/20	6.1													
5/11	6.1								<0.05					
5/11	6.2													
5/11	6.2													
5/11	6.2													
8/26	6.6								<0.05					
8/26	6.5													
8/26	6.5													
8/26	6.5													
10/27	5.9					29.3	46		<0.05					
10/27	5.9													
10/27	5.9													
10/27	5.9													

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Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW46														
3/04	6.4	123	63	17.1	6.87	13.4	14	<0.01	<0.01	0.276	<0.005	<2	0	0
3/04	6.4													
3/04	6.4													
3/04	6.4													
5/27	6.3								<0.05					
5/27	6.4													
5/27	6.3													
5/27	6.3													
9/09	6.3								<0.05					
9/09	6.3													
9/09	6.3													
9/09	6.3													
12/11	6.1								<0.05					
12/11	6.1													
12/11	6.2													
12/11	6.1													
MW47														
3/20	7.8	708	366				128		<0.01			<2		
6/26	7.8								0.142					
9/11	5.4								<0.05					
2/11	7.1								0.39					
MW48														
3/04	6.6	111	62	15.4	6.29	12.3	11	<0.01	<0.01	0.146	<0.005	<2	0	1
3/04	6.5													
3/04	6.4													
3/04	6.4													
5/27	6.3								<0.05					
5/27	6.3													
5/27	6.3													
5/27	6.3													
9/09	6.1								<0.05					
9/09	6.1													
9/09	6.1													
9/09	6.1													

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
12/11	6.1								<0.05					
12/11	6.1													
12/11	6.0													
12/11	6.1													
MW50														
1/29	6.3	94	55	11.4	4.61	12.0	9	<0.01	<0.01	0.172	<0.005	<2	0	0
1/29	6.3													
1/29	6.2													
1/29	6.2													
4/03	6.1								<0.05					
4/03	6.1													
4/03	6.1													
4/03	6.1													
4/03	6.1													
7/28	6.6								<0.05					
7/28	6.5													
7/28	6.4													
7/29	6.4													
10/07	5.9								<0.05					
10/07	5.9													
10/07	5.9													
10/07	5.9													
MW51														
1/29	6.1	94	62	10.5	4.41	10.8	10	<0.01	<0.01	0.532	<0.005	<2	0	0
1/29	6.1													
1/29	6.0													
1/29	6.0													
4/07	6.1								<0.05					
4/07	6.1													
4/07	6.1													
4/07	6.1													
7/23	6.4								<0.05					
7/23	6.4													
7/23	6.3													
7/23	6.3													
10/07	6.1													
10/07	6.0													
10/07	6.0													
10/07	6.0													

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Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW52														
1/74	6.2	64	73	13.6	5.66	13.9	11	<0.01	<0.01	0.112	<0.005	<2	0	1
1/24	6.2													
1/24	6.2													
1/24	6.2													
4/03	6.3								<0.05					
4/03	6.3													
4/03	6.3													
4/03	6.3													
7/23	5.8								<0.05					
7/23	6.7								<0.05					
7/23	6.6													
7/23	6.5													
7/23	6.4													
10/13	6.1								<0.05					
10/13	6.1													
10/13	6.1													
10/13	6.1													
MW53														
1/24	6.0	108	59	13.8	4.59	13.0	8	<0.01	<0.01	0.146	<0.005	<2	0	0
1/24	6.0													
1/24	6.0													
1/24	6.0													
4/08	6.2								<0.05					
4/08	6.2													
4/08	6.2													
4/08	6.1													
7/23	5.8													
7/23	5.8													
7/23	5.8													
10/13	6.3								<0.05					
10/13	6.2													
10/13	6.2													
10/13	6.2													

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW54														
1/29	6.6	138	107	24.8	6.45	14.4	8	<0.01	<0.01	1.15	<0.005	<2	0	0
1/29	6.5													
1/29	6.4													
1/29	6.4													
4/10	6.6								<0.05					
4/10	6.6													
4/10	6.6													
4/10	6.5													
7/23	6.6								<0.01					
7/23	6.5													
7/23	6.3													
7/23	6.3													
10/07	6.5								<0.05					
10/07	6.6													
10/07	6.5													
10/07	6.5													
MW57														
1/30	6.9	332	147	42.8	10.2	26.1	7	<0.01	0.01	0.884	<0.005	<2	0	1
1/30	6.9													
1/30	6.9													
1/30	6.7													
4/30	7.1								<0.05					
4/30	7.1													
4/30	7.0													
4/30	7.0													
7/28	6.7								<0.05					
7/28	7.1													
7/28	7.1													
7/28	6.9													
11/18	7.4								<0.05					
11/18	7.3													
11/18	7.2													
11/18	7.2													

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Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW59														
10/28	6.0	185	76	8.21	3.03	34.5	13	<0.01	<0.01 ⁿ	<0.005	<0.005	<2		
10/28	6.0													
10/28	6.0													
10/28	6.1													
MW60														
7/27														
10/28	6.2	306	113	22.0	7.54	64.0	41	<0.01	<0.01	<0.005	<0.005	<2		
10/28	6.3													
10/28	6.4													
10/28	6.3													
MW61														
10/28	6.0	242	94	15.1	6.04	51.3	46	<0.01	<0.01 ⁿ	<0.005	0.007	<2		
10/28	6.1													
10/28	6.1													
10/28	6.1													
MW62														
10/28	7.2	NA	NA	33.4	10.4	9.72		<0.01	NA	0.154	<0.005	NA		
10/28	7.2													
10/28	7.2													
10/28	7.2													
11/06	6.9	163	152				6		<0.01			<2		
MW63														
1/09	6.3	153	91	24.0	6.88	17.6	15	<0.01	<0.01	0.029	<0.005	<2	0	0
1/09	6.5													
1/09	6.3													
1/09	6.3													
4/09	6.1													
4/09	6.1													
4/09	6.1													
4/09	6.1													

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
7/08	6.7								<0.05					
7/08	6.6													
7/08	6.6													
7/08	6.5													
11/03	6.2								0.064					
11/03	6.3													
11/03	6.3													
11/03	6.3													
<i>MW64</i>														
4/24	6.9								0.051					
4/24	7.2													
4/24	7.2													
4/24	7.3													
7/22	6.5								<0.05					
7/22	6.8													
7/22	6.7													
7/22	6.9													
11/04	7.1								<0.05					
11/04	7.2													
11/04	7.2													
11/04	7.2													
<i>MW65</i>														
1/09	5.9	79	61	15.4	6.44	13.9	12	<0.01	<0.01	<0.005	<0.005	<2	0	0
1/09	5.9													
1/09	6.1													
1/09	6.0													
4/21	6.0													
4/21	6.1													
4/21	6.1													
4/21	6.0													
7/08	6.4								<0.05					
7/08	6.5													
7/08	6.5													
7/08	6.4													
11/03	6.8								<0.05					
11/03	6.8													
11/03	6.8													
11/03	6.8													

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Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW66														
1/24	6.1	178	88	30.2	6.86	16.3	20	<0.01	<0.01	0.014	<0.005	<2	0	0
1/24	6.1													
1/24	6.1													
1/24	6.1													
4/29	6.6								<0.05					
4/29	6.4													
4/29	6.2													
4/29	6.2													
7/22	6.7								<0.05					
7/22	6.4													
7/22	6.5													
11/19	6.6								<0.01					
11/19	6.3													
11/19	6.3													
11/19	6.3													
MW67														
1/14	5.9	99	57	14.1	5.80	12.5	11	<0.01	<0.01	0.018	<0.005	<2	0	0
1/14	6.0													
1/14	6.0													
4/28	6.3													
4/28	6.4								<0.05					
4/28	6.4													
4/28	6.3													
7/21	6.1								<0.05					
7/21	6.1													
7/21	6.1													
11/04	6.9													
11/04	6.8								<0.05					
11/04	6.8													
11/04	6.8													

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
MW68														
1/22	5.7	245	77	31.2	12.9	22.2	59	<0.01	<0.01	<0.005	<0.005	<2	0	0
1/22	5.9													
1/22	5.9													
1/22	5.9													
4/23	6.8								<0.05					
4/23	6.8													
4/23	6.5								<0.05					
4/23	6.5													
7/21	6.4													
7/21	6.3													
7/21	6.3													
7/21	6.3													
10/29	6.1								<0.05					
10/29	6.2													
10/29	6.1													
MW69														
1/23	6.3	395	248	38.4	15.7	71.4	91	<0.01	<0.01	6.7	<0.005	<2	0	0
1/23	6.5													
1/23	6.5													
4/28	6.7								<0.05					
4/28	6.7													
4/28	6.9													
4/28	6.9								<0.05					
7/30	6.4													
7/30	6.4													
7/30	6.7													
7/30	6.5													
MW71														
1/22	5.8	292	97	30.0	12.1	51.4	72	<0.01	<0.01	0.009	<0.005	<2	0	0
1/22	5.8													
1/22	5.8													
1/22	5.8													

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Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
4/28	6.5								<0.05					
4/28	6.4													
4/28	6.3													
4/28	6.3													
7/22	6.6								0.526					
7/22	6.3													
7/22	6.2													
10/29	6.3								0.113					
10/29	6.3													
10/29	6.2													
10/29	6.3													
<i>MW154</i>														
3/18	6.3	708	99	23.2	10.2	60.8	5	<0.01	<0.01	0.043	<0.005	<2	0	0.35
3/18	6.3													
3/18	6.3													
3/18	6.3													
6/19	6.0								<0.05					
6/19	6.3													
6/19	6.3													
6/19	6.4													
9/08	6.5								<0.05					
9/08	6.7													
9/08	6.3													
9/08	6.3													
12/03	6.9								<0.05					
12/03	6.9													
12/03	6.8													
12/03	6.8													
<i>MW184</i>														
1/31	6.4	540		115.2	36.6	26.5	14	<0.01	<0.01	6.19	<0.005			
3/30	6.3			109.0		25.5		<0.01	<0.05	5.86	<0.005			
10/19	NA			98.3	33.2	24.8		<0.01	<0.05	5.38				
<i>MW220</i>														
7/09	6.6					33.4		<0.002	<0.05		<0.01			
7/09	6.6					34.9		<0.002	<0.05		<0.01			

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
8/25	6.8					29.8		<0.005	<0.05		<0.005			
11/16	6.7													
11/16	6.8													
11/16	6.8													
11/16	6.8													
7/09	6.5													
11/16	6.4					40.5		<0.002	<0.05		<0.01			
11/16	6.4					45.1		<0.005	<0.05		<0.005			
11/16	6.4													
11/16	6.3													
11/16	6.3					47.2		<0.005	<0.05		<0.005			
11/16	6.3													
11/16	6.3													
11/16	6.3													
11/16	6.4					38.9		<0.005	<0.05		<0.005			
11/16	6.4													
11/16	6.5													
11/16	6.4													
11/16	6.2					45.8		<0.005	<0.05		<0.005			
11/16	6.3													
11/16	6.3													
11/16	6.3													
11/16	6.3					74.3		<0.005	<0.05		<0.005			
11/16	6.3													
11/16	6.3													
11/16	6.3													

Table 5.9 (continued)

Date	pH (units)	TDS ^a (mg/L)	Alkalinity (mg/L)	Ca ^b (mg/L)	Mg ^c (mg/L)	Na ^d (mg/L)	Cl ^e (mg/L)	Cd ^f (mg/L)	Cr ^g (mg/L)	Mn ^h (mg/L)	Se ⁱ (mg/L)	PO ₄ ^j (mg/L)	²⁴¹ Am ^k (pCi/L)	⁶⁰ Co ^l (pCi/L)
11/16	6.3					42	MW225	<0.005	<0.05		<0.005			
11/16	6.3													
11/16	6.3													
11/16	6.3													

^aTotal dissolved solids.

^bCalcium.

^cMagnesium.

^dSodium.

^eChloride.

^fCadmium.

^gChromium.

^hManganese.

ⁱSelenium.

^jPhosphate.

^kAmericium.

^lCobalt.

^mNot analyzed.

ⁿHolding time exceeded for this sample.

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Table 5.10. Results of 1992 Phase III groundwater monitoring

Date	TCE ^a (μg/L)	⁹⁹ Tc ^b (pCi/L)
	<i>MW98</i>	
February 25	<1	30
	<i>MW99</i>	
March 3	<1	3
	<i>MW102</i>	
February 28	<1	0
	<i>MW103</i>	
February 28	<1	2
	<i>MW104</i>	
February 27	<1	0
	<i>MW107</i>	
April 22	1	
	<i>MW108</i>	
April 7	1200	55
April 7	1300	
April 7	1800	52
April 7	1200	50
April 8	1200	
April 8	1100	
April 9	920	
April 9	1000	
April 9	920	
April 9	910	
April 9	870	
April 9	960	60
April 10	940	
April 10	910	52
April 10	950	
	<i>MW109</i>	
April 16	810	
	<i>MW110</i>	
April 22	<1	
	<i>MW114</i>	
April 16	9	

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Table 5.10 (continued)

Date	TCE ^a (µg/L)	⁹⁹ Tc ^b (pCi/L)
	<i>MW115</i>	
April 20	<1	
	<i>MW117</i>	
April 20	48	

^aTrichloroethylene.

^bTechnetium-99.

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Table 5.11. Results of 1992 Paducah Gaseous Diffusion Plant (PGDP) state Cabinet of Human Resources (CHR) radiochemical data comparison for groundwater

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
R-2							
4420-92	2-12-92	-4.8	12±2	556	333±5	611	574±13
4954-92	5-13-92	6.5	13±2	330	321	545	531±13
5512-92	8-18-92	9.8	15±2	535	498±6	910.8	813±15
6166-92	11-10-92	2.6	16±2	698	679±8	1102	1008±9
Annual maximum ^a		14.7	16±2	698	679±8	1102	1008±9
Annual minimum ^a		-8.1	12±2	166	321	442	531±13
R-17							
4421-92	2-12-92	5.1	3±1	121	107±3	161	173±9
4955-92	5-13-92	-0.4	4±1	160	150±4	243	256±10
5513-92	8-18-92	2.9	3±1	127	135±3	202.2	222±10
6167-92	11-10-92	3.0	2±1	119	115±3	215	178±5
Annual maximum		5.4	4±1	183	150±4	287	256±10
Annual minimum		-2.8	2±1	119	107±3	158	173±9
R-4							
4422-92	2-12-92	4.1	2±1	35	28±2	48	36±8
4956-92	5-13-92	-1.4	<1	33	14±1	<25	16±8
5514-92	8-18-92	-1.4	2±1	23	21±2	34	29±8
6168-92	11-10-92	2.7	<1	27	12±1	39	16±4
Annual maximum		6.5	2±1	35	28±2	121	36±8
Annual minimum		-2.4	<1	-4	12±1	<25	16±4
R-5							
4467-92	2-12-92	2.5	<1	4	<2	<25	NR ^b
4957-92	5-13-92	1.5	<1	1	<2	<25	NR
5515-92	8-18-92	1.5	<1	-3	<3	<25	NR
6169-92	11-10-92	0.6	<1	-3	<2	<25	NR
Annual maximum		3.7	<1	4	<3	<25 ^c	
Annual minimum		-5.4		-6	<2		
R-10							
4423-92	2-12-92	2.8	<1	5	<2	<25	NR
4958-92	5-13-92	2.4	<1	3	<2	<25	NR
5516-92	8-18-92	Backup ^d	<1	Backup	<3	Backup	NR
6170-92	11-10-92	-2	<1	-3	<2	<25	NR
Annual maximum		3.2	<1	13	<3	<25 ^c	
Annual minimum		-5.2		-5	<2		
R-40							
4424-92	2-12-92	3.2	<1	3	<2	<25	NR
4959-92	5-13-92	0.9	<1	1	3±1	<25	NR
5517-92	8-18-92	Backup	<1	Backup	<3	Backup	NR
6171-92	11-10-92	0	<1	1	3±1	<25	NR
Annual maximum		4.5	<1	10	3±1	25 ^c	
Annual minimum		-3.0		-4	<2		

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Table 5.11 (continued)

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
R-21							
4425-92	2-12-92	1.0	1±1	13	<2	<25	NR
4965-92	5-13-92	-0.8	2±1	0.8	3±1	<25	NR
5519-92	8-18-92	0.3	2±1	-2	<3	<25	NR
6173-92	11-10-92	-2.8	<1	1	2±1	<25	NR
Annual maximum		1.0	2±1	13	3±1	<25 ^c	
Annual minimum		-7.9	<1	-7	<2		
R-26							
4436-92	2-12-92	0.5	<1	3	<2	<25	NR
4961-92	5-13-92	Backup	2±1	Backup	2±1	Backup	NR
5520-92	8-18-92	Backup	<1	Backup	<3	Backup	NR
6174-92	11-10-92	Backup	<1	Backup	<2	Backup	NR
Annual maximum		0.5 ^e	2±1	3 ^e	<3	<25 ^c	
Annual minimum			<1		<2		
R-13							
4960-92	5-13-92	3.5	<1	3	<2	<25	<9
5518-92	8-18-92	2	<1	-0.2	<3	<25	NR
6172-92	11-10-92	-1	<1	-0.8	<2	<25	NR
Annual maximum		6.2	<1	11	<3	<25 ^c	<9
Annual minimum		-12.6		-8	<2		
R-6							
4427-92	2-12-92	3.7	3±1	8	2±1	<25	NR
4962-92	5-13-92	6.0	3±1	6	4±1	<25	NR
5521-92	8-18-92	2.0	3±1	-2	<3	<25	NR
6175-92	11-10-92	3.7	2±1	5	2±1	<25	NR
Annual maximum		10.4	3±1	17	4±1	<25 ^c	
Annual minimum		-2.1	2±1	-4	2±1		
R-253							
4428-92	2-12-92	Backup	2±1	Backup	<2	Backup	NR
4963-92	5-13-92	6.8	<1	6	2±1	<25	NR
5523-92	8-18-92	0.8	<1	0	<3	<25	NR
6176-92	11-10-92	Backup	1±1	Backup	<2	Backup	NR
Annual maximum		6.8	2±1	6	<3	<25 ^c	
Annual minimum		0.8	<1	0	<2		

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Table 5.11 (continued)

Sample ID	Date	Gross alpha (pCi/L)		Gross beta (pCi/L)		⁹⁹ Tc (pCi/L)	
		PGDP result	CHR result	PGDP result	CHR result	PGDP result	CHR result
R-254							
4429-92	2-12-92	Backup	<1	Backup	<2	Backup	NR
4964-92	5-13-92	1.1	<1	–1	<2	<25	NR
5523-92	8-18-92	Backup	2±1	Backup	<3	Backup	NR
6177-92	11-10-92	Backup	1±1	Backup	3±1	Backup	NR
Annual maximum		1.1 ^e	2±1	–1 ^e	3±1	<25 ^c	
Annual minimum			<1		<2		

^aThe annual maximum and annual minimum values reported by PGDP are the maximum and minimum values that resulted from all samples taken by PGDP at the specified location in 1992, not those taken in conjunction with the CHR. The total number of samples taken in 1992 differed among sampling locations (e.g., a single sample was collected and analyzed from R-26 in 1992, while approximately 52 samples were collected and analyzed from R-10 in 1992). A maximum of one sample per location was taken per quarter by the CHR; therefore, the annual maximum and minimum values reported by the CHR are the maximum and minimum of the CHR results reported in this table.

^bNot run.

^cTechnetium-99 results for all samples taken at this location in 1992 were <25 pCi/L.

^dSamples designated as backup were collected by PGDP at the same time the CHR samples were collected. These samples were not analyzed by PGDP unless the corresponding CHR samples were damaged, lost, or yielded questionable results.

^eA single sample was collected and analyzed for this constituent by PGDP at the specified location in 1992.

6. Biological Monitoring

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All data for this section are presented in Part 1.

7. Soil and Sediment Monitoring

All data for this section are presented in Part 1.

8. Unusual Occurrences and Special Studies

All data for this section are presented in Part 1.

9. Solid Waste Management Program

All data for this section are presented in Part 1.

10. Quality Assurance

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Table 10.1. PGDP environmental analysis procedures for air

Parameter	Procedure ^a	NIOSH ^b or EPA ^c method	Lowest concentration reported
Gross alpha, beta, air filters, radiochemistry	R-1-A	APHA 601, 602 ^d	Result obtained
Fluoride, air, SIE ^e (μg/sample)	SA-F-2		5
Fluoride, stacks, SIE (mg/L)	SA-F-2		0.1 sample solution
Gamma-ray spectroscopy, air filters	R-52		Result obtained
Metals in air particulates, emission spectroscopy (μg/sample)	SC-35-2	NIOSH 7300 ^f	For 35 metals, mostly 1–10 each
Pu, air filters, radiochemistry	R-50	EPA-680/4-75-001	Result obtained
⁹⁹ Tc, air filters, radiochemistry	R-46		Result obtained
Th, alpha isotopes, radiochemistry	R-17		Result obtained
U isotopes, air filters, radiochemistry	TIMS 3	EPA-680/4-75-001	Result obtained
U, stack gases	TIMS 3		Result obtained
U, stack samples, fluorometric (mg/L)	SA-U-10 (draft)		0.001 sample solution
²²⁶ Ra	R-55		Result obtained
²²² Rn	R-51		Result obtained
⁶⁰ Co	R-52		Result obtained
¹³⁷ Cs	R-52		Result obtained
⁴⁰ K	R-52		Result obtained

^aPaducah Gaseous Diffusion Plant, Mar. 1, 1991. *Technical Procedures*, Ky/L-176, Vols. I and II, Martin Marietta Energy Systems, Inc.

^bNational Institute for Occupational Safety and Health.

^cU.S. Environmental Protection Agency.

^dAPHA Methods, American Public Health Assoc., 1977.

^eSpecific ion electrode.

^fNIOSH *Manual of Analytical Methods*, Third Ed., U.S. Dept. of Health, Education, and Welfare, 1989.

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Table 10.2. PGDP environmental analysis procedures for water

Parameter	Procedure ^a	EPA ^b method	Lowest concentration reported ^c
Alkalinity (CaCO ₃) (mg/L)	W-10	310.1	5
Gross alpha activity	R-4	900.0	Result obtained
Gross beta activity	R-4	900.0	Result obtained
²⁴¹ Am	R-52		Result obtained
As and Se, furnace-AA			
As (mg/L)	SC-ENV-1	206.2	0.005
Se (mg/L)	SC-ENV-1	270.2	0.005
BOD ^d (5 d) (mg/L)	W-20	405.1	5
COD, ^e spectrophotometric method (mg/L)	W-40	Hach 8000	5
Anions, ion chromatograph ^f (mg/L)			
Chloride (mg/L)	W-50	300.0	2
Nitrate (N) (mg/L)	W-50	300.0	1
Sulfate (mg/L)	W-50	300.0	5
Phosphate (P) (mg/L)	W-50	300.0	2
Chlorine (total residual), amperometric (mg/L)	W-160	330.1	0.01
Chromium (VI), spectrophotometric (mg/L)	W-100	USGS ^g	0.01
Coliform bacteria (fecal) (colonies/100 mL)	W-80	909C Std. Mth. ^h	1
Coliform bacteria (total) (colonies/100 mL)	W-85	909A Std. Mth.	1
Color (color units)	SA-CLR-1	110.2	1
Conductance (specific) (µmho/cm)	SA-COND-1	120.1	0.5
Cyanide (total) (5-cm cell)	EPA-335.2	335.2	0.004
Fluoride (mg/L)	SA-F-5, SA-F-7	340.2	0.1
Gamma-ray emitters	R-52		Result obtained
Hg (total) (mg/L)	SC-ENV-2	245.1	0.0002
²³⁷ Np	R-8, R-52		Result obtained
Nitrogen, ammonia, SIE ⁱ (mg/L)	SA-NH3-2	350.3	0.2
Oil and grease, gravimetric (mg/L)	SA-O-G-1	413.1	5
Oil and grease, infrared (mg/L)	GA-28	413.2	0.1
pH, electrometric (mg/L)	W-110	150.1	Nearest 0.1 pH unit
Phosphorus (all forms) spectrophotometric (mg/L)	W-120	365.3	0.05
Pu isotopes	R-50		Result obtained
PCBs ^j (µg/L)	AL-OP-1	608	0.1 each Arochlor
Priority pollutants, organic (volatile, purgeable)	AL-OP-3, AL-OP-4	624	
Trichloroethylene (µg/L)	AL-OP-3, AL-OP-4	624	1
Acetone (µg/L)	GA-34	R-3810	1000
Isopropanol (µg/L)	GA-34	R-3810	1000
Benzene (µg/L)	AL-OP-3, AL-OP-4	624	5
Toluene (µg/L)	AL-OP-3, AL-OP-4	624	5
Ethyl benzene (µg/L)	AL-OP-3, AL-OP-4	624	5
Total xylene (µg/L)	AL-OP-3, AL-OP-4	624	10
1,2-Dichloroethane (µg/L)	AL-OP-3, AL-OP-4	624	1
1,1,1-Trichloroethane (µg/L)	AL-OP-3, AL-OP-4	624	5
Tetrachloroethene (µg/L)	AL-OP-3, AL-OP-4	624	5
Trihalomethanes (µg/L)	AL-OP-3, AL-OP-4	624	5
1,2-Dichloroethene (µg/L)	AL-OP-3, AL-OP-4	624	5

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Table 10.2 (continued)

Parameter	Procedure ^a	EPA ^b method	Lowest concentration reported ^c
Solids (dissolved) (mg/L)	W-140	160.1	10
Solids (total) (mg/L)	W-140	160.3	10
Solids (undissolved) (mg/L)	W-140	160.2	4
⁹⁹ Tc	R-46		Result obtained
Thorium isotopes	R-17		Result obtained
Total petroleum hydrocarbons (mg/L)	GA-28	418.1	0.1
Total organic carbon, combustion or oxidation	W-150	415.1	1
Turbidity (NTU) ^k	W-170	180.1	0.05
Uranium (total), fluorometric (mg/L)	SA-U-8		1 × 10 ⁻³
Uranium isotopes	TIMS 3		Result obtained
Uranium isotopic abundances	TIMS 3		Result obtained

^aPaducah Gaseous Diffusion Plant, Mar. 1, 1991. *Technical Procedures*, Ky/L-176, Vols. I and II, Martin Marietta Energy Systems, Inc.

^bU.S. Environmental Protection Agency.

^cThe lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the LCRs are higher than the method detection limits (MDLs) listed by the EPA. This is consistent with guidance from the EPA; however, any data reported below the MDLs must be supported by sound documentation. The LCRs applied by Martin Marietta Energy Systems, Inc., laboratories meet the needs of the programs they support.

^dBiological oxygen demand.

^eChemical oxygen demand.

^fApproved for drinking water only (reagent water).

^gU.S. Geological Survey, "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediment," Open-File Report 78-679; N. W. Skougstad et al., "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," Chapter A1, in *Techniques of Water-Resources Investigation*, Book 5, U.S. Geological Survey, 1979.

^hAll references to *Standard Methods* for the 16th Edition, 1985.

ⁱSpecific ion electrode.

^jPolychlorinated biphenyls.

^kNephelometric turbidity unit.

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Table 10.3. PGDP atomic absorption and inductively coupled plasma environmental analysis procedures for water (lowest concentration reported)^a

Element	PGDP SC-ENV-1 ^b EPA 200 series graphite furnace AA (mg/L)	PGDP SC-ENV-4 ^b and SC-ICAP-1 ^b EPA 200.7 ICP (mg/L)
Ag		0.03
Al		0.1
As	0.005	0.1
Ba		0.005
Ca		0.01
Cd		0.01
Cr		0.05
Cu		0.01
Fe		0.01
K		2.0
Li		0.02
Mg		0.002
Mn		0.005
Mo		0.05
Na		0.04
Ni		0.05
Pb		0.2
Se	0.005	0.2
Zn		0.005

^aThe lowest concentration reported (LCR) may vary among specific samples, depending on interferences in the sample matrix. However, these LCRs have been assigned to accommodate most minor interferences. Some of the LCRs are higher than the method detection limits (MDLs) listed by the U.S. Environmental Protection Agency (EPA). This is consistent with guidance from the EPA; however, any data reported below the MDLs must be supported by sound documentation. The LCRs applied by Martin Marietta Energy Systems, Inc., laboratories meet the needs of the programs they support.

^bPaducah Gaseous Diffusion Plant, Mar. 1, 1991. *Technical Procedures*, KY/L-176, Vols. I and II, Martin Marietta Energy Systems, Inc.

Table 10.4. PGDP environmental analysis procedures for biota

Parameter	Procedure ^a	Lowest concentration reported (mg/kg)
Fluoride in vegetation	SA-F-3	3
Gamma-ray spectrometry of vegetation	R-53	Result obtained
Uranium (total and isotopic) in vegetation	I-4	Result obtained

^aPaducah Gaseous Diffusion Plant, Mar. 1, 1991. *Technical Procedures*, KY/L-176, Vols. I and II, Martin Marietta Energy Systems, Inc.

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Table 10.5. PGDP environmental analysis procedures for soil and sediment

Parameter	Procedure ^{a,b}	EPA ^c method ^{d,e}	Lowest concentration reported (mg/kg)
Hg (total), flameless AA	SC-ENV-2	245.5	0.2
Np, direct gamma spectrum	R-15		Result obtained
²³⁷ Np, radiochemical	R-8		Result obtained
Pu, radiochemical	R-50		Result obtained
PCBs ^f , gas chromatographic	AL-OP-1	RCRA-8080	0.1
Priority pollutants organic (volatile purgeables)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	
Trichloroethene	AL-OP-4	RCRA-8260	1
Benzene	AL-OP-4	RCRA-8260	1
Toluene	AL-OP-4	RCRA-8260	1
Ethyl benzene	AL-OP-4	RCRA-8260	1
Xylenes (total)	AL-OP-4	RCRA-8260	1
1,1,1-Trichloroethane	AL-OP-4	RCRA-8260	1
Tetrachloroethene	AL-OP-4	RCRA-8260	1
⁹⁹ Tc, radiochemical	R-46		Result obtained
Th (alpha-emitting) isotopes, radiochemical	R-17		Result obtained
Uranium (total and isotopic), isotope dilution mass spectrometric	I-4		Result obtained
Uranium isotopes, radiochemical	I-4		Result obtained
Aluminum	SC-ENV-5 & SC-ICAP-1	200.7	6.0
Arsenic	SC-ENV-1	206.2	0.5
Barium	SC-ENV-5 & SC-ICAP-1	200.7	0.04
Beryllium	SC-ENV-5 & SC-ICAP-1	200.7	0.1
Cadmium	SC-ENV-5 & SC-ICAP-1	200.7	0.6
Calcium	SC-ENV-5 & SC-ICAP-1	200.7	2.0
Chromium	SC-ENV-5 & SC-ICAP-1	200.7	0.4
Cobalt	SC-ENV-5 & SC-ICAP-1	200.7	0.4
Copper	SC-ENV-5 & SC-ICAP-1	200.7	0.2
Iron	SC-ENV-5 & SC-ICAP-1	200.7	1.0
Lead	SC-ENV-5 & SC-ICAP-1	200.7	4.0
Magnesium	SC-ENV-5 & SC-ICAP-1	200.7	0.1
Manganese	SC-ENV-5 & SC-ICAP-1	200.7	0.1
Molybdenum	SC-ENV-5 & SC-ICAP-1	200.7	1.6
Nickel	SC-ENV-5 & SC-ICAP-1	200.7	0.8
Potassium	SC-ENV-5 & SC-ICAP-1	200.7	10.0
Selenium	SC-ENV-1	270.2	0.5
Silver	SC-ENV-5 & SC-ICAP-1	200.7	0.6
Sodium	SC-ENV-5 & SC-ICAP-1	200.7	1.0
Vanadium	SC-ENV-5 & SC-ICAP-1	200.7	0.6
Zinc	SC-ENV-5 & SC-ICAP-1	200.7	0.4

^aEC designation refers to procedures in *Environmental and Effluent Analysis Manual*, Martin Marietta Energy Systems, Inc., Sept. 19, 1989.

^bOther designations in this column refer to Paducah Gaseous Diffusion Plant, Mar. 1, 1991. *Technical Procedures*, KY/L-176 Vols. I and II, Martin Marietta Energy Systems, Inc.

^cU.S. Environmental Protection Agency.

^dProcedures with RCRA designations refer to U.S. Environmental Protection Agency, December 1987, *Test Methods for Evaluating Solid Waste*, SW-846.

^eRemainder of procedures are from U.S. Environmental Protection Agency, March 1983, *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020.

^fPolychlorinated biphenyls.

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Table 10.6. PGDP analysis procedures for off-site well waters

Parameter	Procedure ^a	EPA ^b method ^{c,d}	Lowest concentration reported
Gross alpha activity	R-4	900.0	Report result obtained
Gross beta activity	R-4	900.0	Report result obtained
Benzene (µg/L)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	5
1,2-Dichloroethane (µg/L)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	5
Ethyl benzene (µg/L)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	5
PCBs ^e (µg/L)	OP-1	RCRA-8080	0.1
Total petroleum hydrocarbons (mg/L)	GA-28	418.1	0.1
Toluene (µg/L)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	5
1,1,1-Trichloroethane (µg/L)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	5
Trichloroethylene (µg/L)	AL-OP-3, AL-OP-4	RCRA 8240, RCRA-8260	1
⁹⁹ Tc (pCi/L)	R-46		25
Xylenes (total, µg/L)	AL-OP-3, AL-OP-4	RCRA-8240, RCRA-8260	10

^aDesignations in this column refer to Paducah Gaseous Diffusion Plant, Mar. 1, 1991. *Technical Procedures*, KY/L-176 Vols. I and II, Martin Marietta Energy Systems, Inc.

^bU.S. Environmental Protection Agency.

^cProcedures with RCRA designations refer to U.S. Environmental Protection Agency, December 1987, *Test Methods for Evaluating Solid Waste*, SW-846.

^dRemainder of procedures are from U.S. Environmental Protection Agency, March 1983, *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020.

^ePolychlorinated biphenyls.

Table 10.7. PGDP analysis procedures for field measurements

Parameter	Procedure ^a	EPA ^b method	Lowest concentration reported
pH	ES-214	150.1	0.1 ^c
Dissolved oxygen (mg/L)	ES-214	360.1	0.1
Temperature	ES-214	170.1	0.1 ^d
Total residual chlorine (mg/L)	ES-216	330.5	0.01
Depth (ft)	ES-202	NA	0.01

^aDesignations in this column refer to the PGDP Environmental Monitoring Department *Standard Operating Procedures Manual*.

^bU.S. Environmental Protection Agency.

^cNearest pH unit.

^dNearest degree F.

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**Table 10.8. PGDP internal measurement control program
laboratory control data (inorganic)**

Measurement identification	Accepted mean ^a	Observed mean ± limit of error	Number of analyses	Percent limit of error per analysis ^b	Percent recovery
<i>Fluorimetric analysis</i>					
Low-level uranium	0.008 mg/L (T) ^c	0.0077 ± 0.0002	84 ^d	20	96.3
	0.005 mg/L (T)	0.0049 ± 0.0001	120 ^d	17	99.2

^aSamples sent at various theoretical levels. Statistics are reported on the ratio of reported result to the theoretical value with 1.000 indicating agreement.

^bLimit of error of the 95% confidence level.

^cT = theoretical value.

^dExcludes one outlier.

**Table 10.9. PGDP internal measurement control program
laboratory control data (organic)**

Measurement identification	Accepted mean	Observed mean ± limit of error	Number of analyses	Percent limit of error per analysis ^a	Percent recovery
<i>Total organic halogens (TOX)</i> (µg/L)					
TOX, as trichlorophenol, in water (matrix-well)					
Model DX-20	100.0	101.2 ± 1.1	86	10	101.2
	20.0	21.0 ± 0.2	72	7	104.9
Model MC-3	100.0	98.4 ± 1.5	77	10	98.4
	20.0	20.5 ± 0.2	90	7	102.7
Model 10 sigma	100.0	101.1 ± 3.2	15	12	101.1
<i>Polychlorinated biphenyls (PCBs)</i> (µg/L)					
PCB, spike recovery, in water (matrix-water and well)	0.10	0.102 ± 0.005	18	20	101.6
<i>Trichloroethylene (TCE)</i> (µg/L)					
TCE, spike recovery, in groundwater (matrix-well)	5.0	4.56 ± 0.07	96	14	91.2
TCE, spike recovery, in water (matrix-water)	5.0	4.69 ± 0.12	26	12	93.8

^aLimit of error of the 95% confidence level.

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**Table 10.10. U.S. Environmental Protection Agency (EPA) Performance Evaluation
Discharge Monitoring Report—Quality Assurance Study Number 012
for the Paducah Gaseous Diffusion Plant, January 1992**

Parameter	Reported value	True value ^a	Acceptable limits	Warning limits	Performance evaluation ^b
<i>Trace metals (µg/L)</i>					
Aluminum	937	950	778–1130	823–1090	Acceptable
Chromium	322	315	266–371	279–358	Acceptable
Copper	130	130	113–144	117–140	Acceptable
Iron	515	540	471–613	489–595	Acceptable
Nickel	2280	2200	1970–2410	2020–2360	Acceptable
Zinc	1480	1400	1230–1570	1270–1520	Acceptable
<i>Miscellaneous parameters (mg/L)^c</i>					
pH (units)	6.7	6.80	6.63–6.96	6.67–6.92	Acceptable
Total suspended solids	39	40.0	31.6–45.1	33.2–43.5	Acceptable
Oil and grease	9.7	11.0	4.13–15.7	5.59–14.2	Acceptable
Total residual chlorine	0.9	0.97	0.605–1.20	0.684–1.12	Acceptable
<i>Demand (mg/L)</i>					
COD ^d	99	98.8	75.4–117	80.7–112	Acceptable
BOD ^e (5 d)	66	64.2	38.8–89.7	45.1–83.3	Acceptable

^aBased on theoretical calculations or a reference value when necessary.

^bPerformance evaluation by the EPA: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for check for error; outside 2.58 standard deviations for unacceptable.

^cUnits in mg/L except for pH, which is reported in pH units.

^dChemical oxygen demand.

^eBiological oxygen demand.

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**Table 10.11. January 1992 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Alkalinity as CaCO ₃ (mg/L)	1	53	57.07	55.38	0.750	Acceptable
	2	54	57.68	56.75	0.841	Acceptable
Aluminum (μg/L)	1	104	83.5	86.0	1.43	Acceptable
	2	164	149.3	156.6	0.252	Acceptable
Ammonia as N (mg/L)	1	0.35	0.34	0.372	0.162	Acceptable
	2	1.6	1.52	1.52	0.414	Acceptable
Antimony (mg/L)	1	80.5	106.3	99.8	1.133	Acceptable
	2	534	552.3	537.1	0.048	Acceptable
Arsenic (μg/L)	1	20.4	19.35	19.62	0.258	Acceptable
	2	395	386.99	386.50	0.214	Acceptable
Barium (μg/L)	1	247	250.4	253.28	0.331	Acceptable
	2	1797	1797.9	1780.75	0.178	Acceptable
Beryllium (μg/L)	1	64.5	67.77	66.21	0.481	Acceptable
	2	143	143.07	141.35	0.175	Acceptable
BOD ^b (mg/L)	1	181	185.0	172.1	0.29	Acceptable
	2	28	24.4	23.1	1.239	Acceptable
Cadmium (μg/L)	1	20.5	17.43	17.59	1.477	Acceptable
	2	127	116.2	119.21	0.961	Acceptable
Calcium (mg/L)	1	2.3	2.37	2.35	0.216	Acceptable
	2	3.4	3.33	3.36	0.144	Acceptable
Chloride (mg/L)	1	23	24.5	24.35	0.843	Acceptable
	2	43	43.5	43.61	0.229	Acceptable
Chlorobenzene (μg/L)	1	33	36.04	34.55	0.367	Acceptable
	2	52	52.11	51.44	0.149	Acceptable
Chloroform (μg/L)	1	18	19.54	17.88	0.438	Acceptable
	2	83	83.49	77.93	0.470	Acceptable
Chromium (μg/L)	1	30.4	31.23	31.85	0.433	Acceptable
	2	133	134.76	135.62	0.238	Acceptable
Cobalt (mg/L)	1	148	147.96	147.82	0.019	Acceptable
	2	328	330.41	329.13	0.068	Acceptable
COD ^c (mg/L)	1	250	297.8	280.7	0.865	Acceptable
	2	31	38.8	33.9	0.339	Acceptable
Conductivity (μmho/cm)	1	240	264.6	232.8	0.622	Acceptable
	2	286	311.6	277.4	0.572	Acceptable
Copper (μg/L)	1	55.5	56.8	57.4	0.387	Acceptable
	2	197	203.0	206.7	0.838	Acceptable
Fluoride (mg/L)	1	1.4	1.427	1.445	0.524	Acceptable
	2	5.2	5.213	5.325	0.371	Acceptable
Hexavalent chromium (mg/L)	1	0.03	0.034	0.031	0.091	Acceptable
	2	0.14	0.149	0.145	0.320	Acceptable
Iron (μg/L)	1	98.9	94.8	93.8	0.461	Acceptable
	2	531	505.1	503.9	0.833	Acceptable
Lead (μg/L)	1	168	156.0	156.0	0.815	Acceptable
	2	344	328.1	326.2	0.800	Acceptable
Magnesium (mg/L)	1	0.948	0.933	0.95	0.024	Acceptable
	2	8.2	7.96	0.58	0.278	Acceptable
Manganese (μg/L)	1	34.1	33.6	33.44	0.304	Acceptable
	2	211	202.0	202.7	0.958	Acceptable

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Table 10.11 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Mercury	1	1.2	0.910	0.994	0.723	Acceptable
(µg/L)	2	4.9	4.72	4.58	0.428	Acceptable
Molybdenum	1	167	176.8	172.1	0.197	Acceptable
(mg/L)	2	297	299.5	305.8	0.258	Acceptable
Nickel	1	36.1	31.57	32.64	0.756	Acceptable
(µg/L)	2	108	103.55	106.26	0.220	Acceptable
Nitrate as N	1	<1	0.42	0.421		Not rated
(mg/L)	2	1.4	1.29	1.31	0.654	Acceptable
Oil and grease	1	6.1	6.46	6.49	0.146	Acceptable
(mg/L)	2	36.5	39.62	34.84	0.216	Acceptable
Orthophosphate as P (mg/L)	1	<2	0.43	0.43		Not rated
	2	2.7	2.64	2.66	0.215	Acceptable
pH	1	6.75	6.79	6.707	0.233	Acceptable
(units)	2	7.7	7.73	7.614	0.347	Acceptable
Potassium	1	8.5	8.41	8.46	0.050	Acceptable
(mg/L)	2	12.8	13.11	13.37	0.0695	Acceptable
Selenium	1	22.1	18.3	18.5	1.391	Acceptable
(µg/L)	2	98.1	85.2	87.6	0.689	Acceptable
Silver	1	22.4	22.05	21.98	0.183	Acceptable
(µg/L)	2	101	111.88	111.42	1.587	Acceptable
Sodium	1	42.3	41.6	42.17	0.047	Acceptable
(mg/L)	2	31.5	32.7	33.59	1.099	Acceptable
Sulfate	1	21	18.9	18.90	1.015	Acceptable
(mg/L)	2	10	10.30	11.23	0.471	Acceptable
TDS ^{d,e}	1	65	93.3	103.4	1.283	Warning
(mg/L)	2	273	290.5	105.3	0.526	Acceptable
Thallium	1	52	54.56	53.39	0.175	Acceptable
(µg/L)	2	466	491.08	486.02	0.433	Acceptable
TOC	1	114	112.1	114	0.009	Acceptable
(mg/L)	2	15	14.6	15.0	0.019	Acceptable
Toluene	1	25	28.79	27.48	0.757	Acceptable
(µg/L)	2	49	51.03	49.25	0.052	Acceptable
Total hardness as CaCO ₃	1	6	9.76	10.36	2.373	Warning
(mg/L)	2	9	41.09	41.06	8.380	Unacceptable
Total organic halides	1	23	26.9	27.64	0.876	Acceptable
(µg/L)	2	167	207.9	186.5	0.837	Acceptable
Total residual chlorine	1	0.9	0.974	0.933	0.279	Acceptable
(mg/L)	2	1.15	1.168	1.192	0.276	Acceptable
TSS ^{e,g}	1	26	33.9	89.8	1.32	Acceptable
(mg/L)	2	259	283.3	93.7	0.45	Acceptable
1,1,1-Trichloroethane	1	17	19.39	18.80	0.647	Acceptable
(µg/L)	2	75	75.68	73.65	0.123	Acceptable
1,1,2-Trichloroethane	1	7	7.96	7.55	0.346	Acceptable
(µg/L)	2	110	113.85	107.91	0.117	Acceptable
Uranium	1	175	160.2	164.9	1.005	Acceptable
(µg/L)	2	935	961.0	957.2	0.429	Acceptable

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Table 10.11 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Vanadium	1	48.4	45.57	45.21	0.550	Acceptable
(µg/L)	2	1065	1054.8	1075.0	0.171	Acceptable
Zinc	1	32.6	26.95	27.75	1.014	Acceptable
(µg/L)	2	135	123.96	125.88	1.038	Acceptable

^aPerformance evaluation made using U.S. Environmental Protection Agency criteria: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for marginal; more than 2.58 standard deviations for unacceptable.

^bBiological oxygen demand.

^cChemical oxygen demand.

^dTotal dissolved solids.

^eAverage percent recovery for participating laboratories.

^fTotal organic carbon.

^gTotal suspended solids.

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**Table 10.12. March 1992 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Alkalinity as CaCO ₃ (mg/L)	1	35	34.18	33.44	0.608	Acceptable
	2	32	30.94	32.32	0.112	Acceptable
Aluminum (μg/L)	1	109	59.7	58.3	5.13	Unacceptable
	2	513	497.8	495.2	0.374	Acceptable
Ammonia as N (mg/L)	1	0.40	0.873	0.830	2.793	Unacceptable
	2	1.5	1.815	1.785	1.181	Acceptable
Antimony (mg/L)	1	449	459.9	445.4	0.069	Acceptable
	2	704	689.9	683.9	0.289	Acceptable
Arsenic (μg/L)	1	81.2	58.05	55.65	2.975	Unacceptable
	2	505	445.04	428.09	1.477	Warning
Barium (μg/L)	1	510	527.2	527.8	0.336	Acceptable
	2	1480	1515.7	1506.1	0.359	Acceptable
Beryllium (μg/L)	1	59.7	62.75	59.79	0.020	Acceptable
	2	124	125.5	119.49	0.547	Acceptable
BOD ^b (mg/L)	1		113.9	113.9		Not reported
	2	22	23.1	23.9	0.329	Acceptable
Cadmium (μg/L)	1	59.2	58.1	56.67	0.426	Acceptable
	2	245	232.4	226.34	0.620	Acceptable
Calcium (mg/L)	1	3.18	3.13	3.13	0.124	Acceptable
	2	5.68	5.59	5.37	0.641	Acceptable
Carbon tetrachloride (μg/L)	1	14	14.8	14.28	0.137	Acceptable
	2	65	76.7	73.78	1.166	Acceptable
Chloride (mg/L)	1	19	19.97	19.97	0.679	Acceptable
	2	85	85.70	85.52	0.113	Acceptable
Chlorobenzene (μg/L)	1	8	8.4	8.40	0.374	Acceptable
	2	110	114.1	111.90	0.169	Acceptable
Chloroform (μg/L)	1	21	21.5	22.35	0.572	Acceptable
	2	111	103.6	101.76	0.775	Acceptable
Chromium (μg/L)	1	54.5	57.34	56.80	0.491	Acceptable
	2	114	114.69	116.07	0.206	Acceptable
Cobalt (mg/L)	1	147	150.2	149.46	0.412	Acceptable
	2	448	450.6	445.03	0.161	Acceptable
COD ^c (mg/L)	1	170	183.4	180.3	0.601	Acceptable
	2	40	37.2	36.1	0.543	Acceptable
Conductivity (μmho/cm)	1	174	187.0	170.4	0.274	Acceptable
	2	444	476.1	441.1	0.106	Acceptable
Copper (μg/L)	1	63.4	64.96	64.13	0.101	Acceptable
	2	267	267.98	266.07	0.068	Acceptable
1,2-Dichlorobenzene (μg/L)	1	36	87.3	47.2	1.065	Acceptable
	2	92	175.8	96.5	0.207	Acceptable
1,2-Dichloroethane	1	15	13.8	15.01	0.003	Acceptable
	2	143	140.7	144.91	0.088	Acceptable
2,4-Dinitrotoluene	1	23	23.3	16.0	1.247	Acceptable
	2	76	84.5	71.7	0.198	Acceptable
Ethyl benzene (μg/L)	1	31	31.2	32.51	0.302	Acceptable
	2	62	67.2	67.16	0.765	Acceptable
Fluoride (mg/L)	1	2.3	2.25	2.18	0.339	Acceptable
	2	5.3	5.25	5.19	0.225	Acceptable
Hexachlorobutadiene	1	26	44.0	24.2	0.262	Acceptable
	2	37	65.2	35.8	0.117	Acceptable

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Table 10.12 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Hexavalent chromium (mg/L)	1	0.06	0.057	0.055	0.911	Acceptable
	2	0.11	0.115	0.120	0.601	Acceptable
Iron (µg/L)	1	85.0	78.38	81.15	0.234	Acceptable
	2	437	435.4	435.1	0.051	Acceptable
Lead (µg/L)	1	142	136.7	136.16	0.263	Acceptable
	2	249	246.0	245.07	0.132	Acceptable
Magnesium (mg/L)	1	1.59	1.53	1.51	0.585	Acceptable
	2	10.3	9.97	9.86	0.699	Acceptable
Manganese (µg/L)	1	60.8	61.5	59.47	0.245	Acceptable
	2	196	193.3	190.62	0.355	Acceptable
Mercury (µg/L)	1	30.7	29.74	26.70	0.330	Acceptable
	2	89.4	89.22	77.08	0.352	Acceptable
Molybdenum (mg/L)	1	125	127.5	120.7	0.211	Acceptable
	2	318	318.6	311.6	0.117	Acceptable
Nickel (µg/L)	1	57.1	61.93	61.09	0.438	Acceptable
	2	293	294.2	290.1	0.151	Acceptable
Nitrate as N (mg/L)	1	<1	0.228	0.295		Not rated
	2	1.4	1.585	1.593	0.736	Acceptable
Oil and grease (mg/L)	1	5.8	5.56	6.15	0.125	Acceptable
	2	22.5	22.46	22.47	0.004	Acceptable
Orthophosphate as P (mg/L)	1	<2	0.486	0.520		Not rated
	2	2.2	2.180	2.194	0.015	Acceptable
Pentachlorophenol	1	56	80.4	53.17	0.182	Acceptable
	2	107	158.1	124.57	0.306	Acceptable
pH (units)	1	4.3	4.28	4.26	0.223	Acceptable
	2	7.7	7.85	7.65	0.176	Acceptable
Potassium (mg/L)	1	6.38	6.31	6.24	0.315	Acceptable
	2	17.8	17.74	17.69	0.081	Acceptable
Selenium (µg/L)	1	51.9	40.09	38.79	2.647	Acceptable
	2	166	140.3	134.28	1.724	Unacceptable
Silver (µg/L)	1	71.1	71.65	71.63	0.060	Acceptable
	2	115	119.42	119.90	0.386	Acceptable
Sodium (mg/L)	1	25.6	25.47	25.46	0.065	Acceptable
	2	52.8	52.25	52.69	0.033	Acceptable
Sulfate (mg/L)	1	15	14.93	14.46	0.397	Acceptable
	2	38	38.17	37.59	0.211	Acceptable
TDS ^{d,e} (mg/L)	1	197	199.0	109.3	0.545	Acceptable
	2	353	357.6	103.8	0.794	Acceptable
Thallium (µg/L)	1	38.8	36.38	38.30	0.032	Acceptable
	2	649	642.64	636.04	0.176	Acceptable
TOC ^f (mg/L)	1	77	69.0	71.7	1.072	Acceptable
	2	15	14.0	14.9	0.029	Unacceptable
Toluene (µg/L)	1	27	27.01	27.23	0.084	Acceptable
	2	48	51.17	50.28	0.473	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	12	14.13	14.5	1.184	Acceptable
	2	13	55.0	54.5	13.959	Unacceptable
Total organic halides (µg/L)	1	27	34.3	31.54	0.309	Acceptable
	2	214	219.5	193.23	0.233	Acceptable

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Table 10.12 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Total residual chlorine (mg/L)	1	0.60	0.620	0.564	0.461	Acceptable
	2	2.7	2.48	2.199	1.142	Acceptable
TSS ^{e,g} (mg/L)	1	59	71.3	88.6	0.666	Acceptable
	2	144	155.7	92.2	0.040	Acceptable
1,1,1-Trichloroethane	1	13	13.8	13.80	0.385	Acceptable
	2	63	70.8	69.12	0.658	Acceptable
1,1,2-Trichloroethane (µg/L)	1	11	9.87	10.04	0.520	Acceptable
	2	71	68.7	67.48	0.353	Acceptable
2,4,6-Trichlorophenol	1		12.4	8.74		Not reported
	2	101	130.6	111.2	0.285	Acceptable
Uranium (µg/L)	1	139	140.1	127.56	0.864	Acceptable
	2	305	340.3	318.84	0.764	Acceptable
Vanadium (µg/L)	1	274	281.3	280.37	0.610	Acceptable
	2	1047	1054.8	1053.71	0.187	Acceptable
Zinc (µg/L)	1	24.1	21.6	21.62	0.543	Acceptable
	2	142	134.7	135.60	0.473	Acceptable

^aPerformance evaluation made using U.S. Environmental Protection Agency criteria: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for marginal; more than 2.58 standard deviations for unacceptable.

^bBiological oxygen demand.

^cChemical oxygen demand.

^dTotal dissolved solids.

^eAverage percent recovery for participating laboratories.

^fTotal organic carbon.

^gTotal suspended solids.

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**Table 10.13. May 1992 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Alkalinity as CaCO ₃ (mg/L)	1	17	14.6	15.2	1.126	Acceptable
	2	29	29.8	29.9	0.534	Acceptable
Aluminum (μg/L)	1	50.9	49.8	52.8	0.132	Acceptable
	2	195	199.1	201.2	0.263	Acceptable
Ammonia as N (mg/L)	1	0.79	0.777	0.743	0.348	Acceptable
	2	2.0	2.055	1.989	0.042	Acceptable
Antimony (mg/L)	1	247	275.4	268.2	0.519	Acceptable
	2	522	550.7	539.3	0.446	Acceptable
Arsenic (μg/L)	1	56.2	57.0	58.0	0.348	Acceptable
	2	147	152.0	157.7	0.565	Acceptable
Barium (μg/L)	1	381	392.5	395.5	0.504	Acceptable
	2	1473	1472.0	1467.7	0.107	Acceptable
Benzene (μg/L)	1	22	22.0	22.13	0.045	Acceptable
	2	85	83.3	84.30	0.046	Acceptable
Beryllium (μg/L)	1	17	17.6	17.9	0.392	Acceptable
	2	188	188.2	185.4	0.220	Acceptable
BOD ^b (mg/L)	1	124	115.4	112.7	0.751	Acceptable
	2	22	19.0	17.6	1.337	Acceptable
Cadmium (μg/L)	1	59.3	58.1	58.3	0.191	Acceptable
	2	246	232.4	233.5	0.770	Acceptable
Calcium (mg/L)	1	2.48	2.59	2.57	0.345	Acceptable
	2	13.6	13.4	13.4	0.158	Acceptable
Chloride (mg/L)	1	17	17.8	18.0	0.777	Acceptable
	2	67	67.4	66.6	0.093	Acceptable
Chlorobenzene (μg/L)	1	7	7.11	7.06	0.094	Acceptable
	2	64	63.2	62.46	0.140	Acceptable
Chloroform (μg/L)	1	22	21.4	22.2	0.071	Acceptable
	2	120	121.2	122.5	0.083	Acceptable
Chromium (μg/L)	1	22.8	22.9	24.6	0.375	Acceptable
	2	111	114.7	115.6	0.490	Acceptable
Cobalt (mg/L)	1	189	184.9	186.5	0.287	Acceptable
	2	403	385.6	386.8	0.983	Acceptable
COD ^c (mg/L)	1	160	185.8	180.2	1.224	Acceptable
	2	29	30.6	28.9	0.003	Acceptable
Conductivity (μmho/cm)	1	129	134.7	129.8	0.133	Acceptable
	2	422	453.8	424.7	0.110	Acceptable
Copper (μg/L)	1	77.8	81.2	81.5	0.599	Acceptable
	2	201	203.0	204.6	0.289	Acceptable
1,2-Dichlorobenzene (μg/L)	1	8	7.07	7.24	0.680	Acceptable
	2	170	144.7	148.9	0.831	Acceptable
Ethyl benzene (μg/L)	1	8	7.8	8.16	0.145	Acceptable
	2	100	97.5	102.0	0.081	Acceptable
Fluoride (mg/L)	1	3.0	2.94	2.88	0.229	Acceptable
	2	8.5	8.43	8.70	0.332	Acceptable
Hexavalent chromium (mg/L)	1	0.04	0.034	0.037	0.357	Acceptable
	2	0.17	0.178	0.174	0.430	Acceptable
Iron (μg/L)	1	126	124.6	123.0	0.198	Acceptable
	2	344	332.3	335.4	0.348	Acceptable
Lead (μg/L)	1	143	156.0	156.0	0.852	Acceptable
	2	428	390.0	388.4	1.568	Acceptable

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Table 10.13 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Magnesium (mg/L)	1	1.42	1.503	1.547	0.574	Acceptable
	2	5.22	5.047	5.114	0.340	Acceptable
Manganese (µg/L)	1	82.3	79.1	80.6	0.290	Acceptable
	2	362	351.4	357.4	0.321	Acceptable
Mercury (µg/L)	1	0.857	0.95	1.022	0.819	Acceptable
	2	4.52	4.77	4.816	0.619	Acceptable
Methylene chloride (µg/L)	1	34	34.6	36.2	0.253	Acceptable
	2	80	86.5	89.5	0.448	Acceptable
Molybdenum (mg/L)	1	112	114.7	113.3	0.133	Acceptable
	2	251	254.9	254.7	0.161	Acceptable
Nickel (µg/L)	1	73.4	61.93	63.2	1.654	Acceptable
	2	248	232.2	239.9	0.492	Acceptable
Nitrate as N (mg/L)	1	<1	0.558	0.546		Not rated
	2	4.1	4.109	4.011	0.186	Acceptable
Oil and grease (mg/L)	1	17.6	18.9	15.0	0.641	Acceptable
	2	44.4	47.5	39.8	0.685	Acceptable
Orthophosphate as P (mg/L)	1	<2	0.369	3.71		Not rated
	2	7.8	7.58	7.62	0.211	Acceptable
pH (units)	1	9.4	9.59	9.46	0.223	Acceptable
	2	2.7	2.62	2.64	0.583	Acceptable
Potassium (mg/L)	1	2.56	3.033	3.078	0.865	Acceptable
	2	26	25.265	25.385	0.390	Acceptable
Selenium (µg/L)	1	28.7	25.06	24.63	0.735	Acceptable
	2	88.4	75.2	71.60	1.562	Acceptable
Silver (µg/L)	1	101	95.5	95.98	1.176	Acceptable
	2	190	191.1	193.76	0.205	Acceptable
Sodium (mg/L)	1	18.4	17.8	17.6	0.437	Acceptable
	2	44.4	42.9	43.4	0.333	Acceptable
Sulfate (mg/L)	1	15	14.9	14.8	0.077	Acceptable
	2	53	52.9	52.3	0.241	Acceptable
TDS ^{d,e} (mg/L)	1	163	186.3	100.4	0.697	Acceptable
	2	224	245.9	99.7	0.741	Acceptable
Tetrachloroethene	1	18	18.6	18.62	0.162	Acceptable
	2	120	125.9	116.05	0.177	Acceptable
Thallium (µg/L)	1	41.6	42.4	42.53	0.073	Acceptable
	2	303	303.1	269.12	0.562	Acceptable
TOC ^f (mg/L)	1	75	69.9	71.6	0.386	Acceptable
	2	12	11.5	12.4	0.192	Acceptable
Toluene (µg/L)	1	48	47.7	45.1	0.807	Acceptable
	2	55	53.5	57.0	0.145	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	10	12.6	12.5	1.413	Acceptable
	2	56	54.3	54.7	0.471	Acceptable
Total organic halides (µg/L)	1	81	36.6	42.57	1.997	Acceptable
	2	164	146.2	134.38	1.191	Acceptable
Total residual chlorine (mg/L)	1	0.35	0.365	0.353	0.050	Acceptable
	2	4.4	5.82	5.44	1.497	Acceptable
1,1,1-Trichloroethane	1	8	7.9	8.57	0.336	Acceptable
	2	55	53.7	56.36	0.105	Acceptable
TSS ^{e,g} (mg/L)	1	54	71.7	89.9	1.893	Acceptable
	2	268	298.5	92.9	0.570	Acceptable

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Table 10.13 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Uranium	1	136	140.1	137.08	0.168	Acceptable
(µg/L)	2	384	440.4	413.00	1.171	Acceptable
Vanadium	1	41.1	42.3	42.93	0.373	Acceptable
(µg/L)	2	1018	1016.1	1024.0	0.152	Acceptable
Zinc	1	51.9	47.69	49.19	0.432	Acceptable
(µg/L)	2	243	238.4	238.25	0.455	Acceptable

^aPerformance evaluation made using U.S. Environmental Protection Agency criteria: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for marginal; more than 2.58 standard deviations for not acceptable.

^bBiological oxygen demand.

^cChemical oxygen demand.

^dTotal dissolved solids.

^eAverage percent recovery for participating laboratories.

^fTotal organic carbon.

^gTotal suspended solids.

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**Table 10.14. July 1992 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Alkalinity as CaCO ₃ (mg/L)	1 2	18 25	15.7 24.1	16.4 24.0	0.894 0.470	Acceptable Acceptable
Aluminum (µg/L)	1 2	76.7 207.0	71.63 204.66	73.60 205.11	0.207 0.057	Acceptable Acceptable
Ammonia as N (mg/L)	1 2	0.47 4.7	0.49 5.09	0.509 5.07	0.323 0.625	Acceptable Acceptable
Antimony (mg/L)	1 2	47.4 1316.0	55.07 1363.03	49.4 1325.2	0.236 0.060	Acceptable Acceptable
Arsenic (µg/L)	1 2	60.0 283.8	56.99 284.76	56.65 284.12	0.597 0.011	Acceptable Acceptable
Barium (µg/L)	1 2	294.6 1478.0	294.4 1472.0	292.5 1457.5	0.113 0.190	Acceptable Acceptable
Benzene (mg/L)	1 2	10.8 102.6	9.8 103.7	9.85 102.58	0.820 0.002	Acceptable Acceptable
Beryllium (µg/L)	1 2	15.8 131.4	15.08 125.6	14.75 124.30	0.763 1.028	Acceptable Acceptable
BOD ^b (mg/L)	1 2	157 11	127.9 7.6	125.2 9.0	1.515 0.595	Acceptable Acceptable
Cadmium (µg/L)	1 2	30.98 122.9	29.05 116.20	29.80 116.05	0.337 0.820	Acceptable Acceptable
Calcium (mg/L)	1 2	3.16 12.7	3.02 12.51	3.107 12.53	0.155 0.194	Acceptable Acceptable
Chloride (mg/L)	1 2	45 55	44.7 53.1	44.8 52.6	0.059 0.861	Acceptable Acceptable
Chlorobenzene (µg/L)	1 2	8.1 167.9	8.00 174.90	8.080 174.197	0.015 0.273	Acceptable Acceptable
Chloroform (µg/L)	1 2	28.9 81.3	25.70 79.30	25.57 77.15	0.951 0.361	Acceptable Acceptable
Chromium (µg/L)	1 2	62.6 126.8	62.54 125.07	62.81 124.74	0.040 0.147	Acceptable Acceptable
Cobalt (µg/L)	1 2	130.4 263.1	128.5 257.0	127.92 253.32	0.322 0.701	Acceptable Acceptable
COD ^c (mg/L)	1 2	205 12	205.9 12.3	194.7 14.0	0.472 0.312	Acceptable Acceptable
Conductivity (µmho/cm)	1 2	242 331	249.4 348.1	241.8 323.0	0.013 0.378	Acceptable Acceptable
Copper (µg/L)	1 2	71.7 156.9	73.08 162.41	73.97 163.40	0.418 0.657	Acceptable Acceptable
1,2-Dichloroethane (µg/L)	1 2	37.0 75.2	32.4 71.2	31.76 70.40	1.394 0.570	Acceptable Acceptable
Ethyl benzene (µg/L)	1 2	31.9 57.14	31.80 67.60	31.165 67.028	0.236 1.200	Acceptable Acceptable
Fluoride (mg/L)	1 2	2.5 5.9	2.38 5.76	2.37 5.84	0.956 0.191	Acceptable Acceptable
Hexavalent chromium (mg/L)	1 2	0.07 0.46	0.078 0.469	0.075 0.478	0.543 0.434	Acceptable Acceptable
Iron (µg/L)	1 2	48.4 431.9	41.53 415.33	44.13 411.34	0.460 0.898	Acceptable Acceptable
Lead (µg/L)	1 2	121.8 424.6	105.67 396.26	106.14 393.06	1.614 1.217	Acceptable Acceptable

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Table 10.14 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Magnesium (mg/L)	1	3.41	3.17	3.20	0.853	Acceptable
	2	2.33	2.20	2.23	0.840	Acceptable
Manganese (µg/L)	1	58.4	56.01	55.66	0.667	Acceptable
	2	235.9	224.05	220.45	1.196	Acceptable
Mercury (µg/L)	1	13.8	1.67	1.732	60.657	Unacceptable
	2	4.85	4.77	4.641	0.315	Acceptable
Methylene chloride (µg/L)	1	26.1	21.7	24.61	0.231	Acceptable
	2	100.9	93.4	92.56	0.490	Acceptable
Molybdenum (mg/L)	1	91.2	102.0	99.65	0.784	Acceptable
	2	241.9	254.9	251.65	0.475	Acceptable
Nickel (µg/L)	1	49.9	50.51	50.90	0.164	Acceptable
	2	155.1	154.84	156.38	0.089	Acceptable
Nitrate as N (mg/L)	1	<1	0.35	0.356		Not rated
	2	3.0	2.73	2.68	0.996	Acceptable
Oil and grease (mg/L)	1	5.2	5.11	5.083	0.055	Acceptable
	2	20.4	21.81	20.09	0.075	Acceptable
Orthophosphate as P (mg/L)	1	<2	0.79	0.80		Not rated
	2	7.8	7.86	7.90	0.266	Acceptable
pH (units)	1	3.7	3.84	3.76	0.312	Acceptable
	2	8.7	8.92	8.72	0.068	Acceptable
Potassium (mg/L)	1	34.2	33.14	33.17	0.267	Acceptable
	2	27.3	26.55	26.49	0.363	Acceptable
Selenium (µg/L)	1	22.0	20.98	20.73	0.470	Acceptable
	2	73.0	65.58	63.45	1.047	Acceptable
Silver (µg/L)	1	48.1	47.77	47.17	0.157	Acceptable
	2	187.6	191.07	188.15	0.030	Acceptable
Sodium (mg/L)	1	14.87	14.37	14.96	0.073	Acceptable
	2	28.6	28.19	28.33	0.120	Acceptable
Sulfate (mg/L)	1	15	14.996	14.978	0.012	Acceptable
	2	35	35.865	35.676	0.245	Acceptable
TDS ^{d,e} (mg/L)	1	171	173.8	101.5	0.266	Acceptable
	2	303	309.3	101.4	0.463	Acceptable
Tetrachloroethene (µg/L)	1	30.6	30.70	29.33	0.349	Acceptable
	2	80.1	96.10	92.83	0.965	Acceptable
Thallium (µg/L)	1	165.9	167.94	159.75	0.345	Acceptable
	2	343.6	335.89	322.070	0.543	Acceptable
TOC ^f (mg/L)	1	89	77.5	79.8	1.097	Acceptable
	2	6	4.6	5.18	0.849	Acceptable
Toluene (µg/L)	1	15.6	15.2	14.85	0.483	Acceptable
	2	57.1	65.1	63.62	0.867	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	23	20.6	21.08	1.249	Acceptable
	2	40	40.6	40.30	0.143	Acceptable
Total organic halides (µg/L)	1	34	29.4	27.89	0.568	Acceptable
	2	282	249.7	238.1	2.132	Warning
Total residual chlorine (mg/L)	1	0.68	0.789	0.734	0.423	Acceptable
	2	2.80	3.72	3.43	1.101	Acceptable
1,1,1-Trichloroethane (µg/L)	1	42.2	37.80	36.64	1.173	Acceptable
	2	49.1	52.10	50.95	0.263	Acceptable

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Table 10.14 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
1,1,2-Trichloroethane	1	16.0	15.1	14.37	0.784	Acceptable
(µg/L)	2	105.5	104.3	107.38	0.090	Acceptable
TSS ^{e,g}	1	57	73.2	89.5	1.275	Acceptable
(mg/L)	2	243	261.6	93.0	0.023	Acceptable
Uranium	1	154	160.2	158.0	0.450	Acceptable
(µg/L)	2	787	800.8	763.3	0.539	Acceptable
Vanadium	1	44.6	42.33	42.54	0.582	Acceptable
(µg/L)	2	1285.0	1270.2	12642.17	0.513	Acceptable
Zinc	1	44.9	42.92	43.07	0.305	Acceptable
(µg/L)	2	193.9	190.75	188.46	0.422	Acceptable

^aPerformance evaluation made using U.S. Environmental Protection Agency criteria: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for marginal; more than 2.58 standard deviations for unacceptable.

^bBiological oxygen demand.

^cChemical oxygen demand.

^dTotal dissolved solids.

^eAverage percent recovery for participating laboratories.

^fTotal organic carbon.

^gTotal suspended solids.

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**Table 10.15. September 1992 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Alkalinity as CaCO ₃ (mg/L)	1	62	65.1	63.72	0.753	Acceptable
	2	16	14.6	15.43	0.293	Acceptable
Aluminum (μg/L)	1	88.5	81.86	81.58	0.627	Acceptable
	2	174.0	153.49	161.32	0.512	Acceptable
Ammonia as N (mg/L)	1	0.56	0.60	0.619	0.486	Acceptable
	2	4.5	4.66	4.785	0.486	Acceptable
Antimony (mg/L)	1	44.8	57.26	51.15	0.894	Acceptable
	2	863.0	954.29	892.71	0.414	Acceptable
Arsenic (μg/L)	1	127.0	94.99	91.37	3.658	Unacceptable
	2	435.0	379.94	380.11	1.620	Acceptable
Barium (μg/L)	1	524	522.4	511.26	0.514	Acceptable
	2	1315	1306.1	1298.19	0.282	Acceptable
Benzene (μg/L)	1	9	9.5	9.45	0.434	Acceptable
	2	71	69.3	68.16	0.340	Acceptable
Beryllium (μg/L)	1	12.7	12.55	12.00	0.462	Acceptable
	2	13.1	125.50	122.16	12.192	Unacceptable
BOD ^b (mg/L)	1	218	234.3	212.0	0.127	Acceptable
	2	5	4.2	5.18	0.103	Acceptable
Cadmium (μg/L)	1	31.2	29.05	29.08	0.554	Acceptable
	2	154	145.2	144.85	0.583	Acceptable
Calcium (mg/L)	1	27.9	29.70	30.69	0.832	Acceptable
	2	7.94	7.74	8.14	0.254	Acceptable
Carbon tetrachloride	1	39	40.3	38.54	0.105	Acceptable
	2	49	52.4	51.72	0.488	Acceptable
Chloride (mg/L)	1	129	135.1	134.63	1.170	Acceptable
	2	33	36.0	35.97	0.757	Acceptable
Chlorobenzene (μg/L)	1	8	7.7	7.97	0.034	Acceptable
	2	66	64.9	64.57	0.274	Acceptable
Chloroform (μg/L)	1	13	13.6	13.67	0.451	Acceptable
	2	68	67.7	67.31	0.107	Acceptable
Chromium (μg/L)	1	22.7	21.89	22.57	0.049	Acceptable
	2	228.0	234.51	233.99	0.336	Acceptable
Cobalt (mg/L)	1	181.0	179.9	176.30	0.407	Acceptable
	2	493.0	488.4	483.87	0.339	Acceptable
COD ^c (mg/L)	1	365	377.1	362.12	0.142	Acceptable
	2	20	6.80	10.67	1.689	Acceptable
Conductivity (μmho/cm)	1	754	839.5	749.6	0.145	Acceptable
	2	192	195.8	187.4	0.573	Acceptable
Copper (μg/L)	1	80.6	81.20	80.407	0.032	Acceptable
	2	204.0	203.01	203.592	0.027	Acceptable
1,2-Dichlorobenzene (μg/L)	1	33	31.1	29.89	0.791	Acceptable
	2	58	51.4	50.52	1.032	Acceptable
Ethyl benzene (μg/L)	1	15	15.1	15.02	0.013	Acceptable
	2	84	84.9	82.83	0.109	Acceptable
Fluoride (mg/L)	1	3.0	3.14	3.033	0.131	Acceptable
	2	5.2	5.25	5.255	0.250	Acceptable
Hexavalent chromium (mg/L)	1	0.09	0.094	0.092	0.222	Acceptable
	2	.12	0.125	0.124	0.382	Acceptable
Iron (μg/L)	1	46.8	41.53	43.84	0.355	Acceptable
	2	424.0	415.33	413.72	0.314	Acceptable

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Table 10.15 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Lead	1	78.8	79.25	77.969	0.140	Acceptable
(µg/L)	2	395.0	396.26	393.012	0.088	Acceptable
Magnesium	1	11.6	11.83	11.89	0.352	Acceptable
(mg/L)	2	4.48	4.34	4.36	0.472	Acceptable
Manganese	1	55.7	56.01	54.96	0.206	Acceptable
(µg/L)	2	111.0	112.02	110.77	0.034	Acceptable
Mercury	1	0.113	0.95	0.833	2.616	Unacceptable
(µg/L)	2	1.36	4.77	4.720	5.002	Unacceptable
Methylene chloride	1	21	20.6	23.52	0.596	Acceptable
(µg/L)	2	78	76.0	75.90	0.189	Acceptable
Molybdenum	1	96.4	101.97	99.60	0.593	Acceptable
(mg/L)	2	310.0	318.65	318.43	0.504	Acceptable
Nickel	1	75.4	76.28	75.37	0.005	Acceptable
(µg/L)	2	306.0	289.88	289.49	1.041	Acceptable
Nitrate as N	1	<1	0.64	0.635		Not rated
(mg/L)	2	4.6	4.5	4.511	0.245	Acceptable
Oil and grease	1	6.4	7.19	5.94	0.189	Acceptable
(mg/L)	2	32.7	35.3	29.9	0.380	Acceptable
Orthophosphate as P (mg/L)	1	<2	0.55	0.554		Not rated
	2	7.4	7.52	7.53	0.285	Acceptable
pH	1	6.6	6.78	6.66	0.312	Acceptable
(units)	2	7.3	6.62	7.49	1.183	Acceptable
Potassium	1	53.9	52.28	52.943	0.256	Acceptable
(mg/L)	2	9.97	9.68	9.879	0.111	Acceptable
Selenium	1	45.2	39.34	38.341	1.674	Acceptable
(µg/L)	2	57.3	52.46	55.098	0.254	Acceptable
Silver	1	47.5	47.77	47.279	0.029	Acceptable
(µg/L)	2	233	238.84	237.93	0.219	Acceptable
Sodium	1	68.9	65.18	66.12	1.170	Acceptable
(mg/L)	2	14.3	13.04	13.16	1.026	Acceptable
Sulfate	1	70	74.1	74.82	0.548	Acceptable
(mg/L)	2	15	13.3	13.00	1.408	Acceptable
Tetrachloroethylene	1	12	12.4	12.19	0.113	Acceptable
(µg/L)	2	89	95.2	90.22	0.137	Acceptable
Thallium	1	34.6	33.59	32.87	0.506	Acceptable
(µg/L)	2	267.0	268.71	256.36	0.371	Acceptable
TOC ^d	1	152	141.95	143.566	0.521	Acceptable
(mg/L)	2	3	2.56	3.267	0.345	Acceptable
Total hardness as CaCO ₃	1	120	123.6	119.75	0.057	Acceptable
(mg/L)	2	38	37.4	37.12	0.543	Acceptable
Total organic halides	1	35.5	29.40	29.36	0.574	Acceptable
(µg/L)	2	172.0	149.90	146.92	0.690	Acceptable
Total residual chlorine	1	0.67	0.742	0.702	0.413	Acceptable
(mg/L)	2	3.55	4.915	4.605	2.305	Warning
TSS ^{e,f}	1	37	48.7	89.78	2.068	Warning
(mg/L)	2	201	228.9	92.01	0.646	Acceptable
1,1,1-Trichloroethane	1	25	26.2	25.28	0.076	Acceptable
(µg/L)	2	94	99.7	95.64	0.112	Acceptable
1,1,2-Trichloroethane	1	14	14.4	13.98	0.013	Acceptable
(µg/L)	2	60	56.8	57.86	0.297	Acceptable

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Table 10.15 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Trichloroethylene	1	19	20.2	19.5	0.276	Acceptable
	2	109	111.7	107.3	0.135	Acceptable
Uranium	1	79	80.1	77.67	0.107	Acceptable
(µg/L)	2	874	880.9	846.50	0.422	Acceptable
Vanadium	1	43.3	42.22	41.469	0.601	Acceptable
(µg/L)	2	1740	1689.12	1686.78	0.910	Acceptable
Zinc	1	27.0	23.84	25.22	0.423	Acceptable
(µg/L)	2	195.0	190.75	188.87	0.385	Acceptable

^aPerformance evaluation made using U.S. Environmental Protection Agency criteria: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for marginal; more than 2.58 standard deviations for unacceptable.

^bBiological oxygen demand.

^cChemical oxygen demand.

^dTotal organic carbon.

^eAverage percent recovery for participating laboratories.

^fTotal suspended solids.

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**Table 10.16. November 1992 Analytical Products Group, Inc.,
Proficiency Environmental Testing Program**

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Alkalinity as CaCO ₃ (mg/L)	1	20	59.6	58.98	14.49	Unacceptable
	2	55	20.7	21.57	12.90	Unacceptable
Aluminum (μg/L)	1	55.8	51.16	51.603	0.646	Acceptable
	2	287.0	153.49	157.313	4.882	Unacceptable
Ammonia as N (mg/L)	1	0.45	0.415	0.462	0.089	Acceptable
	2	2.1	2.05	2.041	0.251	Acceptable
Antimony (mg/L)	1	142	211.0	216.5	2.38	Warning
	2	493	633.2	692.1	2.22	Warning
Arsenic (μg/L)	1	20	19.0	19.05	0.532	Acceptable
	2	119	151.9	153.41	1.364	Acceptable
Barium (μg/L)	1	258	261.2	259.80	0.134	Acceptable
	2	1302	1306.1	1313.28	0.179	Acceptable
Benzene (μg/L)	1	6.98	8.0	8.393	1.281	Acceptable
	2	92.68	98.8	102.843	0.765	Acceptable
Beryllium (μg/L)	1	17.1	17.57	17.13	0.025	Acceptable
	2	124.0	125.5	123.31	0.110	Acceptable
Cadmium (μg/L)	1	46.2	47.13	47.005	0.284	Acceptable
	2	120.0	117.83	119.942	0.009	Acceptable
Calcium (mg/L)	1	2.78	2.861	2.788	0.028	Acceptable
	2	29.2	30.65	30.485	0.406	Acceptable
Chloride (mg/L)	1	51	51.1	50.95	0.023	Acceptable
	2	91	91.6	91.67	0.232	Acceptable
Chlorobenzene (μg/L)	1	10.43	11.40	11.207	0.631	Acceptable
	2	62.83	65.90	65.985	0.268	Acceptable
Chloroform (μg/L)	1	20.66	21.00	21.046	0.104	Acceptable
	2	91.61	88.10	86.672	0.549	Acceptable
Chromium (μg/L)	1	20.4	22.25	22.425	0.741	Acceptable
	2	109.0	111.27	112.984	0.531	Acceptable
Cobalt (mg/L)	1	41.8	41.13	41.76	0.013	Acceptable
	2	259.0	257.04	259.01	0.001	Acceptable
COD ^b (mg/L)	1	145	182.3	174.0	1.995	Warning
	2	52	56.8	53.3	0.222	Acceptable
Conductivity (μmho/cm)	1	460	505.3	454.7	0.271	Acceptable
	2	395	423.6	390.2	0.235	Acceptable
Copper (μg/L)	1	50.1	48.72	49.47	0.176	Acceptable
	2	161.0	162.41	164.23	0.348	Acceptable
1,2-Dichlorobenzene (μg/L)	1	13.79	15.40	15.226	0.750	Acceptable
	2	121.58	129.70	129.642	0.401	Acceptable
Ethyl benzene (μg/L)	1	27.38	29.50	28.358	0.283	Acceptable
	2	79.08	84.50	84.966	0.411	Acceptable
Fluoride (mg/L)	1	2.9	3.0	3.027	0.505	Acceptable
	2	5.8	6.0	6.169	0.749	Acceptable
Hexavalent chromium (mg/L)	1	0.07	0.070	0.067	0.269	Acceptable
	2	0.20	0.209	0.203	0.193	Acceptable
Iron (μg/L)	1	125.0	124.6	123.083	0.165	Acceptable
	2	222.0	207.6	210.069	0.761	Acceptable
Lead (μg/L)	1	47.1	42.27	43.72	0.635	Acceptable
	2	223.0	211.34	213.55	0.583	Acceptable

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Table 10.16 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
Magnesium (mg/L)	1	2.22	2.266	2.203	0.098	Acceptable
	2	10.8	10.853	10.853	0.043	Acceptable
Manganese (µg/L)	1	38.2	39.21	39.28	0.547	Acceptable
	2	138.0	140.03	139.70	0.241	Acceptable
Mercury (µg/L)	1	1.56	1.43	1.436	0.470	Acceptable
	2	2.57	2.38	2.517	0.175	Acceptable
Methylene chloride (µg/L)	1	22.79	23.10	23.364	0.184	Acceptable
	2	54.17	64.60	69.882	0.918	Acceptable
Molybdenum (mg/L)	1	60.9	72.35	66.987	0.749	Acceptable
	2	214.0	241.17	229.163	0.890	Acceptable
Nickel (µg/L)	1	31.2	30.51	31.195	0.002	Acceptable
	2	125.0	122.05	123.367	0.258	Acceptable
Nitrate as N (mg/L)	1	1.1	0.743	0.749	4.028	Unacceptable
	2	3.8	3.70	3.711	0.211	Acceptable
Oil and grease (mg/L)	1	8.5	7.65	7.475	0.382	Acceptable
	2	41.6	45.51	40.116	0.220	Acceptable
Orthophosphate as P (mg/L)	1	<2	0.690	0.686		Not rated
	2	7.5	7.45	7.496	0.005	Acceptable
pH (units)	1	8.7	8.99	8.87	0.704	Acceptable
	2	5.9	5.99	5.93	0.132	Acceptable
Potassium (mg/L)	1	41.4	43.39	41.97	0.134	Acceptable
	2	5.8	5.47	5.39	0.836	Acceptable
Selenium (µg/L)	1	18.2	15.74	15.911	1.003	Acceptable
	2	64.9	65.58	64.343	0.090	Acceptable
Silver (µg/L)	1	31.5	33.44	34.50	0.525	Acceptable
	2	112.0	119.42	122.11	1.051	Acceptable
Sodium (mg/L)	1	57.8	59.00	58.82	0.310	Acceptable
	2	19.5	19.06	19.34	0.188	Acceptable
Sulfate (mg/L)	1	66	66.4	66.34	0.056	Acceptable
	2	20	18.9	18.62	0.941	Acceptable
TDS ^{c,d} (mg/L)	1	127	136.7	105.09	0.803	Acceptable
	2	342	355.3	101.83	0.667	Acceptable
Tetrachloroethylene	1	26.65	31.20	28.899	0.719	Acceptable
	2	57.76	62.90	59.675	0.313	Acceptable
Thallium (µg/L)	1	60.3	60.46	61.299	0.140	Acceptable
	2	277	268.71	265.488	0.358	Acceptable
TOC ^e (mg/L)	1	82	68.6	70.37	2.399	Warning
	2	24	21.4	22.13	1.270	Acceptable
Toluene (µg/L)	1	14.84	16.80	16.558	0.975	Acceptable
	2	66.38	69.20	68.335	0.231	Acceptable
Total hardness as CaCO ₃ (mg/L)	1	8.6	16.48	16.76	6.311	Unacceptable
	2	77	121.2	120.75	6.875	Unacceptable
Total organic halides (µg/L)	1	35	29.0	31.58	0.405	Acceptable
	2	354	319.4	308.82	0.990	Acceptable
Total residual chlorine (mg/L)	1	0.45	0.496	0.477	0.546	Acceptable
	2	2.52	3.010	2.818	1.162	Acceptable
TSS ^{e,f} (mg/L)	1	39	43.7	91.79	0.415	Acceptable
	2	198	221.0	94.47	0.911	Acceptable

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Table 10.16 (continued)

Parameter	Level	Reported value	Reference value	Mean of reporting labs	Number of standard deviations from the mean	Performance evaluation ^a
1,1,1-Trichloroethane	1	12.31	15.00	14.564	1.559	Acceptable
(µg/L)	2	54.89	62.00	61.802	0.915	Acceptable
Trichlorethylene	1	27.51	33.30	30.441	0.839	Acceptable
(units)	2	115.33	137.20	133.351	0.933	Acceptable
Uranium	1	162	160.2	152.83	0.985	Acceptable
(µg/L)	2	312	300.3	289.29	0.765	Acceptable
Vanadium	1	79.6	84.45	84.683	0.826	Acceptable
(µg/L)	2	1019.0	1055.70	1060.417	1.308	Acceptable
Zinc	1	24.0	23.84	24.854	0.258	Acceptable
(µg/L)	2	123.0	119.22	120.057	0.312	Acceptable

^aPerformance evaluation made using U.S. Environmental Protection Agency criteria: 0–1.96 standard deviations for acceptable; 1.97–2.58 standard deviations for marginal; more than 2.58 standard deviations for unacceptable.

^bChemical oxygen demand.

^cTotal dissolved solids.

^dAverage percent recovery for participating laboratories.

^eTotal organic carbon.

^fTotal suspended solids.

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**Table 10.17. January 1992 National Institute for Occupational Safety and Health (NIOSH)
Proficiency Analytical Testing (PAT) Program**

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	Number of labs
Asbestos (fibers/mm ²)	1	608.9	748.2	471.4–1210.5	Acceptable	1209
	2	417.9	495.8	282–769.6	Acceptable	1209
	3	184.9	232.8	116.3–389.3	Acceptable	1209
	4	290.4	356.9	197.6–562.8	Acceptable	1209
Cadmium (total mg)	1	0.092	0.0099	0.0084–0.0113	Acceptable	375
	2	0.0144	0.0147	0.0126–0.0169	Acceptable	375
	3	0.0200	0.0190	0.0165–0.0215	Acceptable	375
	4	0.0072	0.0069	0.0059–0.0079	Acceptable	375
Chromium (total mg)	1	0.0722	0.0744	0.0619–0.0868	Acceptable	370
	2	0.1720	0.1713	0.1392–0.2034	Acceptable	370
	3	0.1050	0.1010	0.0839–0.1181	Acceptable	370
	4	0.1518	0.1470	0.1209–0.1730	Acceptable	370
Lead (total mg)	1	0.0470	0.0494	0.0431–0.0556	Acceptable	380
	2	0.0785	0.0783	0.0676–0.0889	Acceptable	380
	3	0.0320	0.0304	0.0266–0.0342	Acceptable	380
	4	0.0612	0.0592	0.0523–0.0662	Acceptable	380

^aReference value calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

**Table 10.18. April 1992 National Institute for Occupational Safety and Health (NIOSH)
Proficiency Analytical Testing (PAT) Program**

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	Number of labs
Asbestos (fibers/mm ²)	1	144	245	67.5–533.2	Acceptable	1209
	2	1158	721.2	256.5–1420.8	Acceptable	1209
	3	485	490.1	173.9–966.4	Acceptable	1209
	4	227	279.4	85.7–584.3	Acceptable	1209
Cadmium (total mg)	1	0.0212	0.0218	0.0190–0.0245	Acceptable	382
	2	0.0174	0.0178	0.0154–0.0201	Acceptable	382
	3	0.0080	0.0079	0.0069–0.0090	Acceptable	382
	4	0.0108	0.0118	0.0103–0.0134	Acceptable	382
Lead (total mg)	1	0.0216	0.0220	0.0144–0.0246	Acceptable	386
	2	0.0378	0.0376	0.0326–0.0425	Acceptable	386
	3	0.0760	0.0743	0.0651–0.0835	Acceptable	386
	4	0.0460	0.0474	0.0416–0.0532	Acceptable	386
Zinc (total mg)	1	0.0760	0.0809	0.0671–0.0946	Acceptable	380
	2	0.1098	0.1142	0.0987–0.1297	Acceptable	380
	3	0.1935	0.1944	0.1708–0.2180	Acceptable	380
	4	0.1335	0.1536	0.1330–0.1743	Acceptable	380

^aReference value calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

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**Table 10.19. July 1992 National Institute for Occupational Safety and Health (NIOSH)
Proficiency Analytical Testing (PAT) Program**

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	Number of labs
Asbestos (fibers/mm ²)	1	368	383.3	205.8–615.6	Acceptable	1201
	2	801.2	863.1	477.9–1361.2	Acceptable	1201
	3	304	383.4	216.1–598.5	Acceptable	1201
	4	540	572.2	296.4–938	Acceptable	1201
Cadmium (total mg)	1	0.0053	0.0050	0.0043–0.0056	Acceptable	378
	2	0.0116	0.0117	0.0103–0.0131	Acceptable	378
	3	0.0161	0.0158	0.0141–0.0174	Acceptable	378
	4	0.0090	0.0089	0.0077–0.0101	Acceptable	378
Chromium (total mg)	1	0.2170	0.2177	0.1648–0.2706	Acceptable	376
	2	0.1900	0.1780	0.1411–0.2149	Acceptable	376
	3	0.0728	0.0748	0.0605–0.0892	Acceptable	376
	4	0.1235	0.1223	0.0950–0.1497	Acceptable	376
Lead (total mg)	1	0.0540	0.0489	0.0423–0.0555	Acceptable	382
	2	0.0285	0.0275	0.0235–0.0315	Acceptable	382
	3	0.0688	0.0650	0.0555–0.0744	Acceptable	382
	4	0.0833	0.0785	0.0694–0.0876	Acceptable	382

^aReference value calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

**Table 10.20. October 1992 National Institute for Occupational Safety and Health (NIOSH)
Proficiency Analytical Testing (PAT) Program**

Parameter	Control number	Reported value	Reference value ^a	Performance limits	Performance evaluation ^b	Number of labs
Asbestos (fibers/mm ²)	1	625	645.9	256.2–1212.6	Acceptable	1206
	2	422	382.1	138.3–747	Acceptable	1206
	3	146	163.5	43.3–361	Acceptable	1206
	4	354	412.9	168.1–765.9	Acceptable	1206
Cadmium (total mg)	1	0.0175	0.0175	0.0152–0.0197	Acceptable	388
	2	0.0100	0.0098	0.0085–0.0111	Acceptable	388
	3	0.0665	0.0059	0.0050–0.0067	Outlier	388
	4	0.0138	0.0136	0.0120–0.0152	Acceptable	388
Lead (total mg)	1	0.0302	0.0291	0.0249–0.0333	Acceptable	394
	2	0.0770	0.0734	0.0650–0.0819	Acceptable	394
	3	0.0410	0.0414	0.0375–0.0454	Acceptable	394
	4	0.0665	0.0627	0.0552–0.0701	Acceptable	394
Zinc (total mg)	1	0.0738	0.0745	0.0617–0.0873	Acceptable	386
	2	0.1430	0.1434	0.1202–0.1665	Acceptable	386
	3	0.2030	0.2067	0.1724–0.2410	Acceptable	386
	4	0.1780	0.1782	0.1506–0.2058	Acceptable	386

^aReference value calculated from transformed variables. See NIOSH PAT protocol for details.

^bPerformance limits set by NIOSH. Those within range are acceptable; those outside range are outliers.

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**Table 10.21. March 1992 Environmental Measurements Laboratory (EML)
Semiannual Report of the Department of Energy Operational Safety,
Health, and Environment Division Quality Assessment Program**

Parameter	EML value	Reported value (Rp)	Ratio (Rp/EML)	Performance evaluation ^a
<i>Air (pCi/filter)</i>				
⁷ Be	0.286E+02	0.276E+02	0.97	Acceptable
¹⁴⁴ Ce	0.639E+02	0.802E+02	1.26	Marginal
⁵⁷ Co	0.793E+01	0.657E+01	0.83	Acceptable
⁶⁰ Co	0.581E+01	0.578E+01	0.99	Acceptable
¹³⁷ Cs	0.576E+01	0.572E+01	0.99	Acceptable
¹³⁴ Cs	0.444E+01	0.448E+01	1.01	Acceptable
⁵⁴ Mn	0.597E+01	0.574E+01	0.96	Acceptable
²³⁸ Pu	0.270E+00	0.260E+00	0.96	Acceptable
²³⁹ Pu	0.285E+00	0.264E+00	0.93	Acceptable
<i>Soil (pCi/g)</i>				
¹³⁷ Cs	0.523E+01	0.550E+01	1.05	Acceptable
⁴⁰ K	0.719E+03	0.753E+03	1.05	Acceptable
<i>Water (pCi/mL)</i>				
¹⁴⁴ Ce	0.189E+03	0.240E+03	1.27	Marginal
⁶⁰ Co	0.940E+02	0.100E+03	1.06	Acceptable
¹³⁴ Cs	0.718E+02	0.811E+02	1.13	Acceptable
¹³⁷ Cs	0.846E+02	0.940E+02	1.11	Acceptable
⁵⁴ Mn	0.566E+02	0.621E+02	1.10	Acceptable
²³⁸ Pu	0.450E+00	0.501E+00	1.11	Acceptable
²³⁹ Pu	0.580E+00	0.424E+00	0.73	Marginal
U (μg/mL)	0.330E-01	0.340E+02		Unacceptable
<i>Vegetation (pCi/g)</i>				
¹³⁷ Cs	0.246E+02	0.257E+02	1.04	Acceptable
⁴⁰ K	0.294E+03	0.335E+03	1.14	Acceptable

^aPerformance evaluation determined by using the ratio of our value to the EML value. Acceptable range is 0.8–1.2; marginal range is 0.5 to 0.8 and 1.2 to 1.5; unacceptable range is <0.5 or >1.5.

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**Table 10.22. September 1992 Environmental Measurements Laboratory (EML)
Semiannual Report of the Department of Energy Operational Safety,
Health, and Environment Division Quality Assessment Program**

Parameter	EML value	Reported value (Rp)	Ratio (Rp/EML)	Performance evaluation ^a
<i>Air (pCi/filter)</i>				
⁷ Be	0.308E+03	0.316E+03	1.03	Acceptable
¹⁴⁴ Ce	0.433E+02	0.351E+02	0.81	Acceptable
⁵⁷ Co	0.640E+01	0.660E+01	1.03	Acceptable
⁶⁰ Co	0.306E+01	0.336E+01	1.10	Acceptable
¹³⁴ Cs	0.372E+01	0.346E+01	0.93	Acceptable
¹³⁷ Cs	0.582E+01	0.613E+01	1.05	Acceptable
⁵⁴ Mn	0.259E+02	0.273E+02	1.05	Acceptable
²³⁸ Pu	0.420E-01	0.370E-01	0.88	Acceptable
²³⁹ Pu	0.450E-01	0.440E-01	0.98	Acceptable
<i>Soil (pCi/g)</i>				
¹³⁷ Cs	0.285E+03	0.268E+03	0.94	Acceptable
⁴⁰ K	0.384E+03	0.372E+03	0.97	Acceptable
<i>Water (pCi/mL)</i>				
¹⁴⁴ Ce	0.512E+02	0.414E+02	0.81	Acceptable
⁶⁰ Co	0.278E+02	0.240E+02	0.86	Acceptable
¹³⁴ Cs	0.441E+02	0.176E+02	0.40	Unacceptable
¹³⁷ Cs	0.290E+02	0.112E+02	0.39	Unacceptable
⁵⁴ Mn	0.333E+02	0.289E+02	0.87	Acceptable
²³⁸ Pu	0.197E+01	0.166E+01	0.84	Acceptable
²³⁹ Pu	0.238E+00	0.337E+00	1.42	Marginal
U (μg/mL)	0.906E-02	0.900E-02	0.99	Acceptable
<i>Vegetation (pCi/g)</i>				
¹³⁷ Cs	0.292E+02	0.269E+02	0.92	Acceptable
⁴⁰ K	0.101E+04	0.952E+03	0.94	Acceptable

^aPerformance evaluation determined by using the ratio of our value to the EML value. Acceptable range is 0.8–1.2; marginal range is 0.5–1.5; unacceptable range is <0.5 or >1.5.

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**Table 10.23. 1992 Environmental Measurements Systems Laboratory—Las Vegas
(EMSL-LV) Intercomparison Study**

Parameter/matrix	Known value	Control limits	Reported average ^a	Performance evaluation
<i>January</i>				
Plutonium in water	16.8 pCi/L	13.9–19.7	15.27	Acceptable
<i>February</i>				
Gross alpha in water	30.0 pCi/L	16.1–43.9	21.67	Acceptable
Gross beta in water	30.0 pCi/L	21.3–38.7	35.33	Acceptable
Iodine in water	59.0 pCi/L	48.6–69.4	74.33	Above control limit (warning)
Gamma in water				
¹³³ Ba	76.0 pCi/L	62.1–89.9	76.67	Acceptable
⁶⁰ Co	40.0 pCi/L	31.3–48.7	38.67	Acceptable
¹³⁴ Cs	31.0 pCi/L	22.3–39.7	33.0	Acceptable
¹³⁷ Cs	49.0 pCi/L	40.3–57.7	49.67	Acceptable
¹⁰⁶ Ru	203.0 pCi/L	168.3–237.7	215.33	Acceptable
⁶⁵ Zn	148.0 pCi/L	122.0–174.0	143.0	Acceptable
<i>March</i>				
Uranium in water	25.3 pCi/L	20.1–30.5	23.13	Acceptable
Alpha on air filters	7.0 pCi/filter	6.0–15.7	7.33	Acceptable
Beta on air filters	41.0 pCi/filter	32.3–49.7	42.67	Acceptable
¹³⁷ Cs on air filters	10.0 pCi/filter	1.3–18.7	9.67	Acceptable
<i>May</i>				
Gross alpha in water	15.0 pCi/L	6.3–23.7	14.33	Acceptable
Gross beta in water	44.0 pCi/L	35.3–52.7	53.67	Acceptable
<i>June</i>				
Gamma in water				
¹³³ Ba	98.0 pCi/L	80.7–115.3	97.67	Acceptable
⁶⁰ Co	20.0 pCi/L	11.3–28.7	21.00	Acceptable
¹³⁴ Cs	15.0 pCi/L	6.3–23.7	15.00	Acceptable
¹³⁷ Cs	15.0 pCi/L	6.3–23.7	14.33	Acceptable
¹⁰⁶ Ru	141.0 pCi/L	116.7–165.3	143.00	Acceptable
⁶⁵ Zn	99.0 pCi/L	81.7–116.3	103.00	Acceptable
<i>July</i>				
Uranium in water	4.0 pCi/L	0.0–9.2	4.13	Acceptable

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Table 10.23 (continued)

Parameter/matrix	Known value	Control limits	Reported average ^a	Performance evaluation
<i>August</i>				
Alpha on air filter	30.0 pCi/filter	16.1–43.9	29.33	Acceptable
Beta on air filter	69.0 pCi/filter	51.7–86.3	78.00	Acceptable
¹³⁷ Cs on air filter	18.0 pCi/filter	9.3–26.7	15.33	Acceptable
Iodine in water	45.0 pCi/L	34.6–55.4	43.00	Acceptable
Plutonium in water	9.0 pCi/L	7.4–10.6	8.07	Acceptable
<i>September</i>				
Gross alpha in water	45.0 pCi/filter	25.9–64.1	35.00	Acceptable
Gross beta in water	50.0 pCi/filter	41.3–58.7	55.33	Acceptable
<i>October</i>				
Gamma in water				
¹³³ Ba	74.0 pCi/L	61.9–86.1	7.33	Outlier
⁶⁰ Co	10.0 pCi/L	1.3–18.7	10.00	Acceptable
¹³⁴ Cs	8.0 pCi/L	0.0–16.7	7.67	Acceptable
¹³⁷ Cs	8.0 pCi/L	0.0–16.7	8.33	Acceptable
¹⁰⁶ Ru	175.0 pCi/L	143.8–206.2	160.00	Acceptable
⁶⁵ Zn	148.0 pCi/L	122.0–174.0	157.00	Acceptable

^aResults reported on three aliquots and averaged by EMSL-LV.

Appendix A

Paducah Gaseous Diffusion Plant Chemical Release Data

Appendix A

Paducah Gaseous Diffusion Plant (PGDP) Chemical Release Data

In addition to indicating the concentrations of various chemicals present in the environment near U.S. Department of Energy (DOE) facilities, in recent years the annual environmental reports have contained an estimate of the quantities of certain chemicals being emitted to the environment. This appendix contains an expanded list of chemicals with additional information regarding the types of releases, the estimated quantities released, the major processes contributing to the releases, and a brief description of the basis of estimates for CY 1992. Radiological chemical releases for CY 1992 are not included in this appendix; they are reported in the applicable sections in this report.

Three categories of chemical releases at each DOE facility are reported in this appendix: (1) Superfund Amendments and Reauthorization Act of 1986, Sect. 313 (SARA 313), chemicals, (2) other large inventory chemicals, and (3) steam plant emissions. The SARA 313 chemicals are summarized from information being compiled for the SARA Title III, Sect. 313 report, required by SARA. This report is submitted on July 1 of each year for the previous calendar year and contains chemicals on the U.S. Environmental Protection Agency's (EPA's) toxic substance list. At present, more than 300 specific chemicals and 20 chemical categories must be reviewed and possibly reported under SARA 313. If any of these chemicals were manufactured in excess of 25,000 lb, processed in excess of 25,000 lb, or "otherwise used" in excess of 10,000 lb at a facility during CY 1992, the chemical must be reported. In many instances the estimate of quantities released was obtained through material balance calculations, monitoring data, or engineering calculations. In some cases no quantitative monitoring data, inventory

estimates, or emission factors were readily available, and release estimates were based on "best engineering judgement." Information obtained from air permits, rates of operation, quantities used, and known treatment efficiencies were used to estimate quantities released into the environment. Typically, assumptions based on best engineering judgement were required to perform the calculations when all variables were not known.

The second category of chemicals reported in this appendix is "other large inventory chemicals." This listing is included to provide the reader with additional chemical information not reportable under SARA 313. Note that this is not a complete listing of all chemicals that may have been released at a site. This list was developed to better inform the reader of the additional chemicals (i.e., those that may be of interest to the general public) that are used and released at PGDP.

The third category, "steam plant emissions," consists of release estimates of certain chemicals from the coal- and/or gas-fired steam plants located at each site.

Information contained in this appendix may not coincide for all chemicals with the information to be reported under SARA, Title III, Sect. 313. The SARA 313 report must be submitted to the EPA and the Kentucky Department of Environmental Protection no later than July 1, 1993. The information for this appendix was generated in March and April 1993; additional refinements are under way. It is imperative that information generated in May and June be used as well to ensure compliance under SARA Title III, the community right-to-know law. The following table summarizes the chemical release information for PGDP.

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Paducah Gaseous Diffusion Plant 1992 chemical release information

Chemical name	Type of release	Quantity released (lb/kg)	Major release source	Basis of estimate
<i>SARA 313^a</i>				
Chromium ^b	Air: fugitive emissions	4,433/2,015	Cooling tower system	Material balance
	Water: Big Bayou Creek	29/13	C-616 chromium reduction facility	Monitoring
	Water: Little Bayou Creek	9/4	Cooling tower system	Monitoring
	Land: to C-616 sludge lagoon	15,500/7,046	C-616 chromium reduction facility sludge	Monitoring
Trichloroethylene	Air: point source	22,534/10,221	C-400 degreaser/storage tanks	Material balance
	Water: Big Bayou Creek	27/12	C-400 degreasing operations	Monitoring
	Water: Little Bayou Creek	1/0.5	Degreasing operations	Monitoring
Sulfuric acid	Air: fugitive emissions		Cooling tower system	Engineering calculations
Chlorine	Air: fugitive emissions	9,234/4,197	Cooling tower system	Engineering calculations
	Water: Big Bayou Creek	17/8	C-615 sewage treatment plant	Monitoring
	Water: Little Bayou Creek	1/0.5	Once-through cooling water	Monitoring
Freon 114	Air: fugitive emissions	376,000/170,704	Process cooling	Engineering calculations
<i>Other large inventory chemicals</i>				
Fluorides	Air: stack emissions	14,421/6,547	C-310 stack emissions	Engineering calculations/ continuous stack sampling
Nitric acid	Air: point source	6/3	C-400 storage tank	Engineering calculations
Ammonia	Air: fugitive emissions	300/136	Blueprint machines	Material balance

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Paducah Gaseous Diffusion Plant 1992 chemical release information (continued)

Chemical name	Type of release	Quantity released (lb/kg)	Major release source	Basis of estimate
<i>Other large inventory chemicals (continued)</i>				
Freon 11	Air: fugitive emissions	2,400/1,080	Air-conditioning systems	Material balance
Freon 22	Air: fugitive emissions	360/500	Air-conditioning systems	Material balance
Freon 113	Air: fugitive emissions	2,120/964	C-360 flush solution for sample cooldown	Material balance
<i>Steam plant emissions</i>				
Sulfur dioxide ^c	Air: stack emissions	856,808/388,648	Fossil fuels combustion	Emission factors
Nitrogen	Air: stack emissions	570,318/258,696	Fossil fuels combustion	Emission factors
Particulates ^c	Air: stack combustion	49,713/22,550	Fossil fuels combustion	Emission factors
Carbon monoxide ^c	Air: stack emissions	22,550/10,238	Fossil fuels combustion	Emission factors
Non-methane volatile organic compounds	Air: stack emissions	2,126/964	Fossil fuels combustion	Emission factors
Methanes	Air: stack emissions	939/426	Fossil fuels combustion	Emission factors

^aSuperfund Amendments and Reauthorization Act of 1986, Title III, Sect. 313.

^bQuantity calculated as chromium; chemical compound is sodium bichromate.

^cU.S. Environmental Protection Agency, October 1986. *Compilation of Air Pollutant Emission Factors*, Vol. 1 (Suppl. A).

Appendix B

Errata for the *Paducah Gaseous Diffusion Plant Environmental Report for 1991*

Appendix B

Errata for the *Paducah Gaseous Diffusion Plant Environmental Report for 1991*

1. Table 4.1 in Part 1 should include the following:

Location SW29 should also list ^{99}Tc , ^{239}Pu , ^{237}Np , and ^{235}U as parameters. PO_4 should be listed as $\text{PO}_4\text{-P}$.

Location SW30 should also list suspended alpha and beta, ^{99}Tc , ^{239}Pu , ^{237}Np , and ^{235}U as parameters. PO_4 should be listed as $\text{PO}_4\text{-P}$.

Location SW13, weekly, should also list ^{99}Tc , ^{235}U , and temperature as parameters. PO_4 should be listed as $\text{PO}_4\text{-P}$.

Location SW1, monthly, should also list PO_4 as $\text{PO}_4\text{-P}$.

The results for all these analyses are listed in Tables 4.16 through 4.22 in Part 2.

2. Tables 4.2, 4.4, 4.6, 4.7, 4.12, 4.13, 4.14, 4.16, 4.17, 4.20, and 4.21 in Part 2 should all list as a parameter "phosphate as phosphorus" instead of "phosphate."
3. Table 5.6 in Part 1 should list as a parameter "phosphate as phosphorus" instead of "phosphate."
4. Table 5.7 in Part 2 should list NO_3 as $\text{NO}_3\text{-N}$.
5. Table 5.10 in Part 2 should list PO_4 as $\text{PO}_4\text{-P}$.

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